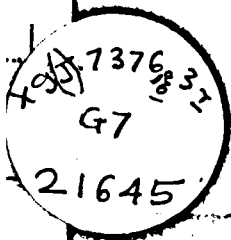


A Year's Progress in Solving Farm Problems of Illinois

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A YEAR'S PROGRESS IN SOLVING FARM PROBLEMS OF ILLINOIS

ANNUAL REPORT

of

H. W. Mumford, Dean and Director
Illinois Agricultural Experiment Station
College of Agriculture
University of Illinois

Compiled and Edited from
Reports of Heads of Departments and
Project Leaders
By F. J. Keilholz

Forty-Ninth Report
For Year Ended
June 30, 1936

Urbana, Illinois
1937

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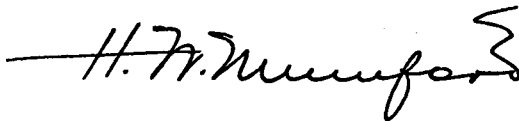
LETTER OF TRANSMITTAL

Urbana, July, 1937

To the President:

I submit herewith the Forty-Ninth Annual Report of the Agricultural Experiment Station of the University of Illinois, for transmission to the Trustees, the Governor, and other officers in accordance with the laws and with the rules of the University.

Very truly yours,

A handwritten signature in cursive script, reading "H. F. Munford". The signature is written in dark ink and is positioned above the printed name "Director".

Director

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A YEAR'S PROGRESS IN SOLVING FARM PROBLEMS OF ILLINOIS

AFTER SIXTY YEARS this may be the time to review briefly some of the things that have been accomplished in soil conservation and erosion prevention. Far too many citizens still mistakenly believe that until recently little had been done about these problems, the reason being, perhaps, that the increased emphasis now being placed upon these matters has brought them more prominently into the public attention than ever before. Even so, the mistaken conclusion of some people that little was done previously is not as serious nor as false as the belief of others that the problem will be solved in a few years with emergency methods.

It seems appropriate to reflect upon these matters at this time, since the year covered by this report is the sixtieth one in which the problems of soil mining and destruction have been attacked by the College of Agriculture. Even before 1876 the problem had not been ignored, but the attack took definite form that year with the laying out of the Morrow plots—now recognized as America's oldest soil experiment plots.

But for such foresight as this exercised by the University of Illinois College of Agriculture and similar institutions, the problems of soil conservation and erosion control would be far more serious than they are. Sixty or seventy-five years ago farmers of Illinois thought their rich prairie soils would never wear out. The idea of even trying to prove otherwise was almost openly scoffed at. Nevertheless Professor George E. Morrow and his associates were foresighted and courageous enough to lay out the north end of the plots so that corn could be grown continuously year after year, much in the manner that early farmers of the state believed they could farm. What would have happened in the way of soil destruction had farmers gone on farming in this manner is unquestioned after sixty years' results from these plots.

On still other of the Morrow plots there is also being demonstrated in simple and striking form the "Illinois System of Permanent Soil Fertility" so vigorously promulgated by the late Dr. Cyril G. Hopkins and other staff members of the agricultural college. How clearly they foresaw that the spreading of limestone and, where needed, phosphorus; the growing of legumes; and the rotating of crops would be more successful, more profitable, and more permanent than building terraces, plowing in gullies, and following other emergency practices after the rich top soil was gone! As the late Andrew Sloan Draper,

former president of the University, pointed out forty years ago, "The wealth of Illinois is in her soils and her strength lies in its intelligent development."

It has long been recognized, too, that soil development and conservation methods differ because of the great variation in soil types making up the state's farms. Thus it was that many years ago the Experiment Station inaugurated a soil survey to inventory those soils, map their location, and work out sound methods of management and cropping for each of them. Soil reports are now available for 56 counties of the state, and for all other counties there is a growing volume of information and facts.

All of this pioneering work is but a small part of the program which the Experiment Station and the University of Illinois are now carrying on thruout the state to cope with the problem of soil conservation and improvement, erosion control, and land utilization. This program is being furthered thru a score or more of soil experiment fields located in various parts of the state, thru thousands of actual farm demonstrations, thru meetings, exhibits, printed bulletins and circulars, and other means, all of which are part of the field educational effort.

Backing these field activities, and reported in this volume, are the results not only from the Morrow plots and the soil experiment fields, but also from some thirty other experiments and studies which have a more or less direct bearing upon the problems of soil conservation and erosion control. Many of these projects are of almost as long standing as the Morrow plots and equally as significant.

The next sixty or one hundred years will put these measures to their real test and produce the record of success or failure in soil conservation and erosion control. Successful as they may be, however, soil conservation and erosion control will not, in themselves alone, make agriculture stable and profitable nor rural life satisfying and happy.

That cannot be until a complexity of other problems is solved, too. These include such matters as crop and livestock insurance in the broadest sense of the word thru improved varieties and types, reduction of losses and wastes, better management, and efficient marketing; grain and crop storage; tenancy; consumer interests; new crops, uses and methods; finer communities; and more convenient and more satisfactory homes.

On all these problems and on others which will arise in the future the Experiment Station seeks to be as foresighted and as useful as it was on the challenge of soil conservation sixty years ago.

(H.W.M.)

ADMINISTRATION

Majority of Rural Group Leaders Are Voluntary Workers

More than 12,000 voluntary leaders participated in organizing and directing local groups of farm people in 80 Illinois counties in 1935. Thru the help of these local leaders, 86 percent of the rural communities in the 80 counties from which reports were received were organized to receive extension work in agriculture and home economics. There was an average of 143 local leaders to a county and 10 to a community.

This evidence of the prominent part played by local leaders in improving farm life and in making adjustments to changing conditions has come out of further studies of farmers' organizations by D. E. Lindstrom, Rural Sociology; H. W. Mumford, Administration; and R. C. Ross, Agricultural Economics.

More than 13,000 community meetings were held in 1935. These meetings were attended by approximately 690,000 persons, an average of 53 to a meeting. Seven hundred and forty-six groups were formally organized and cooperating in 75 counties. These groups, an average of 9.9 to a county, represented 58 percent of all rural communities in the counties and 70 percent of those reporting cooperation in carrying out the extension program.

Rapid changes in the national, state, county, and local situations make it increasingly important to develop organizations and programs to aid in agricultural adjustment and improvement. No longer are the new organizations needed primarily economic; they are fundamentally social. Present conditions call for the development of proper human and group relationships. Rural community organization and social planning such as that being developed in Illinois will play a large part in the building of programs to improve farm life and to bring about needed adjustments to changing conditions. (1 Administration)

Farmers Alert to Problems and Needs in Conservation

Altho Illinois is a relatively level prairie state with a large proportion of highly productive land, a century of farming has brought about impoverishment of agricultural resources to the extent that the maintenance and improvement of these resources demands serious attention both from farmers and the general public. That farmers are alert at least to some of these problems is shown in the results of further studies made during the past year by H. W. Mumford, Administration, in connection with the Experiment Station's long-time project on agricultural adjustment.

These further studies in agricultural adjustment were based upon a survey which the U. S. Department of Agriculture undertook in

TABLE 1.—ILLINOIS LAND USE IN 1934,¹ 1936 INTENTIONS,² AND 1936 WITH CONSERVATION,³ EXPRESSED AS PERCENTAGES OF 1929⁴ ACREAGES, BY FARMING-TYPE AREAS (1929 = 100 percent of each use)

Type-of-farming areas	Illinois	1	2	3	4A	4B	5A	5B	6	7A	7B	7C	8	9
<i>Land in farms, total, 1934</i>	103.1	106.1	102.1	101.1	101.0	101.9	106.3	101.7	104.9	109.7	102.6	106.1	105.6	107.3
1936 intentions.....	103.2	106.1	102.1	101.0	101.0	102.1	106.3	101.7	104.9	109.7	102.6	106.1	105.6	107.3
1936 with conservation.....	102.9	106.1	101.9	100.2	100.7	100.4	106.9	101.7	104.9	109.7	102.6	106.1	105.6	107.3
<i>Cropland, total, 1934</i>	100.0	103.6	98.0	96.7	100.0	100.0	103.2	94.1	103.4	105.5	94.7	102.0	103.8	101.9
1936 intentions.....	100.4	103.9	101.2	96.6	100.2	99.7	103.2	92.9	103.1	106.7	95.7	103.1	102.3	103.4
1936 with conservation.....	96.7	102.0	97.8	91.7	97.9	94.1	99.9	89.4	101.0	98.6	92.3	98.7	95.2	96.0
<i>Harvested, 1934</i>	92.7	95.5	86.2	77.2	87.2	93.6	102.1	85.2	107.8	121.7	107.4	118.6	112.3	119.8
1936 intentions.....	105.3	104.8	103.1	95.9	101.4	101.7	111.3	102.4	111.8	135.7	120.4	126.3	116.3	124.9
1936 with conservation.....	101.6	102.8	99.2	90.8	98.7	96.1	108.0	99.9	108.3	128.1	118.2	121.6	112.2	119.1
<i>Corn, 1934</i>	91.0	121.9	93.3	82.9	84.3	89.0	84.2	77.5	104.9	121.9	122.2	119.8	106.5	118.1
1936 intentions.....	109.2	128.5	112.8	105.4	102.0	107.1	102.3	106.6	115.9	145.5	155.1	125.5	116.1	129.6
1936 with conservation.....	98.2	120.2	103.6	93.6	96.1	88.0	90.5	97.0	106.3	136.1	138.7	103.9	80.6	105.3
<i>Oats, 1934</i>	73.3	65.2	72.6	41.2	78.0	76.7	82.8	55.8	112.6	107.2	136.3	101.9	85.6	84.3
1936 intentions.....	82.0	82.5	100.5	74.8	71.6	73.8	97.6	108.1	108.4	114.2	200.1	100.7	80.4	74.2
1936 with conservation.....	75.3	76.1	84.6	71.6	63.8	72.6	91.7	105.9	100.3	100.9	203.4	104.3	106.7	72.7
<i>Wheat, 1934</i>	99.4	38.9	70.6	68.2	59.9	86.3	112.5	103.7	110.7	207.0	304.0	222.4	148.2	204.2
1936 intentions.....	97.9	73.4	71.8	70.2	57.9	81.5	120.7	91.6	112.4	193.0	272.0	196.3	147.4	157.3
1936 with conservation.....	96.6	74.9	78.4	66.0	75.0	77.8	110.5	91.5	108.3	192.5	314.3	194.9	128.4	144.2
<i>Soybeans grown alone, 1934</i> ⁵	287.6	1 414.4	1 228.9	411.9	352.8	293.2	198.5	328.2	149.1	160.7	230.6	126.8	182.4	146.1
1936 intentions.....	422.2	1 781.7	1 801.9	451.6	753.3	356.4	223.7	285.7	169.3	268.0	447.7	324.9	133.2	144.9
1936 with conservation.....	416.5	1 586.2	2 035.5	406.1	714.2	362.7	223.4	220.4	164.0	291.3	531.1	323.4	243.7	181.5
<i>Hay, total, 1934</i>	111.2	110.9	97.2	113.9	136.0	128.4	126.5	99.9	110.3	96.4	81.2	105.3	114.6	109.4
1936 intentions.....	108.6	112.2	95.8	101.3	122.5	114.8	99.5	99.6	111.9	115.2	93.1	123.6	120.1	130.5
1936 with conservation.....	123.8	120.5	103.6	114.6	152.8	159.1	114.4	110.4	125.9	112.5	95.0	135.0	148.4	152.6
<i>Idle, failure, fallow, 1934</i>	164.2	213.7	378.1	471.2	573.4	188.6	111.3	136.4	85.8	64.9	57.5	63.8	76.0	67.7
1936 intentions.....	57.9	92.4	57.5	111.4	57.1	72.0	45.7	47.4	67.9	34.2	23.1	49.8	56.1	62.2
1936 with conservation.....	54.5	92.4	64.5	108.7	68.7	66.5	43.2	39.4	71.5	24.8	16.6	45.8	39.5	51.7
<i>Pasture, total, 1934</i>	107.7	113.7	109.6	107.6	100.7	102.2	110.1	112.3	103.7	113.6	102.2	108.0	104.0	107.9
1936 intentions.....	106.8	112.7	102.0	107.8	99.7	104.7	110.2	114.0	104.8	111.3	120.0	105.7	108.3	105.1
1936 with conservation.....	115.6	118.1	109.1	114.9	109.1	119.1	119.2	117.2	111.3	127.3	129.4	116.5	125.7	118.1
<i>Woodland not pastured, 1934</i>	118.0	112.7	94.6	113.5	84.6	125.0	132.3	98.6	127.2	143.3	103.7	120.5	127.6	119.9
1936 intentions.....	118.1	112.7	94.6	115.0	84.4	124.6	132.3	99.5	127.2	143.3	103.7	120.5	127.6	119.9
1936 with conservation.....	123.9	113.6	100.1	167.9	95.1	132.6	140.4	117.5	125.5	148.2	105.3	123.7	136.8	119.9
<i>Other land in farms, 1934</i>	119.5	103.3	119.8	127.3	132.4	133.5	117.9	107.2	105.4	113.5	94.8	123.0	117.9	118.8
1936 intentions.....	119.4	103.3	119.8	126.7	132.2	133.5	117.8	107.2	105.4	113.5	94.4	123.0	117.9	119.8
1936 with conservation.....	118.0	103.3	121.2	127.2	131.4	132.8	115.2	107.2	105.0	104.8	83.8	113.7	120.0	119.8

¹From U. S. Census of Agriculture, 1935. ²Returns from question 2A: Probable production of the various farm products in the county in 1936, assuming normal weather conditions, present farming practices and prospective prices, and that no production or marketing control was in operation. ³Returns from question 2B: Probable production of the various farm products in the county in 1936 under the conditions outlined in 2A above except that farm practices are assumed to have been adjusted to maintain soil fertility and control erosion. ⁴From the Fifteenth U. S. Census, 1930. ⁵Data for 1934 taken from report of Illinois Cooperative Crop Reporting Service.

1935 to obtain estimates of farmers on probable future farm production without any form of production or marketing control and also with adjustments made to maintain soil fertility and control erosion. The Agricultural Experiment Station and Extension Service gathered the data under the direction of H. W. Mumford and J. D. Bilsborrow, Assistant State Leader of Farm Advisers and leader of the federal-county agricultural adjustment planning project.

Estimated increases recommended in hay, pasture, and soybeans and the reduction of corn and wheat as reported in Table 1 show that farmers apparently are aware of what is needed to prevent erosion and maintain soil fertility. The study further indicates that farmers' estimates of desirable changes in livestock production relate closely to their opinions concerning the desirable use of land for cropping purposes.

The data submitted by farmers to county program-building committees included estimates of land use, crop acreage and production, crop disposal, livestock inventories, production of livestock and livestock products, and the disposal of livestock and livestock products.

Farmers estimated the 1936 corn acreage would be increased 9 and 18 percent respectively over the 1929 and 1934 acreages. These estimates assumed normal weather conditions and continuation of present farming practices and prospective prices but no production or marketing control activity. On the other hand, in answer to the question regarding the probable production of the various farm products in 1936 under normal weather conditions, present prospects for prices, and assuming no production or marketing control but with farming practices adjusted to maintain soil fertility and to control erosion, farmers estimated that the corn acreage should be reduced 2 percent below the 1929 level. Estimates of wheat acreage were slightly changed, and those of oats changed even less, under the assumed conditions, on account of the downward adjustments that had already taken place during 1925-1935. Estimates also indicated the permanent adoption of soybeans in a long-time program for Illinois agriculture. Estimates for important crops by type-of-farming areas are given in Table 1.

In addition to this state survey a regional agricultural adjustment study, as it applies to Illinois, was initiated by the Experiment Station in the spring of 1935 in cooperation with the Bureau of Agricultural Economics, U. S. Department of Agriculture. A brief report of this survey appears in the report of Agricultural Economics 214, pages 197-200. (2 Administration)

Farming Attracts Large Share of 4-H Club Members

More than half, or 56.8 percent, of the farm-boy members and past members of a representative group of Illinois 4-H clubs prefer farming as an occupation. Among farm-boy nonmembers farming is the

choice of but 45 percent, and is preferred by only 31.7 percent of boy nonmembers living in town. These and other significant facts relative to the occupational preferences of 4-H club members have been brought out in a study which D. E. Lindstrom, Rural Sociology, and H. W. Mumford, Administration, have made to determine the effectiveness of the club program. This investigation, the data for which were obtained in 1932, was carried on in LaSalle, Grundy, Livingston, Marshall-Putnam, and Woodford counties.

Significant differences in attitude, achievement, and in three other indexes were found when member and nonmember boys were grouped on the basis of their preference for nine other occupations. These nine other occupations, in the order of their popularity among 876 boys, were aviation, mechanics, engineering, professional work, commercial work, teaching, coaching, skilled labor, and artisan employment. A number of the boys were uncertain as to their choice of occupation, as shown in Table 2.

TABLE 2.—OCCUPATIONAL PREFERENCES OF 876 RURAL BOYS IN NORTH-CENTRAL ILLINOIS, 1932

Occupational preferences	Boys indicating preference	Farm boys	Farm boys	Town boys
		4-H members and past members	not 4-H members	not 4-H members
		<i>percl.</i>	<i>percl.</i>	<i>percl.</i>
Farming.....	439	56.77	45.13	31.73
Aviation.....	74	6.87	8.30	16.34
Mechanics.....	41	4.44	6.86	.....
Engineering.....	42	4.04	4.33	9.62
Professional.....	52	4.65	5.42	13.46
Commercial.....	44	5.66	5.78	.....
Teaching and coaching.....	28	3.23	4.33	.....
Skilled labor and artisan fields.....	39	3.32	4.69	9.62
Undecided.....	117	11.11	15.16	19.23
Total.....	876	100.00	100.00	100.00

The study also revealed significant differences in favor of 4-H club members and past members in the five variables. The data indicate that 4-H club members, more than nonmembers, have faith in the possibilities of farming, that they had a much higher achievement score, that they came from the better homes and farms, and that they participated in a greater number of organizations.

Farm-boy members and past members who preferred to be farmers did not have as strong faith in the possibilities of improving farm life as did farm-boy members and past members who preferred seven other occupations, including engineering, teaching, coaching, the commercial field, skilled labor or artisan fields, or the professional field. Farm-boy nonmembers who preferred to be farmers did not have as strong faith in the possibilities of improving farm life as did the farm-boy non-

members who preferred only four other fields; namely, the mechanical fields, aviation, engineering, and the professional field. Only town-boy nonmembers who preferred the professional field had a stronger faith in the possibilities of farming or improving farm life than town-boy nonmembers who preferred farming as an occupation. Evidently the rural boys, having decided upon farming as a life work, had a better understanding of its limitations. The work of 4-H clubs can be strengthened, it would seem, by teaching boys the possibilities in farming and in improving farm life, as well as by teaching them the everyday farm skills and approved practices.

Evidence also appeared that rural boys who showed greater knowledge of scientific agriculture, who were more intelligent, who were older, and who participated more in organizations preferred occupations other than farming more than they did farming. This was especially true of the farm-boy nonmembers and town-boy nonmembers.

Finally, farm-boy members and past members who preferred farming had been in 4-H club work longer than those who preferred other occupations, especially those preferring the skilled labor and artisan fields, teaching, coaching, or aviation.

Evidently 4-H club work can lead boys to desire farming as an occupation. It has its greatest influence on those boys whose attitudes show an appreciation of farm life as they have experienced it. However, the above would imply a need for greater educational effort to paint a true picture of farm life—its limitations as well as its opportunities—and to show its significance to the whole of society. This is a challenge to other educational agencies as well as to the Extension Service in Agriculture and Home Economics. (4 Administration)

Efforts for Better Use of Land Are Coordinated

Problems of land use are so numerous and diversified and are being attacked by the Experiment Station and other agencies in so many ways that proper coordination of the efforts being made is in itself a considerable problem. This is receiving the attention of H. W. Mumford, Administration, his assistants, and the heads of departments under whom various of the special problems are being studied.

Activities of the past year bearing directly upon the subject of land use included a study of soil percolation and runoff; a regional study of agriculture in the corn belt, with special emphasis upon Illinois conditions and practices; more intensive and extensive pasture investigations; and the further analysis and mapping of the soils of special areas, such as the Kaskaskia river basin and of special areas subject to erosion. The Station has also cooperated on land-use matters with the Federal Soil Conservation Service, the State Department of Conservation, the Federal Rural Resettlement Administration, county farm

bureaus, and other interested agencies. Results of the investigations are reported by the different departments according to subject matter. (5 Administration)

New Study Considers Human Factor in Care of Soil

How and to what extent is land affected by the character and ability of the people living upon it? How and to what extent are people affected by the fertility and nature of the land upon which they live?

Light on these and similar questions is being obtained in a study by D. E. Lindstrom, Rural Sociology, and H. W. Mumford, Administration, assisted by an advisory committee consisting of R. C. Ross, Farm Management; A. L. Lang, Soil Experiment Fields; and Ruth Crawford Freeman, Home Economics. This study was begun in June, 1936.

That soil depletion and erosion limit economic achievement and the securing of satisfactory social life by individual farmers occupying the land is recognized. Likewise there is a relationship between the character and capacity of farmers and the extent to which proper methods of soil maintenance and soil erosion control are practiced. It is believed that a greater knowledge of the influence of the human element in the matter will facilitate adoption of improved practices with respect to better handling of the soil.

The study is being made on eight areas selected on the basis of the extent of soil depletion and erosion. Representative farms within these areas will be selected, and the families that have lived upon and operated each farm will be carefully studied.

Factors to be studied will include tenant turnover, character of operators, farm practices used by operators, adequacy with which the farm supports the operator's family, and the capacity of the farm to continue to support a farm family with a reasonable standard of living. Contact will be maintained with other public agencies studying various aspects of the general problem in order to benefit from and to supplement their findings. (6 Administration)

SOILS AND CROPS

Soil Reports Are Now Printed for 56 Illinois Counties

Advantageous utilization of land and comprehensive plans for the improvement and conservation of that land are impossible without definite facts about the existing types or kinds of soil. Soil reports are now available for 56 counties as a result of the Experiment Station's long-continued soil-survey project; and work in other counties was carried on as rapidly as possible during the past year. The survey of Boone county was completed and about half of Kendall county was mapped. R. S. Smith, Soil Physics and Soil Survey, is in charge.

With the new emphasis upon soil conservation, county agricultural program planning, and agricultural adjustment, demands for soil information from public agencies and private individuals continued to increase. A mimeographed soil-type description booklet has been prepared as an aid in interpreting the soil maps in terms of land use.

The 56 counties for which soil reports are now available, listed in the order in which the reports have been printed, are: Clay, Moultrie, Hardin, Sangamon, LaSalle, Knox, McDonough, Bond, Lake, McLean, Pike, Winnebago, Kankakee, Tazewell, Edgar, DuPage, Kane, Champaign, Peoria, Bureau, McHenry, Iroquois, DeKalb, Adams, Grundy, Hancock, Mason, Mercer, Johnson, Rock Island, Randolph, Saline, Marion, Will, Woodford, Lee, Ogle, Logan, Whiteside, Henry, Morgan, Douglas, Coles, Macon, Edwards, Piatt, Effingham, Wayne, Macoupin, Fulton, Fayette, Calhoun, Ford, Jackson, Schuyler, and Clinton.

Unbound soil maps are available for Alexander, Crawford, Cumberland, Franklin, Jasper, Marshall, Putnam, Monroe, Pulaski, St. Clair, Shelby, Stark, Vermilion, Wabash, Warren, Washington, and White counties.

In addition to the county soil reports and unbound soil maps a mimeographed booklet containing three state maps, entitled "Parent Material of Illinois Soils," "Subsoil Permeability of Illinois Soils," and "Surface Character of Illinois Soils," is available. (201 Agronomy)

Water Absorption Studied as Factor in Soil Management

One of the factors that must be taken into account in working out sound soil-management and cropping practices for the 21 million acres of cropland in Illinois is the ability of the soil to take up water. Quantitative data on the infiltration capacity of certain important soils are being obtained by R. S. Smith and R. S. Stauffer, Soil Physics.

This study has not been in progress long enough for any definite conclusions to be drawn. However, during nine months the water

lost as runoff ranged from 14 percent of the total precipitation from Tama silt loam, a permeable soil, to 28 percent from Osceola silt loam, a slowly permeable soil.

Samples from eight extensive soil types occurring in different parts of the state and having profiles of variable permeability are included in this study.

Cylinders 36 inches in diameter and 40 inches long were forced down into the soil in such a manner as to disturb the natural structure as little as possible. The cylinders with the cores of soil in them were then brought to the Experiment Station and set up so that water falling on the surface of the soil is free to escape as surface runoff or to drain down thru the soil as water of percolation. The two amounts are measured separately and recorded. Since the soils are fallow, the only other form in which water is removed is thru evaporation. The total precipitation is obtained by a rain gage located near the cylinders of soil. From these data it is possible to calculate what portion of the total precipitation is removed from these soils in the various ways. (216 Agronomy)

Illinois Soils Are in No Danger of Sulfur Shortage

In recent years the question has been raised in many parts of the United States whether sulfur deficiency in soils is a condition which limits crop yields. In certain restricted regions of the United States sulfur shortage in the soil is the most important fertilizer problem.

For many years the Experiment Station has been accumulating information to give a definite answer to this question. The adequacy of soil sulfur depends upon the amount present in the soil plus that added to the soil by natural means, as balanced against the losses by removal in drainage waters and its utilization by growing crops.

Soil samples collected in the systematic survey of Illinois soils have been analyzed for their sulfur content under the direction of E. E. DeTurk, Soil Technology, and R. H. Bray, Soil Survey Analysis; and studies of the leaching losses in the drainage water have been made with the assistance of J. C. Anderson, Soil Fertility.

Soil analyses have shown that surface soils usually vary in sulfur content from 200 to 1,000 pounds an acre, with most of the values ranging well below 800 pounds, altho a few soils contain more than 2,000 pounds. The amounts are from one-half to two-thirds as high as the corresponding values for soil phosphorus, which is frequently a limiting factor in crop growth. Against these comparatively low soil supplies it is found that growing crops remove significant amounts of sulfur. A four-ton crop of alfalfa, for instance, contains on the average 24 pounds of sulfur and 19 pounds of phosphorus. In grain crops the sulfur exceeds the phosphorus content in the straw and stover, while the reverse is true in the grain.

TABLE 3.—SULFUR REMOVED FROM SOIL IN DRAINAGE WATER
(Average annual pounds an acre during ten-year period, 1924-25 to 1933-34)

Cropping system	Oct. to Mar.	April to Sept.	Total for 12 months
	<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>
Corn, wheat, timothy.....	31.5	21.8	53.3
Corn, wheat, red clover.....	26.2	18.0	44.2
Corn, oats (sweet clover), ¹ wheat (sweet clover).....	24.2	18.4	42.6
Corn, soybeans, wheat (sweet clover).....	24.9	19.3	44.2
Corn, oats (sweet clover), straw and stalks removed.....	26.5	20.3	46.8
Corn, oats (sweet clover), straw and stalks burned.....	25.3	20.3	45.6
Corn, oats (sweet clover), straw and stalks returned.....	25.9	19.7	45.6
Corn, oats, straw and stalks removed.....	30.8	21.6	52.4
Continuous alfalfa.....	25.3	10.1	35.4
Continuously bare, cultivated.....	29.7	25.2	54.9

¹Parentheses () indicate crops grown for green manuring and plowed under preceding the next crop in the rotation.

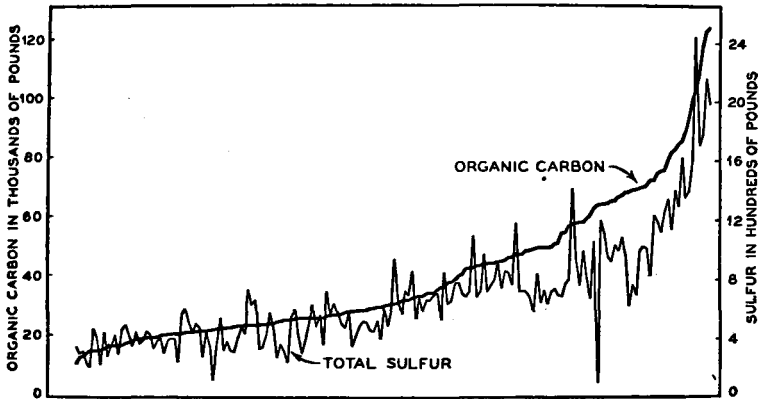


FIG. 1.—RELATIVE AMOUNTS OF SULFUR AND ORGANIC CARBON IN ILLINOIS SURFACE SOILS

In soils containing up to 40,000 pounds an acre of organic carbon, there is about one pound of sulfur to each 50 pounds of organic carbon or to each 86 pounds of organic matter. In soils higher in organic matter the proportionate amount of sulfur is less.

Removal of sulfur from soils in drainage water has been measured during the past ten years by the use of lysimeters constructed for leaching studies. These provide excessive leaching conditions by the prevention of all surface runoff. The average annual amount of sulfur removed in drainage water is shown in Table 3.

In this experiment 200 pounds an acre of superphosphate containing 10.75 percent, or 21.5 pounds of sulfur, was added annually as a fertilizer. Three systems—corn, wheat, timothy; corn, oats, without sweet clover; and bare fallow—allowed large leaching losses of around

53 pounds of sulfur an acre a year. Alfalfa, the crop which is highest in sulfur content of any of the common farm crops, permitted the leaching of only 35 pounds, while all the other rotations varied but slightly from an average of 45 pounds. These losses are approximately double the amount added in the superphosphate.

These results indicate the possibility of a rapidly increasing shortage of sulfur for crop production, particularly if no sulfur-containing fertilizers were used. This would undoubtedly be the case if this element were not renewed from the atmosphere by means of rainfall. When plants or plant remains are decomposed either thru decay or thru combustion, as in the burning of wood or coal, most of the sulfur which they contain is released in the form of sulfur dioxide gas, which is readily washed from the air into the soil by rain. Analyses of rain water at Urbana have shown that the sulfur added to the soil in this way exceeds the requirements of average crops. The average monthly precipitation of sulfur at Urbana over a six-year period 1917-1924, excluding 1922 and 1923, was as follows:

<i>Month</i>	<i>Pounds an acre</i>	<i>Month</i>	<i>Pounds an acre</i>
January.....	3.6	July.....	2.4
February.....	3.3	August.....	2.9
March.....	4.8	September.....	2.8
April.....	5.0	October.....	3.7
May.....	5.6	November.....	3.4
June.....	3.1	December.....	3.3
		Total for year.....	43.9

The minimum sulfur in the rainfall in any one year was 31.6 pounds and the maximum 50.2, with an average of 43.9 pounds distributed over the entire year. Inasmuch as coal consumption is one of the chief factors in charging the air with sulfur, the sulfur brought down in rain water was measured at a number of points thruout Illinois during two growing seasons. The average pounds an acre a month at the different points was as follows:

<i>Location</i>	<i>Sulfur in rain water, pounds an acre a month</i>	
	<i>1921</i>	<i>1922</i>
Carlinville, Macoupin county.....	2.44	4.98
Carthage, Hancock county.....	2.17	....
Clayton, Adams county.....	2.04	....
Dixon, Lee county.....	4.83	5.76
Ewing, Franklin county.....	2.72	....
Hartsburg, Logan county.....	3.70	....
Joliet, Will county.....	....	3.44
LaMoille, Bureau county.....	2.51	....
Lebanon, St. Clair county.....	3.40	....
Newton, Jasper county.....	3.13	....
Oquawka, Henderson county.....	2.24	....
Sparta, Randolph county.....	7.08	....
Spring Valley, Bureau county.....	5.75	....
Toledo, Cumberland county.....	1.57	2.98
Unionville, Massac county.....	.72	....

The variation in the amount of sulfur in rain water in different localities is wide, the lowest values occurring in the more sparsely populated regions of southern and southeastern Illinois, while the highest values were obtained near large cities or where other known sources of atmospheric supply existed.

An investigation of the sulfur content of soils in relation to organic matter indicates the strong probability that the portion of the soil sulfur which is retained against leaching is combined largely with the soil organic matter. Fig. 1 shows in graphic form the organic carbon and sulfur content of the upland surface soils of twenty-eight counties widely distributed thruout the state. The sulfur-carbon ratio is about 1:50 in soils containing up to about 40,000 pounds of organic carbon in 2 million pounds of soil, and falls to a wider ratio in the soils which are richer in organic matter. The close correlation between these two elements suggests that the sulfur, as well as the carbon, is combined with the organic matter of the soil.

The relatively large sulfur requirements of farm crops could not be met by the limited quantities in soils were it not for the natural renewal of the soil supply from the atmosphere by means of the rainfall. This source of renewal is believed to be large enough for maximum yields of all farm crops.

The sulfur which is added to the soil by precipitation is soluble and easily passes thru with the drainage water, except for such portions as are taken up by growing plants, converted to organic forms, and thus retained in the soil when the plant residues become a part of the soil organic matter. (116 and 118 Agronomy)

Tight Substrata Found to Differ in Illinois Soils

Situations where "slick spots" occur in Illinois were described in the Forty-Seventh Annual Report. They are found in association with "tight clay," or claypan. The agricultural significance of slick spots is that they represent a strong development of tight clay which occurs near the surface and is thicker than is the claypan adjacent to the slick spot.

In northeastern Illinois a slowly pervious material which is sometimes confused with tight clay occurs at varying depths beneath the surface. This material differs from claypan in that it is but a slightly weathered, fine-grained, strongly compacted glacial till. Claypan consists of very fine-grained soil particles which have accumulated in the subsoil as the soil was developing, while the slowly pervious glacial till was deposited by the ice sheet during the Glacial period. Both interfere seriously with underdrainage, but while claypan is strongly acid, the slowly pervious glacial till is high in lime.

A paper on slick spots is in course of preparation by G. D. Smith, Soil Survey, and two papers on the slowly pervious till have been

published, one by R. S. Stauffer, Soil Physics, and one by Eric Winters and Herman Wascher, Soil Survey. This study is under the general direction of R. S. Smith, Soil Physics and Soil Survey. (208 Agronomy)

Soil Conservation Proves Worth in Long-Time Tests

Possibilities of substantial rewards to the farmer who uses soil-conserving and building practices are emphasized in results of studies which the Experiment Station has now been conducting for twenty-five years. Since the soil is the most important source of wealth in Illinois, failure on the part of the farmer to employ soil-conserving and building practices will sooner or later interfere with his own economic security as well as with public welfare in general. Variations in the quality of the parent material from which the soils of the state were made and in the stages of soil development impose widely varying natural limitations upon the crop-producing powers of Illinois soils. Because of these factors there must be more or less variation in the management practices used by the farmer if the soil resources of the state are to be conserved and built up to profitable levels of productivity. One of the objectives of this investigation being carried on by F. C. Bauer, A. L. Lang, C. J. Badger, L. B. Miller, C. H. Farnham, P. E. Johnson, and L. F. Marriott, Soil Experiment Fields, is to determine what systems of soil treatment should be used on the various kinds of soils found in Illinois to protect productivity and at the same time be economically worth while to the farmer. This investigation has now been in progress for more than a quarter of a century, and the results obtained are of considerable significance.

Studies conducted on twenty-three soil experiment fields represented by ten widely varying soil groups reveal considerable variation in the character of soil-treatment systems needed and in the relative levels of the economic benefits resulting from their use. Without the use of soil-treatment practices the economic returns from crop production range from fairly high values on the good soils to negative values on the less productive soils. There is no soil condition, however, that was not improved thru the use of some system of soil treatment. A study of the data also reveals that no single system of soil treatment is equally satisfactory for all soil conditions, but that different systems are needed for the effective use of the different soils.

Crop yields for the four-year period ending in 1935 have been converted into what is called "investment returns" in order to show the variation in the need for different systems of soil treatment and in their relative effectiveness with different kinds of soils. These figures have been calculated as the difference between the gross crop values and the total costs for growing, marketing, and treatment. The remainder—investment returns—represents that portion of the gross crop values that must be used for taxes, interest, repayment of princi-

TABLE 4.—INVESTMENT RETURNS OR LOSS (-) FROM DIFFERENT SYSTEMS OF TREATMENT ON DIFFERENT SOIL TYPES
(For four-year period ending in 1935)

Rank and field	Soil group	Treatment in livestock systems ¹				Treatment in grain systems ²				
		None	M	ML	MLrP	None	R	RL	RLrP	RLrPK
1 McNabb.....	III	\$13.17	\$13.32	.....	\$11.70 ³	\$12.87	\$13.28	.....	\$11.40 ³	.....
2 Aledo.....	I	11.41	13.15	\$12.66	10.03	10.22	12.40	\$14.51	12.24	\$11.01
3 Hartsburg.....	II	8.77	12.41	12.33	9.38	10.48	12.04	11.19	9.89	7.46
4 Kewanee.....	III	7.69	9.58	10.38	7.67	10.61	12.02	12.91	10.20	7.26
5 Minonk.....	II	9.33	9.06	7.01	5.33	6.90	8.81	7.92	5.94	4.13
6 Lebanon.....	V	6.56	9.61	12.33	9.92	9.00	8.96	13.93	12.02	11.12
7 Dixon.....	IV	7.50	11.88	11.29	8.84	7.85	6.76	7.51	5.14	5.78
8 Mt. Morris.....	IV	6.00	8.55	8.24	5.84	6.24	8.04	8.25	7.74	6.90
9 Carthage.....	V	3.58	3.90	4.77	2.41	3.69	3.11	4.37	2.89	1.39
10 Carlinville.....	V	3.15	4.56	5.32	2.82	3.82	2.67	4.91	3.03	3.76
11 Joliet.....	VI	1.55	1.47	.68	-1.61	.75	-.14	-1.00	-2.55	-2.22
12 Clayton.....	V	.18	1.73	3.08	1.48	1.10	1.15	1.96	.16	-1.07
13 Oblong.....	VII	-.54	1.06	6.15	4.40	-.35	-.18	2.51	1.30	4.07
14 Oquawka.....	XIV	-1.65	1.02	4.80	2.31	-.80	-1.47	3.33	-.38	1.04
15 Enfield.....	X	-1.56	1.10	4.24	2.81	-1.62	-1.55	.70	-.90	1.89
16 Newton.....	VII	-1.99	.08	3.33	1.50	-1.21	-1.79	-1.45	-3.50	.51
17 Raleigh.....	X	-2.39	.20	3.29	1.42	-1.36	-1.49	1.24	.26	1.62
18 Toledo.....	VII	-1.92	.81	3.15	1.51	-1.92	-1.18	-1.46	-1.46	2.04
19 Ewing.....	VII	-2.77	-.13	4.02	2.58	-2.56	-3.22	-1.17	-1.68	1.40
20 West Salem.....	X	-2.69	1.91 ³	3.39 ³	3.14	-1.86 ³	-2.70 ³	.29 ³	.44	3.07
21 Unionville.....	X	-3.21	-1.72	1.12	-.27	-3.20	-3.46	-.37	-1.42	-.79
22 Elizabethtown.....	XIV	-3.27	.06	4.16	3.38	-3.27	-3.78	.47	1.97	1.31
23 Sparta.....	X	-3.56	-2.88	.13	-1.62	-3.83	-4.13	.38	-1.81	-2.55

¹M = manure; L = limestone; rP = rock phosphate; R = residues; K = potash. ²No limestone. ³Four tons of limestone applied in 1912.

pal, and rewards for ownership or operation. Crop prices that have prevailed during the past four-year period, as well as the hazards of weather and insects that have been important factors in some sections, should be kept in mind in studying these figures.

The various kinds of soils involved in these experiments are classified among ten of the sixteen recognized soil groups found in the state and are described as follows:

Group

- I. Dark soils with heavy noncalcareous subsoils
- II. Dark soils with heavy calcareous subsoils
- III. Dark soils with noncalcareous subsoils
- IV. Dark soils with open noncalcareous subsoils
- V. Dark soils with impervious noncalcareous subsoils
- VI. Dark soils with heavy, impervious calcareous subsoils
- VII. Gray soils with impervious noncalcareous subsoils
- X. Yellowish gray soils with impervious noncalcareous subsoils
- XIV. Sandy loams and sands
- XVI. Hilly, forest, orchard, and pasture land

The data for nine different systems of soil treatment are presented in Table 4, with the most effective treatments in the livestock and grain systems in blackface type. The individual fields are arranged in the descending order of the average of the untreated land in both the livestock and grain systems of farming, an arrangement which makes it easier to correlate the effects of the treatments with declining productivity.

Untreated dark-colored soils all show positive values. Untreated gray, yellow, and sandy soils all show negative values. Some system of treatment has given positive value on every field. In general the simplest systems gave the highest investment returns on the more productive soils, while the more complicated systems were required on the soils of lower productivity, as may be seen from the values in blackface type. Treatments used in the grain systems of farming tended to give equal or greater returns than treatments used in the livestock systems of farming on the more productive soils. On the less productive soils, treatments in the livestock systems of farming usually gave larger returns than in the grain systems.

With this report Project 603 is merged with Project 601 and hereafter will be regarded as a phase of Project 601 rather than as an independent project. (601 and 603 Agronomy)

Soil Conservation Involves Three Major Factors

Cultivation, crop rotation, and soil treatment all figure in land-use policies and in soil conservation. Cultivation practices of some kind are essential on all lands and cannot be avoided in the production of farm crops. Rotation and treatment practices may be just as essential, but are of such a nature that they may be ignored to a greater or less extent by many farmers. Used alone, cultivation practices may hasten

depletion of the soil and quickly intensify the problems of soil conservation. The best interests of the farmer and the nation are served when all three practices are properly employed. Farmers therefore need to know something about the comparative influence of these practices and how to plan for the effective use of them on their farms.

The Morrow plots, established in 1876 on the University campus, provide some interesting facts on the comparative influence of cultivation, rotation, and soil treatment under Illinois corn-belt conditions. In the long-time crop yields obtained in these experiments, rotation practices were somewhat superior to cultivation practices in corn production, and both were closely followed by treatment practices. This project is now under the supervision of F. C. Bauer, A. L. Lang, and C. H. Farnham, Soil Experiment Fields.

The Morrow plots are so designed that three cropping practices are directly comparable: (1) continuous corn; (2) a corn, oats rotation; and (3) a corn, oats, and red-clover rotation. Since 1904 each system of cropping has been carried on with and without soil treatment. As there is only enough land in each system to grow one crop each season, it is not possible to obtain comparative corn yields annually. Once each six years, however, corn is grown on all plots, thus permitting a direct comparison of the various factors under similar seasonal conditions. This relationship has recurred five times since 1904. The average yields of corn obtained under similar seasonal conditions provide valuable data in connection with the comparative influence of cultivation, rotation, and treatment factors in the use of agricultural land.

The average yields of corn produced on the Morrow plots when all grew corn during the same season are recorded in Table 5. If it is assumed that the yield of corn in continuous culture without treatment represents the influence of the cultivation factors, then the comparative influence of the rotation and treatment factors may be easily determined from these yields. Such data are set forth in Table 6.

Of the three factors, rotation, including a red-clover legume crop, ranks first, being 19 percent better for producing corn than the cultivation factor. Rotation without a legume produced less than half the corn produced by the cultivation factors. Soil treatment was less effective than the cultivation factor by more than 12 percent.

When the various combinations of two factors are compared with the cultivation factor, increases ranging from 32 to 119 percent are obtained. In these combinations only those including red clover in the rotation produced increases of more than 100 percent.

When all three factors are combined, the highest yields of corn are obtained. They were more than doubled in the two-year rotation without the legume, and nearly trebled in the three-year rotation with the legume.

TABLE 5.—COMPARATIVE INFLUENCE OF CULTIVATION, ROTATION, AND SOIL-TREATMENT PRACTICES ON THE YIELD OF CORN
(Yields from Morrow plots when all plots grew corn the same season, 1907, 1913, 1919, 1925, and 1931)

Practice	Yield resulting	Index of yield
	<i>bu.</i>	
Cultivation.....	23.2	100.0
Rotation.....		
Two-year.....	10.4	44.8
Three-year.....	27.6	119.0
Treatment.....	20.3	87.5
Cultivation and rotation.....		
Two-year.....	33.6	144.8
Three-year.....	50.8	219.0
Cultivation and treatment.....	43.5	187.5
Rotation and treatment.....		
Two-year.....	30.7	132.3
Three-year.....	47.9	206.5
Cultivation, rotation, and treatment.....		
Two-year.....	55.2	237.9
Three-year.....	66.0	284.5

These data are of considerable significance in connection with the problems of land use. Cultivation practices alone are inadequate for the efficient use of land. Crop yields decline and the problems of soil conservation intensify more or less rapidly. Crop rotations, especially those that include legumes, rank high in their influence on soil productivity. With such rotations crop yields are maintained and increased, and the fertility resources of the soil are well protected. Under the conditions of this experiment soil treatment also ranks high. Roughly speaking, the three factors, cultivation, rotation, and soil treatment, are somewhat similar in their comparative effectiveness. The proper combination of these factors is highly important in the preservation of soil

TABLE 6.—CORN YIELDS OBTAINED IN DIFFERENT ROTATIONS WITH AND WITHOUT SOIL TREATMENT
(Yields from Morrow plots when all plots grew corn the same season, 1907, 1913, 1919, 1925, and 1931)

Cropping system	Yields with—	
	No treatment	Manure, limestone, phosphate
	<i>bu.</i>	<i>bu.</i>
Continuous corn.....	23.2	43.5
Corn, oats.....	33.6	55.2
Corn, oats, red clover.....	50.8	66.0

productivity and in restoring the soil to its inherent possibilities. (602 Agronomy)

Sound Soil-Saving Plan Replaces Lacking Minerals

If farm lands of Illinois are to be conserved and improved, deficiencies of essential materials must be replenished by means of suitable treatment practices. Among the deficiencies that may need attention under general conditions are organic matter, lime, phosphorus, and potassium. These may be cared for thru applications of animal manures, crop residues, green manures, limestone, phosphates, and potash-supplying fertilizers singly or in various combinations. Application of such materials may be expected to give better crop yields when applied where they are needed. An interesting question that arises in connection with the use of these materials is whether the response to them bears any particular relationship to various soil conditions; for instance, to the general level of productivity as revealed by the crop yields from untreated land. Field experiments being conducted by F. C. Bauer, A. L. Lang, C. J. Badger, L. B. Miller, C. H. Farnham, P. E. Johnson, and L. F. Marriott, Soil Experiment Fields, indicate that responses to various soil-treatment materials are related to the productivity levels of soils. The relation tends to be a direct one with respect to organic matter and an inverse one with respect to mineral fertilizers.

These studies have been conducted for twenty-five years on a number of Illinois soils varying somewhat widely in productiveness. These soils may be classified into ten of the recognized sixteen groups of soils as indicated in Table 7.

The problem of fertilizer response in relation to soil productivity levels may be studied by converting the crop-yield data to a percentage basis. This should be done from a common base in order to provide a direct comparison between all factors. A convenient base would be the average crop yields from some of the better corn-belt soils. In this study the average crop yields for the four-year period ending in 1935 on the untreated land of the experiment fields located on soils classified in soil Groups I and II were used as the base figure of 100 percent. In terms of the average annual acre-yields this figure is 1,848 pounds of digestible nutrients. The percentage variations from this figure are presented in Table 7.

In the first column the productivity levels as represented by the crop yields from untreated land are given for the respective soil groups. Group I ranks first, with a level of nearly 112 percent. Group XVI is the lowest, with a level of 16.5 percent. The dark-colored soils range from 50 percent upward, while the sandy and light-colored soils fluctuate between 16 and 32 percent.

Data on the response from the various kinds of soil-treatment ma-

TABLE 7.—RELATION OF SOIL-TREATMENT RESPONSES TO LEVELS OF NATURAL SOIL PRODUCTIVITY¹
(Based on results from Illinois soil experiment fields, 1932-1935)

Soil group	Productivity levels, untreated land	Changes in productivity levels as a result of application of fertilizer materials						
		Manure (M)	Crop residues (R)	Limestone (L)		Rock phosphate (rP)		Potash over RLrP
				Over M	Over R	Over ML	Over RL	
	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>
I.....	111.7	32.0	18.0	9.8	22.9	-1.9	.5	4.5
III.....	99.4	25.1	16.7	11.7	6.8	4.1	4.1	-3.5
II.....	94.1	22.8	16.2	1.2	3.1	0	1.9	-1.7
IV.....	80.7	35.3	6.0	5.9	18.0	.3	3.9	9.4
V.....	63.1	24.5	-.1	18.7	24.9	2.6	5.4	5.2
VI.....	54.4	12.1	1.0	4.1	2.8	5.9	10.9	11.3
XIV.....	32.5	22.0	1.2	37.0	40.8	2.3	-1.3	13.9
VII.....	25.8	12.4	2.0	33.1	19.1	5.0	5.1	32.4
X.....	20.8	13.1	4.0	30.8	24.9	6.1	6.6	15.2
XVI.....	16.5	20.0	-.5	32.0	35.6	10.9	28.4	1.0

¹The average yields of digestible nutrients produced on Group I and II soils, which may be taken as representing corn-belt soils of good productivity, was used as the base of 100 percent in making these calculations, thus making all figures directly comparable with each other.

terials suggest rather definite tho imperfect relationships between responses and productivity levels. The response to manure and crop residues tends to be greatest on the most productive soils and least on the less productive soils. The response to the various minerals—namely, limestone, rock phosphate, and potash—shows the opposite relationship. That is, as the productivity levels decline, response tends to increase.

Such findings would imply that all farmers should plan to incorporate organic matter into their soils no matter what the productive level may be. The better soils will give excellent responses to such practices. Soils having lower productive levels do not give as large responses, probably because of the deficiency of one or more of the mineral treatment materials. When these deficiencies are made up, better responses are obtained, not perhaps from the mineral alone, but thru the better functioning of the organic matter.

These data also imply that the need for mineral treatment materials can be gaged by productivity levels. The higher the level, the less the need for mineral fertilizers; the lower the level, the greater the need. Declining productivity should be regarded as a danger signal. Minerals of some kind will undoubtedly be needed to halt the decline and preserve and improve the inherent productiveness of the soil. Failure to heed these signals in the past is no doubt largely responsible for the intensified problem of soil conservation that now confronts the state and the nation. (605, 606, 607, 612, and 615 Agronomy)

Potash Raises Soil-Improvement Value of Sweet Clover

Experiences of thousands of Illinois farmers have confirmed the results of experiments which show that in addition to its high value as a pasture crop, sweet clover is the most effective soil-improving crop grown extensively for that purpose. Possibilities of increasing still further the effectiveness of sweet clover for green-manure purposes are being brought out in experiments on the relationship of potash fertilization to the crop.

When sweet clover was first used as a soil-improving crop, it was expected to "unlock" sufficient available potassium to meet the needs of ordinary crops on most soils. Recent trends in crop yields indicate, however, that such is not the case with many Illinois soils, particularly those in the southern half of the state. Instead of sweet clover increasing the usefulness of soil potash, potash fertilization has increased the value of sweet clover for soil improvement. E. E. DeTurk, Soil Technology; F. C. Bauer, Soil Experiment Fields; and O. H. Sears and L. E. Allison, Soil Biology, are cooperating in determining the reasons for these relationships. These investigations are expected to be of value in increasing the effectiveness of sweet clover for green-manure purposes.

Results secured thus far indicate that the repeated growing of sweet clover, with the accompanying increase of other crops, removes large amounts of potassium from the soil. Where available potassium is present naturally in limited amounts, increased crop yields can be secured only by supplying potassium in the form of straw, manure, or thru potash fertilizers.

It is believed also that a balance of plant-food elements is necessary in the soil solution and that the growing of sweet clover may require the adjustment of this balance in some soils. This adjustment frequently requires potash fertilization. (121, 310, and 618 Agronomy)

New Phosphates Not Yet Fully Proved for Illinois

Recently certain new methods of processing phosphate rock for fertilizers have been developed by the U. S. Department of Agriculture and the Tennessee Valley Authority. In order to determine the availability of these new phosphates to growing crops, the Experiment Station is cooperating with the U. S. Department of Agriculture in conducting greenhouse and field experiments to compare the new materials with older phosphates of known value, such as rock phosphate and superphosphate.

Yields of wheat and sweet clover in the first experiment have just been obtained by E. E. DeTurk, Soil Technology, and J. C. Anderson, Soil Fertility. The new phosphates referred to and their content of phosphoric acid are calcined rock phosphate, 37.4 percent P_2O_5 ; fused rock phosphate, 29 percent P_2O_5 ; and calcium metaphosphate, 63.9

TABLE 8.—EFFECT OF DIFFERENT PHOSPHATES ON GROWTH OF WHEAT AND SWEET CLOVER IN GREENHOUSE TESTS

Phosphate ¹	Wheat yield on—			Sweet-clover yield on—		
	Clinton silt loam unlimed	Muscatine silt loam		Clinton silt loam unlimed	Muscatine silt loam	
		Unlimed	Limed		Unlimed	Limed
	<i>gms.</i>	<i>gms.</i>	<i>gms.</i>	<i>gms.</i>	<i>gms.</i>	<i>gms.</i>
None.....	4.4	19.8	12.3	.1	14.9	12.2
Rock phosphate.....	9.0	23.1	15.8	4.6	22.5	17.8
Ca metaphosphate.....	21.6	22.8	21.8	4.2	25.5	23.6
Calcined phosphate, 20-mesh.....	14.3	23.3	20.2	7.1	23.6	28.0
Superphosphate.....	21.9	23.7	23.6	4.1	24.2	26.4
Fused rock phosphate.....	23.0	25.1	23.4	7.8	26.5	30.3
Ca glycerophosphate.....	....	24.5	21.8	....	26.1	21.3
Na glycerophosphate.....	....	24.2	22.6	....	36.3	29.3

¹All phosphates applied so as to give equal amounts of phosphoric acid, 126 pounds an acre of P_2O_5 .

percent P_2O_5 . Two new organic phosphates are also included, whose use as fertilizers has been proposed by Stewart and Spencer, University of Nevada. These are calcium glycerophosphate, 31.8 percent P_2O_5 ; and sodium glycerophosphate, 23.1 percent P_2O_5 . The special merit of the glycerophosphates is in their tendency to remain soluble and penetrate thoroly into the soil before becoming fixed by the usual chemical soil processes.

Availability of all these phosphates will be measured by the amounts of phosphorus taken up from them by the different crops. Their relative effectiveness is indicated, however, by the growth response of crops. Yields of wheat and sweet clover, grown with old and new phosphates in comparison, are given in Table 8. They were grown in 2-gallon pots in the greenhouse, and the yields are given in grams.

It is not possible now to know whether these new phosphates are to be recommended. It is evident from the data given that they are all effective in increasing crop growth on phosphorus-deficient soils. The poor sweet-clover growth on Clinton silt loam is the result of the high acidity of the soil, which is not fully corrected by the fertilizers used, even tho they did produce some increase in yield. Wheat is less sensitive to acid soils and produced good yields on this soil where phosphates were supplied.

The cost to the farmer in using these new phosphates is an important point to consider, and neither this cost nor the cost of manufacture has been determined at the present time. (105 Agronomy)

Surveys Improve Quality of Limestone Sold in Illinois

Illinois farmers, who have applied 7 million tons of limestone in the past fifteen years, are getting material of better quality as the

result of systematic surveys of the sources from which it comes. These surveys, one of which was made in 1922 and another in 1930, have been carried on by the Experiment Station in conjunction with the Illinois Agricultural Association. A third survey, in which the determinations of quality were made by E. E. DeTurk, Soil Technology, and E. B. Earley, Soil Fertility, was completed in 1936. Since these surveys were begun, a distinct improvement in the quality of limestone sold in Illinois has been noted.

In 1922 most of the agricultural limestone used in Illinois was supplied by 10 companies, whose products were examined chiefly to determine their purity, or neutralizing value, for acid soils. In 1930 the products of 33 companies were examined, while in 1936 approximately 60 sources were considered of sufficient importance to justify examination. A noticeable trend in recent years has been the development of local deposits, the crushing often being done by portable outfits. Those deposits examined were of sufficient size to supply areas beyond the immediate neighborhood, while a great many smaller concerns which crushed only for nearby farms were not inspected.

One measure of the quality of limestone is its acid-neutralizing value, determined by chemical analysis. This is essentially its purity and is expressed as calcium carbonate equivalent (C.C.E.), compared to pure calcium limestone as 100. Considerable gain in this respect was made in the earlier part of the period, the average values of all sources being 86.8 percent C.C.E. in 1922, 92.3 percent in 1930, and 92.6 percent in 1936.

Evidently the insistence upon better quality by the Experiment Station, the Illinois Agricultural Association, and other agencies resulted in more rigid selection of deposits to be worked, the discarding of low-testing strata, or the exercise of more care in quarrying and preparation in order to lessen contamination with dirt. Eight sources were active and examined at all three of the inspections—1922, 1930, and 1936. The improvement in their products is indicated by the respective C.C.E. average values of 86.9, 93.6, and 93.9 percent.

More recently the effectiveness of limestone as influenced by fineness of grinding has been investigated. The inspections of 1930 and 1936 included an evaluation of the products in this respect based upon a rating score described in the Forty-Fourth Annual Report of the Experiment Station, page 25. The average rating of all sources in 1930 was 81.2; in 1936, 84.2. An effort at improvement in this respect is shown by the increase in rating of the eight sources continuously available since 1922 from 75.5 at the time of the 1930 inspection to 86.5 at the 1936 inspection.

One other feature of the limestones available to Illinois farms should be mentioned. Special pulverized grades comparatively free of the coarser 8- to 4-mesh sizes present in ordinary screenings and

rating 90 or higher by the fineness score are desirable for "light liming" and may also be used in general liming practice. Such grades were almost unobtainable in Illinois in 1922. By 1930 they were offered by 10 producers and may now be obtained from at least 23 of the sources inspected this year. (109 Agronomy)

Effect of Soil Practices Upon Crop Composition Studied

Variations in chemical composition of farm crops are important, not only from the standpoint of their requirements for fertilizer elements and the removal of such elements from the soil, but also because the chemical composition is related to the quality of the crop for feed or food or for other purposes.

The Experiment Station has continued for many years a systematic study of the effects of soil-management practices and fertilizer treatments upon yield and general quality of the crops grown on the more important soils in diverse regions of Illinois. A study is now being undertaken by F. C. Bauer, Soil Experiment Fields, and E. E. DeTurk, Soil Technology, to determine the relation between the yield and chemical composition of crops as affected by different soil-management systems and fertilizer treatments. Fields used for this investigation are the Morrow plots, the oldest and one of the most valuable experimental soil plots in this country; the Aledo experiment field, representing a section of high crop yields; and the Toledo field, representative of a comparatively low level of crop yields.

This broadening of the scope of an investigation which even in its previous form was of fundamental significance in the agriculture of the state has been made possible by the appropriation of federal funds under the recently enacted Bankhead-Jones Act of Congress.

Work on this project has just been started and will be pursued actively during the coming year. (121A and 618A Agronomy)

Variety Tests Protect Expanding Acreage of Alfalfa

One evidence of crop adjustment and the trend to more pastures and forage in Illinois is the fact that within the past five years the acreage of alfalfa has almost doubled. There were 240,000 acres harvested in 1931 and 476,000 acres grown in 1935. It is likely that there will be a further steady increase in Illinois. Proper management and wise selection of varieties of alfalfa to be grown remains an important problem. Studies are being continued by W. L. Burlison, Crop Production, and J. C. Hackleman, Crops Extension, on the behavior and adaptability of varieties to Illinois soils and climate.

Wilt and winter injury have proved to be the most serious threats to alfalfa production in Illinois, as judged by the results of these studies, and further expansion of the acreage will depend upon locating varieties which can withstand these hazards. Wilt became so serious

TABLE 9.—EFFECTS OF WILT UPON ALFALFA AS SHOWN BY THE 1932-1934 AVERAGE YIELDS OF EIGHT VARIETIES IN COMPARISON WITH 1935 YIELDS, URBANA EXPERIMENT FIELD

Variety	Three-year average acre-yields, 1932-1934	Variety	Acre-yields, 1935
	<i>tons</i>		<i>tons</i>
Hardigan.....	6.00	South Dakota 12.....	1.91
Argentine.....	5.72	Utah.....	1.85
Kansas Common.....	5.58	Nebraska.....	1.83
South Dakota 12.....	5.57	Argentine.....	1.83
Grimm.....	5.47	Hardistan.....	1.78
Nebraska.....	5.39	Kansas Common.....	1.77
Utah.....	5.33	Grimm.....	1.63
Hardistan.....	4.78	Hardigan.....	1.60

in one series of variety tests at Urbana that the plots were discontinued during the spring of 1936.

This field had been seeded in 1931, and three cuttings had been taken each season since 1932. In 1934 before the wilt became serious, the average yield of the eight varieties in this test was 5.39 tons an acre. The 1932-1934 three-year average yields for the eight varieties are shown in Table 9 in comparison with the 1935 yields for the same varieties. It is interesting that Hardigan and Grimm, two variegated alfalfas, were good yielders during the early years of the test, but were lowest in yield in 1935. This confirms previous indications that variegated alfalfas are more susceptible to wilt than are the common alfalfas.

With this series of tests discontinued because of wilt damage, studies of alfalfa types and varieties were continued on the Mumford plots, which were seeded in August, 1934. Many new varieties are included in this test. The ten leading types for the past two years, together with their acre-yields, include Hardigan 19910, 3.68 tons; Ladak 20190, 3.66 tons; Hardigan 18999, 3.65 tons; Cossack 19973, 3.65 tons; Grimm (Montana), 3.54 tons; Cossack 18836, 3.53 tons; Hardigan (Michigan Farm Bureau 2911-388), 3.45 tons; Ontario Variegated 19216, 3.43 tons; Grimm (North Dakota), 3.42 tons; and Hardistan 21271, 3.41 tons. (522 Agronomy)

Soybeans Are Soil Improvers if Properly Handled

Rising importance of the soybean in Illinois agriculture is indicated by the fact that more than 1,500,000 acres are now grown annually in the state. This high acreage is the result of the favorable cash returns which farmers have received from the crop. In addition it is believed by many farmers that the soybean crop has soil-improvement value because it is a legume. Thus it is important to know to what extent the soybean is valuable for soil improvement, how its usefulness for this purpose may be increased, and at what place or places

in the rotation it may be grown most advantageously. Furthermore it is desirable to discover the limitations of the soybean crop for soil-improvement purposes.

Results thus far obtained by O. H. Sears, Soil Biology, indicate that:

1. The best results for soil improvement are secured when the soybean is used as a green-manure crop; that is, when the entire crop is plowed under. Even with this practice it is important to guard against soil erosion.

2. A spring-planted crop usually is more satisfactory than a crop seeded in the fall immediately after harvesting the soybean crop.

3. Where wheat follows soybeans, the yields are usually improved by phosphate fertilization, particularly where the soil is low in available phosphorus.

The tops of the soybean constitute about 90 percent of the plant. Consequently even well-nodulated soybeans add little or no nitrogen to the soil when the seed crop is sold, even if the straw is returned to the land. Considerable amounts of phosphorus and potassium are removed in the seed. Obviously the soil-improving value of soybeans is limited where the crop is removed.

The soybean removes plant nutrients from the soil until late in the season. Consequently there is little time for replenishing the available nutrients where a fall-planted crop is used. As a result phosphate fertilization is frequently advisable where wheat is seeded after the soybeans.

The soybean definitely improves the tilth of the soil. This tendency to loosen the soil makes it easy to prepare a seedbed. There is reason to believe, however, that the looseness of the soil may be a factor contributing to poor clover stands which sometimes occur in wheat following soybeans. (311 Agronomy)

Long-Time Studies Guide Expansion in Soybean Crop

Interest of the industries in the possibilities of soybeans is now greater than ever in the history of the crop. The esteem in which this legume is held both by farmers and by industrialists is reflected in the notable increase that has been made in the acreage during recent years. In 1914 Illinois produced about 1,000 acres of soybeans, while the acreage for seed in 1935 was 1,213,000 acres. Investigations carried on by the Experiment Station for more than a quarter of a century are giving intelligent direction to development of the soybean industry in this state. These studies are now under the direction of W. L. Burlison, Crop Production, and J. C. Hackleman, Crops Extension.

The average comparable acre-yields of the ten highest yielding varieties grown in the South-Central rotation during the period 1923-1935 were as follows:

Variety	Yield in bu.	Years grown
A. K. 92.....	35.7	1
T 117.....	34.6	3
04002-B.....	33.9	6
A. K. 125.....	33.9	6
Manchuria 13-177.....	33.3	8
A. K. 146.....	33.1	6
93996-4.....	33.0	1
A. K. 114.....	32.8	3
Aksarben.....	32.6	2
Scioto.....	32.4	2
Illini.....	31.2	10

Hay-type soybean varieties also have been compared with seed-type varieties produced for hay and seed at Urbana. For the six-year period closing in 1934 the average yield of the hay-type varieties was 2.99 tons of hay and 24.4 bushels of beans an acre, while the average yield of the seed-type varieties was 3.02 tons of hay and 30.4 bushels of seed. On productive soils in central Illinois seed-type beans will yield as much hay an acre as the finer-stemmed, sparsely podded, hay-type varieties.

At Alhambra in Madison county the five highest yielding varieties based on average yields for five years or more are: Macoupin, 26.6 bushels; Mansoy, 25.8 bushels; Morse, 25.0 bushels; Illini, 24.3 bushels; and Manchuria 13-177, 24.3 bushels.

At DeKalb in northern Illinois the best-producing types as judged by a three- to five-year period are: Manchu (Wisconsin), 28.0 bushels; Funman, 27.7 bushels; Manchu (Thomas), 26.7 bushels; Hybrid Population, 26.2 bushels; and Illini, 26.1 bushels.

Of the 75 importations which were sent to the Station in 1928, a number now are included in the yield trials, and some of these are showing promising results. Additional importations were sent by the U. S. Department of Agriculture to this Station in 1932, 1933, and 1935. Approximately 500 varieties or types were grown last year in the soybean nursery for observation and to test yielding ability. About 280 of the better varieties or types were selected for study in 1936.

Included among the recent importations are several strains that are used in the orient for human consumption, either dry or green. A number of the importations have been found to rate as choice on the basis of palatability. Results of these cooking tests are reported in Home Economics Project 104, pages 294 to 297. Studies of the different soybeans for human consumption are being carried on in cooperation with the Departments of Home Economics and Horticulture. (504 Agronomy)

Breeding May Advance Soybean Crop Still Further

Improvement of the soybean thru breeding has played a leading role in making Illinois the leading soybean-producing state of the

nation and in making the soybean itself one of the leading crops of the state. New strains have been introduced from the orient or developed by breeding and found to be adapted. This is one factor in the increasing popularity of the crop, the consequent increase in acreage, and the improvement in yield and quality of the crop.

Further improvement in the crop is being sought in continued studies by C. M. Woodworth, Plant Genetics. Many crosses are made each year by artificial hybridization, and these are carried to the second and in some cases to the third generation. Then the seed is bulked and carried on as hybrid populations. These furnish abundant material for selection.

In 1935 several hundred plant selections were grown. Of these, 46 were harvested in their entirety, each to be planted in a pair of rows for observation in 1936. Selections were also made from plant rows that were segregating.

Investigations on inheritance of number of seeds a pod were continued. Second-generation progenies of several crosses were grown. These involved parents which were predominately two-, three-, or four-seeded types. In general the second-generation progeny were intermediate between the parent types in number of seeds a pod, but were closer to the lower than to the higher parent.

Thirty-five third-generation families of a cross between a two-seeded and a four-seeded type were grown, pods classified, and frequency distributions made. Certain families gave distributions resembling one or the other parent, and the rest fell in between. Many families differed so much in number of seeds a pod that they showed no overlapping at all. There was also considerable difference in variation exhibited by the several families. Correlation between the second-generation parent plants and the mean of the third-generation progenies was $+ .68 \pm .06$. This indicates that second-generation plants with high number of seeds a pod will likely transmit that characteristic to the progeny.

Continuation of studies on the genetics of the soybean revealed facts of interest. Discovery was made of a new variegated type, the leaves of which lack considerable chlorophyll in the seedling stage of the plant. The later leaves produced are green, so that the plants appear normal so far as chlorophyll is concerned. They are not so vigorous, however, as normal plants. A cross between two other yellowish types gave normal green in the first generation and a ratio of 9 green to 7 yellow in the second generation. Of 186 second-generation plants, 112 were green and 74 yellow. On the basis of a 9:7 ratio, the expected numbers are 105:81, a deviation of 7.

Types of soybeans with a high proportion of four-seeded pods have narrow leaves, a character which is a simple recessive to normal leaf. Second generation of crosses between these and ordinary types

reveals evidence of linkage between leaf shape and number of seeds a pod. This confirms results already obtained by a Japanese worker. The one-seeded type discovered at the Illinois station has a leaf shape different from the two mentioned. When this is crossed with the narrow type, the normal is produced in the first generation.

Thirty strains were compared in a well-replicated rod-row test. Yields a rod row ranged from 906 grams for the lowest to 1,453 grams for the highest. The highest yielding variety, Manchuria 13-177, was exceeded by 14 of the 28 selections included in the test. (405 Agronomy)

Inoculation Studies Further Growing of Legumes

In view of the emphasis which the soil-conservation program is placing upon the growing of more legumes and of the fact that they cannot be grown satisfactorily without nodule bacteria in the soil, the matter of obtaining good inoculation is of immediate and increasing importance. However, the mere presence of nodule bacteria is insufficient. This is because, like other living things, they differ in effectiveness. Varieties of a given legume also differ in their ability as hosts for the nodule bacteria. There is thus great need for an understanding of the relationships between the nodule bacteria and the host plant. Information contributing to such an understanding and so to the more successful growing of legumes is being obtained in a continued study of factors affecting the inoculation of legumes. O. H. Sears, Soil Biology, is in charge.

That the Illini soybean is easily nodulated, whereas the Peking variety has few nodules, has been ascertained. In addition a study of first-, second-, and third-generation crosses between these two varieties indicates that the resistance as well as susceptibility to infection by the nodule bacteria is an inherited character.

Different kinds of annual lespedezas also differ in their ease of nodulation. Frequently Korean lespedeza shows good nodulation under conditions where Common lespedeza shows few or no nodules. This difference in susceptibility to the nodule organism also appears to be related to genetic make-up.

Further studies on these qualities of the nodule bacteria may be expected to aid in securing more uniform nodulation of common legumes by furnishing the plant breeder information with respect to desirable characters for which to breed. (312 Agronomy)

Six of Eight Legume Inoculants Found of Equal Value

With more land being turned back to legumes by farmers in Illinois and other states, there is more of a premium than ever on the use of proper inoculants. The farmer who does not inoculate with the proper group of efficient legume bacteria misses an opportunity to

reduce his production costs as well as to conserve his soil-fertility resources. Since the use of inferior or worthless cultures may under certain conditions lead to a partial or even complete crop failure, the need for information on the quality of inoculants sold to Illinois farmers is evident. In work under the direction of O. H. Sears and L. E. Allison, Soil Biology, close attention is given to determining which of the materials available are of value.

Recent laboratory, greenhouse, and field tests on 93 samples representing eight brands of inoculants sold in Illinois revealed that six of these are equally good and that two are worthless from the standpoint of nodule production. Fortunately the worthless brands do not have a wide distribution in the state. Considerable improvement was noted in the general quality of inoculants.

Farmers are urged to purchase fresh cultures of some reliable brand to insure maximum results from inoculation. Such cultures usually carry an expiration date on the container. (314 Agronomy)

Demonstrated Practices Would Reduce Clover Failures

The acreage devoted to legumes in Illinois would be considerably larger if red clover could be depended upon to produce a crop more regularly. With less than half the seedings yielding a crop, as is the case at present, attempts to grow red clover often result in disrupted rotations and the loss of money and labor. Aside from its irregularity, red clover is recognized as a crop of many merits, and to find means of overcoming that difficulty has been the object of continued studies under J. J. Pieper, Crop Production, and W. P. Flint, Illinois Natural History Survey. The number of failures, it has been demonstrated, can be reduced if certain practices developed thru experimental work are followed.

In a test to determine the effect of different varieties of spring grain on the stand of clover, the crop was irregular and poor, and, following further reduction in number of plants because of winter injury, the field was plowed. Previous results have shown barley to be the best nurse crop for clover. Where red clover was broadcast and drilled at two different dates—March 22 and April 19—in winter wheat, no clover survived the late seeding; while from the early seeding on land which had been limed and phosphated, 4 to 10 plants a square foot were noted. As between the red clover drilled and broadcast, no difference was recorded.

In a study of the effect of the rate and method of seeding the nurse crop on the production of red clover, it was noted that the stand of clover was best at the lower rates of seeding of the nurse crop but was not materially affected up to six pecks of drilled oats. Broadcast oats gave a poorer stand of clover than drilled oats. There was no difference in the stand of clover where oats were drilled 8 inches and

16 inches apart, but the clover was slightly larger with the 16-inch rows.

This year (1935) there was no increase in yield of hay as a result of fall clipping, whereas previous records showed an average increase of 25 percent for fall clipping. Seed yields were increased about 12 percent, whereas the average shows about 20 percent.

A field of red clover was permitted to stand over for the third year. Here the yields of hay were about one-third those of a similar field which was two years old. The yield of first-year clover, when cut in the fall of the year, was 1,770 pounds an acre.

Red clover seeded in oats has failed for the past six years. Because of these failures an attempt was made to establish red clover on a field where it had failed by drilling it alone on March 27, at the rate of 10 pounds an acre. Since the land had to be plowed early for winter wheat, only one cutting of clover was taken. Because of a wet spring the clover hay on the best treated plots contained 25 to 30 percent weeds. Plots receiving no lime or phosphate contained 55 to 95 percent weeds. On the best treated land nearly $\frac{3}{4}$ ton of weed-free hay an acre was obtained.

Over a period of twenty-eight years alsike clover failed more than 40 percent of the time. Seed yields, as an average of ten years, are 1.43 bushels an acre; hay yields, as an average for twelve years, 1.96 tons. In 1935 the clover failed for the fourth year in succession.

Results of these studies may be summarized, then, as follows: Best stands of clover may be obtained by seeding in barley as a nurse crop. Early seeding of clover in winter grain is superior to late seeding. No advantage appears from drilling red clover in winter grain as compared with broadcasting.

Red clover does best at the lower rates of seeding the nurse crop. Drilled oats give better stands of clover than broadcast oats. The spacing of the rows of the nurse crop has no effect on the stand of clover.

Hay and seed yields of red clover are usually increased materially by fall clipping of first-year clover.

Clover allowed to remain over for the third year yielded only about one-third as much as second-year clover. A fall cutting of first-year red clover yielded $\frac{3}{4}$ ton of hay an acre.

Where red clover was seeded alone in the spring on plots treated with lime and phosphate, the hay contained 25 to 30 percent weeds. It yielded about $\frac{3}{4}$ ton of weed-free hay an acre.

Alsike clover failed more than 40 percent of the time when seeded in spring grain at DeKalb. Yields of seed (1.43 bushels an acre) and hay (1.96 tons an acre) compare favorably with those of red clover. (507 Agronomy and 1.3 Illinois Natural History Survey)

Seed With Damaged Crowns Yields One-Fourth Less Corn

The seed coat of much of the 7 to 9 million acres of corn that is planted every year in Illinois is injured at the crown. Heavy losses which growers suffer because of such seed are indicated in the results of further experiments on the problem by Benjamin Koehler, Crop Pathology. Yields from seed injured at the crown were reduced 26.2 and 27.5 percent respectively, as compared with yields from sound seed in two plantings made during the past year. This was utility-type Reid Yellow Dent. In 1933 there was a loss of 23.2 percent of the yield from crown-injured seed and in 1934 a loss of 18.2 percent.

Tests made in the hope of solving these losses thru seed treatment have now established the fact that good seed treatment is likely to be of considerable benefit to early-planted seed regardless of how good the seed may be. It seems likely that in late-planted corn the benefit from seed treatment will be largely in proportion to the extent of seed-coat injury and perhaps to other less common factors that favor seedling disease infection.

The two 1935 plantings with crown-injured seed were made a month apart, April 30 and May 30. The early planting went thru a long siege of cold, wet weather starting immediately after planting, but the late planting had no such setback. Field stands from both injured and uninjured seed were decidedly the best in the late planting, but the yields of grain were best, by a small margin, in the early planting. The loss in yield from injury to the seed coat was practically the same in both plantings.

The striking difference between the two tests was that in the late planting the application of a good seed disinfectant almost completely forestalled any injury to the seedlings grown from seeds with injured seed coats. These plants were as vigorous and yielded nearly as well as those from sound seed. This agreed with results obtained in the two previous years. On the other hand, in the early planting, which had the unusually unfavorable growing conditions, seed treatment was only a partial corrective for seed-coat injury. Acre-yields from sound and injured seed that was untreated were 77.6 and 57.3 bushels respectively. When the seed was treated with a good commercial seed-corn disinfectant, the yields were 86 and 72.9 bushels respectively for sound and injured seed. In the early planting, seed treatment benefited both the sound and injured seed to a marked extent. In the late planting, seed treatment benefited only the injured seed, giving results nearly equal to those from treated sound seed. (543 Agronomy)

Seed Treatment Improves Yield of Early-Planted Corn

Seed-corn disinfectants have been proving their worth by increasing the yields of early-planted corn an average of 3 to 5 percent over

a period of years, according to yield determinations made on numerous test plots in Illinois. In 1935 the benefit from seed treatment was especially good because the weather was unusually cold and wet during most of May. With New Semesan Jr. being used for the seed treatment, yields of grain were increased an average of 5.7 percent in three tests in the northern section of Illinois; 4.4 percent in three tests in the north-central section; and 12.4 percent in two tests in the south-central section of the state. These were cooperative tests conducted by Benjamin Koehler, Crop Pathology; George H. Dungan, Crop Production; C. M. Woodworth and W. J. Mumm, Plant Genetics; A. L. Lang, Soil Experiment Fields; and J. R. Holbert, U. S. Department of Agriculture.

Experiments on the effect of storing treated seed for different lengths of time before planting have been continued. High-grade yellow-dent seed was used in each test. The 1933 seed was divided into three lots, seed from the same ears being represented equally in each lot. One lot was treated in May, 1934; one lot in May, 1935; and the other lot left untreated. Storage was in loose muslin bags buried in a bushel of other shelled corn similarly treated, all held in an ordinary canvas grain sack tied shut.

TABLE 10.—INCREASES IN YIELD OF CORN GROWN FROM SEED TREATED WITH CERTAIN COMMERCIAL SEED DISINFECTANTS AND STORED FOR VARIOUS LENGTHS OF TIME BEFORE PLANTING, URBANA EXPERIMENT FIELD

Seed from crop year	Storage after treating and before planting	Yield of untreated check	Increase in yield of shelled corn over untreated check		
			New Semesan Jr.	Barbak III	Merko
	days	bu.	perct.	perct.	perct.
1933.....	1	72.4	7.2	3.3	1.5
1933.....	355	72.4	6.8	1.2	4.3
1934.....	1	65.9	7.6	7.4	4.9
1934.....	91	65.9	10.2	6.8	5.3
1934.....	91 ¹	65.9	1.2 ¹	-1.2 ¹	-.3 ¹

¹Treated seed, stored in an open shed. All others stored in a dry building heated to 60° or 65° F. during the cold part of the year.

Results shown in Table 10 are in fair agreement with those obtained in previous years. When storage was in a dry building, seed treatment applied early in the season to high-grade seed caused no appreciable injury to germination or yield of grain even tho the treated seed was stored for as long as a year before planting. Storing the seed in an open shed appeared to cause slight injury even to untreated seed, but the effect was much more pronounced in treated seed. (530 Agronomy)

Composition of Corn Widely Influenced Thru Breeding

In studies carried on at the Experiment Station since 1896, selection has resulted in strains of corn with a protein content 62 percent higher than that of the original stock and an oil content 165 percent higher. The purpose of this work has been to determine the effect of continuous selection upon the chemical composition of corn. The results suggest vast possibilities in the adaptation of strains to particular purposes thru breeding. C. M. Woodworth and W. J. Mumm, Plant Breeding, are in charge.

At the beginning of the experiment the protein content of the corn, which is of the Burr White variety, measured 10.92 percent and the oil content 4.70 percent. By selecting each year those ears analyzing highest in protein and those lowest in protein and proceeding in the same way with respect to oil content, the investigators have developed four strains: High Protein, Low Protein, High Oil, and Low Oil.

Each year 60 ears are analyzed from each of these strains. The 12 highest ears in the high strains and the 12 lowest in the low strains are used for planting the next year. Pollinating is done artificially by bagging shoots and tassels in order to prevent outcrossing with other strains and too much inbreeding within the strains. Formerly the strains were grown in isolated plots and every other row detasseled to avoid inbreeding as much as possible. The present method is used because of the difficulty of locating well-isolated plots each year.

Tho the results from year to year have varied with the seasons, there has been general progress toward higher percentages of protein and oil in the high strains and toward lower percentages in the low strains. The analyses for 1935 were as follows:

<i>Strain</i>	<i>Analysis</i>	<i>Ratio to original analysis^a</i>
High Protein.....	17.71 percent protein	162.2
Low Protein.....	5.90 percent protein	54.0
High Oil.....	12.47 percent oil	265.3
Low Oil.....	1.32 percent oil	28.1

(*Taking the original analysis as 100 percent.)

The 1935 crop of Low Protein gave the lowest analysis on record, and the 1935 crop of High Oil the highest on record.

Additional data were obtained on the effect of discontinuing selection. In analysis the 1934 crop used for this phase of the experiment resembled closely the strains carried on under selection. For the 1935 crop seed was taken from unselected ears of the 1934 crop. Results for both years with and without selection are given below:

<i>Year</i>	<i>High Protein</i>		<i>Low Protein</i>		<i>High Oil</i>		<i>Low Oil</i>	
	<i>Selection</i>	<i>No selection</i>	<i>Selection</i>	<i>No selection</i>	<i>Selection</i>	<i>No selection</i>	<i>Selection</i>	<i>No selection</i>
1934....	23.79	22.43	10.73	11.42	11.36	10.79	1.04	1.16
1935....	17.71	17.33	5.90	7.09	12.47	9.57	1.32	1.19

This phase of the experiment has not been carried on long enough for the determination of trends. It will be continued. (401 Agronomy)

Hybrids Promise to Reduce Fluctuation in Corn Crop

Greater stabilization of the Illinois corn crop appears likely as a result of the use of hybrid varieties. In successive years the total corn grown in the state has frequently varied as much as 100 million bushels, owing principally to differences in seasonal conditions. Hybrid corn, however, has been found to perform better than open-pollinated varieties in unfavorable as well as in favorable seasons, for which reason it may be expected to aid materially in reducing year-to-year fluctuations in yield.

It is estimated that enough hybrid seed was produced in Illinois in 1935 to plant 200,000 acres, and that enough foundation hybrids were planted the following spring to produce seed for at least a million acres provided a normal yield was obtained. Under C. M. Woodworth and W. J. Mumm, Plant Breeding, continued studies in the breeding of corn for disease resistance and yield have been made, and in view of the rapidly increasing interest in hybrids these have had first attention the past year. Cooperating with the U. S. Department of Agriculture in field tests at Bloomington, the Experiment Station has distributed some foundation single crosses for hybrid seed production to small growers without facilities for producing such seed for themselves. The seed so distributed, however, has constituted but a very small percentage of the seed used for producing hybrid corn in Illinois.

Most of the breeding work centered about the production of superior inbred lines that transmit valuable qualities to the crosses in which they enter. Qualities such as good root systems, sturdy stalks, high yield, high grain quality, heat and cold resistance, insect resistance, fertilizer response, low ear, and good husk covering are carried and transmitted by the different inbred lines in commercial use, but none of them contain all these good qualities.

Many new single-cross and double-cross hybrid combinations were made in order to study the effect of introducing new inbred lines into the different combinations and to improve further the commercial hybrids that are available. This crossing program was enlarged by making use of several good inbred lines developed by corn breeders of neighboring experiment stations.

All breeding stocks were produced in much larger volume than in previous years, not only because of a favorable season, but also by making use of several isolated fields. Strip tests were widely scattered in the state and, along with the performance tests, were used in getting information about the adaptation of hybrid combinations.

Seed of 86 double-cross hybrids, 78 of which represented new combinations, was produced. About 2,800 pounds of this seed was dis-

tributed over the state in the spring of 1936 for testing. About 2,000 pounds of single-cross hybrid and 270 pounds of foundation inbred seed were produced. Much of this seed has been used in furthering the hybrid-corn program in the state.

About 600 pounds of double-cross hybrid seed was distributed in the spring of 1935. As a result several inbred lines developed at this Station proved to be valuable in hybrid combinations. Inbreds 5120, 4211, 4226, and 5675 gave the most promise. These inbreds were included in many of the new combinations made up for testing in 1936.

The season was favorable for the study of lodging. Much lodging was caused by attacks of the southern corn rootworm. Corn that was frozen before it was matured also tended to lodge badly before harvest time. Crosses containing certain inbreds were more susceptible to injury by the rootworm than were other hybrids made up of different lines. Resistant hybrids apparently were able to re-establish themselves after a part of their roots were cut off. Inbreds 4226 and 5675 indicated that they had especially good root and stalk quality.

Several hybrids were entered in silage tests. Silage from hybrid corn contained a larger proportion of ear and leaves and not so much stalk as silage made from open-pollinated corn. In addition it was easier to harvest because it stood up better. (404 Agronomy)

Hybrid Corns Vary Widely in Yields and Adaptation

In an attempt to keep up with the demands for seed, corn breeders and seedsmen are making new hybrids each year. These need to be tested for performance in different areas of the state to determine their range of adaptation. Such tests were conducted cooperatively in 1935 by George H. Dungan, Crop Production; J. R. Holbert, U. S. Department of Agriculture; W. J. Mumm, Plant Genetics; J. H. Bigger, Illinois Natural History Survey; and A. L. Lang, Soil Experiment Fields.

The performance tests were conducted in farmers' fields at fifteen places in Illinois. The fields were chosen with respect to the soil type and climatic area represented. Of the 274 different kinds of corn grown, 202 were hybrid and 72 were open-pollinated. Hybrids were found to differ greatly in their relative productivity and in their adaptation to different sections of the state.

In all cases the better hybrids lodged less and produced larger yields of sound grain than the open-pollinated varieties. In northern Illinois the five best hybrids yielded 16.7 bushels more sound corn an acre than the five best open-pollinated varieties as an average for three fields; north-central section, 19.8 bushels more as an average for three fields; central section, 20.2 bushels more as an average for three fields; south-central, 13 bushels more as an average for two fields; and southern, 6.9 bushels more as an average for two fields.

For the state as a whole, the average yield of sound corn of the five best hybrids was 84.2 bushels an acre. The corresponding yield of the five best open-pollinated varieties was 69.2 bushels an acre, or 15 bushels less than the average yield for the best hybrids.

Soil-adaptation studies showed that the superior hybrids utilized more effectively and economically than did open-pollinated varieties



FIG. 2.—PLANTING ONE OF THE ILLINOIS CORN-PERFORMANCE TEST FIELDS

These fields were located on farms at fifteen different points in the state. In all tests the better hybrids lodged less and produced larger yields of sound grain than open-pollinated varieties. The five best hybrids in 1935 averaged 15 bushels more of sound corn than the five best open-pollinated varieties.

the plant-food materials available in highly fertile soils, and so produced larger yields of better-quality corn.

Information on the performance of particular hybrids and open-pollinated varieties on the different fields was reported in Illinois Agricultural Experiment Station Bulletin 427, "Illinois Corn Performance Tests—Results for 1935." (501 Agronomy)

Plowing Down Cornstalks Preferable to Burning Them

Burning of cornstalks as a general practice is not warranted on the basis of results which have now been obtained by D. C. Wimer, Soil Physics, in studies to determine the fertilizing value of the stalks. Corn and wheat yields have been slightly higher on land where cornstalks were plowed down than where they were burned and the ashes returned. While the differences between the two methods, based on comparisons made since 1925, are no doubt too small to be significant, the results certainly do not favor burning. This investigation is an outgrowth of the corn-borer situation, since burning of cornstalks may become necessary as one means of combating the borer when it reaches Illinois.

The residue and ash treatments are made just previous to preparing

the land for soybeans, which follow corn in a four-year rotation including red clover on a productive dark-colored soil, Muscatine silt loam. One series of eight 1/160-acre soil bins is devoted to each crop. The second growth of clover, as well as the stubble of other crops, is not removed. The cornstalks, as residues, are applied at the rate of 2 tons of dry material an acre, while an equivalent amount of cornstalks is burned and the resultant ashes returned to the alternate plots.

In 1935 the average yields of corn, soybeans, and wheat were practically the same on the plots treated with cornstalk residues and on those treated with cornstalk ashes. With red clover the yield of hay was 620 pounds an acre more with residues than with ashes. To date there have been harvested ten crops each of soybeans, wheat, and hay, and seven crops of corn after residue and ash treatments. The yields have been the same for both treatments with soybeans and with clover and soybean hay. Residues, however, are somewhat better than ashes for corn and wheat, the average differences in favor of residues being 1.4 and 1.7 bushels an acre respectively for the two crops. It seems probable that burning cornstalks would have a more serious effect upon crop yields on soils of low productivity and under poor systems of cropping than it would upon yields of crops grown under more favorable conditions. (212 Agronomy)

Corn Hybrids Resistant to Lodging Reduce Ear Rots

A threefold gain in stabilizing Illinois' corn crop could be made if corn ear rots could be controlled. Because of these rots and other hazards and factors the crop during the past five years has varied from 353 million bushels in 1931 to 146 million bushels in 1934. First, corn ear rots are responsible for badly rotted ears which usually are not harvested at all or if harvested are thrown out later. Second, in dry corn, rotted kernels weigh only about half as much as sound corn, and thus there is a direct loss in yield. Third, there are some rotted ears which get to market and in dry corn are the principal factors determining the commercial grade and hence the price.

Ear-rot damage in the field can be largely overcome by using a hybrid that is both resistant to lodging and resistant to ear rots. This has now been demonstrated in studies which Benjamin Koehler, Crop Pathology, is making of factors influencing the amount of ear rot. In the studies during the past year special attention was given to the effect of lodging and the use of resistant varieties.

Plants were artificially lodged at two-week intervals beginning September 4, just before denting commenced. Roots on one side of a hill were cut with a spade and then the plants pushed over so that they lay flat on the ground. The artificially lodged plants were still fully as well anchored as those which were naturally lodged in the same plots, largely as a result of damage by the corn rootworm. In all lodged

stalks, however, anchorage was very poor when compared with that of the standing stalks.

In utility-type, open-pollinated Reid the total commercial damage from rots as measured in the shelled corn was increased from 1.7 percent in standing corn to 7.5 percent in that lodged early artificially. In an old line of open-pollinated yellow dent damage was increased from 1.9 to 10.7 percent. In a high-yielding hybrid not especially bred for ear-rot resistance damage was increased from 2.9 to 9.9 percent. In Illinois Hybrid 172, bred for high yield and ear-rot resistance, damage was increased from .8 to 3.2 percent by early artificial lodging. Lodgings made at intermediate dates gave intermediate results.

Four kinds of ear rots were observed and recorded separately. These were caused by the fungi *Diplodia zeae*, *Fusarium moniliforme*, *Gibberella saubinetii*, and *Nigrospora sphaerica* (*Basisporium gal-larum*). In addition in the early-lodged corn there were some other rots, the cause of which was not identified.

In all cases early lodging had a marked effect on increasing rots caused by *Nigrospora*, *Fusarium*, and *Diplodia*. *Nigrospora* was especially outstanding in corn lodged early, but negligible in standing corn. Rots caused by *Gibberella* were the only ones not increased by lodging.

Reduction in total yield of grain from the first plants lodged, as compared with the yields from stalks standing until husking time, was approximately 25 percent in the two open-pollinated varieties used and 30 and 32 percent respectively in the two high-yielding hybrids used. Reductions in test weight a bushel from early lodging ranged from 6.5 to 8.9 percent.

Lodging had a bad effect on yield of grain and on test weight a bushel and greatly increased the percentage of rot. Under natural lodging, however, Hybrid 172 produced only 13.5 percent lodged plants under heavy rootworm infestation as compared with 28.6, 29.8, and 42.4 percent in the other varieties used. Damage to grain from lodging, therefore, can be largely overcome by using a hybrid that is both resistant to lodging and resistant to ear rots. (525 Agronomy)

Resistance of Corn Hybrids Related to Carbohydrates

With about 6,000 acres of hybrid seed corn being produced in Illinois in 1936 for 1937 planting and the production of hybrids rapidly increasing, the question of their behavior under a wide range of soil and climatic conditions has become a matter of interest to farmers in all parts of the state.

One phase of this study conducted by E. E. DeTurk, Soil Technology, and E. B. Farley, Soil Fertility, in cooperation with J. R. Holbert, U. S. Department of Agriculture, consisted of a complete chemical analysis of the carbohydrates of a well-established resistant line of hybrid corn, R₄ × Hy, and another line, Lan. × R313, which is sus-

ceptible to low temperatures in the fall and to Diplodia stalk rot. The purpose was to determine the relationship of the carbohydrates to these two factors. Results to date indicate that the resistance of $R_4 \times H_4$ to low temperature and Diplodia is definitely associated with high total active carbohydrates and total sugars, whereas the susceptibility of $Lan. \times R313$ is associated with low carbohydrate concentrations.

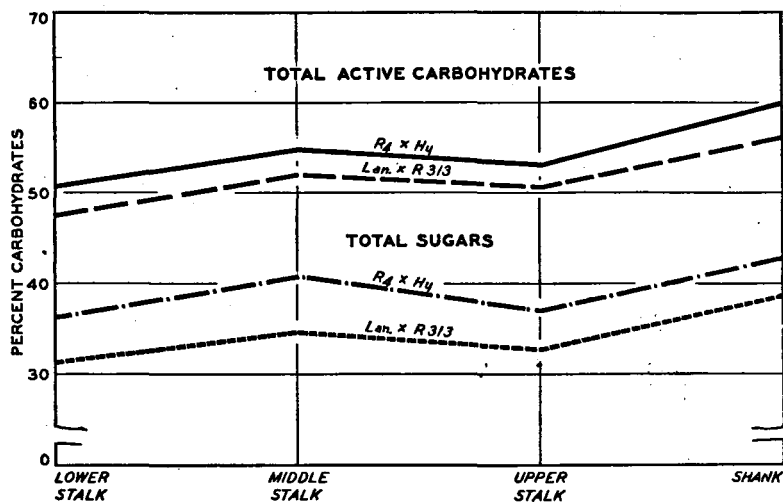


FIG. 3.—VARIATION IN AMOUNT OF CARBOHYDRATE IN TWO DIFFERENT CORN HYBRIDS

The high total active carbohydrates and total sugars in $R_4 \times H_4$ probably are definitely associated with its resistance to low temperature and Diplodia, whereas the low carbohydrate concentration of $Lan. \times R313$ is probably associated with its susceptibility to these hazards.

The curves in Fig. 3 show $R_4 \times H_4$, the resistant hybrid, exceeding $Lan. \times R313$, the susceptible hybrid, in total active carbohydrates and total sugars in the samples of stalk and shank tissue taken September 13, 1935.

In view of these findings it appeared that a reduction of carbohydrate synthesis by removing a significant percentage of the leaf area should result in increasing their susceptibility to cold injury or Diplodia infection or both. Field demonstration plots showed this to be the case, where 30 percent of the leaf area was clipped from plants of these two hybrids shortly after pollination. Chemical tests proved that the clipping significantly decreased the total active carbohydrates and total sugar. The data given in Fig. 4 are for total sugars only, as the total active carbohydrate data are similar. (114 Agronomy)

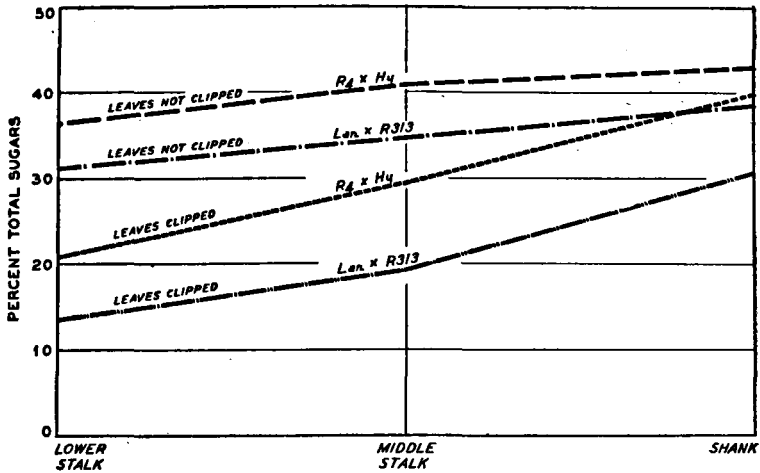


FIG. 4.—REDUCTION OF CARBOHYDRATE SYNTHESIS OF THE CORN PLANT AS A RESULT OF REMOVING PART OF THE LEAF AREA

This reduction increased the susceptibility of both hybrids to cold injury and to *Diplodia*, thus supporting the probability that the low carbohydrate concentration of Lan. x R313 in Fig. 3 is associated with its susceptibility to low temperatures and *Diplodia*.

Brill, New Winter Wheat, Consistently Good Yielder

Altho Illinois' five-year average yield of 17.7 bushels of wheat is about two bushels more than that of the country as a whole, there is still much that can be gained in efficiency of production by growing better-adapted varieties. Continued drill-plot tests by W. L. Burlison and George H. Dungan, Crop Production, show that the highest producing winter wheat at Urbana exceeded the poorest one in the test by a little more than 35 percent. The best-yielding variety exceeded Turkey, a standard wheat, by more than 10 percent.

Table 11 shows the yields of the five leading winter wheats at DeKalb, Urbana, and Alhambra.

Brill has the phenomenal record of being among the five highest yielding wheats on all three of the fields. It is unusual that a typical hard wheat, as Brill is, can perform so well at Alhambra, where the soft red winter varieties are adapted. Brill originated as a selection from Turkey by Benjamin Koehler, Crop Pathology. It was chosen because of its unusual resistance to the scab disease and because of its high yields. Since it has proved so promising as a grain producer, milling and baking tests have been made recently by D. A. Coleman, U. S. Department of Agriculture. Reports of these studies show Brill

TABLE 11.—YIELDS OF THE BEST-PRODUCING WINTER WHEATS IN DRILL PLOT TESTS ON THE DEKALB, URBANA, AND ALHAMBRA EXPERIMENT FIELDS, 1933-1935

Field and variety	Number years represented in the average	1933	1934	1935	Average comparable rating
<i>DeKalb</i>					
Ioturk.....	4	41.6	14.3	20.0	117.0
Brill.....	4	36.9	8.0	20.6	109.4
Minturki.....	10	37.6	10.8	25.4	107.7
Purkof.....	10	36.3	7.0	26.0	105.9
Wisconsin 2.....	8	38.1	5.2	25.2	105.6
<i>Urbana</i>					
Brill.....	5	36.5	38.2	35.8	113.9
Kawvale.....	3	36.7	34.9	38.3	113.1
Tenmarq.....	5	35.0	34.0	35.0	109.5
Cheyenne.....	4	33.2	40.2	28.6	107.9
Wisconsin 2.....	8	34.5	35.4	29.7	107.5
<i>Alhambra</i>					
Fulcaster.....	9	17.6	27.3	27.6	119.5
Nabob.....	5	17.4	28.4	30.0	117.1
Brill.....	4	20.0	26.7	28.0	113.3
Michigan Amber.....	9	16.3	26.0	27.6	110.7
Red Sea.....	7	17.4	26.2	26.9	108.5

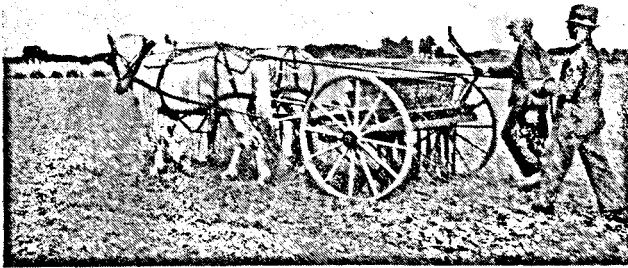


FIG. 5.—SEEDING DRILL PLOTS OF WINTER WHEAT ON THE ALHAMBRA CROP EXPERIMENT FIELD

Similar wheat-variety trials also are conducted at DeKalb and at Urbana. Ioturk has the best three-year average on the DeKalb field, Brill on the Urbana field, and Fulcaster on the Alhambra field.

to be a very good bread wheat. This wheat has enough good qualities to merit its production commercially. Two weaknesses of Brill include susceptibility to the mosaic disease, tho not to rosette, and its tendency to lodge on exceptionally fertile soil. It is similar to Turkey in stiffness of straw. (505 Agronomy)

Shrinkage of Hay Studied to Improve Storage Methods

As most of the hay produced in Illinois is kept for a time either in mows or stacks, the reduction of storage losses, especially in the weight of hay, is a problem common to many of the state's 231,000 farms. Information as to the shrinkage of hays under different conditions would be helpful in determining the best methods of storage. Such information for alfalfa and soybean hays has been obtained in continued studies of the storage and shrinkage of crops under W. L. Burlison and George H. Dungan, Crop Production, in cooperation with E. W. Lehmann and R. H. Reed, Agricultural Engineering.

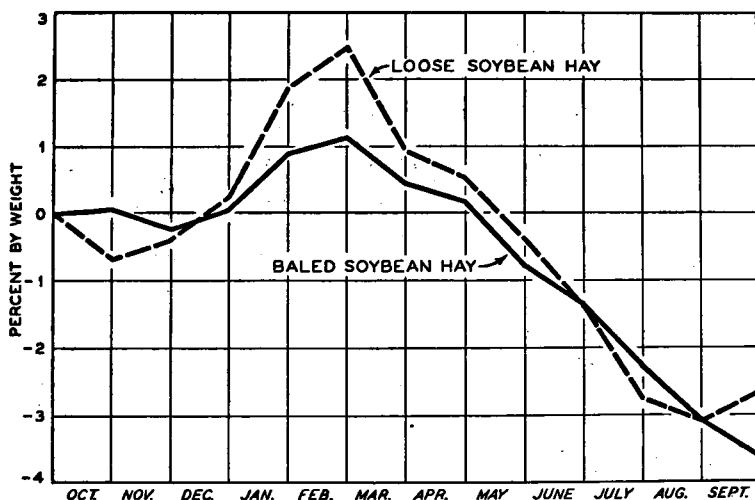


FIG. 6.—AVERAGE PERCENTAGE CHANGES IN WEIGHT OF SOYBEAN HAY DURING A YEAR'S STORAGE

On the average, the hay was heavier during December, January, February, March, and April than it was when it was stored. It was lightest in August and September.

Baled and unbaled lots of both kinds of hay were stored in the cribs used for determining the shrinkage of grains. The third cutting of alfalfa was used for this study. The loose hays were packed in the cribs as tightly as possible by tramping. The bales were carefully stacked in the cribs so as to utilize the space as efficiently as possible. The sides of the cribs were slatted and the ends were weather-boarded solid with shiplap lumber. The cribs and contents were weighed once each week, and the average shrinkage calculated by months. Four

different lots of baled and loose soybean hay and one lot of baled and loose alfalfa hay were included in the tests.

Changes in the weight of the soybean hay are shown in Fig. 6. The weight of hay as it went into storage was considered as the base in figuring the percentage change. It is clear that two factors enter into the amount of shrinkage of hay. One of these is the amount of mois-

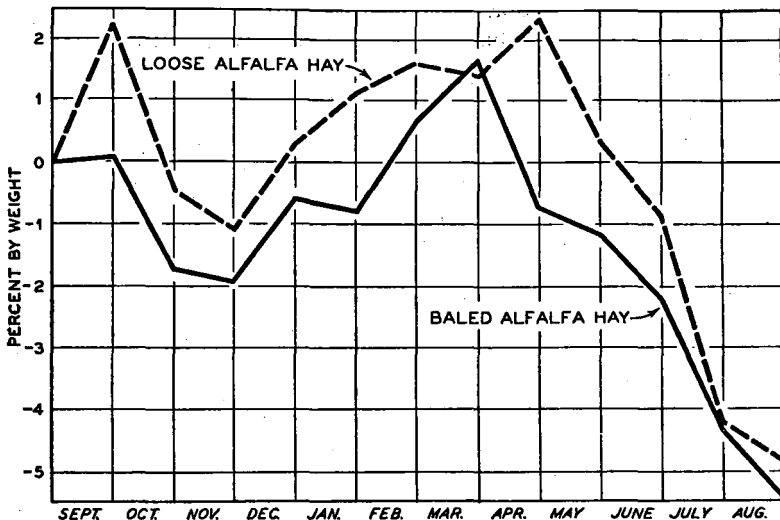


FIG. 7.—AVERAGE PERCENTAGE CHANGES IN WEIGHT OF ALFALFA HAY DURING THE FIRST YEAR OF TWENTY-ONE MONTHS' STORAGE

Shrinkage both of loose and of baled hay was rapid during May, June, July, and August of the first year of storage. The maximum shrinkage, 6 percent, was reached in October of the second year in the case of baled alfalfa hay and in May of the second year in the case of loose alfalfa hay.

ture in the hay at the time it is stored, and the other is the conditions affecting rate of drying.

Two lots of the baled and two of the loose soybean hay were so dry when placed in storage that they shrank below their original weight only twice and then very little. On the other hand, two lots of the baled and two of the loose hay were so high in moisture at time of storage that the shrinkage was more than 7 percent as a maximum at six different times of observation. The soybean hay, on the average, was heavier during December, January, February, March, and April than it was when it was stored. It was the lightest in August and September.

The data on alfalfa-hay shrinkage over the first 12 months of a

21-month storage period are given in Fig. 7. Here again the weight of the loose hay fluctuated more widely than that of the baled hay, but the baled hay lost more weight as a maximum than the loose hay. Shrinkage of both was rapid during May, June, July, and August of the first year. The maximum amount of shrinkage, 6 percent, was reached in October of the second year in the case of baled alfalfa hay and in May of the second year in the case of loose alfalfa hay. (534 Agronomy and 601 Agricultural Engineering)

Resistance to Lodging and Rust Stressed in Wheat

Growing conditions during the 1935 season brought out the importance of having varieties of winter wheat that are resistant to lodging and to yellow leaf rust, if the state's average annual crop of more than 1¾ million acres is to be of the highest quality produced at the lowest cost. Accordingly these resistant characteristics were stressed in the wheat-improvement studies being carried on by C. M. Woodworth and O. T. Bonnett, Plant Genetics. Only those strains which could stand up under high moisture, high fertility conditions, which showed marked resistance to yellow leaf rust, and which, in addition, were soft were kept for growing the following year.

Many strains from a large number of crosses were grown and observed for the first time. In all, about 1,700 strains and varieties were grown in the head row, preliminary observation series, and replicated rod-row yield plots. Selections from 30 crosses representing 27 different varieties of winter wheat were studied. Marked differences were noted among the different crosses and in the number of promising strains that could be obtained from them. Certain crosses produced very few strains of any value, while in other crosses many desirable types were noted. In the future greater attention will be given to those crosses producing the higher percentage of desirable selections.

In order to combine the desirable characteristics of a greater number of varieties, the investigators made crosses between the first-generation progeny of two different crosses. By this method there were brought together the characteristics of four varieties, instead of two, as when single crosses are made. The principal weakness of this method lies in having too few crossed seeds, and hence of not having some of the recombination types represented in the progeny. However, by concentrating upon only two combinations, it was possible to produce 200 crossed seeds in one case and nearly 300 in the other. A careful study is being made to determine the value of this method of producing hybrid progeny.

Mosaic disease of winter wheat was quite prevalent in Illinois in 1935 and caused considerable damage in certain fields planted to mosaic-susceptible varieties. In one field planted to Illinois 2, a soft red winter wheat susceptible to mosaic, more than 95 percent of the

stand was lost. It was noted on this particular field that some plants were highly resistant to the disease. One hundred eighty-seven plants were selected and planted in plant rows on mosaic-infected soil in the fall of 1935. Results from this planting showed that more than 90 strains are highly resistant to the mosaic disease. Those strains continuing to show resistance in further tests will be used for producing a mosaic-resistant Illinois 2 wheat.

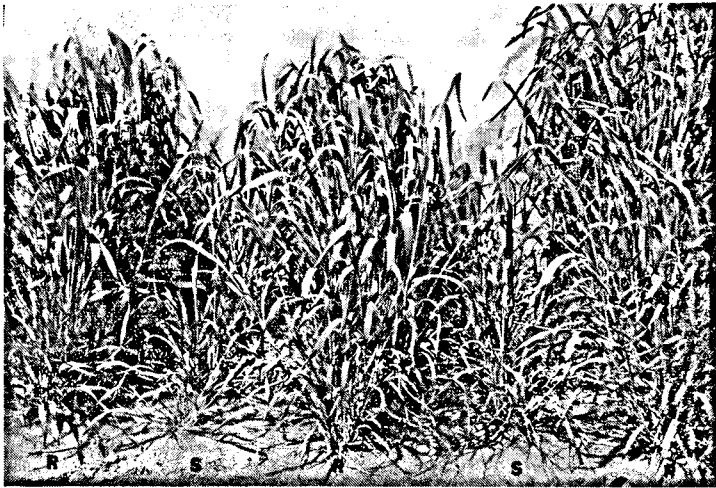


FIG. 8.—SELECTIONS OF WINTER WHEAT RESISTANT TO MOSAIC DISEASE

The resistant lines (R) are shown growing with two susceptible lines (S) on infected soil at the mosaic-disease nursery, Ralph Allen farm, Delavan. These resistant lines and other strains continuing to show resistance in further tests will be used for producing a mosaic-resistant Illinois 2 wheat.

A purification plot of Brill, a new hard red winter wheat produced by the Illinois Agricultural Experiment Station, was grown. The method used in planting and harvesting the purification plot is mentioned because it shows the procedure followed in preparing new varieties of small grain for distribution.

In the 1934 season 5,000 kernels of Brill wheat were spaced 4 inches apart in nursery rows. At harvest these plants were pulled and sorted. All plants that were not typical of the variety were discarded. About 2,000 plants remained after the preliminary sorting. The seed of each plant was kept separate and planted in 8-foot rows in the purifying plot. Before harvest in 1935 the nursery was carefully examined and rows which showed any mixture or any deviation from the type of the variety were cut and discarded. The remaining rows were harvested

with a binder and threshed on a small nursery thresher. This seed was then planted in an increase plot from which seed for distribution was obtained. Such a procedure is followed to insure seed stock of a high degree of uniformity and purity. (403 Agronomy)

Serious Mosaic Disease of Wheat Can Be Controlled

When environmental conditions are favorable for the disease, wheat mosaic may cause an 80 percent crop failure in susceptible vari-

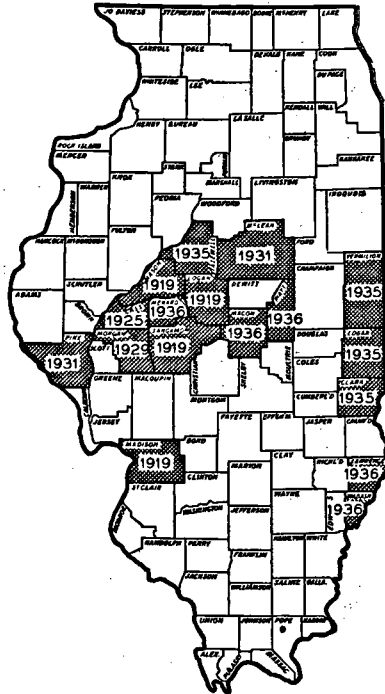


FIG. 9.—EXTENT OF WHEAT MOSAIC DISEASE AND YEAR OBSERVED

Mosaic disease is now known to occur in seventeen Illinois counties, being widespread in some of these and more restricted in others. The disease is harbored in the soil and is not seed-borne.

eties, according to investigations by Benjamin Koehler, Crop Pathologist, and H. H. McKinney, U. S. Department of Agriculture. This disease is of special interest to Illinois farmers because it is causing more damage to wheat on Illinois farms than in any other area in the world, as far as now known. When it was first discovered near Granite

City in 1919 and found to be a soil-borne disease not transmitted by seed, it was supposed to be of local importance in a few counties only. Since then wheat mosaic has been found in new locations from time to time, until now it is scattered pretty well thru central and south-central Illinois.

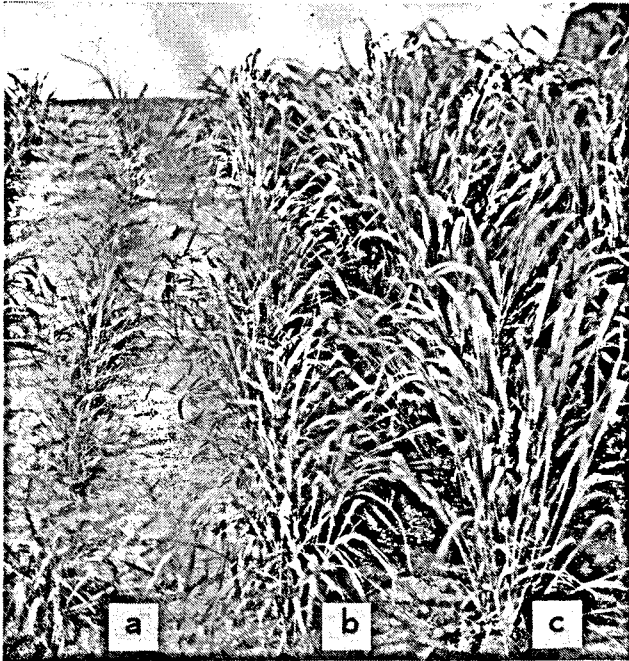


FIG. 10.—VARIATIONS IN THE SUSCEPTIBILITY OF THREE DIFFERENT VARIETIES OF WHEAT TO MOSAIC DISEASE

Variety *a* is Harvest Queen. It was severely stunted and many plants were dying when the picture was taken on May 6. Variety *b*, Purkof, is considerably injured, but not so severely stunted. Variety *c* is Fulcaster which was practically free from injury by this disease.

In 1936 the disease was found causing damage in four new counties,—namely, Menard, Macon, Lawrence, and Wabash,—thus making a total of 17 Illinois counties in which its occurrence is now known.

The disease attacks only winter wheat, but the symptoms do not develop until growth is resumed in the spring. Some susceptible varieties when grown on infected soil and when environmental conditions are favorable for the disease to be destructive show leaf mottling and a severely stunted condition in the spring from which the plants never

recover (Fig. 10, *a*). Some other varieties never show this extreme stunting but show pronounced mottling of the leaves and a lack of vigor (Fig. 10, *b*). Still other varieties were found to be very resistant to any injury whatever from this disease (Fig. 10, *c*).

In south-central Illinois, Fulcaster and Fulhio are adapted varieties that are highly resistant to mosaic. In central Illinois the experiments have not yet gone far enough so that any varieties can be highly recommended for use on infected soil. None of the hard wheats are susceptible to the severe stunting known as rosette, but all so far tested are susceptible to mosaic of the type shown in row *b*, Fig. 10. Of the soft or semihard established varieties some are highly resistant. According to experimental results obtained in Mason, Tazewell, and Clark counties in 1935-36, some of the varieties can be classified as follows:

<i>Very resistant</i>	<i>Moderately resistant</i>	<i>Very susceptible</i>	
Bald Rock	Duffy	Early Red May	Nigger
Fulcaster	Ilred	Harvest Queen	Nittany
Fulhio	Michigan Amber	Illinois Progeny 2	Purdue 1
Nabob	Red Rock	Kawvale	Purkof
Shepherd	Red Wave	Michikof	Tenmarq
Trumbull	Gladden	Missouri Blue Stem	Red Cross
Wabash			

From the standpoint of such important characters as high yield, stiff straw, winter hardiness, rust resistance, and milling quality, none of the varieties listed as very resistant or moderately resistant are desirable in all characters for central Illinois. Some breeding work for mosaic resistance and all these other characters, now being carried on by the Experiment Station and the U. S. Department of Agriculture, is producing promising new mosaic-resistant strains which may prove to be more satisfactory. (544 Agronomy)

Progress and Illinois 1 Are Best Spring Wheats

Spring wheat acreage in Illinois has been small during the past few years. Only 21,000 acres of this crop were harvested in 1935. According to estimates the acreage in 1936 will be substantially increased. Information on varieties, especially their yielding ability and climatic adaptation, is needed. Data of this kind are obtained in spring wheat field tests by George H. Dungan, W. L. Burlison, and C. A. Van Doren, Crop Production.

Progress and Illinois 1 have proved to be the two best adapted varieties of spring wheat for Illinois. Garnet has the highest average yield record of any variety in the tests, but it is not a good bread wheat.

Disease resistance plays an important part in determining the choice of a spring wheat. This crop ripens a little later in the season than winter wheat and is therefore exposed a longer time in a green, susceptible condition to invasion by disease-causing fungi. Only the most disease-resistant varieties proved themselves suited to Illinois condi-

TABLE 12.—YIELDS OF SPRING-WHEAT VARIETIES ON THE URBANA AND DEKALB EXPERIMENT FIELDS

Variety	Urbana		DeKalb	
	1935	Comparable average	1935	Comparable average
	<i>bu.</i>	<i>bu.</i>	<i>bu.</i>	<i>bu.</i>
Garnet.....	19.3	33.8 (9) ¹	10.8	24.8 (9) ¹
Sturgeon.....	19.3	27.8 (1)	.....	.....
Progress.....	16.0	24.6 (9)	14.3	22.3 (9)
Illinois 1A.....	16.5	24.6 (9)	16.3	21.6 (8)
Illinois 1B.....	14.7	23.9 (9)	16.6	20.8 (8)
Komar.....	15.0	24.8 (3)	10.7	18.4 (3)
Reward.....	19.6	26.1 (5)	12.1	17.0 (5)

¹The figures in parentheses () indicate the number of years represented by the comparable average yield.

tions in 1935. Scab and leaf rust were abundant on all but the best ones. Scab, especially, was abundant on Garnet, Reward, and Thatcher. Illinois 1, and to some extent Progress and Sturgeon, are resistant to the scab fungus. Yields of spring-wheat varieties that were grown on the DeKalb field in northern Illinois and on the Urbana field in east-central Illinois are shown in Table 12. (513 Agronomy)

Utilization of Crop Residues Is Given Further Study

Residues from the 15 million acres of field crops grown in Illinois constitute a source of soil fertility which is receiving more attention with the new emphasis upon soil conservation and balanced farming. Straw of both oats and wheat, for example, contains as much phosphorus, twice as much potassium, and three times as much organic matter as ordinary stable manure.

While marked benefits have resulted from the return of straw to Illinois soil, either in the form of manure or by direct spreading on the land, experience has shown that it must be used advisedly. This is largely because its high organic matter and low nitrogen content may result in bacterial action which is temporarily unfavorable to the growing crop. For example, straw applied to cornland a few years ago at the Ewing soil experiment field produced a 20-bushel increase on some plots, while on others it reduced the yield 20 bushels. The difference was caused by a potassium deficiency on one set of plots and by a deficiency of nitrogen on the others.

Under O. H. Sears, Soil Biology, studies to determine the most effective utilization of crop residues are being made. Tho no new information has been obtained this year, the studies are being continued in order to observe the effects of straw upon the organic matter of the soil, upon the total nitrogen present, and upon the available or immediately useful nitrogen. Methods for the best procedure in han-

dling straw so that it may be utilized economically are also being studied. (313 Agronomy)

Smut Treatments Continue Activity in Stored Oats

In the use of ethyl-mercury-phosphate (Ceresan) and formaldehyde for the control of smut, which seriously cuts the yield of the average Illinois oats crop of 3,900,000 acres, results have differed according to the length of the period the treated oats were stored before being planted. To determine the effect of storage of the treated grain upon the dosage needed has been the object of a continued study under Benjamin Koehler, Crop Pathology. As a result of this work safer use of the treatments for smut can be made.

Iowar oats infected with both loose and covered smut, the checks of which produced 6.3 percent smutty heads, were used in the 1936 tests. Ceresan was applied at the rates of $\frac{1}{2}$, $\frac{1}{4}$, and $\frac{1}{8}$ ounce a bushel of grain 67 days, 23 days, 1 day, and 10 minutes before sowing, all the oats being sown the same day.

Smut records were made on 2,400 heads of each combination. One-half ounce of Ceresan completely controlled smut in all cases. One-fourth ounce allowed 0, 0, .42, and .49 percent smut respectively, for the different storage periods, while $\frac{1}{8}$ ounce allowed .04, .25, 1.17, and 1.54 percent smut.

Oats treated with formaldehyde by the spray method were stored 67 days, 23 days, and 1 day before being sown. In seed treated with formalin at the rate of 1 pint to 50 bushels of grain, the smut percentages for the different periods of storage were 0, 0, and .08 respectively. For that treated at the rate of 1 pint to 100 bushels, the smut percentages were .08, .25, and 1.54 respectively, while the dosage of 1 pint to 150 bushels resulted in smut percentages of 1.13, 1.69, and 2.92.

Both Ceresan and formaldehyde continued their activity in stored grain for some weeks and perhaps months. This was indicated by the fact that there was less smut in the oats stored 67 days than in those stored 23 days. The previous conclusion that the dosage of Ceresan or formaldehyde should be reduced below the amount customarily recommended according to the length of time it is planned to store oats treated with them, if storage is to be for a week or longer, is corroborated by these results. (540 Agronomy)

New Red Oat Makes Promising Showing in First Test

Altho oats are not a high money crop, the yearly average of oats grown in Illinois during 1894 to 1933 was more than 4 million acres. However, in 1934, because of drouth and chinch bug attack, the acreage dropped to about 3 million acres. Hazards such as these make it more urgent than ever that everything possible be done to stabilize the crop thru improved and superior varieties. Such varieties are the goal of oat-

improvement work being conducted by C. M. Woodworth and O. T. Bonnett, Plant Genetics. The primary objectives are to produce good yielding varieties that are resistant to smut and other important oat diseases and that have a good straw so that they will stand up under widely different growing conditions.

The oat nursery in 1934 was so badly injured by chinch bugs and drouth that it was not harvested. Indications were that in 1935 the chinch bugs would be as bad or worse than in 1934, so the planting was restricted. Only 63 strains were tested in the yield plots. The highest yielding strain was Columbia, grown as a check. Of the 10 highest yielding strains, 5 were new types tested for the first time and 5 were strains which had been under test for a considerable time. The most promising strains were kept for testing in 1936.

A new selection from a cross between a Fulghum selection and Kherson, or Sixty-Day, was increased for testing in the field plots. This promising new strain is a red oat and for two out of three years had a better yield record in the nursery yield tests than Columbia.

A study of the morphological development of the oat panicle was carried on. This study was similar to those which had already been made of the development of the barley and wheat spike. The purpose was to follow and photograph the major changes which take place from the very earliest stages of the development of the growing point to the formation of the oat panicle. A detailed study was also made of the development of the various parts of the flower of the spikelet. Such studies give a better understanding of the plant and make possible a more accurate interpretation of the variations in growth observed under field conditions. (407 Agronomy)

Red Oats Lead White Varieties in Southern Illinois

Common as the oats crop is in Illinois, there is no one variety which is best suited to the soils and climates in all parts of the state. Studies carried on by the Experiment Station have proved this and at the same time have shown the need for more information as to the best varieties for different areas. Even tho oats production of the state has declined in recent years, 3,847,000 acres, or approximately 13 percent of the farm land in Illinois, was devoted to the crop in 1935. Multiplied by such an acreage, the improvement in yield and quality of grain that could be brought about thru use of varieties best adapted to each area would add much to the total value of the crop.

Results secured by George H. Dungan, W. L. Burlison, and C. A. VanDoren, Crop Production, show definitely that oats of the red type are better suited for the southern Illinois area, as represented by the Alhambra field. Early maturing varieties of either the red or white types are best in central Illinois. Early white varieties are at the top in yield at DeKalb in northern Illinois.

For southwestern Illinois the varieties which have been grown for a minimum of four years on the Alhambra field, in the order of their rank in average yield, are Brunker, Columbia, Burt (C. I. 293), Illinois 137, Illinois 140, Iowar, Burt, Gopher, and Albion. Of these the first three are red oats. Even tho Brunker has a small margin in yield over Columbia, the latter is believed to be a more desirable variety for this region because it has a stiffer straw than Brunker. Illinois 137 and Illinois 140 are promising new white oats for this area. Both are pure-line selections from Kherson.

For central Illinois the varieties which have been grown on the Urbana field for five or more years include, in the order of their rank in yield, Columbia, Burt (C. I. 293), Kanota, Albion, Gopher, Illinois 140, Nebraska 21, Minota, Richland (Iowa 105), and State Pride. Of these Columbia and Gopher have the greatest lodging resistance, altho they will go down when grown on exceptionally fertile land. Gopher has a white kernel and is therefore preferable to the bronze-colored Columbia if the crop is to be used for market.

Northern Illinois varieties yielding best on the DeKalb field during tests of at least four years include Iowar, Albion (Iowa 103), Richland (Iowa 105), Kanota, Iogren, Gopher, Iogold, and State Pride. These are all early varieties, except Iogren, which is midseason. (503 Agronomy)

Wisconsin Barbless Barley Does Best in Illinois Tests

Owing largely to chinch bug invasions and threats of invasions, the acreage of barley grown in Illinois either in 1934 or in 1935 was less than one-fourth the annual average of more than 400,000 acres produced during the years 1928-1932. Nevertheless the relatively high yields of grain and the premium prices paid for barley of the quality

TABLE 13.—YIELDS OF BARLEY VARIETIES AT URBANA IN 1935 AND AVERAGE COMPARABLE YIELDS AT URBANA AND DEKALB

Variety	Urbana field			DeKalb field		
	Number years tested	Yield in 1935	Average comparable yield	Number years tested	Yield in 1935	Average comparable yield
Wisconsin Barbless.....	6	<i>bu.</i> 57.4	<i>bu.</i> 45.7	5	<i>bu.</i> Barleys	<i>bu.</i> 42.9
Trebi.....	5	58.7	53.0	4	not	39.9
Spartan.....	8	53.4	46.2	5	grown	37.6
Glabron.....	7	43.3	40.0	6	in	37.5
Velvet.....	9	52.4	41.6	8	1935	37.3
Manchuria 2121.....	1	46.2	40.8	0	....	....
Oberbrucker (Wisconsin Pedigree 5).....	9	47.5	39.5	8	....	34.9
Kherson (Sixty-Day) oats...	9	45.5 ¹	41.0 ¹	9	46.1 ¹	36.3 ¹

¹Kherson oats were figured at 48 pounds a bushel to be comparable with barley.

necessary for malting and brewing give this cereal a favored place in the cropping plans of many farmers, and a considerable increase in its production is confidently expected.

Results obtained in continued tests of barley varieties by George H. Dungan and W. L. Burlison, Crop Production, will help farmers in the selection of varieties best adapted to Illinois conditions. These results, which were obtained in drilled plots, indicated that for all-round purposes Wisconsin Barbless (Pedigree 38) is the best.

The highest yielding barley at Urbana has been Trebi, with Wisconsin Barbless following. At DeKalb the Wisconsin Barbless variety has ranked at the top in yield. Because of the expectation that chinch bugs would be numerous, barley was not grown on the DeKalb field in 1935. The yield of varieties at Urbana in 1935, together with the average comparable yields thruout the period of their test at both Urbana and DeKalb, are presented in Table 13.

It may be noted that both at DeKalb and Urbana the better yielding varieties of barley produced more pounds of feed an acre than did the standard variety of oats, Kherson. (537 Agronomy)

Forage and Pasture Studies Boon to Soil Conservation

With the present trend toward the wider use of soil-conserving crops, studies started several years ago by the Experiment Station to work out the best combinations of forage plants and to study new pasture and hay crops have taken on added importance.

These studies have been continued along a number of different lines during the past year by J. J. Pieper and W. L. Burlison, Crop Production. Alfalfa mixtures including alfalfa varieties, timothy, orchard grass, red clover, and alsike clover were seeded in adjoining plots and yields of hay taken. Small plots of pure cultures of important grasses and legumes were seeded and harvested for pasture. Combinations of grasses and legumes were seeded in mixtures for pasture. Reed canary grass strains were grown for pasture and hay. Forage-crop mixtures including reed canary grass were grown for pasture. Various species and varieties of lespedeza were grown at different experiment fields thruout the state to determine their adaptation as measured in hay and seed yields. Commonly grown small grains were tried for hay production. Newly developed timothy strains are being tried for adaptation, production, and disease resistance. New forage crops are being grown to study their adaptation and use.

Results of these various tests have a wide application to current problems of soil conservation and better land utilization. As an average of eight years a mixture of South Dakota 12 alfalfa and Grimm alfalfa has yielded slightly more than either variety grown separately. Neither red clover nor alsike clover has yielded better in a mixture with alfalfa than has alfalfa alone. Both timothy and orchard grass

have increased the yield when combined with alfalfa. Timothy gives a larger increase than orchard grass when mixed with alfalfa, but it disappears from the mixture in about two years.

The highest yielding pasture plants for 1935 were these legumes: zigzag clover, Ladino clover, South Dakota 12 alfalfa, white sweet clover, and Grimm alfalfa. For a four-year period the highest yielding species were bromegrass, South Dakota 12 alfalfa, Grimm alfalfa, tall oatgrass, redtop, white sweet clover, zigzag clover, timothy, meadow fescue, and orchard grass.

In those pasture mixtures in which alfalfa occurred, the yields were high in 1935. As an average of four years a mixture made up of four grasses and four legumes yielded best. The next three highest mixtures contained alfalfa. Bromegrass, orchard grass, and timothy each increased the yields when added to a basic mixture. Redtop added to the mixture decreased the yield.

Reed canary grass continues to yield high when used for hay or pasture. In tests with a series of mixtures including reed canary grass, practically all species had been crowded out at the end of two years by the reed canary grass.

Lespedeza stands were reduced by damping off of seedlings as a result of the wet spring. Growth was slowed up definitely by the summer drouth, but increased rapidly with late summer and fall rains. An early frost reduced seed yields materially. Korean continues to be the highest yielding variety over the entire state. However, occasionally one of the late varieties, Kobe or Tennessee 76, outyields Korean even in north-central Illinois. The very low yields of Harbin and Early Korean (59379) make them undesirable. An Early Common 81742 and another Early Korean 19604 are promising new varieties. Strain 04730 of *Sericea* continues to be more winter-hardy than Strain 12087.

Rates of seeding of more than 20 pounds an acre have yielded better than rates of 20 pounds and less. Reseeding has increased yields over new seedings and self-seedings, especially for the northern regions and for the late varieties. Disking a field of lespedeza in the fall for winter grain or in the spring for spring grain usually increases the yield of lespedeza. Lespedeza yields best without a nurse crop.

Winter rye proved the best yielder and spring wheat the poorest as a grain hay. Late oats yielded well.

Strains of timothy varied considerably in yield, the highest yielding 2,811 pounds an acre and the lowest 1,983 pounds an acre.

Zigzag clover, crown vetch, crested wheat grass, and Ladino clover are new forage plants which are promising.

Variation in Grasses Studied.—Work to improve Illinois pastures and lawns thru development of better types of grasses is in progress under C. M. Woodworth and O. T. Bonnett, Plant Breeding. Studies

to determine the variation in growth and in the type of different plants are being made.

Special attention has been given to Kentucky bluegrass and redtop. In a preliminary study of 400 single plants of each of these types of grasses wide differences were found in the width of leaf, erectness and compactness of growth, rate of spread in the formation of a sod, and in resistance to leaf rust and mildew.

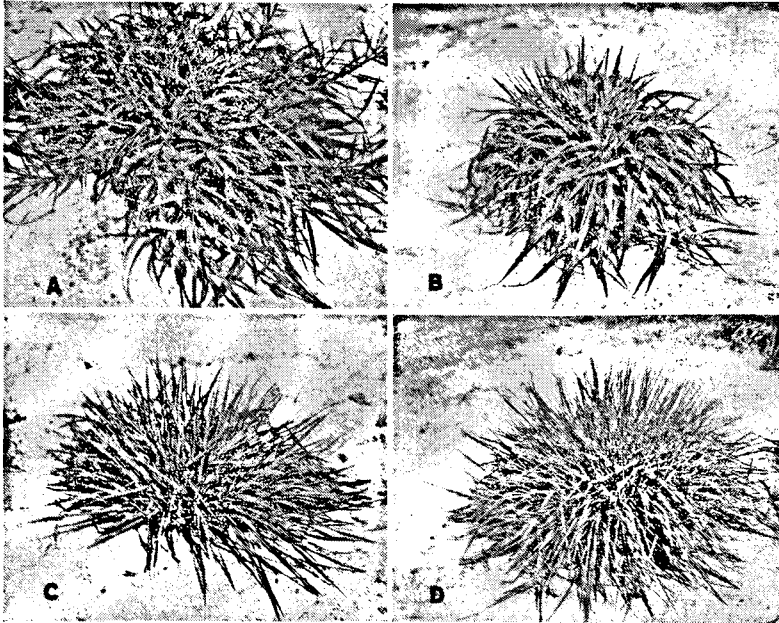


FIG. 11.—VARIATIONS BETWEEN SINGLE PLANTS OF REDTOP

Seedlings from selfed seed from redtop plants were as variable as seedlings from open-pollinated seed. Neither did seedlings from different plants of redtop resemble the parent plant, but showed wide variation. Plant *A* has branched stems and wide leaves; plant *B* wide leaves; plant *C* medium leaves, and plant *D* narrow leaves.

Forty plants of Kentucky bluegrass and 43 plants of redtop which differed from each other in the characters just mentioned were chosen for further study. Each plant was divided into 25 pieces, and the pieces planted 40 inches apart each way upon an area a rod square. The growth and behavior of these plantings are being carefully observed. The better types will furnish seed for future plantings.

Some plants of both Kentucky bluegrass and redtop were covered with muslin bags to produce self-fertilized seeds. It was observed that

Kentucky bluegrass produced selfed seed more readily than redtop. Seedlings from self-fertilized and open-pollinated seed of bluegrass and redtop plants were started in 2-inch clay pots in the greenhouse and later transplanted to the field. Little difference was noted in the types of plants produced from the selfed and open-pollinated seed of single plants of Kentucky bluegrass. While the seedlings of a single plant were alike, differences were observed among the seedlings of different plants. On the other hand, seedlings from selfed seed from redtop plants were as variable as seedlings from open-pollinated seed. Neither did seedlings from different plants of redtop resemble the parent plant, but showed wide variation. Differences in the types of seedlings obtained from parent plants of Kentucky bluegrass and redtop seem to indicate that Kentucky bluegrass is either a self-fertilized crop or reproduces in such a manner that the resulting seedlings resemble the parent very closely, but that redtop is cross-fertilized. (532 Agronomy)

Chlorates Show Effectiveness in Illinois Weed Studies

The loss from farm weeds in the United States has been estimated at 1 to 3 billion dollars a year. As a leading agricultural state Illinois bears a heavy share in this loss. In work under J. J. Pieper, Crop Production, and J. C. Hackleman, Crops Extension, a continued attack upon the problem of weed eradication has gone forward.

Continued work with chlorates in the control of quack grass indicates that an application of 2 pounds a square rod in the fall is more effective than twice that amount applied during the active growing period.

Use of the quack-grass eradicator has again given the same successful results as previously reported. This is the most successful and economical means of eradicating quack grass in large patches.

Where ammonium thiocyanate (Weedex), limestone-chlorate mixture, and Atlacide were applied at the rates of 3, 5, and 10 pounds a square rod to poison ivy in an apple orchard on November 15, the poison ivy under the highest rate of application for all the chemicals was in most cases reduced to a mere trace, as noted June 13 the following year. No choice of chemicals can be made until further results are obtained. Up to this time none of the trees seem to be affected. From two years' results it appears that apple trees are more resistant to certain chemicals than is poison ivy and that the latter may be eliminated from orchards by such means.

In the continued life-history studies of wild onion and garlic, seed and the various types of bulbs are planted in paper pots and placed in the soil. By means of the paper pots all the material may be recovered. Growth and development are noted thru examination of specimens gathered from the plantings each month of the growing season.

Aerial bulblets of wild onion which had been planted on October 10, 1933, produced ripe aerial bulblets by the first of July. All bulbs had started growth by this time and 40 percent had divided to form two bulblets.

Aerial bulblets of wild onion which had been planted September 27, 1934, also produced ripe aerials. In 40 percent of the cases the old bulb did not produce a plant but was still alive. Twenty percent of the plants divided to form two bulbs, while another 40 percent grew but without the bulb dividing.

The subterranean bulbs behaved very much like aerial bulblets except that they produced more vigorous plants and at the end of two years had divided to form two and three bulbs, whereas the aerials at most had formed only two bulbs. No plants were formed either from wild onion or garlic as a result of planting seed.

All forms of bulblets of wild garlic had produced hard-shelled bulblets by the first of July. With the aerial bulblets only 20 percent of the plants had produced two hard shells, all others producing only one. With hard-shelled bulblets 80 percent had produced two and 20 percent three, while with the soft-shelled bulbs 60 percent had produced three hard shells. In all plants a soft-shelled bulb was present either as a result of enlargement of the original bulb or, in a few plants, as the result of forming a new soft shell, in which cases the old soft shell had been utilized in producing a seed stalk. Aerial bulblets being produced by these three forms of plants were immature. By fall, division began in those bulbs of wild onion which had not divided up to that time. This included a few bulbs from the 1933 planting and many from the 1934 planting.

A few hard shells were starting from soft-shelled bulbs regardless of the source of the soft-shelled bulbs or the time of original planting. By early June all new bulblets were mature except the aerial bulblets of wild garlic.

From the studies of wild onion and garlic it is seen that propagation of underground bulblets takes place in the fall and spring, and that newly formed bulblets may not germinate until late in the fall. All forms of bulblets, as well as seed, are capable of propagating new plants and may be a source of new infestation. (541 Agronomy)

Control of Weed Menace Sought Thru New Investigations

Weeds have become so numerous and destructive that they now rank with soil erosion, diseases, and insects as a farm menace. Garlic and wild onions alone in 1930 were estimated to have caused damage of \$300,000 to Illinois wheat and of about \$2,000,000 to Indiana wheat. More recently a much worse weed than any yet, the field bindweed, has become such a threat that it, too, must be fought.

As a step toward eradication and control of bindweed and other

weeds, cultural and chemical methods of control, as well as other physiological aspects of the problem, are being studied by L. V. Sherwood, Agronomy, under the guidance of an advisory committee consisting of J. J. Pieper, Agronomy, chairman; E. W. Lehmann, Agricultural Engineering; and M. J. Dorsey, Horticulture.

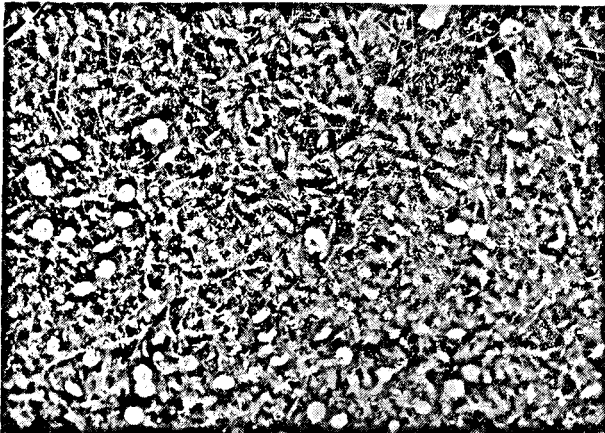


FIG. 12.—FIELD BINDWEED, A GROWING THREAT AS ONE OF THE WORST WEEDS

This weed has been found as far south as Union county in a partial survey that has been made of the state. In an effort to work out sound control measures for this pest, the Experiment Station has set up about 150 chemical plots and is testing as many as eight chemicals. Various plot studies also are being conducted at this Station and in cooperation with farmers to study the effect of cultural methods on control.

Literature on weeds and weed control has been reviewed, and a complete classified bibliography on all material pertaining to weeds is near completion.

In a partial survey of the state field bindweed has been found as far south as Union county. Some of these infestations have probably been brought in with garden seeds and are still limited primarily to small areas, but large field infestations which cover acres have already spread in some parts of the northern half of the state.

Roots of this plant will penetrate as deep as 20 to 30 feet under semiarid conditions where the water table is low. At Urbana they have been found to go as deep as 8 and 10 feet, which is deeper than the water table in both instances. Bindweed has been known to spread 15 to 20 feet in a year from horizontal root development alone.

This plant apparently produces some seed at Urbana. Its root

habits make it possible for it to spread rapidly, especially since any portion of its roots are capable of developing a new plant under suitable conditions. Experiments are now being conducted to determine more about the power and nature of this root development.

This year the reduction in small-grain yields as a result of bindweed infestation was rather small. Small grains are not likely to be damaged so much, since they get an early start in the spring, and bindweed starts fairly late. Damage to corn and other crops will be studied.

About 150 chemical plots have been set up and as many as eight chemicals are being tested for bindweed control. Three chemicals—sodium chlorate, calcium chlorate, and sodium thiocyanate—have been more lethal than any of the others. However, in order completely to kill bindweed, it probably will be necessary to make as many as three or four applications of the chemical.

Various plots have been set up with farmers in order to study the effect of cultural methods upon bindweed control. Root analyses will be made at frequent intervals in order to study the effect of these treatments upon root development and food storage.

Much emphasis should be placed on securing weed-free seed for planting. In this connection C. W. Veach, Agricultural Engineering, is developing a seed-cleaning laboratory and making a study of seed characteristics. A summary of his work will be found under Agricultural Engineering Project 305, page 242. (541A Agronomy)

Search for New Crops and New Outlets Is Continued

What has been accomplished in Illinois and other states during recent years with a relatively new crop like soybeans is an indication of the possibilities in studies which the Illinois Station is making to find new crops and develop new uses for old crops. This work has been continued during the past year in a number of different fields by W. L. Burlison and J. J. Pieper, Crop Production, and C. M. Woodworth, Plant Genetics.

One of the several crops being investigated is artichokes. The intensive study on the general production of artichokes was discontinued this past year, but the outstanding type or strain, 27574, is being increased and will be available for distribution in small amounts next spring. In a cooperative study comprizing plots in Illinois, Oregon, and Washington, this variety led all others. Results of these studies are published in U. S. Department of Agriculture Technical Bulletin 514 entitled, "Studies of the Culture and Certain Varieties of the Jerusalem Artichoke."

The artichoke has for a long time served as a feed for livestock. Artichoke tops have been used as a fresh forage in the form of silage for cattle, while the tubers are fed to all classes of livestock, but chiefly to hogs. As food for man the artichoke, of course, is of con-

siderable value. It has also been suggested in France that the stalks could be used for fuel.

A widespread interest in the plant has developed in this country only within the past decade or so and largely as a result of its possible value as a source of raw stock for the manufacture of levulose and of alcohol.

Limited studies on breeding artichokes have been conducted. In 1935 ten hills each of 114 seedling plants were grown. As expected, the plants raised from tubers of any one seedling hill were very similar in type, but the several seedling strains were different in many characteristics. Tubers were dug and weighed in April, 1936. Yields of tubers from different seedling strains ranged from 7 pounds to 55 pounds. Samples of twenty strains were analyzed by Prof. D. T. Englis, Department of Chemistry, University of Illinois, for levulose and total sugar. In levulose they ranged from 38.4 percent to 61.4 percent; in total sugar, from 60.8 percent to 80.5 percent. In the ratio of levulose to total sugar the range was from 59.4 to 87.3. Tho many flower heads were bagged to produce selfed seed, no seed was obtained.

Grain sorghums and other crops also are being investigated by the Experiment Station in its search for new crops. In 1935 Reid Yellow Dent and Champion White Pearl corn outyielded the best variety of grain sorghum for the year at the Alhambra experiment field. Reid Yellow Dent yielded 64.09 bushels an acre, while the best grain sorghum, Grohoma, yielded 47.1 bushels an acre. As an average of four years Grohoma has outyielded Reid Yellow Dent corn by nearly 2 bushels an acre. In 1935 when the chinch bugs were very serious, grain sorghums outyielded corn by a wide margin. Results seem to indicate that under a heavy infestation of chinch bugs and during severe drouth, sorghums will outyield corn, but under normal conditions corn will outyield grain sorghums.

In the study of buckwheat a mixture of varieties yielded 709 pounds an acre as an average of four years, while Japanese yielded 676 pounds an acre and Silverhull, 678 pounds an acre.

Pyrethrum, a plant whose flowers are used as an insecticide, produced 652 pounds an acre as an average of four years. The yield in 1935 was not so large as the average, being only 447 pounds.

Only one variety of flax (Bison) was grown in 1935, but it yielded 9.86 bushels an acre. The average for a period of five years has been 4.4 bushels an acre. For a period of four years Linota has been the highest yielding variety, with Bison second.

Studies on the utilization of soybean oil for paint purposes have been conducted during the past year with gratifying results. Some general results of these studies have been presented in Circular 438 entitled, "Recent Developments in the Utilization of Soybean Oil in Paint." This circular is available to the public. (542 Agronomy)

LIVESTOCK INVESTIGATIONS

Further Tests Needed to Evaluate Protein Supplements

Illinois farmers market more than a million head of cattle and calves annually, but methods of producing high-quality beef at the lowest possible cost are far from being permanently standardized. Twenty-five years ago, for instance, linseed and cottonseed meal were about the only protein concentrates fed to cattle. Now considerable use is made both of soybean oil meal and animal tankage. Moreover, there are now available both old- and new-process linseed meal; cottonseed meal, cottonseed feed, and cold-pressed cottonseed cake; hydraulic, expeller, and solvent soybean oil meal; dry-rendered and wet-rendered tankage; and in addition a large number of commercial and proprietary feeding stuffs of value largely because of their protein content. While many of these materials have been used more or less extensively by cattle feeders for a number of years, solvent soybean oil meal and dry-rendered tankage are new products about which little information is available. Consequently a comparison of these two feeds with some standard supplements seemed advisable, and such studies were carried out by H. P. Rusk and R. R. Snapp, Beef Cattle Husbandry.

Old-process soybean oil meal, made by the hydraulic method, was chosen as the basis for the comparison, as its value for fattening cattle had been well established by several tests previously made at this Station. In addition ordinary steam-rendered, or digester, tankage was included in the test, as more or less use had been made of such tankage by some of the larger cattle feeders for a number of years. There were then four lots of calves in the comparison: one fed old-process soybean oil meal, one fed solvent soybean oil meal, one dry-rendered tankage, and one ordinary steam-rendered, or digester, tankage.

While the calves in all four lots made good gains and returned satisfactory profits, those in the check lot fed old-process soybean oil meal stood at the top. Those fed dry-rendered tankage, new-process soybean oil meal, and steam-rendered tankage followed in that order. However, the results obtained from the two kinds of tankage were contrary to those obtained in an earlier project with two-year-old steers (Project 271, Forty-Eighth Annual Report). In the earlier project the cattle showed a pronounced dislike for the dry-rendered tankage. In this test all the protein supplements were eaten readily after the cattle had become accustomed to them.

As this probably is the first comparison that has been made between old- and new-process soybean oil meal for fattening beef calves, too

much significance should not be attached to the relatively small differences obtained. Also the lack of agreement between this comparison of dry- and steam-rendered tankage and the test made a year ago indicates that final judgment in regard to the relative value of new protein concentrates should be withheld until they have been thoroly investigated.

Results of the experiment are further evidence that altho agricultural experiment stations probably have made more extensive studies

TABLE 14.—COMPARISON OF DIFFERENT PROTEIN SUPPLEMENTS FOR FATTENING BEEF CALVES, JANUARY 25 TO SEPTEMBER 10, 1935: 228 DAYS
(Average initial weight, 510 pounds)

	Lot 7 Hydraulic soybean oil meal	Lot 8 Solvent soybean oil meal	Lot 9 Dry- rendered tankage	Lot 10 Steam- rendered tankage
Average daily gain.....	<i>lbs.</i> 2.27	<i>lbs.</i> 2.15	<i>lbs.</i> 2.18	<i>lbs.</i> 2.09
Feed for 100 pounds gain				
Shelled corn.....	513	525	525	549
Protein concentrate.....	74	75	58	53
Corn silage.....	315	332	328	341
Alfalfa hay.....	88	93	92	96
Powdered limestone.....	4	4	.....	.....
Selling price a hundredweight at Chicago.....	\$11.90	\$11.75	\$12.00	\$11.60
Hog gains a steer, pounds.....	25.0	21.4	24.0	29.3
Dressing percentage.....	62.0	61.9	62.0	62.6
Carcass grades.....	1 prime— 6 choice+ 5 choice— 2 choice—	1 prime— 2 prime— 5 choice+ 5 choice— 1 good+	3 prime— 4 choice+ 5 choice— 3 choice—	1 prime— 1 prime— 3 choice+ 4 choice— 6 choice—

of the proper use of protein concentrates than of any other feeding problem, much work apparently remains to be done before information is available to permit a definite rating of the various protein feeds for a particular feeding situation. The complexity of the problem is considerably increased by the evolution of new feeds and by changes in the process of manufacture.

Carcasses of the fattened animals were graded by Sleeter Bull, Meats, and two representatives of the Bureau of Agricultural Economics of the U. S. Department of Agriculture. The carcass grades, as well as other results of the test, are shown in Table 14. The carcasses graded unusually high and there were no particular differences traceable to method of feeding. (272 Animal Husbandry)

Dry-Rendered Tankage Is Superior to Digester Product

With the development of the dry-rendering process of manufacturing tankage, this product is now being made by two methods. As

these methods vary considerably and as tankage plays a large part in balancing the rations of Illinois swine, beef cattle, and poultry, there is need for facts concerning the relative nutritive value of the product when made in the different ways.

The old digester method involves the prolonged heating of the animal wastes by steam under pressure for the liberation and removal of the fat. In the more efficient dry-rendering process, which is rapidly replacing the older method, the raw material is cooked in a steam-jacketed cylinder and is thus subjected to less heat. The gases formed are carried out by means of an open stack or are drawn off by a fan blower or water condenser. The dry-rendered product does not have so strong an odor as the digester product and is much lighter in color.

The Department of Animal Husbandry last year secured considerable quantities of digester and dry-rendered tankage which, by special arrangement with the packing house, had been prepared from the same mixture of animal products. This afforded an excellent opportunity for investigating the differences in food value resulting from the respective methods of manufacture. A series of tests was carried out with rats and pigs as the experimental animals. These tests were in charge of H. H. Mitchell and T. S. Hamilton, with the technical assistance of W. T. Haines and Jessie R. Beadles, Animal Nutrition.

As a result of this work it was found that the protein of the dry-rendered tankage is more digestible than that of the digester tankage, either when fed alone or in combination with corn, but that the gross energy in the two products is about equally well utilized. Greater differences were observed with rats than with pigs, either because of a true difference between the two species of animals or because the problem was investigated much more thoroly with the rats, many more of these having been used. Also greater differences were observed between the two tankages when they were fed with corn than when they constituted the sole source of protein in the ration.

The close similarity in composition of the two tankages is revealed by the chemical analyses assembled in Table 15.

In the rat tests the paired-feeding method was used thruout. In the first tests the two tankages were the sole sources of protein, making up about 20 percent of the rations which contained, in addition, minerals, fat, vitamin sources, and starch to 100 percent. The rations were equalized with respect to energy and protein. One ration was fed to one rat in each pair and the other to the other. The food intake of pair mates was always the same and was adjusted to that of the rat consuming the least. The rations were so distasteful that thruout the tests food intakes were low and all but one of the rats lost slightly in weight. For the five weeks of feeding the losses in weight were greater in each of the thirteen pairs for the rat on the digester tankage, which also set the pace in each pair in food consumption. With only one ex-

ception the body length of the rat on the dry-rendered tankage was greater than that of its pair mate. During the test the feces were collected for a seven-day period, dried, and analyzed for nitrogen. In each pair the protein of the ration containing dry-rendered tankage was digested to the greater extent. The average coefficients of digestion, after correction for the metabolic fecal nitrogen chargeable to the starch in the diet, were 89.2 for the dry-rendered tankage and 82.1 for the digester tankage. On the same intake of dry matter the dry weight

TABLE 15.—CHEMICAL COMPOSITION OF TANKAGES TESTED FOR RELATIVE NUTRITIVE VALUES
(Values expressed in percentage)

Tankage	Moisture	Crude protein	Fat	Ash	Crude fiber
Digester, steam-rendered	7.40	62.61	13.51	14.14	1.61
Dry-rendered (meat scraps)	8.75	60.28	11.53	13.04	4.16
	Gross energy ¹	Calcium	Phosphorus	Iron	Copper
Digester, steam-rendered	4.83	3.95	2.21	.183	.0060
Dry-rendered (meat scraps)	4.70	3.15	1.92	.097	.0027

¹Expressed in large calories a gram.

of feces was greater in 11 of the 13 pairs on the digester tankage ration than on the dry-rendered tankage ration, altho the average coefficients of digestibility of dry matter were very nearly the same, being 89.15 and 90.46 respectively.

In the second test with rats the tankages were fed with corn, a salt mixture, and vitamins. The ration containing dry-rendered tankage produced faster gains than that containing digester tankage, but in this case as differences in weight developed between pair mates, the better ration was diluted with a ration identical with it except that corn was substituted for the tankage. Thruout the eight weeks of feeding the gains of pair mates were equalized in this way, the total intake of food (and energy) being the same, but the amount of protein consumed varying inversely with its growth-promoting value. Thus at the end of the test the total gains of pair mates were practically the same, as well as their body lengths, but in 11 of the 12 pairs more nitrogen as digester tankage than as dry-rendered tankage was required to produce these identical nutritive effects. On an average 1.2 grams of nitrogen from digester tankage and corn were the equivalent of 1 gram of nitrogen from dry-rendered tankage and corn. The digestibility of both protein and dry matter was consistently higher for the latter

TABLE 16.—RESULTS OF METABOLISM TESTS ON PIGS FED DIFFERENT KINDS OF TANKAGE

Animal No.	Corn-and-tankage rations				Corn-and-starch rations					
	Dry-rendered tankage		Digester tankage		Dry-rendered tankage			Digester tankage		Metabolizable energy of ration ³
	Digestibility of protein	Digestibility of energy	Digestibility of protein	Digestibility of energy	Digestibility of protein ¹	Daily nitrogen balance	Metabolizable energy of ration ²	Digestibility of protein ¹	Daily nitrogen balance	
<i>perct.</i>	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>	<i>gms.</i>		<i>perct.</i>	<i>gms.</i>		
20-30	81.8	87.2	82.9	87.2	88.6	+8.97	3 887	79.7	+3.14	3 782
0-30	81.5	87.7	79.3	86.1	85.5	+10.50	3 841	82.8	+2.78	3 809
99-30	80.5	86.9	80.8	87.2	88.3	+9.44	3 860	84.2	+7.35	3 877
29- 3	84.2	87.5	77.2	85.6	85.3	+3.78	3 819	84.2	+5.74	3 862
99- 3	84.2	88.7	77.9	85.8	84.4	+6.83	3 791	84.2	+6.71	3 859
99-90	84.1	87.5	79.0	85.7	76.5	+3.78	3 696	85.2	+7.41	3 913
Average	82.7	87.6	79.5	86.3	84.8	+7.22	3 816	83.4	+5.52	3 850

¹Corrected for the metabolic fecal nitrogen produced by the starch: 1 gram of metabolic N to a kilogram of starch. ²Expressed in calories to kilogram of dry matter.

combination, averaging 82.7 as compared with 76.8 for the protein and 87.5 and 86.7 for the dry matter.

In the pig-metabolism experiments six animals weighing initially from 108 to 155 pounds were used. Each animal received, for collection periods of seven days, each of four experimental rations containing digester or dry-rendered tankage combined either with corn or starch. The tankages made up 15 percent of the corn rations and 20 percent of the starch rations. The former contained 16.75 to 17.88 percent of protein and the latter about 13 percent. All pigs received 1,800 grams daily of the corn-tankage rations and 1,600 grams daily of the starch-tankage rations. Ferric oxid was used as a feces marker. On the corn-tankage rations only the feces were collected and analyzed, while on the starch-tankage rations both feces and urines were collected.

Results of these tests are shown in Table 16. The protein of dry-rendered tankage was, on the average, digestible to the extent of 84.8 percent and that of digester tankage to the extent of 83.4 percent, altho one of the six pigs did not show a higher digestibility for the dry-rendered tankage. For the corn and tankage rations the digestion coefficients for protein averaged 82.7 for the dry-rendered tankage ration and 79.5 for the digester tankage ration with two nonconformers among the six pigs. The metabolizable energy contents for the two starch rations were very nearly the same, 3,816 and 3,850 calories a kilogram of dry matter. However, on the corn-tankage rations there is again a slight indication that the ration containing the dry-rendered tankage was slightly better digested with respect to energy as well as protein than the ration containing digester tankage, the average coefficients being 87.6 and 86.3 respectively.

On the starch-tankage rations the daily nitrogen balances averaged somewhat higher for the dry-rendered tankage ration than for the digester tankage ration, 7.22 and 5.52 grams respectively, but such advantage as there is may be ascribed to the greater intake of digestible protein on the dry-rendered tankage ration, so that there is no indication of a difference in biological value of the absorbed protein of the two types of tankage.

Nuts Not Good Substitute for Meat.—Nuts are often spoken of as meat substitutes because, like meats, they consist largely of protein and fat. Furthermore purely chemical studies of nut proteins have shown that, like meat proteins, they contain all of the amino acids essential for animal life and growth. However, few experiments with nuts have been carried out with growing animals to measure quantitatively the extent to which the animal body can utilize nut proteins. Only on the results of such experiments can it be judged whether nut proteins are really good substitutes for meat proteins. The most urgent need in the science of nutrition today is the need for such quantitative infor-

mation of the *net* nutritive value of foods. Far too much reliance is being placed on the chemical composition of foods in their evaluation in the diet.

A study of the nutritive value of nut proteins, with growing albino rats used as subjects, was begun several years ago, and in the Forty-Seventh Annual Report some preliminary data were presented and discussed. Studies of seven of the most popular nuts in the American diet have now been included in this work. The work was done under the direction of H. H. Mitchell, Animal Nutrition, with the technical assistance of Jessie R. Beadles.

On the basis of these studies it appears that nut proteins are invariably less digestible than meat proteins, the pecan proteins in particular being only about 70 percent as digestible as meat proteins. Furthermore the digestible proteins of nuts are, with one exception, much less available in the body for the repair of the tissues and for growth than are digestible meat proteins, the deficiency amounting to one-fourth to one-third. The cashew nut is an outstanding exception in this respect, since its digestible proteins are almost as valuable to the growing animal as those of meats. Finally, on the basis of their content of net protein, that is, protein actually available in the animal body, nuts are far less valuable than meat on a comparable moisture basis. The best nut studied had only about one-fourth as much net protein a pound as a pound of lean meat of the same moisture content.

The starting point of any nutritive study of a food is its chemical composition. In Table 17 will be found the chemical composition of the

TABLE 17.—CHEMICAL COMPOSITION OF NUTS TESTED FOR NUTRITIVE VALUE

Kind of nut	Mois- ture	Fat	Crude protein	Crude fiber	Nitro- gen- free ex- tract	Gross energy	Ash	Calc- ium	Phos- phorus
	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>	<i>cal. a gm.</i>	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>
Peanut, without skin . . .	5.24	51.26	28.25	1.89	10.84	6.85	2.52	.049	.553
English walnut	4.39	61.91	21.16	2.35	8.07	7.32	2.12	.096	.463
Pecan	4.30	72.96	11.28	4.90	5.02	7.69	1.54	.073	.315
Brazil nut	3.50	69.75	16.25	4.48	2.85	7.56	3.17	.195	.664
Cashew	4.39	48.70	19.52	1.20	23.72	6.48	2.47	.041	.507
Almond	4.56	56.75	21.94	3.34	10.29	6.76	3.12	.251	.527
Pilbert	3.60	70.35	13.50	5.26	5.54	7.57	1.85	.100	.305

varieties of nuts tested. Their high fat content and their low content of carbohydrate—crude fiber and nitrogen-free extract—is notable, altho the cashew nut is somewhat exceptional in the latter respect. The peanut, walnut, brazil nut, cashew, and almond are moderately rich in protein, and they are all moderately rich in phosphorus. The almond and brazil nut are highest in calcium, tho most of the nuts are low in this bone-forming mineral, containing less than .1 percent.

The biological studies were concerned with the problem: how much of the protein contained in these nuts, as compared with lean beef, does an animal actually take out of them for its own uses? In the first place there is a wastage in digestion, measured by the coefficient of digestibility. If the protein in a food is 100 percent digestible, it is all broken down in the alimentary canal to the constituent amino acids and is absorbed into the blood, but if the coefficient of digestibility is only 80, then only 80 percent is completely digested and absorbed and 20 percent is passed out of the body, either because the protein itself is broken down incompletely by the digestive enzymes or because the protein is wrapped up in fibrous cellular material which prevents the enzymes from coming in contact with it.

In the second place, there is a wastage of protein that has been digested, absorbed, and carried to the tissues by the blood. This wastage occurs because the mixture of amino acids, representing the products of digestion, are different in chemical character, and if the different amino acids from nut proteins are in such proportions that much of them cannot be used to repair the body cells or to build new cells, they will be wasted, so far as these processes are concerned, in the same way that an excess of brick or of mortar in putting up a building would be wasted. This wastage is measured by the "biological value" of the protein, which is the percentage of digested protein used by the body for repair and growth under carefully standardized conditions. A biological value of 80 means that 80 percent of the digestible protein is usable for tissue repair and growth under the selected conditions, 20 percent being wasted so far as these functions are concerned.

Results of the biological tests on the seven raw nuts, roasted peanuts, and the beef round with which all the nuts were compared, are collected together in Table 18. The digestion coefficients given in the

TABLE 18.—NUTRITIVE VALUE OF PROTEINS OF NUTS COMPARED WITH THAT OF PROTEINS OF BEEF

Food	Protein content	True digestibility of protein	Digestible protein in food	Biological value of protein	Net protein in food
	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>
Beef round ¹	77.62	100	77.6	76	59.0
Peanut, raw.....	28.25	97	27.4	58	15.9
Peanut, roasted.....	28.25	96	27.1	56	15.2
English walnut.....	21.16	84	17.8	56	10.0
Pecan.....	11.28	71	8.0	60	4.8
Almond.....	21.94	94	20.6	51	10.5
Brazil nut.....	16.25	96	15.6	54	8.4
Cashew.....	19.52	96	18.7	72	13.5
Filbert.....	13.50	92	12.4	56	7.0

¹For comparative purposes, reduced to a comparable moisture basis that is .5 percent.

third column of the table are corrected for body nitrogenous wastes in the feces and hence represent true digestibility. Most of the nut proteins are very well digested, tho not so well as the proteins of beef. The proteins of the English walnut and the pecan are digestible to the extent only of 84 and 71 percent respectively. The biological values obtained for the nuts, except the cashew, range between 51 and 60; for the cashew nut a value of 72 was obtained. The values secured for the filbert, averaging 56, were so variable that further work is being done upon this nut.

The percentage of digestible protein, obtained by multiplying the content of total protein by the digestion coefficient and dividing by 100, is fairly high for the peanut, the English walnut, the almond, and the cashew, but in all cases it is less than half the content of digestible protein in beef round on a comparable moisture basis. Multiplying the percentages of digestible protein by the biological values and dividing by 100 gives the percentages of net protein, assembled in the last column of the table. A comparison of these values, varying from 7 to 15.9 for the nuts to 59 for beef round, brings out the great superiority of lean meat as a source of protein to the body. (406 Animal Husbandry)

Pasture Not a Feed Saver in Fattening Beef Calves.

Present trends in land-use policies will make more pastures available for fattening the million cattle and calves that are marketed each year from Illinois farms, but in the case of bluegrass pastures at least cattle feeders are not agreed as to the merits of such forage in fattening beef calves. Some farmers believe that pasture makes a considerable saving in the grain ration with little or no adverse effect on the rate of gains or the degree of finish attained. Others believe that even a limited use of pasture is inadvisable, as it produces beef which is objectionable to market buyers.

The study in the use of pastures in fattening beef calves begun in 1933-34 at the Illinois Station was continued during 1934-35 by H. P. Rusk and R. S. Snapp, Beef Cattle Husbandry, with four lots of pasture-fed calves instead of only two as in the first test (Project 269, Forty-Eighth Annual Report). In addition to two lots fed grain on pasture during the winter, two lots were wintered in drylot on corn silage, alfalfa hay, and 1 pound of soybean oil meal and were turned onto pasture in the spring. One of these lots was fed a full-feed of shelled corn on pasture, while the other was grazed without grain until midsummer and then full-fed in drylot. A fifth lot of calves fed in drylot during the entire feeding period served as a check for the results obtained from the calves fed on pasture. Detailed results are given in Table 19.

The belief that pasture makes a saving in the amount of grain

TABLE 19.—VALUE OF BLUEGRASS PASTURE IN FATTENING BEEF CALVES, 1935

	Lot 8	Lot 6A ¹	Lot 6B	Lot 11A	Lot 11B
	Full-fed in drylot	No grain during winter; grazed on pasture until July 19; full-fed in drylot July 19- Nov. 15	No grain during winter; full-fed on bluegrass pasture until Sept. 10	Full-fed on pasture until Apr. 26; full-fed in drylot April 26- Sept. 10	Full-fed on blue- grass pas- ture until Sept. 10
Total days on pasture.....	None	84	137	91	228
Days fed grain.....	228	119	137	228	228
Date marketed.....	Sept. 16	Nov. 17	Sept. 16	Sept. 16	Sept. 16
Total days in experiment.....	228	294	228	228	228
	lbs.	lbs.	lbs.	lbs.	lbs.
Average daily gain.....	2.15	1.67	1.95	2.09	2.20
Feed for 100 pounds gain					
Shelled corn.....	525	359	455	537	588
Soybean oil meal.....	75	65	80	78	79
Corn silage.....	332	629	522	279	100
Alfalfa hay.....	93	85	41	84	25
Limestone.....	4	4	5	5	4
Pasture (acre-days).....	..	17	15	4	17
Feed cost for 100 pounds gain ²	\$10.56	\$ 9.93	\$10.87	\$10.86	\$11.70
Selling price a hundredweight, Chicago.....	11.75	11.00	11.30	11.20	11.40
Return a steer above cost of cattle and feed ³	27.34	22.84	21.45	20.10	17.84
Dressing percentage.....	61.9	60.5	61.2	61.5	61.8
Carcass grades.....	1 prime 2 prime- 5 choice+ 3 choice 1 good	1 choice+ 1 choice 2 choice- 1 No. 1 4 No. 2 1 No. 3	4 choice 2 choice- 4 good+ 1 No. 1 4 No. 2	1 choice+ 5 choice 6 choice- 2 good+ 1 good	1 choice+ 2 choice 6 choice- 1 good+ 1 good
Color-of-fat grades.....	7 choice 5 choice- 1 good+ 1 good	3 choice 1 medium ⁴	8 good 2 good-	3 choice 4 choice- 5 good+ 2 good 1 good-	1 choice- 2 good+ 6 good 1 good-

¹Owing to a mistake, six carcasses of this lot were shipped out before the grading committee saw them. They were graded by the packer graders as No. 1, 2, or 3. No fat-color grades were obtained on these six carcasses. ²Feed prices used in calculations: shelled corn, 80 cents a bushel; soybean oil meal, \$40 a ton; corn silage, \$5.20 a ton; alfalfa hay, \$15 a ton; limestone, \$7.50 a ton; pasture, \$2 an acre for 28 days. ³Based upon home weight in lots and Chicago prices less 75 cents a hundred. ⁴Firey, but not yellow.

needed to fatten a calf was not borne out by results either of this or last year's experiment. In fact calves fed continuously on pasture ate about 10 percent more corn a head than calves fed continuously in drylot. Calves wintered on silage and hay, grazed without grain until July 19, and afterwards full-fed in drylot until they weighed 1,000 pounds, ate 22 percent less corn than the drylot calves in attaining the same weight. However, the saving on grain was largely offset by the cost of the much greater quantity of silage eaten and by the rental charged for the pasture area used by these cattle. Most important of all from a financial standpoint was the fact that the calves fed in drylot outsold

the four lots fed on pasture from 35 cents to 75 cents a hundredweight despite the fact that all lots yielded almost the same percentage of carcass beef. In this particular test all three lots of pasture-fed cattle would have returned less profit a head than those fed in drylot, even tho no charge whatever had been made for the pasture. Such, however, was not the case in the test of the previous year.

The carcasses were graded by Sleeter Bull, Meats, and two representatives of the Bureau of Agricultural Economics, U. S. Department of Agriculture. Since pasture is generally accused of being a cause of yellow fat, particular attention was given to this point.

Carcasses of the drylot cattle graded highest. They also had a whiter fat than those of the pasture lots. Carcasses of the steers full-fed on bluegrass pasture for 228 days and of those full-fed on pasture for 91 days followed by 137 days in drylot graded about equally well, altho the fat of the latter lot was somewhat whiter. The lot which was wintered with no grain and then full-fed on pasture for 137 days ranked next in grade of carcasses. These carcasses were slightly yellow. Carcasses of the lot wintered with no grain, grazed on pasture for 84 days, and then full-fed in drylot for 119 days graded the lowest. Unfortunately, owing to an error, six carcasses of this lot were sold before the grading committee passed upon them. They had been graded by the packer graders who, however, kept no record of the fat colors. Of the four carcasses of this lot graded by the committee, none had a yellow fat. This lot dressed less than the other lots.

Further investigations are needed to determine the best method for the utilization of bluegrass pasture in the production of baby beef. (273 Animal Husbandry).

Alfalfa Makes Superior Pasture for Fattening Steers

Increased acreages of legumes and other forage crops which have resulted from crop-adjustment and soil-conservation programs of the past two years have aroused an increased interest on the part of farmers in ways of utilizing pasture profitably in livestock production. Several new pasture forages have come into use about which little information is available. Alfalfa, which formerly was regarded in Illinois as almost entirely a hay crop, is now pastured extensively in those parts of the state where more alfalfa is grown than is needed for hay purposes.

Information bearing on the relative value of some of these newer pasture forages for beef cattle was obtained by H. P. Rusk and R. R. Snapp, Beef Cattle Husbandry, during the summer of 1935. In this experiment sweet-clover, alfalfa, and bromegrass pastures were compared, both for full-fed steers and for steers having pasture forage as their only feed. To determine the feed-replacement value of an acre of the different pastures, one group of steers was full-fed in drylot.

TABLE 20.—COMPARISON OF DIFFERENT PASTURE FORAGES FOR GROWING AND FATTENING YEARLING STEERS, MAY 6 TO NOVEMBER 15, 1935: 193 DAYS

	Pasture with grain			Drylot	Pasture without grain		
	Lot 1 Bromegrass	Lot 2 Alfalfa	Lot 3 Sweet clover ¹	Lot 4	Lot 5 Bromegrass	Lot 6 Alfalfa	Lot 7 Sweet clover, ¹ lespedeza ²
Pasture period, May 6-Sept. 23, 140 days							
Average initial weight.....	549	547	574 ¹	543	546	544	569
Average daily gain.....	2.25	2.44	2.28	2.73	1.41	2.16	1.81
Average daily ration.....							
Corn-and-cob meal.....	11.0	11.0	11.5	18.1	....	....	....
Cottonseed meal ³.....	.4	.4	.5	1.0	....	....	....
Alfalfa hay.....	....	....	....	5.0	....	....	....
Drylot period, Sept. 23-Nov. 15, 53 days							
Average daily gain.....	2.57	2.36	2.27	1.70	Above three lots finished together 2.53		
Average daily ration.....							
Shelled corn.....	15.7	15.7	15.7	13.4	13.7		
Cottonseed meal.....	1.0	1.0	1.0	1.0	1.0		
Legume hay.....	5.0	5.0	5.0	5.0	5.2		
Total, 193 days							
Feed cost for 100 pounds gain ⁴	\$7.79	\$7.55	\$8.62	\$9.79	\$4.88		
Feed saved by each acre of pasture.....							
Corn, bushels.....	23.6	27.2	12.0	....	32.4		
Cottonseed meal, pounds.....	164	180	99	....	125		
Legume hay, pounds.....	1579	1651	1039	....	615		

¹Cattle held off sweet clover until May 13 because of wet weather. ²Lot 7 changed to lespedeza pasture August 2. ³Cottonseed meal fed to Lots 1, 2, and 3 after July 19. ⁴Feed prices: corn, 75 cents a bushel; cottonseed meal, \$25 a ton; alfalfa hay, \$15 a ton; soybean hay, \$10 a ton; lespedeza hay, \$12 a ton; pasture, \$2 an acre for a 28-day period.

Alfalfa proved to be much superior to either sweet-clover or brome-grass pasture for both groups of cattle, as reported in Table 20. Altho the cattle on the other forages made good gains during the first part of the summer, their gains fell off rapidly after the first two months. On the other hand, the steers on alfalfa continued to make satisfactory gains until they were removed from pasture on September 23. Following this date all cattle were transferred to drylots, where they were full-fed for 53 days before they were marketed.

Two 5-acre fields of each kind of forage were used in the test. Eight steers fed no grain were put into one field and twelve steers fed corn-and-cob meal were put into the other. On June 21 one steer fed no grain on alfalfa pasture died from bloat, reducing the number in this field to seven. A threatened shortage of grazing for this lot prompted the removal of two steers on August 2, so that only five head were on this alfalfa after that date. On the same day the eight steers on sweet-clover pasture without grain were transferred to 5 acres of spring-sown Korean lespedeza clover and the twelve grain-fed steers were given the run of both 5-acre fields.

After removal from pasture on September 23 one steer from each lot was slaughtered to study the effect of the different pastures on the quality of meat. On October 27, as well as at the close of the experiment on November 15, another steer was removed for slaughter and studied by the Meats division (see Project 1093, below). The remaining steers were sold on the Chicago market.

Upon their removal from pasture on September 23 the three lots of cattle not fed grain were re-sorted into two lots for a comparison of soybean and lespedeza hays as roughages for short-fed steers (see Project 274A, pages 82-83). These two groups of cattle are considered as a single lot after September 23 in Table 20. (274 Animal Husbandry)

Pastures Cause Yellow Fat in Beef But Not Dark Lean

Wider diversion of cropland to pasture, as is advocated under agricultural conservation policies, and the utilization of these pastures for livestock feeding has brought into new prominence the question of the effect of pasture upon quality of beef. Packers discriminate against cattle which have had access to pasture as a part of their fattening ration. They claim that pasture lowers dressing percentages, causes higher cooler shrinks, and lowers quality of beef. Both packers and retailers hold that pasture causes dark-colored lean and yellow-colored fat, both of which are objected to by the consumer. Many cattle feeders, on the other hand, are unable to understand why they are penalized when they market fat cattle which were full-fed on grass or which were fed on grass and finished in drylot.

These points have been under investigation by Sleeter Bull, Meats. Material for the investigation was provided by the cattle used in

Project 274, reported above on page 76 to 78. On September 23 all the lots were removed from pasture and one steer from each lot was slaughtered. After 35 days of drylot feeding a second steer from each lot was slaughtered, and after 63 days of drylot feeding a third steer from each lot was slaughtered. Records were taken on the carcass grades; dressing percentages; shrinkage of carcass, wholesale ribs, retail ribs, and porterhouse steak; physical composition of wholesale ribs as a measure of carcass condition; color of ribeye; and color of fat covering. Percentages of water and fat in ribeye were determined. A rib roast from each carcass was examined by a large number of housewives who expressed their choice and reasons therefor. The ribs were then roasted by the standard method and the roasts scored by a committee of experienced judges.

The other steers were shipped to Chicago. Their carcasses were graded in the packer's cooler by representatives of the packer, the U. S. Department of Agriculture, and the Experiment Station. Unfortunately some of the carcasses were sold by the packer before they were seen by the Department of Agriculture and the Experiment Station graders. The principal results of the experiment are given in Tables 21 and 22.

Claims that steers full-fed in drylot dress higher and produce better carcasses than steers full-fed on pasture or full-fed on pasture and then finished in drylot seem justified by these results, altho the lean meat of the pasture steers was as bright as that of the drylot steers. The fat of the pasture steers was generally more or less yellow in contrast to the creamy white fat of the drylot steers. The objectionable yellow color did not entirely disappear after 63 days of drylot feeding. Carcasses from the sweet-clover steers were much better in this respect than those from the other pasture lots. As expected, the carcasses of the pasture steers fed no grain graded lower and were yellower than those produced with grain.

Altho the results are meager and somewhat conflicting, the carcasses from the drylot steers shrunk a little less than those from the pasture steers. On the other hand, there were no significant differences in the shrinks of the wholesale ribs, retail ribs, and porterhouse steaks. In this connection it may be noted that whether the steer was full-fed in drylot or on pasture had little or no effect upon the condition of the carcasses as measured by the percentages of fat in the wholesale ribs, or upon the marbling as measured by the fat in the eye of beef. Naturally the ribs of the pasture steers which had no grain and of those which were short-fed contained less fat and had less fat in the ribeye than those of the full-fed steers.

In both the first and second slaughter prospective purchasers who examined the retail rib cuts voted first place to the ribs of the drylot steer because of the white color of the fat. The drylot carcass from

TABLE 21.—GRADES, RATIONS, AND OTHER DATA ON STEERS SLAUGHTERED AT CHICAGO IN STUDY OF EFFECT OF PASTURE ON BEEF

Number of steers	Ration	Government grades	Packer grades of "lost" carcasses	Color of fat	Dressing percentage	Selling price
7	Long-fed, drylot ¹	1 choice + 3 choice 1 good +	1 No. 1 1 No. 2	4 creamy white 1 slightly yellow	<i>perct.</i> 62.8	\$11.00
9	Long-fed, alfalfa pasture, drylot ¹	2 choice 1 choice - 3 good +	2 No. 2 1 No. 3 +	2 creamy white 4 slightly yellow	60.0	10.25
9	Long-fed, sweet-clover pasture, drylot ¹	1 choice 3 choice - 1 good + 1 good + 1 good -	2 No. 1	5 creamy white 2 slightly yellow	60.6	10.25
9	Long-fed, bromegrass pasture, drylot ¹	1 choice 2 choice - 2 good + 1 good 2 good -	1 No. 2	2 creamy white 6 slightly yellow	59.4	10.00
8	Short-fed, pasture, drylot ³	1 good + 1 good	1 No. 3 5 No. 4	2 slightly yellow	57.6	9.65 ⁴
8	Short-fed, pasture, drylot ³	1 good 3 good - 1 medium	2 No. 3 + 1 No. 4	5 slightly yellow	56.4	9.65 ⁴

¹The roughage was alfalfa hay. ²The roughage was lespedeza hay. ³The roughage was soybean hay. ⁴Packer stated he should have paid \$8.40 for these cattle

TABLE 22.—EFFECT OF PASTURE ON QUALITY OF BEEF AS REFLECTED IN RESULTS WITH NINETEEN STEERS

Ration	Carcass grade	Color of fat	Cold dressing percentage	Carcass shrink, 10 days	Fat in ribs	Fat in ribeye	Palatability score
Steers in first slaughter, September 24							
Full-fed, drylot ¹	Choice	Creamy white	58.3	2.2	35.4	4.5	57.5
Full-fed, alfalfa pasture.....	Choice—	Slightly yellow	57.3	2.8	32.9	2.5	59.4
Full-fed, sweet-clover pasture.....	Choice—	Creamy	58.5	2.7	31.5	2.5	56.5
Full-fed, bromegrass pasture.....	Good	Yellow	55.7	3.4	24.4	1.9	51.4
Alfalfa pasture.....	Medium+	Slightly yellow	56.8	2.7	28.8	2.3	51.1
Sweet-clover-lespedeza pasture.....	Medium+	Slightly yellow	55.2	3.2	21.3	1.5	51.5
Bromegrass pasture.....	Medium—	Yellow	51.7	4.0	19.4	1.7	44.7
Steers in second slaughter, October 28							
Long-fed, drylot ¹	Choice	Creamy white	60.3	2.7	36.1	3.6	53.6
Long-fed, alfalfa pasture, drylot ¹	Medium+	Yellow	58.8	2.4	28.3	4.1	46.6
Long-fed, sweet-clover pasture, drylot ¹	Good+	Slightly yellow	54.7	3.5	34.3	3.0	51.4
Long-fed, bromegrass pasture, drylot ¹	Choice—	Creamy white	58.5	3.6	35.1	3.6	55.1
Short-fed, alfalfa pasture, drylot ²	Good+	Slightly yellow	56.3	3.5	27.1	2.7	50.5
Short-fed, alfalfa pasture, drylot ³	Good—	Slightly yellow	56.7	3.1	23.4	3.3	52.8
Steers in third slaughter, November 25							
Long-fed, drylot ¹	Choice—	Creamy white	63.9	2.0	34.4	3.6	47.7
Long-fed, alfalfa pasture, drylot ¹	Choice	Creamy	59.0	2.5	38.2	4.8	52.7
Long-fed, sweet-clover pasture, drylot ¹	Choice—	Slightly yellow	59.3	2.1	37.5	5.5	49.6
Long-fed, bromegrass pasture, drylot ¹	Choice—	Yellow	58.8	2.2	37.3	5.1	52.1
Short-fed, alfalfa pasture, drylot ²	Medium+	Slightly yellow	58.0	2.6	30.0	2.6	49.5
Short-fed, alfalfa pasture, drylot ³	Good—	Slightly yellow	57.7	2.5	30.3	3.5	48.4

¹The roughage was alfalfa hay. ²The roughage was lespedeza hay. ³The roughage was soybean hay.

the third slaughter was a dark cutter and, because of this, was voted last. In other words the housewife displayed a distinct prejudice against yellow fat and dark lean.

The palatability committee which judged the cooked ribs in each instance selected a rib from a pasture steer as the best. The drylot rib from the dark cutter was rated as the least desirable of the third group because of off-flavors. Two of the three ribs from the pasture steers which had no grain and all the ribs from the short-fed pasture steers were criticized as having a fishy flavor.

Results of this experiment indicate that the packers' discrimination against cattle which have been full-fed on pasture, or which have been full-fed on pasture and then fed in drylot for as long as 63 days is justified in the cases of alfalfa, sweet-clover, and bromegrass from the standpoint of lower dressing percentage, larger cooler shrink, and lower carcass grades. Altho these pastures did not produce dark lean, as claimed by many packers and retailers, they did produce a yellow fat which was diluted, but not whitened, by a finishing period of 63 days in drylot. The lower carcass grades were caused primarily by yellow covering. This yellow fat was objectionable to the purchaser but did not lower the eating qualities of the roasted ribs.

In connection with the foregoing results attention is called to those in Project 273, pages 74-76. The use of bluegrass, it may be noted, did not lower the dressing percentages, altho it did lower the carcass grades. Altho the bluegrass carcasses were not so white as the drylot carcasses, they were better in this respect than the carcasses from alfalfa, sweet-clover, and bromegrass pastures. With the increase in the use of pastures in corn-belt beef production, it may be necessary to teach the meat trade and the housewife that yellow fat is not necessarily a sign of poor quality in beef. (1093 Animal Husbandry)

Lespedeza and Soybean Hays Put Same Gain On Steers

Altho lespedeza and soybean hays are relatively new crops in Illinois, in the southern half of the state they already are produced more extensively than red clover or alfalfa. Because they are being grown extensively, a considerable need has arisen for more information concerning their feeding value for beef cattle under Illinois conditions. In continued tests under the direction of H. P. Rusk and R. R. Snapp, Beef Cattle Husbandry, no significant differences in feeding value have been observed between the two types of hay.

In a previous feeding trial (Project 271A), details of which are given in the Forty-Eighth Annual Report, lespedeza hay was as valuable as alfalfa for fattening cattle, while soybean hay was slightly inferior to both alfalfa and lespedeza. However, the quality of soybean hay varies considerably according to the stage at which the beans are cut and weather conditions during the curing period. Consequently a

definite rating between soybean and lespedeza hays cannot be made unless the results of several comparisons are known.

This year's trial in which no significant differences in feeding value were observed between lespedeza and soybean hays was carried on in the fall with short-fed steers. Both lots of cattle made exactly the same gain and sold for the same price a hundredweight. However, the cattle fed soybean hay ate more grain, with the result that their gains were slightly more costly. (274A Animal Husbandry)

Soybeans Much Poorer Than Yellow Corn in Vitamin A

Proper utilization of the increasing production of soybeans in Illinois and surrounding states depends in no small measure on the evaluation of the beans as a food for man and livestock. Such an evaluation includes a study of the vitamin content of the beans. Continued studies in this field by H. H. Mitchell and Jessie R. Beadles, *Animal Nutrition*, show that the Illini variety of soybeans, at least, is relatively poor in vitamin A and much poorer in this respect than yellow corn. The bean probably contains considerably less than one-tenth the concentration of vitamin A that is found in Reid Yellow Dent corn.

The same quantitative method of vitamin A assay was used this year as in the preceding year, involving paired-feeding tests upon young growing rats containing initially only a slight storage of the vitamin in their bodies. It was found that rations containing 40, 45, and 50 percent of freshly ground soybeans as the sole source of vitamin A were still markedly deficient in the vitamin. Except when these rations were supplemented with small amounts of carotene, xerophthalmia developed in four or five weeks in all rats on test. In last year's work 10 percent or less of yellow corn was found adequate to protect all rats so fed from eye trouble in four weeks of feeding. (415 Animal Husbandry)

Varying Protein in Ration Produces Marked Results

Rations low in protein are unpalatable and nonproductive. Those high in protein are expensive and may prove detrimental. Between these two there is a certain concentration of protein, characteristic for each mixture of feeds, that is just able to support maximum growth, while above this critical concentration there is probably a considerable range of protein levels that are equally productive. But there are many interesting and important problems that may be solved by studying the effects on growing animals of varying the protein concentration of their diets from very low to very high levels: effects on the animal—its appetite, its metabolism, and the composition of its tissues—and effects on the manner and the efficiency of disposal of the rations themselves. These problems are being studied by T. S. Hamilton, *Animal Nutrition*, as a thesis subject for the doctor's degree, under the

general supervision of H. H. Mitchell. Up to the present time the project has been carried out with albino rats only, altho it is expected later to extend the work to farm animals also, particularly along lines suggested by the experiments on a small laboratory animal.

As the concentration of protein in a ration otherwise well balanced is increased from 4 to 54 percent, the following effects have been demonstrated:

1. The growth-promoting values of the ration increase until the protein level reaches between 12 and 16 percent, and then remain constant.

2. The appetite of the rat or the palatability of the ration increases until about the same protein level is reached and then very perceptibly decreases.

3. The digestibility of the protein and the metabolizability of the energy are not appreciably affected.

4. The heating effect of the food on the rat (the heat increment) decreases to a minimum that is maintained for a range from about 18 percent to 30 percent of protein concentration and then increases rapidly.

5. The net energy of the rations increases to the same range of protein concentration and then decreases.

6. The new tissues formed during growth become richer and richer in protein and poorer in fat up to a concentration of protein in the ration of 16 to 18 percent, above which the changes are inconsiderable.

7. Somewhat incidentally it was demonstrated that the greater the intake of food energy, the greater became the basal expenditure of energy, representing the energy cost of the minimum vital activities.

Thruout most of these experiments a modification of the paired-feeding method was used, involving the feeding of pair mates for equal gains rather than the feeding of equal amounts of food. This modification permitted a more accurate measurement of the differences in nutritive value and nutritive effects of successive pairs of rations that were compared, that is, 4 *vs.* 8 percent of protein, 8 *vs.* 12 percent, 8 *vs.* 18 percent, 12 *vs.* 16 percent, 16 *vs.* 20 percent, 18 *vs.* 22 percent, 22 *vs.* 42 percent, and 20 *vs.* 54 percent. The protein in the rations was practically all derived from dried, ether-extracted whole egg, and the level of protein was varied by the substitution of this material for starch. All rations contained adequate and equal amounts of vitamins and minerals and were fed mixed with sufficient water to permit accurate control and measurement of the intake of food.

Since activity of the rats could be neither controlled nor entirely prevented and since a variable activity would complicate the interpretation of the results, all rats were very closely confined in cage compartments measuring either 7 by 7 by 2½ inches or 7 by 5 by 2½ inches. These specially constructed cages are pictured in Fig. 13.

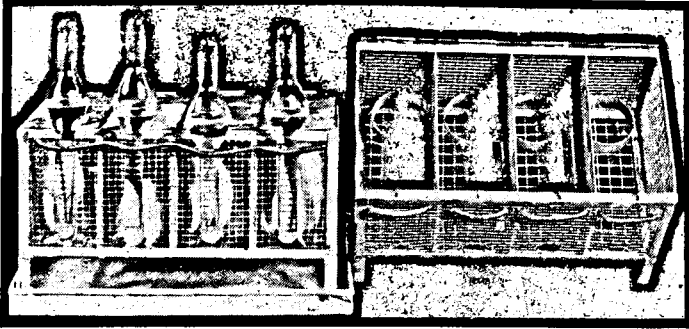


FIG. 13.—SPECIAL FEEDING CAGES FOR TESTING THE EFFECTS OF VARIABLE PERCENTAGES OF PROTEIN

All the rats were closely confined in small cages to eliminate so far as possible the variable activity that would complicate interpretation of results. Some marked effects were demonstrated as a result of increasing the concentration of protein from 4 percent to 54 percent in a ration that was otherwise well balanced.

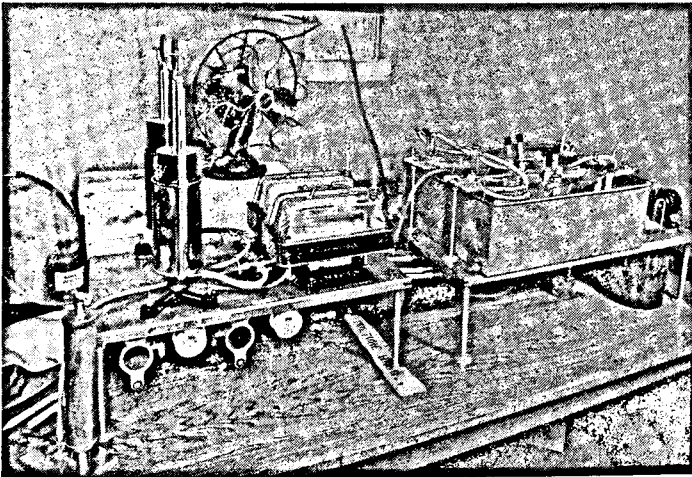


FIG. 14.—DUAL-CHAMBER, CLOSED-CIRCUIT RESPIRATION APPARATUS

The heat production of the rats in fasting and in fed condition, as well as the heating effects of the various rations, was measured by means of this apparatus as one of the steps in determining the effects of variable percentages of protein in the ration.

Balance trials of nitrogen and energy were undertaken for each of the experimental rations in the type of metabolism rat cage developed in this laboratory, while the basal heat production of the rats, as well as the heating effects of the various rations, was measured in a dual-chamber closed-circuit respiration apparatus of the Benedict type. This apparatus is shown in Fig. 14. At the termination of the feeding period, which generally occurred when weights approximating 200 grams were reached, the rats were killed with ether, the body length measured, the contents of the alimentary canal removed and weighed, the carcasses frozen and ground to a homogenous sample, and later analyzed for nitrogen and gross energy (heat of combustion). In all, 224 rats have been used in paired-feeding tests and 79 others in auxiliary tests of one kind or another. More than 450 respiration tests were completed.

When the rats were fed for equal gains, about 40 percent more metabolizable energy was required in a ration containing 4 percent of protein than in a ration containing 18 percent. Between the 18- and 54-percent rations the tendency was slightly in the opposite direction, more of the higher protein rations being required to produce the same gain in weight. The average heat increments of successive rations, expressed in small calories for each gram of food, were:

	<i>cals.</i>		<i>cals.</i>
4 percent protein.....	372	20 percent protein.....	159
8 percent protein.....	402	30 percent protein.....	158
12 percent protein.....	235	42 percent protein.....	492
18 percent protein.....	135	54 percent protein.....	704

The average net energy values, expressed in the same way, were:

	<i>cals.</i>		<i>cals.</i>
4 percent protein.....	4 004	20 percent protein.....	4 373
8 percent protein.....	3 943	30 percent protein.....	4 402
12 percent protein.....	4 128	42 percent protein.....	4 106
18 percent protein.....	4 383	54 percent protein.....	4 007

Between levels of 18 and 30 percent of protein the utilization of the energy of the rations was practically identical, with marked reductions beyond this range in either direction.

As measured by the number of food refusals, the palatability of the rations increased consistently from a protein level of 4 percent to one of about 18 percent. Somewhere above a 22-percent-protein level a marked reversal in palatability was noted. This close paralleling of the palatability and nutritive value of rations is a striking phenomenon, the physiological explanation of which is not apparent.

Another important observation, bringing these rat experiments in line with recently completed experiments on pigs and lambs (Projects 1082 and 1095), has to do with the relation between the protein content of the ration and the protein and fat contents of the new tissues formed during growth. This change in composition may be visualized in the simplest manner by considering the relation between energy

retained and nitrogen retained during growth. The higher this ratio becomes, the more fat and the less protein the animal stores. From rations containing 4 percent of protein to those containing 12 to 16 percent there is a steady decline in the ratio of energy to nitrogen stored, while beyond rations containing 16 percent of protein the ratio remains practically constant at about 100 to 1. Thus concentrations of dietary protein above that needed for maximum growth and maximum utilization of feed do not tend to change appreciably the composition of the carcass. The same seems to be true of pigs.

An interesting observation made in connection with the unequal feeding of pair mates to induce equal gains was that the basal metabolism of the rat on the higher intake of food (energy) was quite generally higher than that of its pair mate. The correlation between daily energy intake and daily basal heat, both reduced to the square meter of body surface, was approximately .7. This correlation brings out another advantage of the balanced over the unbalanced ration, namely, that for the same rate of growth, the maintenance requirement of an animal for energy (and probably for protein) would be less for the balanced ration. If the effect of restricted feeding in lowering maintenance requirements lasts for a considerable time, as the evidence indicates, there is more than a suggestion that the greatest feed economy in developing an animal to some desirable market weight may be secured by restricting its growth for some undefined period of time at the start of the feeding period and then finishing it on full feed, rather than full-feeding it from start to finish. (419 Animal Husbandry)

State Has 58 Herds Accredited Free From Bang's Disease

Control of Bang's disease, most costly of all cattle diseases in Illinois, has now advanced to the point where 58 herds have been accredited. Some of these herds have been kept clean for ten years or longer by avoiding the purchase and introduction of infected animals. As part of the program, 136 veterinarians have been approved to give the rapid-plate test for preliminary examination of herds. A total of 10,826 cattle in 66 counties were enrolled under the program as of May 31, 1936.

The work progressed during the past year with demonstrations of the control of Bang's disease by sanitary measures, the use of the agglutination test for herds, and the segregation or slaughter of reactors being continued under the direction of Robert Graham, C. A. Brandy, and Frank Thorp, Jr., Animal Pathology and Hygiene. As in previous years, preliminary herd tests leading up to accreditation have been conducted by practitioners, but the final test preceding accreditation is checked in the Experiment Station laboratory. Herds free from Bang's disease, as judged by two annual or three semi-

annual negative tests are, as in preceding years, accredited by the Chief Veterinarian of the State Department of Agriculture. All tests conducted by federal authorities are also recognized in state accreditation. Regulations of the State Department of Agriculture, looking to the ultimate suppression and control of Bang's disease in Illinois, have aided in protecting clean herds under this project. Reactors in some herds in the project have been held in temporary isolation under local veterinary supervision.

Enrollment of herds in the project has always been voluntary, but recently the interest in voluntary testing for Bang's disease has been stimulated by the federal-state Bang's disease program of testing herds without charge. Reacting animals under the federal-state plan are slaughtered and an indemnity for reactors paid by the federal government. Indemnity from the state has not been provided for animals reacting to the agglutination test, but an owner may dispose of reactors by immediate slaughter, may sell them into known infected herds, or hold them in temporary isolation at his own risk. In the case of valuable animals temporary isolation has been the means of preserving valuable blood lines. While this procedure entails the danger of the disease spreading, temporary isolation has been successful where calves have been raised in isolation from reacting cows.

One phase of the work during the past year has been a further comparison of different methods of testing. Parallel agglutination tests of herds by the rapid-plate and tube method have been continued during the past year with a favorable correlation of results of the two tests. Further comparisons have also been made during the past year with a field whole-blood test conducted in the stable. Discrepancies with the tube test in the field occur largely in the low-dilution reactors. While the field test is not regarded as one to replace the rapid-plate or tube test in the laboratory, it may apparently be employed as an adjunct to determine the extent or range of the infection in a herd, where laboratory facilities are not available.

In a study of the results of the parallel agglutination test with the same serums with five rapid-plate antigens from laboratories in other states, it is apparent that there is a high degree of correlation in samples that give completely negative or completely positive reactions. However, in certain samples that fall in the zone of partial or incomplete reactions, a variation in the dilution in which the reaction occurs was noted. Some partial-reacting samples proved positive in all dilutions to some plate antigens, while varying degrees of reaction were noted in others. It is apparent that animals with low or partial agglutination titres may be responsible in part for the discrepancy in the results reported by different laboratories on the same samples in the agglutination test for Bang's disease. These variations suggest the possible advantage of a standard-plate antigen to eliminate, in so far as

possible, discrepancies or irregularities in the results of the tests. These irregularities appear to be of less concern in the tube test.

Some observations on the control of Bang's disease in demonstrational herds in a period of over fourteen years may be tentatively summarized as follows:

1. Losses from Bang's disease in herds include calf loss, cow depreciation thru lower production of meat and milk, sterility, and increased udder troubles. Records suggest that Bang's disease may decrease milk flow approximately 20 percent.

2. As noted in preceding reports, dairy and beef herds free from Bang's disease are more profitable, other factors being equal.

3. Each infected herd presents a separate problem. The value of the animals, the number of reactors, and the objective of the herd owner must be taken into consideration in the procedure to follow in the control of Bang's disease. Slaughter of reactors is recommended. However, where only a small percentage react in purebred herds, isolation to preserve valuable blood lines may be desirable.

4. Healthy herds have been developed from normally breeding reacting dams. In many herds with a small percentage of infection, repeated testing, segregation, and proper management of reactors have prevented further spread of the disease. This plan, however, involves more risk than the slaughter method followed by disinfection of premises.

5. Replacements can be more safely secured thru the purchase of and repeated testing of unbred heifers than by the purchase of mature cows from other than accredited herds.

6. Most failures in the establishment of herds free from Bang's disease are traceable to failures in the execution of proved methods of preventing Bang's disease rather than to defects in the essential measures designed to check the disease.

7. While no suitable immunizing agent has been developed to supplement or replace the testing and elimination of reactors, investigations are being projected at some experiment stations to determine the value of vaccines. Preliminary efforts to demonstrate the value of vaccines in guinea pigs have not given encouraging results.

8. The carrier feature of the disease and the necessity of using vaccines possessing antigenic value may possibly create udder infection. Until the results of carefully controlled experiments under practical farm conditions prove the value and place of vaccines in the control of Bang's disease, herd owners and veterinarians are advised against using living culture vaccines in any but badly infected herds.

9. No known cure for Bang's disease has been found.

10. Bang's disease, altho primarily an economic problem confronting the cattle industry, has, according to physicians and public-health officials, disclosed an increasingly important public-health aspect.

11. As the result of an increasing number of cases of undulant fever in man and its close relation to Bang's disease, it is apparent that the successful elimination of the disease in cattle may be the means of reducing or eliminating undulant fever in man.

12. Pasteurization renders milk infected with Bang's disease non-infective to susceptible experimental animals, but to assure additional protection to public health, there is a growing demand that herds be free from Bang's disease in order that fear of possible illness from consuming milk in large quantities will be eliminated.

13. Results of examining milk samples from commercial pasteurizing plants in different localities in Illinois indicate the efficiency of pasteurization in destroying *Brucella* in milk, and this practice is recommended as a public-health measure. (1046 Animal Husbandry and 214 Dairy Husbandry)

Experimental Herd Aids in Study of Paratuberculosis

Altho it has been recognized for many years, paratuberculosis, or Johne's disease, probably affects more of the 2,788,000 cattle on Illinois farms than is indicated by the cases reported. This is because it

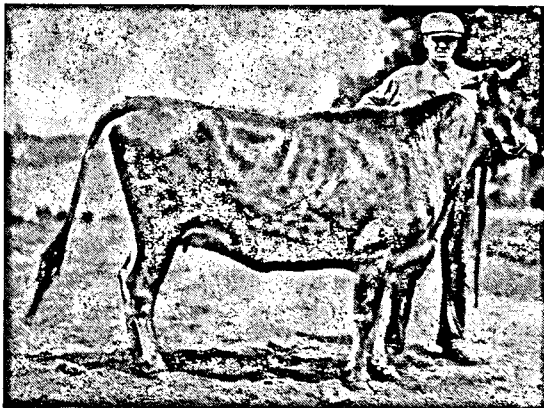


FIG. 15.—A SUBCLINICAL CASE OF PARATUBERCULOSIS

As in bovine tuberculosis, no symptoms are noted in the early stages of paratuberculosis, or Johne's disease. Spread of paratuberculosis often is traceable to animals that appear healthy and are not suspected of harboring the disease. Such animals can be detected by the paratuberculin test; by slaughter of diseased animals and disinfection of premises the disease may be eliminated.

is often confused with tuberculosis, gastritis, and other diseases. Continued studies of the nature of this disease and of its prevention and control have been made under Robert Graham, Animal Pathology and

TABLE 23.—NUMBER OF POSITIVE REACTORS IN ANNUAL PARATUBERCULIN TESTS MADE OF AN INFECTED HERD IN ILLINOIS, 1927 TO 1936

Year	Total number of animals tested	Negative reactors		Positive reactors	
		number	perci.	number	perci.
1927.....	121	87	71.9	34	28.1
1928.....	120	84	70	36	30
1929.....	61	46	75.4	15	24.6
1930.....	98	87	88.8	11	11.2
1931.....	121	119	98.4	2	1.6
1932.....	111	110	99.1	1	.9
1933.....	151	145	96.03	6	3.97
1934.....	130	128	98.5	2	1.5
1935.....	201	190	94.6	11	5.4
1936.....	219	217	99.1	2	.9

Hygiene, and J. P. Torrey and H. W. Johnson, Illinois State Department of Agriculture. Observations of an experimental herd over a period of nine years have constituted a portion of this work.

No clinical cases of Johne's disease were detected in the experimental herd the past year. Likewise, there were no new reactors to the annual test. However, two animals, reactors to the test in another herd, again reacted to the test this year. The evidence suggests that the disease may be reduced to a minimum in infected herds by a testing program, together with isolation and segregation of reactors. Thru annual testing, isolation of reactors, and disinfection of premises, paratuberculosis in one herd, as judged by results of the paratuberculin test, has been reduced from 28 percent to .9 percent over a period of nine years. The results of the testing are summarized in Table 23. (1215 Animal Husbandry)

Pasture Pigs Eat Enough Protein if Fed Free-Choice

During tests in past years there have been some indications that weanling pigs might respond to a larger intake of protein than they voluntarily consume when they are grazing alfalfa and the protein supplement is offered free-choice with corn. Accordingly, this point was made the special object of a test by W. E. Carroll and W. P. Garrigus, Swine Husbandry, during the summer of 1935. Whereas, under such conditions in past tests, the voluntary intake of protein supplement has varied from less than 2 percent to more than 6 percent of the ration, pigs in Lot 2 of this test were fed a ration that contained 9 percent of protein supplement. An abundance of alfalfa forage was available. One group of pigs without forage was included for comparison. The difference in protein intake apparently did not influence either the rate of gain or the amount of feed eaten for a unit of gain.

The 60 spring pigs used averaged 84 days old when the test began

June 7, and each lot was continued on feed until the week end that the average weight of the animals composing it most nearly approximated 200 pounds. There were three lots of 20 pigs each. Lot 1, on an acre of alfalfa pasture, was self-fed a ration composed of 98.5 pounds of cracked corn, 1 pound of ground limestone, .5 pound of salt, and protein supplement free-choice. Lot 2, also on an acre of alfalfa pasture, was fed a ration composed of 89.5 pounds of cracked corn, 1 pound of ground limestone, .5 pound of salt, and 9 pounds of protein supplement. Lot 3 was given the same feed mixture as Lot 1 except that the pigs were kept in drylot.

The supplement fed to Lot 3 contained tankage, soybean oil meal, and alfalfa meal in the ratio of 2:1:1. This same supplement was fed to Lots 1 and 2, except that the alfalfa meal was omitted. Water was kept before all the pigs, and a mineral mixture composed of equal weights of limestone, bone meal, and salt was available to the pigs of Lot 3, the drylot group, in case they desired to eat more mineral than was included in their feed mixture.

The corn that was fed was No. 2 and No. 3 yellow, while the other feeds were of standard commercial grade.

The alfalfa which was used as pasture was seeded the summer of 1932 and had been used with experimental pigs the summer of 1933

TABLE 24.—VALUE OF PROTEIN SUPPLEMENT WHEN FED IN DIFFERENT AMOUNTS TO GROWING-FATTENING PIGS ON ALFALFA PASTURE, AS COMPARED WITH DRYLOT FEEDING
(Test started June 7, 1935, with 20 pigs in each lot)

	Lot 1 Corn, supplement free-choice, and alfalfa pasture	Lot 2 Corn and supple- ment mixed, alfalfa pasture	Lot 3 Corn, supplement free-choice, drylot
	<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>
Average initial weight.....	47	46	46
Average final weight.....	210	196	195
Average daily gain.....	1.24	1.35	1.02
Average daily feed			
Cracked corn.....	4.46	4.58	4.13
Supplement ¹.....	.16	.46	.47
Mineral ².....	.07	.07	.06
Total.....	4.69	5.11	4.66
Feed for 100 pounds gain			
Cracked corn.....	361	340	406
Supplement ¹	13	34	46
Mineral ²	6	6	7
Total.....	380	380	459
Hay harvested			
June 14.....	3 710	3 540	...
July 24.....	850	910	...
Total.....	4 560	4 450	...

¹Tankage and soybean oil meal 2:1 for Lots 1 and 2. Tankage, soybean oil meal, and alfalfa meal 2:1:1 for Lot 3. ²Ground limestone and salt 2:1, mixed as 1.5 percent of the corn of Lots 1 and 2 and as 1.5 percent of the ration of Lot 2.

and by pregnant brood sows on experiment in 1934. Cutting the alfalfa for hay on June 14 and again on July 24 provided an abundance of tender, succulent growth for the pigs thruout the test.

Results showing that the protein intake of the two groups of pigs (Lots 1 and 2) on alfalfa pasture apparently did not influence either rate of gain or the amount of feed eaten for each unit of gain are given in Table 24. The difference of almost 10 percent in rate of gain appears large, but lacks statistical significance. As for the amounts of the two rations which were consumed for each 100 pounds of gain made, exactly the same total amount of feed was eaten by the two lots. The additional protein supplement fed the Lot 2 pigs over the amount fed those of Lot 1 merely replaced an equal weight of corn. These results indicate that the ration fed Lot 1 contained enough protein to sustain maximum growth in pigs of this weight that are fed on alfalfa pasture.

Under price conditions that usually, if not invariably, prevail, the cost of gains made with the Lot 2 ration would be noticeably higher than that made with the lower-protein ration.

Lots 1 and 3 were a comparison between value of alfalfa pasture and drylot feeding. Both lots were fed coarsely ground corn and protein supplement free-choice. The pigs on alfalfa pasture gained more than 20 percent more rapidly than those in drylot and consumed less feed for each pound of gain made. The difference in rate of gain is statistically significant. While there is no measure of significance for the feed difference, it was more than 20 percent in favor of the alfalfa pasture lot and probably is significant.

Last year in a similar test pigs that were fed in drylot gained just as rapidly as, and used no more feed than, similar pigs that were fed on alfalfa pasture. The cause of this difference in the two trials is not clear. The two trials agree, however, in showing that when fed in drylot, pigs eat considerably more protein supplement than when fed on alfalfa pasture. This saving in supplement by using pasture, together with the advantage gained in hay harvested (about 2¼ tons an acre for the two lots this year), gives a very high acre-value to the alfalfa. Disregarding the difference in the amounts of corn consumed by the pasture and the drylot pigs this year, the acre of alfalfa saved approximately 1,000 pounds of protein supplement in addition to producing more than 2 tons of hay. (50 Animal Husbandry)

Protein in Ration Influences Composition of Pork

Balancing of rations for farm animals may be studied from a number of angles. Rates of gain in body weight and feed economy of gains have frequently been studied, but only seldom has attention been directed to the effect of ration balance upon the composition of the tissues formed during growth and fattening. With the continuing

interest in the quality of meat carcasses and of meat, the effect of ration composition is a problem of practical importance.

During the past year W. E. Carroll and W. P. Garrigus, Swine Husbandry, and H. H. Mitchell and T. S. Hamilton, with the technical assistance of W. T. Haines, Animal Nutrition, have studied the effect of rations varying in protein content from 12 to 26 percent on the rates of gain, rates of nitrogen retention, appetites, and carcass composition of growing and fattening pigs. The experiment also affords some information on the susceptibility of the pig to "protein poisoning," or "protein intoxication."

A ration containing 17 percent of protein could not produce maximum gain in weight or in nitrogen storage for pigs up to a weight of about 180 pounds, but was adequate at heavier weights. The higher of two protein rations being compared proved the more palatable only when it promoted more rapid growth on the same intake. With each increase in the protein content of the ration from 17 to 26 percent, the carcasses produced contained more moisture, less fat, and more protein. These changes were more marked at the lower levels of protein. No signs of protein poisoning were evident at any level of feeding.

Three different comparisons of protein levels were made in this experiment: 12 *vs.* 16 percent, 17 *vs.* 22 percent, and 17 *vs.* 26 percent. Ten pairs of pigs were used in each comparison, and the food intakes of paired pigs were equalized thruout the feeding period. The pigs varied in weight from 48 to 75 pounds as they entered the test, but no pair differed by more than 4 pounds. In fact the pigs of most pairs began the test within a pound of each other. The pigs were fed in individual feeding crates twice daily, and the experimental feeding was continued until the week end that the average weight of the two pigs of a pair most nearly approximated 200 pounds.

Corn was the principal ingredient of all rations, and all contained 3 percent of alfalfa meal and .5 percent of salt. A special dehydrated beef meal containing in different samples from 66 to 70 percent of protein, 10 to 12 percent of fat, and 14 to 16 percent of ash was incorporated in the various rations (at the expense of corn) in sufficient amounts to bring the percentage of protein to the desired level. The mineral and energy contents of the rations were equalized by the appropriate additions of corn oil and bone meal. Nitrogen balance studies were carried out with nine pairs of pigs on the 17- and 22-percent-protein comparison, generally at body weights of 95 to 140 pounds, and with eight pairs of pigs on the 17- and 26-percent-protein comparison, generally at body weights of 85 to 115 pounds. At the termination of the feeding periods from six to eight pairs of pigs in each of the three comparisons were slaughtered and submitted to chemical analysis.

Twelve percent of protein in the ration proved to be insufficient

for maximum gain and most economical use of feed, since in all ten pairs the pig that received the ration containing 12 percent of protein gained less and ate more feed for each pound of gain made than his pair mate receiving an equal amount of feed containing 16 percent of protein.

Even 17 percent of protein in the ration is apparently insufficient, at least up to a certain undetermined body weight. At any rate, in eight cases out of ten the pig that was fed the ration containing 22 percent of protein gained more in weight and more economically than his pair mate that consumed the same daily amount of feed containing only 17 percent of protein.

TABLE 25.—AVERAGE RESULTS OF THE ANALYSIS OF THE CARCASSES OF PIGS FED DIFFERENT LEVELS OF PROTEIN

Number of pairs	Protein in ration	Weight of carcass analyzed	Chemical composition of carcass				
			Moisture	Fat	Protein	Ash	Gross energy
		kgms.	perct.	perct.	perct.	perct.	cal. a gm.
7	12 percent....	79.53	40.41	40.67	12.98	3.00	4.31
	16 percent....	88.44	46.91	33.15	15.18	2.87	3.77
6	17 percent....	82.32	44.76	34.47	14.86	3.04	3.87
	22 percent....	86.58	48.96	31.43	15.45	2.92	3.58
8	17 percent....	85.07	44.75	36.50	14.17	3.19	4.01
	26 percent....	83.42	47.42	33.49	14.78	3.44	3.74

The ration that contained 26 percent of protein, however, was no more effective in promoting a gain than the one that carried 17 percent. In this comparison six pairs favored the higher protein level and four the lower—a division too nearly equal to be significant.

The balance trials revealed a greater rate of storage of protein on the 22-percent level and on the 26-percent level than on the 17-percent level at all weights except those above about 180 pounds. At the 17-percent level the protein was 83.6 percent digestible; at the 22 percent level, 86 percent digestible; and at the 26 percent level, 85.7 percent digestible. The percentage of gross energy metabolized, averaging 80.6, was not affected by the protein content of the ration.

Livers and kidneys of the pigs raised on the ration containing 16 percent of protein were larger in each of the eight pairs slaughtered than those of the pigs raised on the 12-percent ration, both on the basis of weight and of percentage of the empty body weight. In the six pairs examined in the comparison of the 17- and 22-percent-protein levels, no significant difference in kidney weight was evident, tho the livers of the high-protein pig were the heavier in five of six pairs examined. But in the comparison of organ weights of the 17- and 26-

percent-protein levels, again the higher protein level was associated with the larger weight both of liver and kidney. The size of these organs seems to be dependent largely upon the percentage of protein in the diet.

Results of the chemical analysis of the carcasses are summarized in Table 25. The average differences in the contents of moisture, fat, protein, and energy between comparative groups of pigs are statistically significant. It may be concluded that as the protein content of the diet increases, the percentage of moisture and of protein in the carcasses increase also, while the percentage of fat decreases. These changes in carcass composition are greater for a given change in protein level at the lower levels of protein intake. (1082 Animal Husbandry)

Rye Pasture for Fall Pigs Saves, Helps Gains

Experience gained from using fall-sown rye for early spring pasture for sows and litters suggested to W. E. Carroll and Wise Burroughs, Swine Husbandry, that rye pasture might also be used to good advantage with fall pigs that are being fattened for market. Accordingly three groups of twenty fall pigs each were used in such a study the winter of 1935-36.

The worth of rye forage was measured from two angles: (1) How much concentrated feed will rye forage save in making a given gain? (2) How much gain can properly be credited to rye forage above that produced by a given amount of concentrates? The rye used had been seeded September 5 at the rate of 89 pounds to the acre and was a thick stand, dark green in color, and 8 to 10 inches high when the test opened November 8.

The pigs of Lot 1 were fed in drylot, while those of Lots 2 and 3 each had access to two acres of rye pasture. The same supposedly adequate feed mixture was fed to all the pigs. Those of Lot 2 were allowed only as much of the mixture in addition to their rye pasture as was necessary to make them gain at the same rate as the pigs of Lot 1, while the pigs of Lot 3, also on rye forage, received daily as much of the mixture as was consumed by the pigs of Lot 1, regardless of gain.

The late beginning of the test (November 8), which was necessitated by the date of farrow of the pigs, and the extremely severe winter both operated against the most satisfactory use of the forage. Temperatures were abnormally low, and snow covered the rye much of the time. In spite of this the pigs spent a great deal of time grazing, even rooting thru the snow to get at the forage.

A summary of the results of the test is given in Table 26. The gains of all the pigs were slow, owing no doubt to conditions mentioned above. On both Lots 2 and 3, however, pasture had a measurable effect. The pigs in drylot at all times set the level of feed intake,

that is, they were fed as much as they would eat, while Lots 2 and 3 on rye would have eaten more of the feed mixture if it had been given to them.

A comparison of Lots 1 and 2 gives the feed saved by rye pasture in making a given gain, while a comparison of Lots 1 and 3 gives the additional pork produced by the consumption of the forage above a given concentrate intake.

Pigs of Lot 1 ate 4.26 pounds of feed daily a head as an average for the entire experiment and gained at the rate of .96 pound, whereas the pigs of Lot 2 on rye pasture made the same gain on 3.87 pounds of feed, a difference of 9 percent. During the first 56 days of the test, however, the pigs of Lot 2 had eaten 22 percent less feed than those in drylot yet had gained equally well.

TABLE 26.—VALUE OF RYE PASTURE FOR FATTENING FALL PIGS, 1935-36¹

	Lot 1 Dry-lot	Lot 2 Rye pasture	Lot 3 Rye pasture
Number of pigs to finish.....	19	19	18
Days in test.....	162	162	155
	<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>
Average initial weight ²	44	44	46
Average final weight ²	199	201	200
Average daily gain ².....	.96	.97	1.00
Average daily feed.....	4.26	3.87	4.10
Feed for 100 pounds gain.....	448	406	421

¹The test began November 8 with 20 pigs to the lot. The same feed mixture was fed to all lots.
²For the pigs that finished.

Whether this greater effect of the pasture during the early rather than the later part of the test was caused by the difference in the age of the pigs or merely by the pasture being covered with snow and ice so much of the later part of the test cannot be judged.

When the feed intake exclusive of pasture was equalized, as was the case with Lots 1 and 3, rye pasture appeared to be especially valuable to young pigs, since during the first 56 days of the test the pigs that had access to it gained 27 percent more than did those that were fed in drylot. Either the rye was less valuable to the pigs as the test continued or the later grazing was reduced by snow and ice.

At any rate the pasture accounted for a saving of only seven days in the time required for the pigs to reach 200 pounds. This made a difference of slightly more than 4 percent in the average daily gain of the two groups of pigs.

When considered from the standpoint of the weight attained at a given time, however, the pasture appears to have a greater value than

this. At the time the pasture-fed pigs had reached an average weight of 200 pounds, those that had been fed in drylot weighed only 183 pounds, a difference of more than 11 percent in the gain made up to this point on approximately equal amounts of concentrates. This difference of 17 pounds of gain to the head for 20 pigs, at no added feed cost, if valued at 8 cents a pound, would give a value of almost \$14 an acre for the rye pasture in this test. For each pound of gain made on pasture, the pigs consumed slightly less than $4\frac{1}{4}$ pounds of concentrates, while the drylot pigs ate practically $4\frac{1}{2}$ pounds for each pound of gain they made.

Body measurements of the pigs were taken and the nutritive index¹ of each was computed both at the beginning and at the end of the trial. As would be expected, there was no material difference in these measurements from lot to lot as the test began, but at the end of the test body length and nutritive index both favored the pasture-fed pigs. Ration treatment appeared to have no influence on the heart girth or the belly girth of the pigs.

This controlled method of feeding with three groups of animals as indicated appears to measure with much more accuracy the value of forage for pigs than does the method commonly used in which no control is exercised over the amount of feed consumed. (53 Animal Husbandry)

Earlier Results Are Confirmed in Anemia Studies

During the past year experimental work on the role of metallic ions in hemoglobin formation was mainly concerned with the clearing up of certain technical details preliminary to publication of the results of a number of years of work by H. H. Mitchell and T. S. Hamilton, Animal Nutrition. In particular the effect of a variable intake of the basal diet of milk alone was restudied, with adequate and inadequate supplements of iron and copper salts given either as a constant daily dose or as a percentage of the milk offered. Earlier experience was confirmed in showing that the rate of recovery from nutritional anemia was dependent upon the amount of milk consumed, as well as upon the amounts of metallic salts given. It was also found that supplements of manganese may or may not favor hemoglobin regeneration, depending probably upon the manganese content of the milk used. (416 Animal Husbandry)

Inheritance Study Aims to Aid Control of Hog Cholera

An unceasing fight against hog cholera must be carried on to protect Illinois swine, which on January 1, 1936, numbered nearly 4 mil-

$\sqrt[3]{\frac{W}{L}}$ in which W is the body weight in pounds and L is the length of the body in inches.

lion head and were valued at more than 57 million dollars. If a strain of swine resistant to hog cholera could be developed, as is the aim in an inheritance study under Elmer Roberts, Animal Genetics, and W. E. Carroll, Swine Husbandry, control of this disease would be greatly aided.

A few swine which survived hog cholera have been used as breeding stock, and during the past year twenty-five offspring from such parents were tested. None survived the disease. Because the original parent stock was small in number, inbreeding has been necessary. This may have contributed to weakening the resistance. (1017 Animal Husbandry)

Certain Corn Strains Differ Widely in Palatability

Further evidence that some strains of corn can be bred so that they will be more palatable than others to animals has come out of continued studies of this subject by Elmer Roberts and J. H. Quisenberry, Animal Genetics. Earlier results of tests of different strains of corn with mice and rats were reported in the Forty-Eighth Annual Report.

In the tests during the past year more than nine times as much of one strain of corn was eaten as of another, despite the fact that all were equally accessible to the experimental rats. The test was run over a period of six days, using Strains A, R₈, 90, 98, A × 90, A × 98, R₈ × A, and R₈ × 90. During the six days 45 grams of A were consumed, 392 grams of R₈, 53 grams of 90, and 196 grams of 98. When the four strains A × 90, A × 98, R₈ × A, and R₈ × 90 were tested, the total amounts in grams consumed were 122, 199, 190, and 62 respectively. These results indicate a definite preference for certain strains.

Observations made by J. R. Holbert, U. S. Department of Agriculture, at Bloomington on damage by mice to different genetic strains of corn also show significant differences. The percentages of ears sampled by mice varied from 34.5 to 98.6. The average number of kernels an ear damaged was as low as 1.2 in one strain and as high as 44.2 in another. (708 Animal Husbandry)

Lespedeza Hay Not Fully Equal to Alfalfa for Ewes

Winter feeding of bred ewes involves a number of problems on Illinois farms. When the flock makes poor returns, there is always a possibility that the ration may have had some influence on the results. Tests of various feeds during considerable portions of the pregnancy and suckling periods are therefore important. Questions pertaining to new feeds and to new combinations of feeds are in the minds of sheep raisers in their attempts to get good lamb crops and reduce production costs.

Korean lespedeza hay maintained ewes in a less thrifty condition

than either alfalfa hay or a supplemented silage ration in tests by W. G. Kammlade, Sheep Husbandry. This difference was especially noticeable in the period after lambing. Differences before lambing were not very marked, altho the ewes fed lespedeza hay were always in a less laxative condition than those fed alfalfa or corn silage.

Fifty-five five-year-old range Corriedale ewes were used in the trial. They had all been bred to a Shropshire ram and were all treated the same for more than two months before being put into the feedlots. The ewes were kept in drylot continuously from the beginning of the test, November 27, 1935, until turned on pasture, May 4, 1936. During that time only the feeds shown in Table 27 were fed. Because the ewes

TABLE 27.—RELATIVE MERITS OF ALFALFA, LESPEDEZA, AND CORN SILAGE FOR EWES, NOVEMBER 27 TO FEBRUARY 19: 84 DAYS

	Lot 1		Lot 2		Lot 3	
Number of ewes.....	18		18		19	
	<i>lbs.</i>		<i>lbs.</i>		<i>lbs.</i>	
Average initial weight.....	116.6		115.1		116.6	
Average weight after 56 days ¹	131.1		130.4		137.6	
Average gain for 56 days ¹	14.5		15.4		21.0	
Lambing record						
Average lambing date.....	(Feb. 21)		(Feb. 17)		(Feb. 18)	
Average birth weight, single lambs.....	10.3		10.2		11.0	
Average birth weight, twin lambs.....	8.6		8.4		9.0	
Feed a ewe	Daily	Total	Daily	Total	Daily	Total
Grain ².....	.5	42	.5	42	.5	41.5
Alfalfa hay.....	3.0	252	.....	.....	.....	.....
Lespedeza hay.....	.....	.....	3.0	252	.....	.....
Corn silage.....	.....	.....	.....	.....	6.2	524
Soybean oil meal.....	.....	.....	.....	.....	.21	17.7
Limestone.....	.....	.....	.....	.....	.02	2.2
Salt.....	.02	2.2	.02	2.2	.02	2.2
Cost of feed a ewe ³	\$.02	\$1.63	\$.02	\$1.63	\$.018	\$1.51

¹This was the last weight obtained before lambing began. ²Equal parts corn and oats by weight.

³Feed prices: shelled corn, 50 cents a bushel; oats, 25 cents a bushel; soybean oil meal, \$25 a ton; alfalfa and lespedeza hays, \$10 a ton; corn silage, \$3.50 a ton; limestone, 90 cents a hundredweight; and salt, 75 cents a hundredweight.

were in thin condition at the start, all were given a small amount of grain. All ewes had access to water. Results were measured by body weights of the ewes, birth weights of the lambs, and the general thriftiness of the ewes. The table contains data for the first part of the test. The same feeds were used, altho in increased amounts after lambing until May 4, when the feeding was discontinued.

Ewes of Lot 3 fed corn silage as the only roughage gained more weight during the fifty-six days before lambing began than did the lots fed alfalfa or lespedeza hay. Ewes fed silage were given a protein and mineral supplement composed of 800 pounds soybean oil meal, 100 pounds ground limestone, and 100 pounds of salt. This was fed

at the rate of .25 pound daily a ewe. Birth weights of the lambs, both singles and twins, were greatest in the lot fed silage.

Lespedeza hay produced approximately the same gain in weight as alfalfa, but the average birth weight of the lambs was slightly less. After lambing, the ewes fed lespedeza lost considerably more a head than did those of the other two lots. Furthermore their lambs, fed the same as the ewes, failed to gain so well as lambs in the other lots which received rations composed of the same kinds of feeds as their dams. Growth of the lambs in the lot fed lespedeza hay was markedly below that of the lambs in the lot fed alfalfa hay. At shearing time, after the ewes had been on feed for approximately five months, the fleeces of those fed lespedeza hay were noticeably poorer in condition than those fed either alfalfa or supplemented silage. Perhaps a small amount of some supplement, such as linseed oil meal or soybeans, might have offset this condition.

Cost of feeding the ewes was lowest in Lot 3, where silage was the roughage. Since each ewe in Lots 1 and 2 received the same amounts of feeds and since the unit costs of feeds used were the same, there was no difference in the cost of maintenance. While lespedeza hay is undoubtedly a valuable feed in many sections, it should not be considered superior to all other roughages merely on the basis of some producers' enthusiasm regarding it. (332 Animal Husbandry)

Alfalfa Excels Lespedeza as a Roughage for Lambs

Purchase price and feed costs are the two biggest items in the total costs of fattening the several hundred thousand range lambs fed on Illinois farms each year. The initial cost a lamb may be reduced significantly by the purchase of lightweight lambs if such lambs respond as well as heavier lambs in the feedlot. New feeds and new ways of using some well-known feeds were studied by W. G. Kammlade, Sheep Husbandry, in lamb-feeding experiments made during the past year.

Lightweight lambs averaging 50 pounds returned more profit than lambs averaging 79 pounds at the start of the test. A ration of shelled corn and alfalfa hay was somewhat more efficient than a ration of shelled corn and lespedeza hay. Corn silage was satisfactory as the only roughage when proper supplements were provided to offset its mineral and protein deficiencies. Such a ration might be of very great value under certain conditions.

The lambs used in this test were white-faced, crossbred Montana lambs. They were delivered to the Experiment Station farm on September 28, 1935. Two days later they were given hemorrhagic septiemia bacterin. Several days later they were dipped, eartagged, weighed individually, and sorted into lots. During the period from September 28 to October 8 they were fed alfalfa hay and had access to salt and water.

Experimental feeding began on October 9 and continued for 103 days. Rations that were compared included the standard ration of corn and alfalfa hay (Lot 1), corn and lespedeza hay (Lot 2), and corn silage and a supplement composed of 8 parts soybean oil meal, 1 part limestone, and 1 part salt (Lot 3). Lambs in Lots 1 and 2 got a definite amount of salt. Lambs in all three lots averaged about 65 pounds and none of them varied more than nine pounds from the average weights of the groups. Two other lots, one of lightweight lambs that averaged 50 pounds (Lot 4), and one of heavy lambs that averaged 79 pounds (Lot 5), were used. The light lambs ranged from 41 to 55 pounds and the heavy lambs from 73 to 92 pounds. Lambs of Lots 4 and 5 were fed the same as those of Lot 3, since the comparisons pertained to the size of the lambs.

All lots of lambs were hand-fed twice daily. Shelled corn was fed first, and then hay to Lots 1 and 2. The silage was placed in the feed racks, and the corn and supplement placed on it for Lots 3, 4, and 5.

A summary of the data obtained is given in Table 28. Lambs fed the regular standard ration of shelled corn and alfalfa hay ate and gained about as lambs usually do on this ration. A gain of .33 pound a day is considered normal. These lambs gained .34 pound daily. In nine previous tests lambs fed this ration have required 350 pounds of corn and 458 pounds of alfalfa for 100 pounds gain. The lambs in Lot 1 in this trial required 335 pounds of corn and 487 pounds of alfalfa hay.

Lambs of Lot 2 fed shelled corn and lespedeza hay gained 2.3 pounds a head less than those of Lot 1. This is a difference of 7 percent in favor of Lot 1. The lambs in Lot 2 required approximately 6 percent more corn and 5.5 percent more hay than those of Lot 1 for each 100 pounds gain. The cost of gain was therefore greater in Lot 2. Lambs of Lot 2 dressed higher than those of Lot 1, however, and aside from the slower and more costly gains the lespedeza hay seemed to be satisfactory altho apparently less palatable than alfalfa.

While the rations used for Lots 3, 4, and 5 may not be advisable except in unusual circumstances, the results may be taken to show the suitability of silage as the only roughage in lamb-fattening rations if properly supplemented with a protein concentrate and limestone. The supplemented silage ration was slightly superior to that containing lespedeza hay.

The lightweight lambs (Lot 4) made the cheapest gains and the heavy lambs (Lot 5) the most expensive gains of any lots. Owing to their light weight and lack of finish, sixteen of the lambs of Lot 4 were kept for further feeding. On the basis of those marketed from this lot, the lightweight lambs were most profitable and heavy lambs least profitable. The heavy lambs were not discounted because of weight, but a discount of 75 cents a hundred pounds would have just permitted

TABLE 28.—RELATIVE MERITS OF ALFALFA, LESPEDEZA, AND CORN SILAGE AS ROUGHAGES FOR WESTERN LAMBS, OCTOBER 9, 1935, TO JANUARY 20, 1936: 103 DAYS

	Lot 1		Lot 2		Lot 3		Lot 4		Lot 5	
Number of lambs.....	42		42		44		41		43	
Died or removed.....	2		2		0		2		0	
	<i>lbs.</i>		<i>lbs.</i>		<i>lbs.</i>		<i>lbs.</i>		<i>lbs.</i>	
Initial weight.....	64.9		64.5		64.5		50.0		79.0	
Total gain.....	35.5		33.2		33.1		31.5		30.3	
Daily gain.....	.34		.32		.32		.31		.29	
Shrinkage in shipping.....	5.2		5.7		5.0		4.7 ^a		5.4	
Dressing percentage.....	49.8		50.9		50.5		50.5 ^a		52.4	
Feed a lamb	Daily	Total	Daily	Total	Daily	Total	Daily	Total	Daily	Total
Corn.....	1.15	119.2	1.14	117.6	1.11	114.3	1.04	105.9	1.19	122.5
Alfalfa.....	1.68	173.1	.....	.....	.....	.....	.....	.....	.....	.....
Lespedeza.....	.....	.....	1.65	170.2	.....	.....	.....	.....	.....	.....
Silage.....	.....	.....	.....	.....	2.88	297.1	2.14	225.0	3.13	322.1
Soybean oil meal.....	.....	.....	.....	.....	.20	21.2	.22	22.4	.22	21.6
Limestone.....	.....	.....	.....	.....	.02	2.6	.03	2.8	.03	2.7
Salt.....	.02	2.4	.02	2.4	.02	2.6	.03	2.8	.03	2.7
Roughage refused.....	1.6%		4.0%		1.7%		2.5%		1.7%	
Feed for 100 pounds gain	<i>lbs.</i>		<i>lbs.</i>		<i>lbs.</i>		<i>lbs.</i>		<i>lbs.</i>	
Corn.....	335		355		345		337		405	
Alfalfa.....	487		.....		.....		.....		.....
Lespedeza.....	.....		513		.....		.....		.....
Silage.....	.....		.....		896		716		1065	
Soybean oil meal.....	.....		.....		63.8		71.4		71.5	
Limestone.....	.....		.....		8.0		8.9		8.9	
Salt.....	6.7		7.1		8.0		8.9		8.9	
Feed cost for 100 pounds gain ¹	\$5.49		\$5.78		\$5.58		\$5.30		\$6.52	
Total feed cost a lamb.....	1.94		1.92		1.84		1.66		1.96	
Profit per head over buying, feeding, and marketing costs ²	1.25		.89		1.08		1.75 ^a		.76	

¹Feed prices: shelled corn, 50 cents a bushel; soybean oil meal, \$25 a ton; alfalfa and lespedeza, \$10 a ton; silage, \$3.50 a ton; limestone, 90 cents a hundredweight; and salt, 75 cents a hundredweight. ²All lambs sold at \$10.25 a hundredweight except 3 in Lot 2 and 1 in Lot 3 which sold at \$9.50. ^aBased on 24 lambs sold. The other lambs in this lot were continued on feed and slaughtered locally.

breaking even on the basis of costs included. Carcasses of the lambs of Lot 5 were well finished.

Illinois feeders may expect good results from home-grown rations if carefully fed to healthy lambs. On the basis of this test farmers in those regions where lespedeza may be grown more readily than alfalfa may fatten lambs satisfactorily with lespedeza. This and previous tests have shown that corn silage may be made to serve as the only roughage for fattening lambs. Shortages or extremely high prices of legume roughages would make this advisable. Sixty- to 65-pound lambs are most suitable for the average feeder. (333 Animal Husbandry)

Lambs Require Less Protein Than Commonly Supposed

Further evidence that protein requirements of lambs are lower than commonly supposed has come out of further studies of this question by the Experiment Station.

Estimates of the nutritive requirements of growing and fattening lambs were published in the Forty-Fifth Annual Report. These estimates were based, not upon feeding experiments, but in part upon the results of carcass analyses of lambs in different stages of development. From these analyses it was possible to compute the rate of deposition of the various nutrients in the body during growth. Estimates of maintenance and activity requirements were also made from other information. Finally all of these estimates were combined to give total net requirements. These estimates were expressed provisionally in terms of digestible protein and total digestible nutrients. The figures thus obtained indicated much lower protein requirements than current feeding standards prescribe. Thus for lambs weighing 50 to 75 pounds, rations with nutritive ratios of 1:10 or 1:11 appeared to be adequate, altho ratios of 1:6.5 up to 1:7.4 are recommended. Altho it may not be possible in practice to prepare rations with as wide a nutritive ratio as 1:11 that are palatable to growing lambs, it seemed important to determine by a feeding experiment whether such a low concentration of protein will suffice for growth and fattening. Such an experiment has been started during the past year by W. G. Kammlade, Sheep Husbandry, and H. H. Mitchell and T. S. Hamilton, with the technical assistance of W. T. Haines, all of the division of Animal Nutrition. Further work is being done during the current year.

A ration containing 9 percent of crude protein, with an estimated nutritive ratio of about 1:10, promoted as rapid growth in lambs weighing 50 to 75 pounds as one containing 13 percent of protein obtained by substituting casein for starch, altho neither ration was particularly palatable. Carcass analysis revealed a slightly greater deposition of protein on the higher-protein ration, but a considerably smaller deposition of energy.

Eight pairs of lambs weighing initially from 54 to 74 pounds were

sheared and put on experimental feeding on November 9, 1935, and fed for 100 days. One lamb in each pair received the low-protein ration containing approximately 9 percent of protein, while the other lamb received the same amount of the high-protein ration containing approximately 13 percent of protein. The two rations were very nearly the same in gross energy value, namely, 3.87 and 3.91 calories a gram. They contained the following ingredients:

	<i>Low-protein ration lbs.</i>	<i>High-protein ration lbs.</i>
Ground corn.....	30	30
Linseed oil meal.....	5	5
Brown sugar.....	11.75	11.75
Starch.....	11.75	6.75
Casein.....	0	5
Alfalfa hay.....	20	20
Timothy hay.....	20	20
Salt.....	.5	.5
Bone meal.....	1	1
Cod-liver oil.....	.5	.5

At the termination of the feeding period the lambs were sheared and measured and those in the three pairs that had not lost in weight were slaughtered for chemical examination.

In general the lambs did very poorly because they consumed little of the rations—only from 1.26 to 2.37 pounds daily. However, the low-protein content of the rations can hardly be the cause, because neither the appetite nor the changes in body weight were improved by the inclusion of 5 percent of casein in the low-protein ration. On the low-protein ration the lambs lost an average of 1.75 pounds and on the high-protein ration, 2.75 pounds during the 100 days of feeding. Also the linear measurements taken at the termination of the experiment revealed no advantage of the high-protein over the low-protein ration, as the following tabulation shows:

	<i>Knee to pastern, inches</i>	<i>Length of head, inches</i>	<i>Top of shoulder to ground, inches</i>	<i>Width of hips, inches</i>	<i>Sternum to ischium, inches</i>
Average for low-protein lambs....	5.51	8.67	23.5	5.92	24.2
Average for high-protein lambs....	5.54	8.55	22.7	5.60	25.3
Number of pairs favoring high-protein ration.....	4	5	3	2	6

These results with lambs are in striking contrast to those obtained with eight pairs of rats which were used in a comparison of the same rations fed to the lambs. After six weeks of feeding, the rats on the 13-percent protein ration had gained 33 percent more than the rats on the 9-percent ration on the same amount of food and had attained the greater body length in each pair. The rates of gain were very good considering the bulkiness of the rations, averaging 2.13 grams daily on the high-protein ration and 1.60 grams daily on the low. These rat

experiments show that both rations were adequate in vitamins and minerals to support a rapid rate of growth when consumed in adequate amounts and that any difference in their growth-promoting values as a result of the difference in protein content will be revealed. With rats such a difference does exist; with lambs apparently no such difference exists.

At the termination of the lamb experiment, Pairs 3, 4, and 6, which showed some gain in weight, were sheared and slaughtered for chemical analysis. The total gains in weight of these pairs, taking the low-protein lamb first, were 9 and 12 pounds, 11 and 8 pounds, and 0 and 3 pounds. Results of the chemical study are summarized in Table 29.

TABLE 29.—CHEMICAL COMPOSITION OF THREE PAIRS OF EXPERIMENTAL SHEEP IN COMPARISON OF HIGH- vs. LOW-PROTEIN RATION

Sheep No.	Protein in ration	Final live weight	Composition of carcass			Nutrients and energy in carcass			Wool protein
			Crude protein	Fat	Gross energy	Crude protein	Fat	Gross energy	
		<i>lbs.</i>	<i>perct.</i>	<i>perct.</i>	<i>cal. a gm.</i>	<i>gms.</i>	<i>gms.</i>	<i>therms¹</i>	<i>gms.</i>
220	9 percent . . .	81	14.16	33.66	3.89	4 350	10 343	119.5	668
235	13 percent . . .	86	15.99	24.70	3.14	4 858	7 504	95.5	806
228	9 percent . . .	79	15.36	30.31	3.64	4 398	8 681	104.4	624
234	13 percent . . .	75	16.20	25.57	3.26	4 557	7 193	91.8	631
222	9 percent . . .	64	15.32	31.34	3.75	3 700	7 569	90.5	519
223	13 percent . . .	66	16.40	24.81	3.27	3 781	5 721	75.4	526

¹One therm is equal to 1,000 calories.

The protein content of the lambs raised on the high-protein ration was higher in each pair, but the fat and energy contents were lower. Furthermore more protein was present in the wool of the high-protein lambs than in that of their pair mates, altho for two pairs the differences were slight. Considering the total protein and energy in both carcass and wool, the three high-protein lambs contained 12.9, 3.3, and 2.1 percent more protein than their respective pair mates, but on the other hand, the low-protein lambs contained 25.1, 13.7, and 20.0 percent more energy. If the protein adequacy of the rations is judged by the changes in body weight and body dimensions or by the availability of the food energy, the 9-percent protein ration would seem to be adequate, but if judged by the ability to promote protein storage, it would seem to be slightly inadequate. (1095 Animal Husbandry)

Value of Horse-Parasite Control Widely Recognized

Value of sanitary measures and annual treatment in the prevention and control of parasites in horses has become widely recognized as a

result of continued studies by the Experiment Station. The recommended procedure is now followed quite generally thruout the state. Further treatment of horses during 1935-36 has confirmed the improvement noted in previous years, while the value of microscopic examinations in the diagnosis of parasitic infestation of horses preparatory to treatment has been repeatedly observed.

For the sixth consecutive season the horse-parasite-control project was continued in various localities of the state during the winter months of the past year under the leadership of Robert Graham and Frank Thorp, Jr., Animal Pathology and Hygiene, and J. P. Torrey, Illinois State Department of Agriculture.¹ Records of horses treated

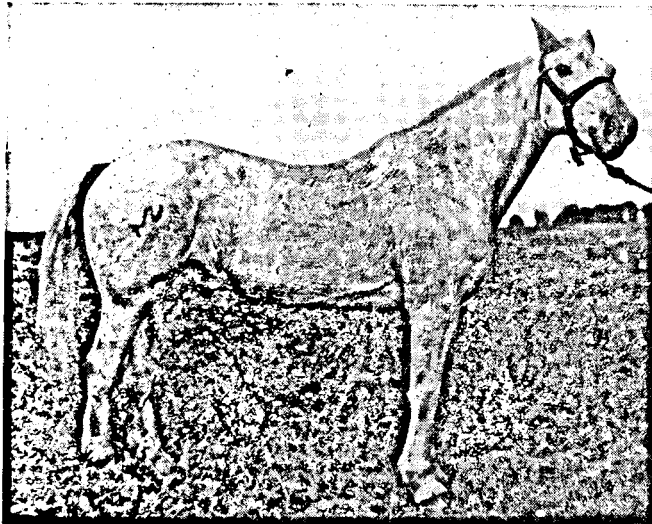


FIG. 16.—HORSE 13A, PROOF OF THE LASTING BENEFITS OF PARASITE-CONTROL TREATMENT

Once given up as a hopeless case and about to be destroyed, this horse on June 9, 1936, had a hemoglobin reading of 12.28 grams in each 100 cc. of blood and weighed 1,180 pounds. Four and a half years before he had been highly parasitized, weighed only 895 pounds, and had a hemoglobin reading of 6.64 grams in each 100 cc. of blood. This horse was treated annually for parasites from 1932 to 1935, but no treatment was administered in 1936.

¹This project is conducted in cooperation with the Illinois State Department of Agriculture, Illinois Veterinary Medical Association, Illinois Natural History Survey, Federal Office of Cooperative Extension Work, Federal Bureau of Animal Industry; Department of Entomology, University of Illinois; Federal Bureau of Entomology; and Extension Service in Agriculture and Home Economics, College of Agriculture, University of Illinois.

were made in a limited number of counties in cooperation with farm advisers and veterinarians. However, improvement following treatment has been demonstrated in many localities of the state and thousands of treated horses in Illinois have worked better, handled easier, and made better use of feed in manufacturing horsepower. Evidence of continued improvement following treatment is found in the case of experimental horse 13A, which is one of a group of horses that has been under observation since 1932. In February of that year this animal was highly parasitized and weighed only 895 pounds and had a hemoglobin reading of 6.64 grams in each 100 cc. of blood. Marked improvement followed repeated treatment for intestinal parasites. This animal was treated annually for intestinal parasites from 1932 to 1935. No treatment was administered in 1936, but the improvement noted in preceding years endured. On June 9, 1936, hemoglobin was 12.28 grams in each 100 cc. of blood and the weight was 1,180 pounds. (1080 Animal Husbandry)

Cause of Cornstalk Disease of Horses Not Yet Found

Certain conclusions about the so-called cornstalk disease of horses have now been reached, but the specific causative agent has not been located in further studies of this problem by Robert Graham and Frank Thorp, Jr., Animal Pathology and Hygiene, and E. H. Barger and J. P. Torrey, Illinois State Department of Agriculture.

During the past year a preliminary study of the pathogenic properties of mold species, including aspergillus, penicillium, actinomyces, and botryosporium, from the brains of naturally affected horses, as well as streptococci and pasteurilla-like microorganisms isolated from the brains of horses that died of so-called cornstalk disease, has been made. None of the mold species on subcutaneous injection into guinea pigs, rabbits, and pigeons or on intravenous or intracerebral inoculation of horses displayed significant pathogenic properties. These molds also were fed in liberal quantities to horses without any results.

A streptococcus isolated from the brain of a naturally affected horse, as well as a pasteurilla strain isolated from the brain of a naturally affected horse, produced death upon intracerebral inoculation into healthy experimental horses. At the point of inoculation a circumscribed area of softening was occasionally encountered at autopsy. The severe method of exposure obviously precluded any specific significance of these microorganisms to the disease other than to support the contention that a localized streptococci or pasteurilla infection of the cerebrum might prove fatal. The intravenous injection of these microorganisms washed from blood-agar slants and suspended on saline, however, frequently proved lethal to horses. On the other hand, these organisms introduced into the blood stream or fed by mouth failed to localize in the brain or produce symptoms of illness in healthy horses.

The difficulty in propagating *pasteurella* from the tissue of fatally affected horses was suggested in the negative results of direct cultures from artificially inoculated horses as well as by the negative results from inoculation of cultures which had been proved positive. Factors influencing the cultural results apparently include the type of media, as well as other known and unknown factors. The irregularity in regaining *pasteurella* from a natural peracute case of cornstalk disease is illustrated in the results of subcutaneous animal inoculations of peritoneal fluid, heart blood, spinal fluid, and brain cultures into rabbits, guinea pigs, and pigeons.

Four of eight animals yielded *pasteurella* from the inoculation of peritoneal fluid cultures. Heart blood which yielded *pasteurella* on direct cultures was inoculated into ten animals, but *pasteurella* was recovered only from the two inoculated animals that died. Only one animal of nine inoculated with cultures from the spinal fluid proved positive to *pasteurella*. Horse-brain liquid cultures inoculated into two animals yielded one isolation.

A resumé of the experimental studies to date follows:

1. No specific etiologic agent has been encountered as the cause of so-called cornstalk disease which occurred in epidemic form in Illinois in 1934 and 1935.
2. So-called cornstalk disease in horses was experimentally reproduced in healthy horses that were allowed to graze in a stock field where the disease had occurred under natural conditions.
3. All efforts to reproduce the disease by the injection of brain tissue from naturally affected horses failed.
4. No evidence of a filtrable virus was found via the inoculation of more than fifty separate horse brain tissues into guinea pigs, rabbits, mice, and pigeons.
5. A variety of aerobic bacteria, including cocci and Gram-negative rods indistinguishable from *pasteurella*, as well as a variety of mold species, were isolated from the brain of naturally infected horses.
6. The 1934-35 outbreak in Illinois was preceded by a drouth. The corn was of inferior quality and badly damaged by the corn ear worm. Many of the afflicted horses grazed in stock fields or were fed damaged corn.
7. Approximately 65 percent of the brains of more than 50 natural cases, as judged by clinical symptoms, showed encephalomalacia or gross softening of the cerebrum.
8. Microscopic pathology of brain tissues from naturally affected horses did not resemble the infectious, or virus, type of encephalomyelitis, commonly referred to as sleeping sickness, as reported in other sections of the United States, particularly the east and west coasts.
9. The blood of horses that suffered from the natural disease failed to show any significant cellular changes.

Until the specific agent or agents involved in the disease can be defined, control measures recommended in the prevention of so-called cornstalk disease in horses include prompt elimination and stimulative treatment of afflicted animals. These measures in the early stages of the disease have yielded quite satisfactory results. Prevention by keeping horses out of cornfields is of the greatest importance, but it is recognized that a similar clinical malady may occasionally develop when horses are not fed damaged corn. (1217 Animal Husbandry)

Weight Most Important Factor in Pulling Ability

Pulling contests have been held for the past ten years to determine what relationship there might be between the characteristics of horses and their pulling ability.

It was concluded by C. W. Crawford, Horse Husbandry, E. T. Robbins, Livestock Extension, and W. M. Dawson, Animal Genetics, that weight was the most important factor and that large heart girth, drafty proportions, a moderate degree of flesh, and sharp shoes contributed to good pulling ability. Disposition, training, and the skill of the driver also are factors of importance, but are not readily appraised.

One contest in 1935 was confined to three-year-old breeding stallions, certified to be sound. Ten were entered. Each one was allowed to pull with any horse for a mate. In addition each colt alone pulled a farm wagon with two men in it. The time to walk a mile on a muddy track with this load varied from 15 minutes and 15 seconds to 19 minutes and 30 seconds. The best of the colts lifted their half of 3,000 pounds on the dynamometer. However, none went the full official distance of $27\frac{1}{2}$ feet with this lift. The state record for teams of any kind is 3,400 pounds lifted $27\frac{1}{2}$ feet. These three-year-old stallion records indicate that some progress can be made in identifying young breeding stallions with the disposition and ability to pull great loads. It is hoped that the efficiency of draft stock may be increased by using good pulling stallions for breeding purposes. (114 Animal Husbandry)

Practicability of Forced Molting Given Further Study

Profits from the chickens which are raised on 95 percent of the 231,000 farms in Illinois could be substantially increased if molting and its accompanying period of nonlaying could be brought on in the early summer, when egg prices are relatively low, instead of during the fall when the prices are relatively high. Further studies of the practicability of forcing hens out of egg production in the summer in the hope of obtaining above-normal production in the fall are being conducted by L. E. Card, H. J. Sloan, and H. H. Alp, Poultry Husbandry.

In the work of the past year two pens of White Leghorns have been subjected to the forced-molting method of management, while a third pen of the same breeding has been kept under the ordinary plan

in which the hens are permitted to molt at the normal time. The early molt was accomplished by restricting the flock to grain only—that is, no mash was fed—for a period of six weeks. This period began on May 30 for one of the pens and on June 28 for the other.

At the end of the first twelve months the results did not indicate any advantage from the forced molt. Instead there was a somewhat lower egg yield and a lower total income from the pens subjected to forced molting than from the control pen. The important data are given in Table 30.

TABLE 30.—EFFECT OF FORCED MOLTING ON EGG PRODUCTION, 1935

Treatment	Average production first 12 months (hen-day basis)	Distribution of eggs by size			Value of eggs a hen ¹
		More than 54 grams	45 to 53 grams	Less than 45 grams	
		<i>perct.</i>	<i>perct.</i>	<i>perct.</i>	
No mash for 6 weeks beginning May 30.....	175	24.5	65.0	10.5	\$3.02
No mash for 6 weeks beginning June 28.....	174	30.2	56.1	13.7	3.05
Control.....	196	27.4	59.8	12.8	3.41

¹Egg values calculated by using four-year average prices, 1932-1935.

Surviving hens are being carried thru a second year of laying in which all will be treated alike. It is possible that the two-year results may show a different outcome. In fact one of the advantages claimed for the practice of forced molting is that it avoids a part of the high depreciation cost which is necessarily incurred in the annual replacement of old hens with pullets. Even tho there is no actual gain in dollars and cents, the practice may still be justified in flocks where it is necessary to maintain a high fall and early winter production of large eggs to supply a special trade. (612 Animal Husbandry)

Program Against Pullorum Disease Is Showing Results

Progress in the control of bacillary white diarrhea, or pullorum disease, one of the most costly maladies in Illinois poultry flocks, is reflected in the fact that only 228 specimens of the disease in chicks were received for diagnosis at the Laboratory of Animal Pathology and Hygiene during the past year. This is a marked decrease in the number of pullorum-disease diagnoses made. The decline in positive diagnosis has paralleled the growth and application of recommended control measures as worked out by Robert Graham, Animal Pathology and Hygiene, and E. H. Barger and J. P. Torrey, Illinois State Department of Agriculture.

One further step during the past year was the preparation for demonstrational purposes of 14,641 doses of pullorum stained antigens for distribution to veterinarians cooperating in the project on control of this disease.

Fifty-eight samples of commercially prepared pullorum stained antigen also have been examined during the past year for purity, density, and sensitivity to assist the State Department of Agriculture in the federal-state program of poultry improvement. The purpose of such examinations of all antigens used in official testing is to eliminate unsatisfactory antigen and thus protect the program of pullorum-disease control. Results of examining different serial lots of antigen from various manufacturers are forwarded to the Chief Veterinarian, State Department of Agriculture. (1205 Animal Husbandry)

Laryngotracheitis Vaccine Is Given Further Study

Profits from the 35 million or more chickens usually raised on Illinois farms each year are closely related to the level of health maintained in the individual flocks. Better control of the respiratory

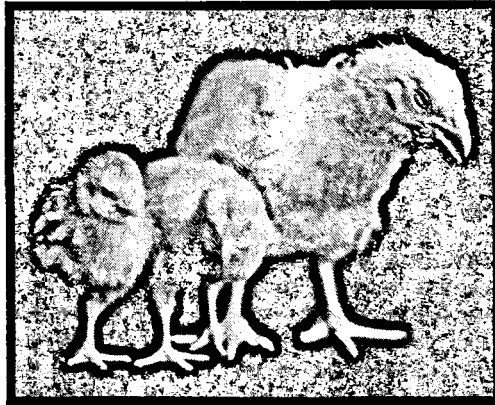


FIG. 17.—CORYZA IN CHICKS, A DISEASE SOMETIMES CONFUSED WITH LARYNGOTRACHEITIS

Spontaneous outbreaks of coryza and of bronchitis in young chicks have on some occasions originated from the same hatchery, suggesting the possibility of infection at the time of or shortly after hatching. Careful cleaning and disinfection of the hatchery, together with disposal of recovered chicks, checks the spread of the disease.

diseases affecting fowls would substantially increase the profits from poultry. Studies of these diseases have been continued. As the result of sporadic outbreaks of infectious laryngotracheitis during the past ----- there was opportunity to extend the application of experimental

autogenous laryngotracheitis vaccine. In this work, which was in charge of Robert Graham and C. A. Brandly, Animal Pathology and Hygiene, more than a thousand doses of autogenous vaccine were prepared for demonstrational purposes in different flocks.

As during the preceding year, the vaccine was prepared from naturally affected fowls by making a 1-percent suspension of the tracheal exudate in a sterile physiological saline solution. Vaccine prepared in this manner was used immediately to avoid deterioration. All experimental autogenous vaccine was supplied to the flock owners thru qualified veterinarians.

In view of the occurrence of coryza-like and laryngotracheitis-like diseases, the importance of a correct diagnosis was emphasized in connection with the vaccination of flocks for laryngotracheitis. The application of laryngotracheitis vaccine in a flock suffering from coryza or other respiratory diseases may apparently intensify the death rate. Since symptoms of dyspnea, or gasping, may be present in different diseases of poultry, an unproved diagnosis of laryngotracheitis followed by vaccination may not only fail to check the disease, but also may superimpose laryngotracheitis upon an existing infection. This danger may be largely eliminated by using an autogenous laryngotracheitis vaccine. Autogenous vaccines for the control of laryngotracheitis also have an apparent advantage as a means of preventing the introduction of extraneous infections thru the use of living-culture vaccine from sources other than infectious fowls in the flock to be vaccinated.

Evidence of the carrier feature of laryngotracheitis in recovered fowls was presented during the past year, the recurrence of the disease in previously affected flocks suggesting the danger of recovered fowls associating with pullets.

In a study of different outbreaks of respiratory diseases in fowls a disease resembling coryza, as well as the disease first described by Schalk and Haun (1931), was encountered in young chicks in different Illinois flocks during the 1936 hatching season. This malady is characterized by difficult respiration, together with an inflammation of the trachea bronchi as well as of the eyes and sinuses. Under farm flock conditions it often appears quite indistinguishable from laryngotracheitis. Laboratory tests, however, failed in several cases to indicate the presence of a filtrable agent as in laryngotracheitis, while pathogenic microorganisms of the group described in connection with natural outbreaks of coryza by investigators of poultry diseases were encountered. Spontaneous outbreaks of coryza and of bronchitis in young chicks as observed in Illinois have on some occasions originated from the same hatchery, suggesting the possibility of infection at the time or shortly after hatching or en route from hatchery to farm. In a study of one outbreak definitely traceable to a common hatchery, it was observed that careful cleaning and disinfection of the hatchery,

together with proper disposition of recovered chicks, eliminated the disease. (1213 Animal Husbandry)

Filtrable-Virus Diseases Probed in New Studies

So-called filtrable-virus diseases of domestic animals constitute a serious hazard to livestock production. The number of diseases known to be caused by agents belonging to this group has increased rapidly during the past decade. This comes about not alone because new virus diseases have been discovered, but also because certain maladies which were previously attributed to other causes have been identified with the filtrable-virus group. Certain of these diseases—for example, rabies—represent important public-health, as well as economic, problems. Approximately twenty diseases of man and forty of animals are recognized as being caused by filtrable-virus or by filtrable-virus-like agents. The present nature of the virus and virus-like diseases is not known. Among the more prevalent filtrable-virus diseases menacing the livestock industry are hog cholera, swine influenza, equine encephalomyelitis, vesicular stomatitis of horses and cattle, the poxes, sore mouth of sheep, canine distemper, infectious laryngotracheitis of chickens, and fowl leucemia.

Heretofore inability to propagate the etiological agents in large quantities in an artificial or an isolated medium has been the most important factor limiting progress in the study of filtrable-virus diseases of animals. More recently the progress in egg propagation of viruses has been recognized as a significant and promising advancement which warrants further critical studies of the subject. Such studies have been undertaken by C. A. Brandly, Robert Graham, G. L. Dunlap, and L. E. Boley, Animal Pathology and Hygiene. The ready adaptability and economy of the method of egg propagation of various viruses have allowed its liberal use in the work conducted to date. Those results which are deemed of sufficient significance and upon which suggestive or conclusive observations have been possible are included in this report.

In order to maintain both fowl-pox and laryngotracheitis viruses at their full infective strength thru continued egg passage, the investigators found that the use of the early lesions transferred directly to a new series of eggs was desirable. However, storage at low temperatures for limited periods, particularly if the material was dried in vacuum in the cold with a satisfactory desiccating agent or agents, preserved the virulence of the viruses for considerable periods of time. Fowl-pox virus so produced and stored was found satisfactory over extended periods for use in experimental and field vaccination. In preliminary observations upon the nature of the "takes" and the severity of post-vaccination reactions, the investigators found that the bacteria-free, egg-propagated, fowl-pox vaccine appeared to possess some dis-



FIG. 18.—FOWL-POX "TAKES" INDICATING DIFFERENCE BETWEEN BACTERIA-FREE, EGG-PROPAGATED VACCINE AND COMB VACCINE

These "takes" are in turkeys eight to nine weeks of age. The ones on the left, with comb vaccine, are darker and deeper and show more of an inflammatory reaction than the ones on the right with egg vaccine.

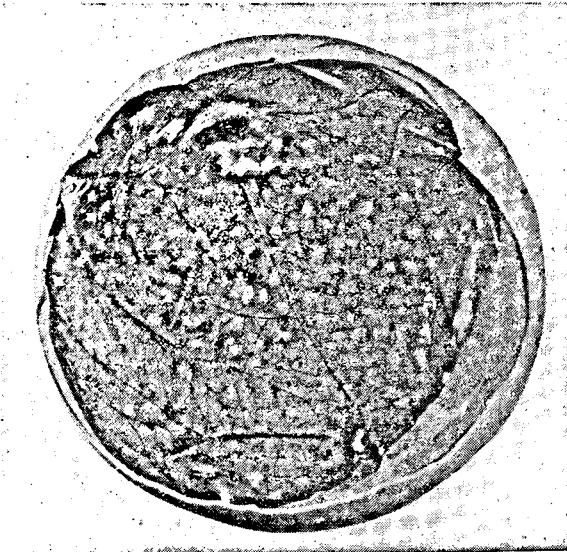


FIG. 19.—INFECTION OF DEVELOPING CHICKEN EGG WITH STRAIN J

This strain is one of two groups of the virus apparently distributed in this country. Results suggest that in vaccination by the cloacal method the egg-cultivated virus may be substituted to advantage for the tracheal exudate.

tinct advantages over the bacteria-carrying, comb-propagated pox vaccine. A feature of the differences obtained is demonstrated in Fig. 18.

Several requests for the egg-cultivated, fowl-pox vaccine have been filled for use by cooperating veterinarians and flock owners. To date complete reports of the results secured have not been obtained.

Studies dealing with egg propagation, particularly in so far as susceptibility of the eggs of species of domestic poultry other than chickens is concerned, have yielded some interesting results. Developing duck, guinea-fowl, and turkey eggs were successfully infected with fowl pox, and some tentative observations relative to immunity and resistance were recorded for further study. In this connection it is of interest to note that the turkey naturally is not so susceptible to fowl pox as the chicken, while this disease is rarely observed in guinea fowl and ducks in Illinois farm flocks.

A repetition of previous susceptibility tests using a strain of laryngotracheitis virus J gave results similar to those that had been obtained in the initial test. Duck and guinea-fowl eggs proved refractory to exposure to this strain of virus, as manifested by the absence of cellular pathology, while turkey as well as chicken eggs were readily infected. This situation, so far as the occurrence of the disease among farm poultry is concerned, is interesting because of the four species only the chicken is susceptible to natural or artificial exposure to laryngotracheitis.

Vaccination and immunity experiments with various strains of egg-propagated laryngotracheitis virus have yielded results suggesting that in protective vaccination by the cloacal method the egg-cultivated virus may be substituted to advantage for the tracheal exudate employed heretofore. It was also found that among the strains of this virus studied, two groups corresponding to the groups occurring in Australia¹ were present and apparently distributed in this country. Fig. 19 represents strain-J infection of the developing chicken egg.

Tentative negative results were obtained in attempts to propagate hog-cholera virus in developing chicken eggs incubated ten to twelve days prior to injection with the bacteria-free blood of cholera-affected swine. (1218 Animal Husbandry)

More Efficient Sanitation Needed to Check Diseases

Estimated farm value of poultry and eggs produced in Illinois annually exceeds \$100,000,000, notwithstanding that flock mortality is seldom lower than 10 to 12 percent and often as high as 40 to 50 percent. The relative importance of different diseases in these losses has been revealed in a preliminary study of causes of mortality in Illinois farm flocks by Robert Graham, C. A. Brandly, and L. E. Boley,

¹BURNET, F. M. Jour. Expt. Med. 63, 685. 1936.

Animal Pathology and Hygiene; and H. W. Johnson, Illinois State Department of Agriculture. These studies were made in the diagnostic work which is a cooperative project between the Illinois State Department of Agriculture and the Department of Animal Husbandry.

In 6,800 autopsies on poultry specimens from Illinois farm flocks, 7,951 diseases were encountered including a variety of specific parasitic, bacterial, mycotic, avitaminotic, and filtrable-virus diseases of poultry. About 40 percent of the cases, or 2,738, were of parasitic worms; 2,081, or approximately 20 percent, were germ or bacterial diseases; while 1,476, or approximately 22 percent, were filtrable-virus diseases. Protozoan diseases were encountered in 1,431 cases, or approximately 20 percent; while nutritional or avitaminotic diseases were encountered in only 4 percent.

A study of the intestinal parasites encountered in the 2,738 parasitic infestations in 6,800 autopsies revealed that 1,311, or approximately 47.9 percent, were tapeworm infestations; 730, or approximately 26.7 percent, were ascarids; while 430, or approximately 15.7 percent, were capillaria infestations; with cecal, gizzard, and filaria infestations in a smaller number of cases.

During 1934-35 autopsies also were conducted on available birds that died in each of twenty-six pens in the Experiment Station flock of 1,372 birds, including hens and pullets. The lowest mortality of any pen was approximately 26 percent, while the highest pen mortality was 74 percent, with an average mortality in all pens of 519 fowls for the year, or 37.83 percent.

Of the 519 fowls that died 319 were subjected to gross autopsy and to bacteriologic and microscopic examination. Leucemia was the predominating flock disease, while tapeworm, roundworm, and cholera losses occurred in the flock in the sequence mentioned. The incidence of parasitic worms together with a knowledge of their ill-effects on poultry health definitely establishes parasitism as a serious factor in poultry mortality. The flock was vaccinated against pox, and as this infection has occurred on the premises, the value of prophylactic measures is again suggested.

A study of the losses in the pen with the highest mortality revealed that fowl cholera was the chief cause of death, while leucemia and tapeworms were encountered in the order mentioned. Development of cholera was possibly favored by the presence of other diseases. Tapeworm infestation predominated in the pen with the second highest mortality, with only a single case of leucemia. In the pen with the second lowest mortality leucemia was the chief offender, followed closely by fowl cholera. In pens having the second highest and second lowest mortality, it is interesting to note that leucemia, tapeworms, coccidiosis, roundworms, and fowl cholera all were encountered. Tho the losses from these different diseases were variable, they prove that a

specific disease may be present with a low mortality. This accounts for apparent unexplained outbreaks of different diseases with heavy losses.

The relation of weather to poultry mortality is suggested in the incidence of mortality experienced during the different months. The highest death rate came in January.

In connection with mortality studies in poultry an opportunity has been afforded to try kamala and lye in the treatment of poultry infested with tapeworms. Untreated birds were left in the flock, and three months after treatment all birds were autopsied and examined. Eight of the 21 birds treated with kamala, or 38 percent, showed tapeworm infestation following treatment, while 15 of the 22 untreated birds, or 68.18 percent, were infested. Thus there was 44 percent less infestation in the treated birds than in the untreated.

In another group of approximately fifty pullets kept on contaminated ground, the lye treatment was administered three consecutive times at monthly intervals. Approximately three months following treatment, the treated and untreated birds in this flock were autopsied and examined. Seven of the 21 treated birds, or 33 percent of them, showed tapeworm infestation, while 10 of the 23 untreated birds, or 43 percent, were infested. Thus there was only 23 percent less tapeworm infestation in the fowls treated with lye than there was in those not treated.

Studies in avian diseases have been extended into still another field in connection with the work which the Illinois State Department of Conservation is doing to protect wild life in Illinois. This program calls for the brooding and hatching of thousands of quail annually. At one of the state game farms which has been operated successfully for many years, a high mortality in baby quail was experienced during the summer of 1935. Many apparently healthy quail, ranging from three days to six weeks of age, died suddenly without showing premonitory symptoms of illness. Baby quail that appeared healthy in the evening were found dead the following morning. In some brooders the mortality was as high as 75 percent, while it was estimated that 60 percent of all quail hatched succumbed.

An inspection of the premises revealed excellent sanitary conditions and approved methods of hygienic feeding. In an effort to determine the cause of the sudden loss of young quail, a bacteriological examination was made of twelve pipped quail eggs immediately preceding hatching, along with sixteen freshly laid eggs and five dead baby quail. The fresh eggs as well as the yolks of pipped eggs yielded unidentified streptococci and colon types. The livers of five dead quail were removed and ground in sterile mortar and pestle. Gentian-violet agar plates were streaked with the finely ground liver tissue. An examination of the inoculated plates following incubation at 37° C. for 24

hours showed numerous isolated colonies which, on staining and transferring to differential media, proved to be Salmonella-like microorganisms. The Salmonella type from quail possesses cultural characteristics resembling *S. newport* and, serologically, the quail Salmonella possesses a group relation to *S. newport*. Further observations will be necessary before the identification of the Salmonella isolated from baby quail can be concluded.

As a result of preliminary studies showing the relation of poultry mortality to prevailing diseases, the only possible immediate remedy to suggest is more efficient sanitation to prevent the development and



FIG. 20.—A NEW STEP IN POULTRY-DISEASE CONTROL

This first school of instruction for veterinarians and clinic for flock owners was held to improve the diagnostic service on poultry diseases thruout the state. Coupled with this improved diagnostic service is the need for more efficient sanitation to prevent the development and dissemination of disease. This latter is the responsibility of the flock owner.

dissemination of disease. This is the responsibility of the flock owner. The need of an improved diagnostic service in poultry diseases by veterinarians thruout the state also is recognized. To assist in the accomplishment of these objectives, the first school of instruction for veterinarians and poultry clinic for flock owners was held June 30, 1936, at the Laboratory of Animal Pathology and Hygiene. The morning session was attended by twenty-one practicing veterinarians from nineteen different counties in Illinois. The afternoon session was devoted to a clinic on poultry diseases for the flock owners. At this meeting afflicted birds were autopsied and the diseased conditions encountered were studied by veterinarians and owners.

It is planned to continue the schools of instruction on poultry dis-

eases for veterinarians thru district meetings in the state. Each school of instruction is to be supplemented with a poultry clinic to assist the flock owner and to obtain additional information on poultry diseases in different localities of the state. (1219 Animal Husbandry)

Soybean Oil Meal Found Good Protein Feed for Chicks

While the results from feeding soybeans to chickens have not been satisfactory when the ground beans made up a very large proportion of the protein supplement, there are other possibilities for their wide and successful use in the rationing of poultry. Soybean oil meal, for instance, has given promising results in past experiments. Means of using it have been studied further in work under H. J. Sloan and L. E. Card, Poultry Husbandry.

The work at this Station during the past few years has been chiefly concerned with the effect of the method of manufacture on the feeding value of the soybean oil meal and with the proportion and kind of ground beans that can be satisfactorily used in rations for growing chicks. Under conditions of strict confinement there was some indication that soybean oil meal manufactured by the expeller process may be slightly better for growth than that manufactured by the hydraulic process when used as the only protein supplement (24 percent)¹ in the ration, altho the differences were slight. Under the same conditions early growth was poor when the protein supplement consisted of 15 percent ground soybeans and 7 percent meat scrap and very poor when ground soybeans were used as the only protein supplement (28 percent), even tho supplemented with sufficient minerals.

To approximate the conditions under which these protein supplements are most likely to be used, that is, farm conditions, a series of four lots of chicks was started in the spring of 1934 in brooder houses and given access to range as the weather permitted. Lot 1, used as the basis of comparison, was fed a ration containing 10 percent meat scrap and 10 percent dried skim milk as the protein supplement. The Lot 2 ration contained 15 percent ground soybeans and 7 percent meat scrap, the Lot 3 ration 24 percent regular expeller soybean oil meal, and the Lot 4 ration 24 percent hydraulic soybean oil meal processed at low temperature.² These rations were otherwise essentially the same with sufficient minerals added to Lots 2, 3, and 4 to make up for the deficiency in the soybeans and soybean oil meal.

It was not long before it could be easily determined that the chicks in Lot 1 were gaining faster than the chicks in the other three lots, while Lots 2, 3, and 4 were very nearly alike. At the end of the twelfth

¹All percentages are expressed as percentages of the mash ration.

²180° F. Hydraulic-process meal, as now manufactured, is nearly all subjected to higher temperatures (215° to 225° F.), with correspondingly increased palatability and feeding value.

week, the chicks in Lot 1 were significantly ahead of those in Lots 2, 3, and 4, but there was still very little difference among the last three lots. Lot 1 made the most economical gain up to 12 weeks of age. At that time grain feeding was started and the cockerels were removed.

The chicks in Lot 1 maintained a weight advantage thruout the 23-week growing period, the average weights of the pullets in the four lots being, respectively, 2.9 pounds, 2.54 pounds, 2.58 pounds, and 2.56 pounds. The actual gains in the four lots during the last eleven weeks, however, were practically the same.

At the beginning of the twenty-fourth week all the pullets from the four lots were put together in one laying house and fed the same ration thruout the laying year of forty-eight weeks. Altho the production up to the first of May of the following spring was approximately the same for each group, by the end of the year the pullets from Lot 1 had laid somewhat more eggs than the pullets from the other three lots. The average production for the four groups was, respectively, 175, 150, 163, and 155 eggs. A representative sample of eggs taken during the spring (May) did not indicate any significant differences in egg weight, but all eggs in the sample were small.

In the spring of 1935 four more groups of chicks were started under the same conditions except that the feed in two of the lots was different. The Lot 1 ration was the same as before, but the Lot 2 ration was changed to contain 15 percent ground roasted soybeans instead of 15 percent ground raw soybeans, with 7 percent meat scrap. Lot 3 received the same ration as Lot 3 the previous year, and Lot 4 was fed 22 percent solvent-process soybean oil meal instead of the hydraulic-process meal.

The results were essentially the same as in the previous year except that the growth in all lots was somewhat less, possibly owing to the cold, damp weather which made outdoor brooding conditions rather unsatisfactory. Again the chicks in Lot 1 were somewhat heavier than the other chicks at the end of the twelfth week, but the respective weights for the four lots at the end of the twenty-third week, 2.65 pounds, 2.49 pounds, 2.63 pounds, and 2.51 pounds, do not indicate any considerable advantage in favor of the control ration.

As was the case last year, the pullets from these lots were put together in one pen at the beginning of the twenty-fourth week and fed and managed in the same way. At the end of twenty weeks of production there was little difference in the number of eggs produced by the different groups of pullets, and the average weight of the eggs was only slightly different. What differences there were in production and egg weight were in favor of the pullets from Lot 1 receiving the meat scrap and dried skim milk as the protein supplement. The experiment was discontinued at the end of twenty weeks, that is, when the pullets were forty-four weeks old. (605 Animal Husbandry)

Further Studies Made on Vitamin-E Needs of Chicks

That vitamin E is required for normal reproduction has been well established by this and other experiment stations. That this vitamin may be required for other functions has been indicated by work with rats. A possible need for vitamin E by growing chicks is indicated on the basis of results from this Station which show that altho it may not be needed specifically for growth, it probably has some physiological function. H. J. Sloan and L. E. Card, Poultry Husbandry, in cooperation with F. B. Adamstone, Zoology, found high mortality and some rather characteristic internal lesions resulted when chicks were fed a ration treated with ferric chlorid to destroy the vitamin. More detailed reports of this work may be found in previous annual reports.

Because previous attempts to prevent the development of the symptoms by the feeding of wheat-germ oil were not successful, a vitamin-E concentrate was prepared from wheat-germ oil for use the past year. The feeding of a ration containing approximately $\frac{1}{2}$ percent of the vitamin-E concentrate reduced the mortality considerably but did not improve the growth appreciably. There also seemed to be considerable reduction in the internal lesions usually found in chicks fed the iron-treated diet. When additional vitamin A was fed in the form of highly potent halibut-liver oil in addition to the vitamin-E concentrate, mortality was low, growth was quite good, and the lesions usually found in chicks fed the iron-treated diet were mostly absent. This would indicate that the slower growth of the chicks on the iron-treated diet may have been the result of a partial deficiency of vitamin A.

When increased vitamin A was fed in the absence of the E-concentrate, the growth was good, as it was in the previous case, but the mortality was as high as in the lot of chicks getting the iron-treated diet only (with the normal amount of vitamin A).

That the regular treated diet (containing 2 percent sardine oil) was not entirely devoid of vitamin A is indicated by the fact that chicks that were on a white-corn diet (deficient in vitamin A) showed some improvement when the iron-treated diet was substituted, and chicks fed a diet low in both vitamin A and E (iron-treated white-corn diet) were more severely affected in appearance and growth than chicks on the regular treated ration, which was supposedly deficient in vitamin E only.

Chicks fed a ration treated with ether only, instead of an ether solution of ferric chlorid, grew normally and were no different from the normal chicks raised on a normal ration.

Results of these trials thus indicate that the slower growth of chicks on the regular iron-treated diet may have been caused by a partial vitamin-A deficiency, but that the high mortality and the internal lesions resulted from either a vitamin-E deficiency or from some reaction that took place during the treatment of the feed. These symp-

toms were alleviated by the feeding of a vitamin-E concentrate. (610 Animal Husbandry)

Genetics May Aid in Control of Pullorum Disease

In continued studies of resistance of chicks to pullorum disease, or bacillary white diarrhea, further evidence has been found that heredity is an important factor in resistance and susceptibility to infection. Results of this work, which is in charge of Elmer Roberts, Animal Genetics, and L. E. Card, Poultry Husbandry, point to the possibility that help in the control of pullorum disease may be obtained thru breeding for disease resistance.

Great differences in resistance to pullorum disease are found not only among different breeds of poultry, but also among strains within the same breed. Survival in birds exposed to infection ranged from 14 to 56 percent for different breeds. In one breed survival for different strains varied from 53 to 76 percent, while in another breed survival for different strains varied from 5 to 23 percent. Such differences afford a basis for effective selection for greater resistance and offer an important aid in the control of the disease. (1035 Animal Husbandry)

Drying of Milk Slightly Lowers Calcium Availability

Commercial dehydration of raw liquid skim milk preserves for human and animal use a by-product of the dairy industry that would otherwise be largely wasted. The milk solids thus conserved are of high nutritive value, particularly with reference to protein, minerals, and vitamin G. The precise evaluation of dried skim milk involves its comparison, first, with the raw product from which it was prepared to detect any possible deterioration during dehydration and, second, with other high-calcium food materials in the human diet and in animal rations with which skim-milk powders must compete.

The sensitivity of milk proteins to dehydration has recently been studied and reported upon,¹ while much work comparing the nutritive value of milk-powder proteins and those of other foods and feeds is already available. However, very few such studies have been concerned with the minerals of milk solids, particularly the calcium in which they are exceptionally rich. Hence a project on this subject has been started by B. W. Fairbanks and H. H. Mitchell, Animal Nutrition, with the aid of funds donated to the University of Illinois by the American Dry Milk Institute.

In this year's work it has been shown that the calcium both of dried skim-milk powder and of raw skim milk is very highly utilizable by the

¹FAIRBANKS, B. W., and MITCHELL, H. H. The nutritive value of skim-milk powders with special reference to the sensitivity of milk proteins to heat. Jour. Agr. Res. 51, 1107-1121. 1936.

growing animal. However, a careful comparison of the two sources of calcium indicates clearly that the dehydration of raw skim milk depresses the nutritive availability of its calcium by about 7 percent, a somewhat smaller depression than results when milk is pasteurized, as shown in earlier experiments from this laboratory.¹ There are clear indications that a destruction of vitamin C in milk by heat may account for this depression of the availability of its calcium by processing.

Some preliminary experiments with rats were concerned with certain problems of method. These experiments showed, among other things,² that the calcium content of experimental animals depends upon the rate of food consumption, as well as upon the calcium content of the food consumed, the relationship being an inverse one, and that the rate of calcium retention is directly dependent upon the initial condition of the calcium stores in the body. It appears from these findings that an accurate comparison of the availability of calcium in different food materials requires a close control of the food intakes of comparative animals and a uniform preliminary treatment to assure a constant, preferably a maximal, filling up of the calcium stores in the skeleton.

With these precautions in mind a comparison was made of the availability of calcium in dried skim-milk powder (spray process, preheated) and in raw liquid skim milk. Young growing rats were used as experimental animals, and the paired-feeding method was followed. All animals received the same synthetic basal diet, containing only from .032 to .087 percent calcium. The milk supplements were fed in amounts to provide only about half of the calcium needed for growth—namely, 5 milligrams of calcium for each gram of gain in body weight—in order that possible small differences in availability would be clearly evident. About 77 percent of the calcium intake of all rats was derived from milk solids. One rat in each pair received a dried skim-milk supplement and the other rat a raw (unpasteurized) skim-milk supplement in amounts to supply the same quantity of calcium. The two rats in each pair were litter mates, of the same sex, and the same or very nearly the same initial weight. They received thruout the feeding period of six weeks the same amount of the basal diet and the same intake of food energy. At the end of the test all rats were sacrificed for chemical analysis, while at the beginning of the test one rat similar in ancestry, sex, and body weight to each of the eight pairs was sacrificed in order to estimate the initial composition of the experimental rats.

¹ELLIS, MARTELL, and MITCHELL, H. H. The effect of pasteurization of milk on the utilization of its calcium for growth in the rat. *Amer. Jour. Physiol.* 104, 1-9. 1933.

²FAIRBANKS, B. W., and MITCHELL, H. H. The relation between calcium retention and the store of calcium in the body, with particular reference to the determination of calcium requirements. *Jour. Nutrition* 11, 551-572. 1936.

At the end of the test there were no significant differences in the weight gains of pair mates nor in the attained body lengths. However, in all pairs the rat receiving the raw-milk supplement contained the greater amount of calcium, both by weight and by percentage of the empty carcass. The differences were highly significant statistically. Estimates of the calcium stored during the feeding test also indicated a marked, if slight, advantage for the raw milk. On the average 5.2 percent more of the consumed calcium from raw milk was stored in the body than that from dried milk, indicating about a 7 percent¹ depression in availability as a result of drying. Previous tests in this laboratory indicated a 12.3 percent impairment in the availability of milk calcium brought about by pasteurization. However, the calcium in both supplements was available to close to 100 percent.

It is known that the heating of milk largely destroys its content of vitamin C. Altho it is commonly believed that the rat does not need vitamin C preformed in its diet, it is possible that its absence from the diet may impair to some extent the utilization of dietary calcium. In order to test this possible explanation of the impairment of the availability of the calcium of milk by commercial dehydration, another paired feeding test was undertaken in which a calcium supplement of dried skim-milk powder was compared with a combined supplement of the same amount of dried skim-milk powder plus 1 milligram daily of ascorbic acid (vitamin C). Except for the nature of the supplements the second experiment was carried out exactly as was the first.

The results indicated with a high degree of probability that the ascorbic acid increased the availability of the calcium in the dried milk powder, as indicated by the calcium contents of the rat carcasses and by the estimates of calcium storage. The average increase in utilization of dried-milk calcium brought about by the ascorbic acid was 11.3 percent. Hence it may be concluded—and the experiment is being repeated for confirmation—that the impairment of the availability of the calcium of skim milk brought about by commercial dehydration is the result of the destruction of vitamin C.

Calcium of Spinach Poorly Utilized.—Among the vegetables spinach ranks high in content of calcium and for this reason, together with its high content of iron and vitamin A, it is widely considered as an exceptionally good "corrective" food, supplementing well the deficiencies of many staple foods making up the bulk of the American diet. However, the content of any one nutrient in a food is a hazard-

¹Since only 77 percent of the calcium in the experimental rations was contained in milk solids, the depression in the utilization of the milk calcium as a result of drying must have been greater than 5.2 percent and may be estimated by dividing 5.2 by .77. The result is a 7-percent depression, which would have been observed experimentally if the calcium in the two rations had all been derived from milk.

ous basis on which to rate it in nutrition, because there is no assurance that all or even most, of the nutrient present is available in the animal body. In their plan of comparing dried skim-milk powder with other high-calcium foods in the American diet as a source of this important mineral, B. W. Fairbanks and H. H. Mitchell, division of Animal Nutrition, compared it with fresh spinach during the past year. The experiment was made possible by a donation of funds to the University of Illinois by the American Dry Milk Institute.

It was clearly shown, in agreement with a number of earlier experiments, that the calcium of spinach is very poorly utilized by the growing animal. In fact results of the experiments failed to show that any portion of the calcium of spinach is available under conditions permitting a very high utilization of milk calcium. It was even suggested that the presence of spinach in the diet may impair the utilization of calcium in foods with which spinach is fed. This unfavorable influence of spinach on calcium utilization is probably associated with its high content of oxalic acid, calcium oxalate being a very insoluble salt.

Curly-leaf spinach bought on the local market was used in these tests. The dried skim-milk powder with which it was compared was prepared by the spray process, being preheated before dehydration. Chemical analysis of these foods is given in Table 31. It should be

TABLE 31.—CHEMICAL COMPOSITION OF FRESH SPINACH AND DRIED SKIM-MILK POWDER

Food material	Moisture	Ether extract	Crude protein	Crude fiber	Ash	Calcium	Phosphorus	Oxalic acid	Gross energy
	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>	<i>cal. a gm.</i>
Fresh spinach.....	90.26	.32	3.49	.90	1.61	.086	.055	.221	.377
Skim-milk powder.....	2.39	.57	34.94	...	7.84	1.268	1.022	...	4.127

noted in particular that the spinach contains 2.57 times as much oxalic acid as calcium, more than enough to combine completely with it.

The biological availability of the calcium in these foods was determined by paired-feeding experiments on young growing rats, eight pairs of rats being used. The basal diet, containing .16 percent of calcium, was fed in equal amounts to the two rats in each pair, and the calcium supplements, fresh spinach and skim-milk powder, in amounts to furnish the same calcium addition but inadequate for maximal calcium retention, that is, no more than 5 milligrams a gram of gain in body weight. The difference in energy value of the supplements was equalized by giving enough sugar (in solution) to the spinach-fed rat to maintain approximately the same rate of growth as its pair mate

receiving skim-milk powder. Forty-four percent of the calcium intake was derived from the test foods. At the end of thirty-one days of feeding the rats were sacrificed and analyzed for calcium and phosphorus.

Altho the rats receiving the spinach supplement gained almost as rapidly as the rats receiving the milk powder, 3.67 grams daily compared with 3.74 grams, the skeletal growth as measured by body length was evidently appreciably slower. Also at the termination of the experiment the calcium content of the carcasses of the rats on the spinach diet averaged only .437 percent, as compared with .660 percent for the milk rats. This difference was apparent in all pairs. The same large difference was shown in the amounts of calcium in the carcasses, as well as in the amounts estimated to have been deposited during the period of experimental feeding. The milk-fed rats stored 2.19 times as much calcium as the spinach-fed rats, the storage amounting to 88.5 percent of the calcium consumed in the one case and only 40.5 percent in the other. In all but two of the pairs the percentage of the amount of calcium consumed that was stored in the body was less than the percentage derived from the basal diet (44.1), so that the results demonstrate a very poor utilization of spinach calcium. These findings are not inconsistent with the belief that the calcium of spinach not only is of no use in animal nutrition, but also that the presence of spinach in the diet may impair the value of the calcium of other foods. (420 Animal Husbandry)

First Tests Throw New Light on Spray Regulations

In fighting insect pests, commercial orchardists at the present time are compelled to use chemicals that are known to be toxic to humans when taken into the body in amounts above certain minimal quantities, the exact values of which have not been determined. Without the use of these materials, partial or complete crop failure would result. One of the most important spray materials is lead arsenate. In order to avoid any possibility of injury to the health of the public, the Federal Food and Drug Administration and the Illinois State Department of Agriculture have set up certain limits for lead and arsenic on fruit.

Most apples must be washed to meet those tolerances. However, the washing treatment must not be too severe, because of the danger of injuring the fruit surfaces. For this reason the tolerances must not be placed unreasonably or unnecessarily low.

At the present time fruit growers, particularly the owners of small orchards, find it extremely difficult to meet the tolerance for lead, which is now .018 grain a pound of fruit. It is less difficult to meet the tolerance for arsenic, which is .01 grain of As_2O_3 a pound. Obviously if these tolerances represent the limits of safety to public health, they must be enforced at all costs, but if they can be raised with no danger

to the public health, the orchardist's costs will be lowered and the consumer will profit in cheaper and better fruit. Information concerning safe dosages of lead and arsenic is badly needed, so that public-health officials can handle this situation intelligently.

From the nature of the problem much of this information must be obtained from experiments on animals. During the past year a series of studies on the metabolism of lead and arsenic compounds in rats and the conditions governing the accumulation of lead and arsenic in the body were initiated by H. H. Mitchell and J. B. Shields, Animal Nutrition, and W. A. Ruth, Pomology, with the advisory assistance of Julia P. Outhouse, Home Economics.

In the first experiments attention was directed to the relation between lead accumulation in the tissues and lead dosage. This was done in the belief that chronic lead poisoning from the continuous eating of lead-contaminated fruits would occur only at levels of feeding that contribute to a piling up of lead in the tissues. Such a piling up, or storage, of lead would indicate that the metal was entering the body at a faster rate than it could be disposed of by the excretory organs.

Results secured at the present writing show clearly, first, that rats subsisting on diets of ordinary foods not deliberately dosed with lead contain from 2 to 4 parts of lead for each one million parts of carcass. On analysis these diets contained from 2 to 5 milligrams of lead a kilogram. In the second place, it was shown that lead, as the acid arsenate, added to such diets did not increase the lead in the tissues of adult rats until the added lead amounted to 48 milligrams a kilogram of ration, equivalent on the dry-matter basis to a little more than three times the present permissible lead residue on fruit.

Much of the time devoted to this project has had to do with the selection of a suitable analytical method for lead, the perfection of analytical technic, and the adaptation of the method to the analysis of rat carcasses. The dithizone method, employed colorimetrically, has been found capable of determining the small amounts of lead present in untreated and treated rats to within a few thousandths of a milligram. Small amounts of lead can be recovered by the method with an accuracy generally of more than 90 percent.

The paired-feeding method was used thruout these experiments. The lead arsenate was added to the basal diets in multiples of 26.7 milligrams a kilogram, equivalent to 16 milligrams of lead. This ratio of lead to dry food is the same as the 1934 legal tolerance of .019 grain a pound of fruit containing 85 percent of water. The pairs of rats received in equal amounts rations containing various dosages of lead and were killed for analysis after consuming 500 grams or 1,000 grams. The rats were confined in cages made of tinned iron wire, no lead-containing solder being used, or in glass cages. The average results obtained to date are summarized in Table 32.

TABLE 32.—ACCUMULATION OF LEAD IN RATS RECEIVING VARIOUS DOSAGES

Lead in each kgm. of ration	Number of rats	Total food consumed	Average days on feed	Average initial weight	Average final empty weight	Average lead in carcasses	
						Total	In each kgm. of empty weight
<i>mgms.</i>		<i>gms.</i>		<i>gms.</i>	<i>gms.</i>	<i>mgms.</i>	<i>mgms.</i>
0	4	500	66	51	194	.55	2.9
16	4	500	66	51	193	.68	3.4
16	6	500	57	54	205	.81	3.9
32	6	500	57	54	207	.82	3.4
0	5	500	55	246	214	.97	4.5
32	5	500	55	247	209	.99	4.8
0	7	500	46	363	309	1.34	4.3
48	7	500	46	360	307	1.59	5.2
32	4	1 000	97	134	208	.78	3.8
64	4	1 000	97	133	205	1.21	6.0
0	3	1 000	105	150	181	.42	2.3
64	3	1 000	105	152	183	1.15	6.3

No accumulation of lead occurred with dosages of 16 or 32 milligrams a kilogram of food, the latter being equivalent to twice the tolerance. At levels of 48 and 64 milligrams a kilogram definite increases in lead storage resulted. The differences are highly significant statistically. While the higher levels could conceivably result in chronic poisoning, the growth of the rats receiving them was not perceptibly retarded nor was their health impaired to all outward appearances. The experimental rat carcasses will be analyzed for arsenic also. (1097 Animal Husbandry and 124 Horticulture)

DAIRY CATTLE AND PRODUCTS

Methods of Testing Dairy Sires Given Further Study

Owners of the million head of milk cows on Illinois farms could increase the productiveness of their herds more rapidly if more satisfactory methods of determining the breeding ability of dairy sires were available. Development of such methods has been in progress in two continued studies under the direction of W. W. Yapp and J. G. Cash, Dairy Cattle.

In one of these studies additional work was done on the influence of frequency of milking on yield of milk and fat. Earlier investigators and others interested in dairy production have generally agreed that more frequent milking increases milk and fat yield. In most of the previous investigations, however, the extent of this increase was determined by comparing the results obtained from twice-a-day milking during one lactation with those obtained from three or more milkings a day in previous or subsequent lactations. In such studies it is obvious that many environmental factors other than frequency of milkings have been influential in determining the yield of milk and fat.

To reduce environmental influence to its minimum, the investigators milked one half of the udder twice a day and the other half three times a day. In all cases the cow was fed three times a day. It was found that of the eight records made in this way, the half of the udder milked three times daily gave 32 percent more milk than the half milked twice a day. Furthermore there was practically no difference in the percentage of fat in the milk from the two sides, the half milked three times a day showing a fat content of 3.68 percent as compared with 3.63 for the side milked twice daily.

Fig. 21 shows that a considerable portion of the increase in yield of the half milked three times a day was secured thru reduction of the decline from month to month. At the beginning of the lactation about 47 percent of the milk was produced by the half of the udder milked twice daily and 53 percent by that milked three times daily. Toward the end of lactation the twice-a-day half yielded 40 percent of the milk produced, whereas the three-times-a-day half yielded 60 percent. Therefore the tendency of three times milking to increase production thru a lactation appears to be an important factor to consider in deciding how frequently to milk a cow.

The second study was confined primarily to methods of sampling a dairy sire to determine his transmitting ability. As a basis for comparing different methods and to show the importance of including not only all the daughters of a given sire but also all their dams, Illini Homestead Piebe Prince was used as an example.

TABLE 33.—COMPARISON OF DIFFERENT METHODS OF MEASURING THE TRANSMITTING ABILITY OF A DAIRY SIRE, ILLINI HOMESTEAD PIEBE PRINCE

Daughter No.	Milk	Fat	Dam No.	Milk	Fat
Records of nine best daughters and their dams					
	<i>lbs.</i>	<i>lbs.</i>		<i>lbs.</i>	<i>lbs.</i>
551.....	21 833.6	760.7	432	15 771.4	508.4
540.....	21 654.1	762.9	370	23 549.7	774.8
533.....	23 522.4	756.9	471	24 659.0	872.1
592.....	20 654.8	755.3	370	23 549.7	774.8
503.....	23 733.0	752.1	429	17 257.5	636.1
539.....	21 402.7	718.8	418	19 686.2	697.3
519.....	19 373.1	696.1	450	21 782.4	749.6
541.....	20 950.1	688.5	425	26 111.4	882.2
546.....	18 381.0	683.3	403	17 723.1	607.2
Average of 9.....	21 278.3	730.5	...	21 121.2	722.5
Transmitting ability of sire, 738.5 pounds fat					
Records of nine poorest daughters and their dams					
	<i>lbs.</i>	<i>lbs.</i>		<i>lbs.</i>	<i>lbs.</i>
512.....	19 918.5	683.2	437	24 681.1	829.4
524.....	17 687.6	672.9	424	14 849.1	489.2
556.....	19 867.9	671.2	482	21 198.3	783.7
504.....	19 607.8	661.4	432	15 771.4	508.4
536.....	17 891.0	640.4	431	17 320.1	548.1
505.....	16 573.5	620.7	438	21 320.1	780.6
549.....	16 221.6	595.1	440	19 323.7	753.9
543.....	15 912.5	531.4	433	21 857.4	741.5
506.....	11 513.0	407.9	440	19 323.7	753.9
Average of 9.....	17 243.7	609.4	...	19 516.1	687.6
Transmitting ability of sire, 531.2 pounds fat					
Highest records (on mature basis) of all the daughters and their dams					
	<i>lbs.</i>	<i>lbs.</i>		<i>lbs.</i>	<i>lbs.</i>
492.....	20 654.8	755.3	370	23 549.7	774.8
503.....	23 733.0	752.1	429	17 257.5	636.1
504.....	19 607.8	661.4	432	15 771.4	508.4
505.....	16 573.5	620.7	438	21 320.1	780.6
506.....	11 513.0	407.9	440	19 323.7	753.9
512.....	19 918.5	683.2	437	24 681.1	829.4
519.....	19 373.1	696.1	450	21 782.4	749.6
524.....	17 687.6	672.9	424	14 849.1	489.2
533.....	23 522.4	756.9	471	24 659.0	872.1
536.....	17 891.0	640.4	431	17 320.1	548.1
539.....	21 402.7	718.8	418	19 686.2	697.3
540.....	21 654.1	762.9	370	23 549.7	774.8
541.....	20 950.1	688.5	425	26 111.4	882.2
543.....	15 912.5	531.4	433	21 857.4	741.5
546.....	18 381.0	683.3	403	17 723.1	607.2
549.....	16 221.6	595.1	440	19 323.7	753.9
551.....	21 833.6	760.7	432	15 771.4	508.4
556.....	19 867.9	671.2	482	21 198.3	783.7
Average of 18.....	19 261.0	669.9	...	20 318.6	705.1
Transmitting ability of sire, 634.7 pounds fat					
Averages of all the records (on mature basis) of all the daughters and their dams					
	<i>lbs.</i>	<i>lbs.</i>		<i>lbs.</i>	<i>lbs.</i>
492.....	20 876.2	727.7	370	20 782.5	694.1
503.....	20 437.4	676.7	429	16 986.1	572.6
504.....	19 607.8	661.4	432	15 771.4	508.4
505.....	16 573.5	620.7	438	20 004.3	713.9
506.....	11 513.0	407.9	440	19 407.1	748.1
512.....	19 918.5	683.2	437	22 446.5	751.2
519.....	19 373.1	696.1	450	22 162.7	732.1
524.....	18 941.7	689.5	424	14 456.7	474.0
533.....	23 522.4	756.9	471	22 194.0	784.9
536.....	17 891.0	640.4	431	15 956.4	499.8
539.....	21 402.7	718.8	418	19 686.2	697.3
540.....	21 654.1	762.9	370	20 782.5	694.1
541.....	20 950.1	688.5	425	23 500.3	794.0
543.....	15 912.5	531.4	433	22 493.1	737.7
546.....	18 381.0	683.3	403	19 376.9	638.6
549.....	16 221.6	595.1	440	19 407.1	748.1
551.....	21 833.6	760.7	432	15 771.4	508.4
556.....	19 867.9	671.2	482	19 820.7	739.3
Average of 18.....	19 159.9	665.1	...	19 500.3	668.7
Transmitting ability of sire, 661.5 pounds fat					

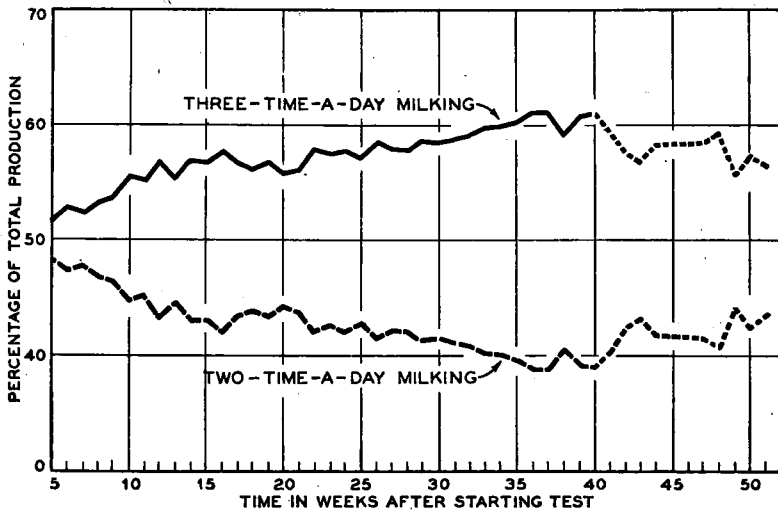


FIG. 21.—PERCENTAGE VARIATION FOR BUTTERFAT PRODUCTION BETWEEN TWO- AND THREE-TIME MILKING

A considerable portion of the increase in yield from three-times-a-day milking was secured thru reduction of the decline from month to month.

Results are summarized in Table 33. There is included:

1. Records of the nine highest-record daughters and their dams. In computing the transmitting ability in this case, the formula $s = 2O - d$ was used in which "s" equals transmitting ability of the sire, "O" equals records of offspring corrected to a mature basis, and "d" equals record of dam similarly corrected.

2. Records of the nine lowest producing daughters and a comparison as in 1.

3. Records of all the daughters of the sire with each daughter credited with the highest record of her performance. The dam is recorded similarly.

4. The averages of all the records of all the daughters and their dams.

It is quite obvious that the method of including all the records of all daughters and all the records of all dams, as well as the records of any daughter ever in milk, is the most desirable index of transmitting ability. (525 Dairy Husbandry)

Lactations Are Correlated for Closer Check on Sires

In connection with the use of milk-production records to indicate the ability of sires to transmit milking quality to their offspring, two

questions frequently arise: How many daughters and how many records of each daughter are needed to give satisfactory results? It is recognized that, in general, the more daughters the better. A point not so well recognized is that the more records on each daughter the better.

Studies under W. L. Gaines, Milk Production, have dealt with the latter point, the object of the work being to determine a satisfactory number and distribution of records by computing the correlation between successive lactation records of the same cow for individual sire-daughter groups. The material used is from the published herd-test records of the Holstein-Friesian Association of America. The correlations have been computed first for the actual records and second for the records corrected for age and number of milkings by the association method.

Fig. 22 gives some of the results for twenty-nine sires individually and Fig. 23 presents a summary for the twenty-nine sires.

Fig. 22 shows very considerable differences between the twenty-nine sires. In the case of Sire 3, one lactation record of a daughter is very closely related to her other lactation records. In the case of Sire 28, on the other hand, one lactation record of a daughter is practically independent of her other lactation records. It is not known how

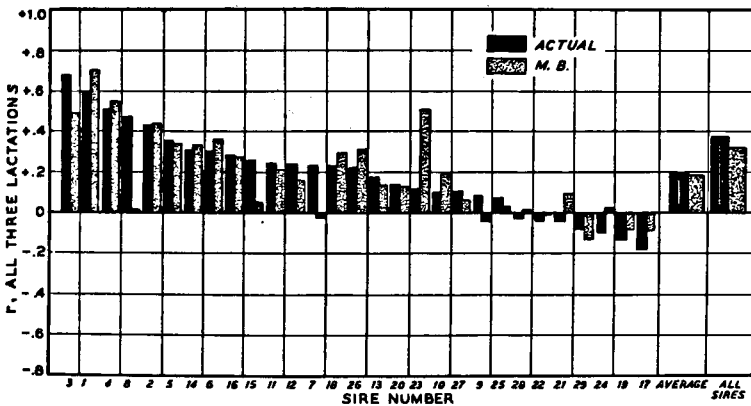


FIG. 22.—COEFFICIENT OF CORRELATION BETWEEN THE FIRST THREE LACTATIONS OF THE DAUGHTERS OF TWENTY-NINE SIRES

In the coefficient of correlation, r , at the left, zero indicates no correlation and 1, perfect correlation. The solid bars represent the actual records of the daughters and the stippled bars, the records of the daughters corrected to a mature basis and three-times-a-day milking. There are very considerable differences between the sires, as shown by the fact that the coefficient of correlation between the first three lactations of their daughters ranges from positive .7 to negative .13.

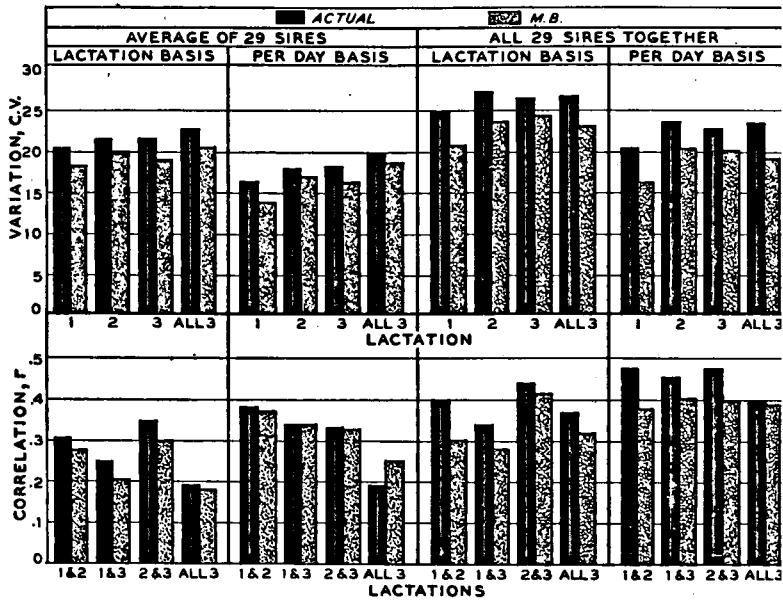


FIG. 23.—SUMMARY OF THE COEFFICIENTS OF VARIATION AND CORRELATION FOR THE TWENTY-NINE SIRES REPRESENTED IN FIG. 22

Apparently the corrected records are no better than the actual records, and the corrections, on the whole, do not help in the breeding problem. The left and right halves of the illustration represent different methods of averaging the same records. In all cases the solid bar represents the actual records of the daughters and the stippled bar, the records corrected to a mature basis and three-times-a-day milking. The upper half shows the variation in terms of the coefficient of variability, CV, and the lower half, the coefficient of correlation, r .

far these differences between individual sires are a matter of heredity and how far a matter of the environment in which the records were made. It is clear, however, that records do not automatically solve the problem of breeding for milking qualities. It is a real problem to know what the records mean from a genetic viewpoint.

Fig. 23 shows that the "corrected" records are no better than the actual records and the corrections, on the whole, do not help at all in the breeding problem. It is an appreciable help, however, to deal with the average daily yield in place of the lactation yield as reported in these Holstein records. The reason for this is that the reported lactation records vary from 150 to 365 days in milk, a nongenetic variation which has a great effect on lactation yield. Simply dividing the lactation yield by the days in milk is of help in eliminating this variation but it is not an approved or sound method. It is, theoretically at least

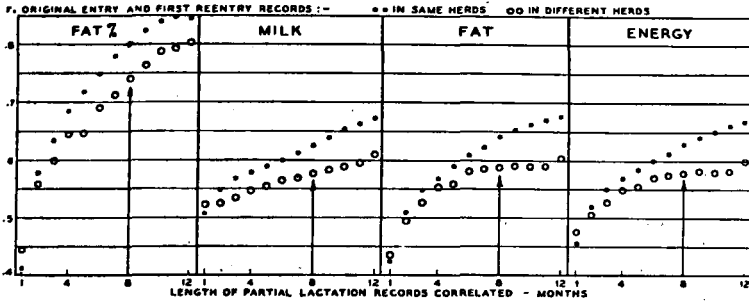


FIG. 24.—RELATIVE GENETIC WORTH OF PARTIAL LACTATION RECORDS FROM ONE TO TWELVE MONTHS IN GUERNSEY COWS

The eight-month partial lactation record, as contrasted with the twelve-month record, is adapted to the great body of cows bred to calve once a year and offers a simple and easy forward step in the handling of herd-test records to secure maximum benefit from them in selecting breeding stock. The coefficient of correlation, *r*, between the original entry record and the first reentry record at eight months and at twelve months indicates that the latter record has only slight advantage over the former. The cows in this case were either farrow or carried a calf less than five months of the 365-day record period.

much better to use a *uniform* eight-month partial lactation record for genetic analysis.

In the Forty-Eighth Annual Report preliminary results were given on the relative genetic worth of the eight-month partial lactation in comparison with the longer and shorter lengths of partial lactation as indicated by certain Guernsey records. Study of these particular records has been completed and the final results are given in Fig. 24. It appears that for farrow cows or late-bred cows the twelve-month partial lactation record is somewhat better than the eight-month partial

SIRE A

OVER DAUGHTER	DAUGHTER NO. OF BIRTH	CALVING INTERVAL RECORD						FIRST 8 MONTHS (67 YEAR) RECORD							
		CALVED DATE	AGE YRS.	CALVING INTERVAL YRS.	MILK IN MILK YRS.	DRY YRS.	MILK LBS.	FAT LBS.	INITIAL CONDITION SCALE 1-9	TOTAL FEED PER DAY	MILKING PER DAY SCALE 1-9	ENVIRONMENT SCALE 1-9	INITIAL LIVE WEIGHT LBS.	ENERGY-SIZE INDEX C-K-D	FAT PERCENTAGE %
A	A	33.907	1.91	1.07	.86	.21	5018	275	5	7	2.17	6	745	21.1	5.38
A	A	34.878	2.98	1.30	1.15	.15	9588	541	5	8	3.00	8	814	23.0	5.50
A	Z	34.928	2.51	.86	.80	.08	8058	388	6	7	2.33	7	800	27.8	6.07
A	Z	35.008	3.39						5	8	3.00	8	888	24.5	5.88
26 DAUGHTERS AVERAGE												812	25.1	5.81	

FIG. 25.—A SUGGESTED HERD-RECORD FORM BASED ON THE CALVING INTERVAL AND EIGHT-MONTH PARTIAL LACTATION

This form includes the complete lactation records and, as an extraction for genetic analysis of the records, the eight-month partial lactation. It is intended that the milk recording will be continuous. For convenience in computing time intervals, dates are expressed decimally. Thus date of birth 32.000 = January 1, 1932; date of calving 33.907 = November 28, 1933; age at calving 33.907 - 32.000 = 1.91 years. The energy-size index is the same in principle as described in the Forty-Seventh Annual Report expressed as calories a kilogram a day, C-K-D.

lactation record as a measure of genetic worth. Such small advantage as it has can be sacrificed in order to have a system adapted to the great body of cows bred to calve once a year. Such a system is provided in the eight-month partial lactation plan. It seems to offer a simple and easy forward step in the handling of herd-test records to secure maximum benefit from them in selecting breeding stock. Fig. 25 presents a suggestion for a record form which includes the complete lactation record and, as an extraction for genetic analysis of the records, the eight-month partial lactation. (528 Dairy Husbandry)

Washing-Powder Chromates Do Not Accumulate in Body

With the increasing use of stainless steel dairy equipment, in the manufacture of which chromium alloys are used, and with the increasing use in dairies of washing powders containing small amounts of chromium compounds, the safety of milk handled with such equipment and with equipment cleaned with such powders has been questioned. Under certain conditions chromium is known to be poisonous. Traces of the metal may sometimes find their way into milk.

To determine whether chromium taken in food in small quantities is excreted or whether it tends to accumulate in the organs of the body, as does lead, has been the object of an investigation by M. J. Prucha, Dairy Bacteriology. It was concluded that chromium does not accumulate in the body, but is excreted.

In this study, which was carried on for several years, rats were fed nothing but milk to which varying amounts of sodium chromate were added. When the last experiment was made, the animals were, for the most part, the third generation of those used when the study was begun, all three generations having been regularly fed milk containing small amounts of chromium.

The study was carried on with different cages of rats. Rats in one group were fed milk containing washing powder known as "Protex Metallum" in such amounts that at all times chromium constituted 20 p.p.m. (parts per million) of the milk consumed. Rats in a second lot received milk which contained sodium bichromate, chromium constituting 20 p.p.m. at all times. Rats in a third lot received milk which contained no chromium.

Analysis of the bodies of the rats revealed no accumulation of chromium and practically no difference in the bodies of the rats from the different cages. (211 Dairy Husbandry)

Survey Shows Bacterial Counts in Milk Containers

Most of the city milk ordinances include a bacterial standard. The question of what technic to use in bacterial counts seems to be a perpetual one. Standard methods have been prepared and are being followed, but there is a continued effort to improve them. At present the

committee on standard methods is centering its activities upon improving the nutrient agar used in standard plate counts. During the year about 800 samples of raw milk have been subjected to bacteriological plate count by M. J. Prucha, Dairy Bacteriology, using four different nutrient agar media. The media used and the results of examining twenty samples of raw milk selected at random are given in Table 34.

TABLE 34.—COMPARISON OF FOUR DIFFERENT NUTRIENT AGAR MEDIA FOR MAKING STANDARD PLATE COUNTS OF BACTERIA

Sample No.	Bacterial count using standard nutrient agar with—			
	Nothing added	.5 percent skim milk added	3 percent corn sugar added	1 percent lactose added
1.....	3 600	7 100	3 500	4 500
2.....	52 800	75 800	70 000	72 400
3.....	31 800	27 600	34 200	29 400
4.....	4 300	5 800	3 200	4 100
5.....	5 500	4 600	5 900	6 200
6.....	4 600	3 500	4 300	6 000
7.....	4 700	3 600	4 700	3 700
8.....	15 000	12 000	13 800	12 500
9.....	8 100	9 700	5 500	9 600
10.....	16 200	27 600	3 700	19 400
11.....	25 400	19 900	28 700	31 200
12.....	3 700	8 600	3 000	5 100
13.....	48 900	47 300	28 800	44 000
14.....	12 100	7 000	8 100	10 500
15.....	10 000	9 200	8 000	10 400
16.....	6 600	9 600	7 200	7 600
17.....	3 700	5 200	4 700	6 500
18.....	19 100	17 800	14 200	18 200
19.....	9 900	11 600	7 500	7 600
20.....	13 300	18 000	17 400	16 400
Average.....	14 965	16 575	13 820	16 265

Bacteriological results obtained from the four different media indicate that none show any pronounced superiority over the standard nutrient agar. From the study so far it would seem that the committee on standard methods should not hasten to make changes in the nutrient agar, for frequent changes are not desirable in any standard procedure. (207 Dairy Husbandry)

Survey Shows Bacterial Counts in Milk Containers

Many or all of the benefits of pasteurization of milk as a public-health measure may be nullified by improper handling of milk after it is pasteurized. For this reason inquiry has been made into the sanitary condition of the containers into which pasteurized milk is being put, the work being carried on in connection with pasteurization studies under J. M. Brannon, Dairy Bacteriology.

Many glass bottles and jugs were found to contain a large number

TABLE 35.—BACTERIAL COUNTS FOUND IN GLASS JUGS AND BOTTLES IN TWENTY-FIVE ILLINOIS MILK PLANTS

Bacteria a container	Number of containers	Bacteria a container	Number of containers
Jugs			
Sterile.....	17	30,001- 40,000.....	4
1- 500.....	44	40,001- 50,000.....	9
501- 1,000.....	13	50,001- 60,000.....	9
1,001- 1,500.....	11	60,001- 70,000.....	4
1,501- 2,000.....	10	70,001- 80,000.....	3
2,001- 3,000.....	10	80,001- 90,000.....	6
3,001- 4,000.....	6	90,001- 100,000.....	2
4,001- 5,000.....	6	100,001- 150,000.....	14
5,001- 6,000.....	6	150,001- 200,000.....	13
6,001- 7,000.....	9	200,001- 250,000.....	7
7,001- 8,000.....	3	250,001- 300,000.....	9
8,001- 9,000.....	0	300,001- 400,000.....	8
9,001-10,000.....	4	400,001- 500,000.....	7
10,001-12,000.....	11	500,001- 600,000.....	6
12,001-14,000.....	4	600,001- 800,000.....	6
14,001-16,000.....	7	800,001-1,000,000.....	2
16,001-18,000.....	17	1,000,001-2,000,000.....	7
18,001-20,000.....	3	2,000,001-4,560,000.....	6
20,001-25,000.....	10	Too numerous to count at 1,000 dilution.....	3
25,001-30,000.....	7		
Bottles			
Sterile.....	118	30,001- 40,000.....	2
1- 500.....	102	40,001- 50,000.....	4
501- 1,000.....	26	50,001- 60,000.....	5
1,001- 1,500.....	12	60,001- 70,000.....	1
1,501- 2,000.....	12	70,001- 80,000.....	8
2,001- 3,000.....	15	80,001- 90,000.....	2
3,001- 4,000.....	16	90,001- 100,000.....	0
4,001- 5,000.....	12	100,001- 150,000.....	11
5,001- 6,000.....	6	150,001- 200,000.....	2
6,001- 7,000.....	8	200,001- 250,000.....	2
7,001- 8,000.....	7	250,001- 300,000.....	5
8,001- 9,000.....	5	300,001- 400,000.....	5
9,001-10,000.....	5	400,001- 500,000.....	1
10,001-12,000.....	8	500,001- 600,000.....	2
12,001-14,000.....	1	600,001- 800,000.....	5
14,001-16,000.....	2	800,001-1,000,000.....	2
16,001-18,000.....	11	1,000,001-2,000,000.....	7
18,001-20,000.....	0	2,000,001-4,560,000.....	6
20,001-25,000.....	2	Too numerous to count at 1,000 dilution.....	5
25,001-30,000.....	11		

of bacteria in a survey of twenty-five milk plants in Illinois. Table 35 gives the results. There seem to be two main causes for these high counts: first, the alkali solution in the bottle washers was not always strong enough to kill the bacteria and, second, many times the bottles were left in warm, damp rooms too long after washing. (209 Dairy Husbandry)

Keeping Quality of Butter Is Given Continued Study

With a production of 71,927,000 pounds of creamery butter in 1934, Illinois held a place among the first ten states in the manufacture of this important food product. Improvement in quality is expected to follow studies which O. R. Overman, Dairy Chemistry, is conducting in the changes taking place in butter during storage.

As stated in the Forty-Sixth Annual Report, the laboratory examination of 36 samples of stored butter was completed early in 1934. Some of these butters had been kept in storage at 0° to -10° F. for more than two years. The data have been tabulated and a manuscript discussing the results is in process of preparation.

During 1935-36 new work has been started in a further study of the keeping quality of butter. This work makes use of a photoelectric cell to measure the increasing intensity of light which passes thru a layer of butterfat colored with methylene blue. As the butterfat is oxidized, the methylene blue is gradually reduced and decolorized. The decolorization of the methylene blue allows an increasing amount of light to pass and act upon the photoelectric cell. The change in activity of the cell is measured by means of a sensitive galvanometer. (305 Dairy Husbandry)

Certain Hybrid Corns Prove Superior for Silage Uses

Millions of tons of silage are used in feeding the 1,372,000 milk cows and heifers in the state, but the best corns to use for this silage is again open to question because of the recent development and wide use of many hybrids. During the past year, W. B. Nevens, Dairy Cattle Feeding, and W. W. Yapp, Dairy Cattle, cooperated with the Department of Agronomy and the U. S. Department of Agriculture in comparing sixteen hybrid corns which were harvested for silage.

These corns were grown on the Experiment Station dairy farm, on land which had been in alfalfa for several years. Station Yellow Dent, a high-yielding strain of Reid Yellow Dent developed at this Station, was used as the basis of comparison, as a previous trial with varieties of corn for silage, which was reported in the Thirty-Seventh to Forty-Second Annual Reports, showed Reid Yellow Dent corn to be one of the best silage varieties for conditions existing at Urbana. The general planting arrangement for the field was two plots of hybrid corn followed by a check plot of Station Yellow Dent, each of the plots being one acre or more in size.

The yields of the hybrids harvested for silage, computed in terms of the dry weight of the crop, were slightly greater than the yield of Station Yellow Dent, altho the yields ranged from 90 percent to 120 percent as much as that of the Station Yellow Dent. Weighed into the silo, the corn made from 10 to 13 tons to the acre. Most of the hybrids contained a slightly higher proportion of ears, and hence a somewhat greater feeding value for a ton of such silage, than did the silage from the Station Yellow Dent.

Results of the trial showed that carefully selected corn hybrids such as those used in this test gave large yields to the acre and produced a silage having a high feeding value to the ton. Dairy farmers

of Illinois, therefore, have the opportunity of increasing the yields from their silage acres thru careful selection of high-yielding corn hybrids. For further details of the trial, see Project 404, pages 39-40.



FIG. 26.—TWO OF THE HYBRIDS (LEFT AND RIGHT) WHICH PROVED SUITABLE FOR SILAGE

Illinois Hybrid 39 (left) and Funk Hybrid 220 (right) were among those grown in comparison with the check variety, Station Yellow Dent (center). Results of the tests indicated that dairy farmers of Illinois have an opportunity to increase the yields from their silage acres thru careful selection of suitable hybrids.

Legumes as silage crops also were studied during the past year. Rainy weather often causes great losses during the curing of hay, particularly in the case of first-cutting alfalfa and late-cut soybean hay. Harvesting for silage under such conditions may be a means of reducing losses to a very low point.

Twenty-six small silos were filled with alfalfa in the fall of 1935. Nevens was assisted in this work by A. F. Kuhlman, Dairy Husbandry. The alfalfa was taken from the field immediately after mowing and chopped into short lengths by a power cutter. The silos were then filled with this green alfalfa before it had wilted to any extent. A few silos were filled with unchopped alfalfa. Different lots of alfalfa contained from 23 to 39 percent of dry matter at the time of ensiling.

Several silos were filled with alfalfa without the addition of any preservative. In other silos substances which it was thought would act as preservatives, including cane feeding molasses, powdered whey, and skim-milk cultures of bulgaricus and lactic-acid organisms, were mixed with the alfalfa at rates ranging from 1 to 5 percent of the weight of the alfalfa.

The silos were emptied during December and January, and all of the silage was found to be in good condition except for the usual amount of spoilage at the surface. The use of the preservatives, particularly the powdered whey, caused a slightly greater development of acid and presumably, therefore, made this silage keep better than the silage put up without any preservative. The unchopped alfalfa kept well, altho there was somewhat greater spoilage at the surface than in the silos containing chopped alfalfa.

Alfalfa silage was substituted for corn silage in the rations of two high-producing dairy cows for six weeks without noticeable effects upon milk production. The alfalfa silage seemed, however, to have a more laxative effect than corn silage.

Further work is needed before final recommendations can be made, but from the results obtained to date it appears that alfalfa harvested at an early haying stage and ensiled directly from the field without wilting is likely to make good silage, altho better keeping qualities are assured thru the addition of 2 percent of molasses, or 40 pounds to each ton of alfalfa. (524 Dairy Husbandry)

Improved Dairy Pastures Possible Thru New Studies

Illinois, fifth state in milk production, already has more than 7½ million acres of pasture, but new pastures are being started and old ones improved under stimulus of current soil-conservation measures. Observations reveal wide differences in pastures on dairy farms and indicate that poor pastures can be improved thru suitable practices. One season's work on methods of improving dairy pastures has now been completed by the division of Dairy Production. The work is being

done in cooperation with the Departments of Animal Husbandry and Agronomy.

One phase of the project deals with the improvement of an old bluegrass pasture. The methods used consist of good management practices, such as delaying pasturing in spring until a good growth has been made; dividing of the pasture into two parts, with alternate graz-

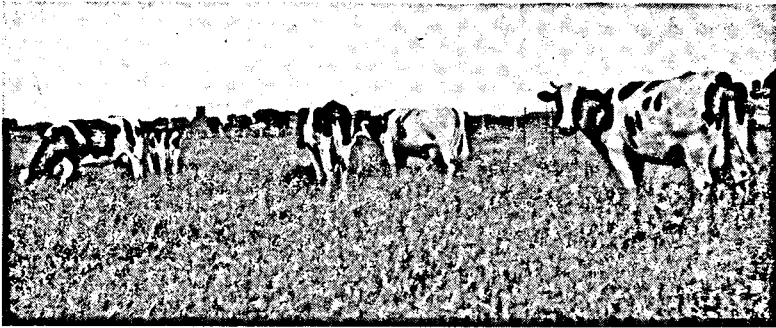


FIG. 27.—AN IMPROVED BLUEGRASS PASTURE

One season's results already indicate that poor pastures can be improved thru suitable practices. As it is now, there are wide differences in the 7½ million acres of pasture on Illinois farms. This weedy bluegrass pasture which had been given no special care for several years responded with increased yields after manuring, clipping, alternate grazing, and other good management practices were adopted.

ing of these plots; regular clipping to control weeds; heavy manuring with stable manure; and other practices which will develop a thick turf, reduce the amount of weeds, and increase the yield of grass. The first season's work in which ten high-producing Holstein cows were pastured on two 4½-acre plots indicates that progress has been made.

A combination of crops which will provide pasture over a number of months is being worked out in another phase of the project. The fields were planted last year, and pasturing will begin this year. Among the crops being studied are winter rye, bluegrass, alfalfa, Korean lespedeza, and Sudan grass.

A third series of plots has been planted to alfalfa with the object of comparing alfalfa for pasture, alfalfa for hay, and alfalfa as a soiling crop.

It seems evident from results obtained to date that high-producing dairy cows which receive all or a large part of their roughage from pasture do not remain in as good a state of flesh and are harder to keep at a high level of production than those which are barn-fed. (531 Dairy Husbandry)

ENTOMOLOGY INVESTIGATIONS¹

Corn Borer Spreads But Not Yet Found in Illinois

While the European corn borer has not been found in Illinois, continued studies of the insect under the supervision of W. P. Flint, Illinois Natural History Survey, and George H. Dungan, Crop Production, in cooperation with the U. S. Bureau of Entomology and Plant Quarantine and the U. S. Bureau of Plant Industry, reveal that it is slowly spreading westward.

A much larger infestation, extending over practically all the eastern counties of Wisconsin, was found during the past year. Some slight westward spread of the borer occurred in Indiana. It has been found in Kentucky at several points along the Ohio river. The north-eastern and eastern areas of Illinois were scouted, but no trace of the borer was found in this state. (3.4 Illinois Natural History Survey)

Paper Barriers Promise Help in Control of Chinch Bugs

Chinch bugs were again thick enough over a considerable area of Illinois in the spring of 1936 to remind farmers that at some future time the outbreak of this pest may become as serious as it was in 1934. That year Illinois farm crops worth 40 million dollars were destroyed. Fortunately in future outbreaks farmers will have the benefit of new and improved types of barriers being tested out by W. P. Flint, J. H. Bigger, and M. D. Farrar, Illinois Natural History Survey, in cooperation with the Department of Agronomy.

Four-inch strips of tarred felt paper set 2 inches into the soil appeared to be the most practical form of barrier to check the bugs as they move into cornfields from small grain. Such strips were satisfactory when treated either at home or commercially. Occasional retreatment with creosote was required, as with all mechanical barriers.

The strips may be obtained by cutting ordinary 15-pound rolls of tarred felt paper into small rolls 4 inches wide. These are soaked in creosote twenty-four hours and then drained to remove excess oil. The paper is then unrolled along the field where the barrier is to be established and set 2 inches into the soil. Two inches of the width of the paper thus is left above ground. To keep this portion rigidly upright, the soil must be firm against both sides of the lower portion.

The paper barrier is left in position for the season, being retreated as necessary. Retreatment is accomplished by pouring a narrow stream of creosote against the paper, on the side next to the small grain.

A quarter mile of 4-inch strip can be obtained from 450 square feet of felt paper. After treatment and installation the paper barrier be-

¹The entomology investigations of the Experiment Station are conducted cooperatively with the Illinois State Natural History Survey.

comes practically proof against rain, dust, and heavy winds, while to maintain it in an efficient condition requires about half as much creosote as when the creosote is applied to soil. Paper barriers also do not require constant attention for the maintenance of a high efficiency in turning chinch bugs. In general it is believed that in future chinch bug campaigns paper barriers will aid materially in reducing losses. (3.5 Illinois Natural History Survey)

Eliminating All Wheat Would Not Stop Chinch Bugs

As a result of the common observation that chinch bugs congregate in certain small grains in preference to others for feeding and breeding, the question is often raised as to whether the complete elimination from a neighborhood of the grains most attractive to the bugs would reduce the bugs and their injury both to small grains and corn. The additional

TABLE 36.—PREFERENCE OF CHINCH BUGS FOR DIFFERENT SMALL GRAINS

Kind of grain	Number of fields examined			Average spring infestation of adult bugs in each linear foot of drill row			
	1934	1935	1936	1934	1935	1936	3-year weighted average
Rye.....	13	5	10	43	13	1.2	22.7
Winter wheat.....	22	8	23	42	12	.6	19.5
Barley.....	7	3	3	20	23	2.5	16.7
Spring wheat.....	3	2	2	17	13	.8	11.2
Oats.....	74	78	86	2	2	.04	1.3

question of the feasibility of using small plantings of the grains most attractive to the bugs as trap crops in which to concentrate and destroy the pests is also frequently asked. Answers to such questions have an important bearing on practical chinch bug control. Field studies have therefore been conducted during the past three years under the supervision of W. P. Flint, M. D. Farrar, J. H. Bigger, and L. H. Shropshire, Illinois Natural History Survey, in cooperation with the U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine, and the Department of Agronomy of the Experiment Station.

Findings made in these studies show quite decisively that the small-grain preferences of chinch bugs migrating from winter quarters vary with the climatic character of the spring season and the condition of the respective grains. Under certain conditions any of the small grains, including oats, may become severely infested. While oats are the least attractive, the elimination from an area of all the small grains except oats would not do away with chinch bug troubles, altho it might reduce them to some extent. Even where all small grains were eliminated from

an area, some infestation developed directly on corn altho infestation in general was probably materially reduced by the absence of small grain. No single small grain was sufficiently more attractive than the others to serve effectively as a trap crop in which the bulk of the bugs in a neighborhood could be concentrated and destroyed.

The above findings are based mainly on actual counts of chinch bug abundance made by Curtis Benton, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, about every ten days in all small-grain fields in several mile-square areas in northern Illinois containing representative types of cropping. A brief summary of the data is given in Table 36. (4.2 Illinois Natural History Survey)

Hibernation Studies Help Farmers Check Insect Loss

Severe outbreaks of chinch bugs and grasshoppers in Illinois during recent years have aroused farmers to the urgency of using all possible means to combat losses from these pests. As part of the search for clues that may possibly lead to better means of control, the Experiment Station conducts studies of numerous insects while they are in hibernation. These studies are in charge of J. H. Bigger, S. C. Chandler, L. H. Shropshire, and M. D. Farrar, Illinois Natural History Survey, in cooperation with the Departments of Agronomy and Horticulture.

Of special interest to grain farmers was the question of the survival of chinch bugs during the past winter (1935-36), the most severe one of the century. Zero and sub-zero weather interferred seriously with the observations on this point. Nevertheless they were carried on thruout the latter part of the winter and spring. The studies indicated that chinch bugs hibernating in exposed locations were very nearly exterminated during the winter. However, those bugs which had lodged in good cover, such as thick hedge or heavy bunch grass, survived to the extent of about 85 percent. These latter places are the most frequently used hibernating quarters of the bugs. As a consequence it was estimated that approximately 75 percent of the total chinch bug population survived the winter of 1935.

Of further interest is the question of the possible survival of the adults of the southern corn rootworm. During the fall of 1935 hundreds of them were located in a piece of timber near Urbana. During March, 1936, it was impossible to find a living specimen of this insect in the timber. (20.1 Illinois Natural History Survey)

Resistant Varieties Reduce Corn Rootworm Damage

In a severe attack made upon the corn-belt section of Illinois in 1935, southern corn rootworms (*Diabrotica duodecimpunctata*) ate off nearly all the primary root system of at least 2 million acres of corn. This damage and subsequent rotting of the roots delayed the plants so

that early frosts reduced the quality of the crop and also caused severe lodging, thereby making harvest more difficult and expensive.

Studies of this problem by J. H. Bigger and W. P. Flint, Illinois Natural History Survey, in cooperation with the Department of Agronomy and J. R. Holbert, U. S. Department of Agriculture, revealed that certain corn varieties and hybrids have a marked resistance to rootworm. With the information now on hand increased effort can be put forth toward breeding this rootworm resistance into improved strains of corn as a part of the corn-improvement program of the state, thereby stabilizing yields, improving quality of grain, and reducing costs of production and harvesting. One important observation was the fact that certain of the hybrids most resistant to lodging following rootworm attack are also resistant to second-brood chinch bugs and are also outstanding for yield and quality of grain in the Illinois corn-performance test plots.

A careful check on the lodging of various varieties and hybrids following rootworm attack was made in extensive plantings of corn on experiment fields thruout the state. During the fall more than 160,000 plants were counted and a careful record made of lodgings. These observations extended over all parts of the state and included records on at least 39 open-pollinated varieties and 179 hybrids, both commercial and experimental. Results shown in Table 37 demonstrate conclusively that hybrid strains are generally more resistant to lodging

TABLE 37.—LODGING OF CORN VARIETIES AND HYBRIDS CAUSED PRINCIPALLY BY SOUTHERN CORN ROOTWORM ON ILLINOIS EXPERIMENT FIELDS
(Data taken at harvest, November 5 to December 2, 1935)

Section of state	Location of fields	Hybrid strains		Open-pollinated varieties	
		Total number of plants examined	Plants lodged	Total number of plants examined	Plants lodged
Northern.....	Rochelle Plainfield	13 074	<i>percl.</i> .5	3 574	<i>percl.</i> 7.5
North-central.....	Cambridge Granville Dwight	31 968	6.7	6 719	30.0
Central.....	Adair Bellflower Armstrong	46 796	33.2	8 823	62.0
South-central.....	Winchester Sullivan	13 420	56.5	5 232	77.6
Southern.....	Alhambra	7 354	73.9	5 894	82.5
Central.....	Strip tests in 15 fields in 7 coun- ties	13 244	29.6	7 418	61.1

than open-pollinated varieties following rootworm attack. Some hybrids are more susceptible to lodging than others, as shown by the fact that the five hybrids showing the least damage in central Illinois were lodged 15.4 percent in the same fields where the five hybrids showing the most damage were lodged 58.6 percent. In the same fields the range of lodging in the open-pollinated varieties was 54.3 percent for the five best and 70.4 percent for the five poorest varieties.

Important data were secured on the Hartsburg experiment field showing that lodging may be more severe on highly productive soil than on less productive or poorly managed soils. On this field the hybrid on first-year cornland of the untreated plot was lodged 13 percent, while the open-pollinated variety was lodged 41 percent. On the plot receiving a manure-lime-phosphate treatment, the hybrid lodged 27 percent and the open-pollinated variety 68 percent. (3.7 Illinois Natural History Survey)

White Grub Damage Is Lessened by Periodic Surveys

At different times large acreages of corn in western and northwestern Illinois have been destroyed by white grubs. Damage caused by this insect is being lessened, however, as the result of periodic surveys conducted by J. H. Bigger and L. H. Shropshire, Illinois Natural History Survey, in cooperation with the Department of Agronomy.

That the white grub becomes relatively abundant every third year is known, as is also the fact that the grubs become established in the soil the year previous to that in which the corn crop is damaged. In view of these facts a survey is made during the fall previous to the year damage is expected. Such a survey during the fall of 1935 indicated that grubs were present in small numbers and that damage during 1936 might be comparatively light.

Information of this kind permits the farmer to make suitable crop adjustments. Thus in years when little damage is expected, as in 1936, corn might safely be planted on land in grass the previous year, whereas if heavy grub damage were expected, such procedure would be inadvisable. (5.2 Illinois Natural History Survey)

Root Aphids on Corn Reduced Following Sweet Clover

Continued study of the effect of rotations upon the abundance of insects on corn are pointing the way to lower production costs of higher-quality corn. In this study being carried on by J. H. Bigger, Illinois Natural History Survey, in cooperation with the Department of Agronomy, thousands of plants are dug each year and examined for insect infestation under varying rotation practices on the soil experiment fields.

Infestations in the corn crop of 1935 were limited, following the almost continuous rains of May, but important data were obtained

regarding infestation by the corn root aphid. At Carthage one series had first- and second-year corn in a rotation of corn, corn, oats, and red clover, and fourth-year corn in a continuous corn plot. Fourteen percent of the first-year corn plants, 28 percent of the second-year, and 36 percent of the continuous corn plants were infested with aphids.

At the Hartsburg soil experiment field .7 percent of the first-year corn plants and 9 percent of the second-year plants were infested with aphids where grain stubble had been plowed down in a livestock system of farming. In contrast 1.7 percent of the first-year corn plants and only 2.5 percent of the second-year plants were infested where sweet clover had been plowed under in a grain system of farming. The rotation in this case was corn, corn, oats and Hubam clover, and wheat, with sweet clover in the wheat in the grain system but not in the livestock system. These data indicate that the infestations from 1934 were able to build up more rapidly under the livestock system than under the grain system of farming. (3.9 Illinois Natural History Survey)

Costly Ear Worm Is Attacked in Enlarged Studies

Corn ear worms, the greenish or yellowish insects often found working at the tips of the ears in sweet corn, cause losses in Illinois ranging from hundreds of thousands to several million dollars a year. They may become so abundant in canning corn as to reduce the crop to a serious extent. In years when the insect is abundant 2 to 7 percent of the kernels in all the ears in a field may be destroyed. These insects also attack field corn. No means of control that is practical commercially has yet been developed. In gardens, or to save especially valuable seed corn, dusting may be resorted to as a means of reducing the damage. However, the best dusts now available reduce the worms only 30 to 40 percent.

In work carried on the past year by J. H. Bigger, W. P. Flint, and L. H. Shropshire, Illinois Natural History Survey, in cooperation with the Department of Horticulture, the ear worm problem has been attacked from two angles, the development of better insecticides for dusting corn and the development of better machinery for applying them. A new type of power-driven machine was developed in cooperation with manufacturers of dusting machinery. This was used to some extent in a cooperative arrangement with the Hoopston Canning Company, one of the largest growers of canning corn in the state. The results from the insecticide tests were rather indefinite, owing in part to the fact that the corn ear worm infestation in 1935 developed late in the season, most of the sweet corn having been harvested before the ear worm became abundant.

A study of the seasonal abundance of the insect was carried on by the use of light and bait traps. It is hoped that by means of these

traps the occurrence of the worms in canning corn can be predicted. The best time to apply insecticides would thus be known. Use of insecticides in field corn would be too costly to be profitable.

An arrangement has been entered into whereby the Survey, the Experiment Station, and the Federal Bureau of Entomology and Plant Quarantine will conduct studies on this insect cooperatively. Two full-time entomologists of the federal bureau are working under this arrangement. It is hoped that the program can be carried on over the next five years, and that by careful study of the fundamental factors governing the abundance of ear worm, better methods of control can be developed. It is planned to spend most of the effort toward control of the worm in field corn on the development of resistant varieties. Preliminary work has shown that a number of varieties of field corn are quite resistant to ear worm attack. (3.2 Illinois Natural History Survey)

New Materials Prevent Insect Damage to Stored Grain

Several new dry materials, some of which are nonpoisonous to man and animals, have effectively prevented insect damage to grain in tests carried on by M. D. Farrar and W. P. Flint, Illinois Natural History Survey, in cooperation with the Department of Agronomy. To date all trials have been made with wheat, but tests with other grains are in progress.

Treatments consisted of mixing 2 ounces of insecticide with each bushel of grain. Copper carbonate, copper phosphate, copper cyanid, and hydrated lime gave perfect protection to wheat subjected to attack by weevils over a period of one year. Two nonpoisonous preparations giving equally good results are pyrethrum powder, containing .95 percent pyrethrins, and a pyrethrum product marketed as "Activated A Dust." The pyrethrum materials are of special interest because grain treated with them can enter normal commercial channels without the complication of toxic residues. Altho highly toxic to insects, pyrethrum is relatively nonpoisonous to man and the higher animals.

All wheat stored for one year with the insecticides mentioned germinated as well as or better than the untreated grain. Grain treated with copper carbonate and hydrated lime germinated more quickly than that given any of the other treatments. (14.1 Illinois Natural History Survey)

Fumigants Tested for Control of Stored-Grain Pests

Severe drouths and resultant feed shortages during recent years, coupled with attempts to balance market supplies of grain with effective demand, have placed a new premium on the safe storage of grains and feeds. Unfortunately one of the farmer's most difficult problems in storing grain is to keep it free of insects. The problem is compli-

cated by the storage of grain and feed thruout the year, which permits insects to develop in small quantities of stored materials during the summer months and to spread to the main storages after harvest. Grain held for more than one year is almost certain to be attacked by several grain insects. These pests not only destroy the grain, but also lower the grade and price by their presence. Unless stored grain is watched, insects may cause heating, molding, and severe spoilage. Most grain on farms is stored in the regular farm buildings, which are not equipped for moving grain mechanically. Hence infested grain must be treated where it is.

Possibilities for solving these problems are being opened thru tests of fumigants conducted by M. D. Farrar and W. P. Flint, Illinois Natural History Survey, in cooperation with the Departments of Agronomy and Animal Husbandry. Good control can be secured by fumigating farmers' grain bins with carbon bisulfid, but the fire hazard of this material limits its use. A commercial fumigant sold as "Chloro-sol" has been tested extensively during 1935. The chemical has no fire hazard and can be used with little danger. When the material is poured onto grain not more than 8 feet deep, five pounds for each 100 bushels of oats has given good insect control. In bins 50 feet deep, 8 pounds for each 100 bushels was required to kill insects thruout the depth of grain. The principal advantage of the fumigant is safety. It penetrates well, leaves no disagreeable odors, and can be used by following simple directions. Of several fumigants tested, only this one meets the requirements for farm use.

Altho certain other fumigants have given good results, they all require either special conditions for application or technical skill and apparatus in making the treatments. Such fumigants have a definite place in elevator and mill fumigation, but are not adapted to farm use. (14.2 Illinois Natural History Survey)

Crib Corn Is Sprayed to Combat Stored-Grain Insects

Unless protected against grain moths and weevils, corn cannot be stored more than one year in southern Illinois without injury. While the bulk of the corn used as seed is planted the spring following its production, there is often an inconvenience and a loss to the farmer in not being able to keep it longer. In each of many of the states the loss from this source runs more than a million dollars a year.

In tests under the direction of M. D. Farrar and W. P. Flint, Illinois Natural History Survey, in cooperation with the Department of Agronomy, corn in cribs near Edgewood was sprayed with oil emulsion to protect it from stored-grain insects. The data obtained indicate that a 10-percent oil emulsion may be used as a spray without injury to the corn. Because of the heavy infestation in the bin at the time of spraying it has been impossible to obtain any positive data on the effect

of the treatment. The moisture content of the corn was not raised more than 1 percent by the spraying. (14.3 Illinois Natural History Survey)

Resistant Varieties Promising as Hessian Fly Control

In three to five years out of every ten the Hessian fly is an important hazard to the Illinois wheat crop. During the ten-year period the pest will destroy 4 to 5 percent of the wheat crop, but in years when it is worst it may destroy 25 to 50 percent of the crop. The 1936 wheat crop was one of those which was badly damaged thruout the western and southwestern portion of the winter-wheat belt. Many fields were so badly damaged that they were plowed up during the fall of 1935 and the spring of 1936.

Recent success in developing varieties of wheat which are resistant to the fly indicates that this may be a helpful procedure for coping with the pest. These studies are under the supervision of J. H. Bigger and W. P. Flint, Illinois Natural History Survey; O. T. Bonnett, Plant Breeding; and G. H. Dungan, Crop Production; with R. H. Painter, of the Kansas Agricultural Experiment Station, cooperating.

Previous experimental work has demonstrated that plowing under old wheat stubble, destroying volunteer wheat, and especially seeding at a recommended date have proved to be a fairly satisfactory method of controlling damage by Hessian fly and producing maximum yield. Despite these measures, however, there are certain years when seasonal developments are such that a late fall brood of fly appears. Since these seasonal developments are uncontrollable and at present unpredictable and since the practices mentioned do not prevent severe damage by the spring brood of fly, there is need for some further means of preventing severe damage.

Breeding varieties of winter wheat resistant to Hessian fly may be accomplished in two ways: (1) by the selection of resistant strains from varieties already in commercial production, and (2) by crossing resistant with susceptible varieties and selecting the resistant progeny. Success by the first method is based upon the fact that within a variety that has never been selected for resistance there may be variation in the degree to which the plants are injured by Hessian fly. Hence by selecting the resistant plants and multiplying the seed from them, resistant varieties can be produced.

Crossing followed by selection can also be used to produce resistant varieties. Crossing is resorted to whenever the resistant variety is undesirable or lacking in some of the essential characteristics of a good variety. By crossing the resistant with the susceptible variety and selecting those progeny that have resistance as well as other desirable characteristics, it is possible to obtain foundation strains for resistant varieties. It is by the two methods just outlined that a new attack is to be made upon the Hessian fly problem.

Preliminary trials of wheat varieties previously tested in Kansas were made in Illinois during the fall of 1931. These trials were satisfactory and were made the basis for further tests including Illinois varieties. From 1932 to 1935 experimental plantings have been made on the soil experiment field at Carthage and the crop experiment field at Alhambra. Nineteen varieties have been planted in duplicate rod rows on these fields during the middle or latter part of September. During December these plants were dug and examined for infestation.

At Carthage infestation has occurred in three of the four plantings, there being none in the 1934 planting. The infestations have not been heavy enough to be of economic importance, and since the figures cannot be considered significant, they are not reported here.

At the Alhambra field heavier infestations have occurred in two of the four years, namely 1932 and 1935. Owing to other conditions it was possible to check on only seven of the varieties during both of these years. Results are given in Table 38. Results of the other two years are omitted because they lack significance.

TABLE 38.—COMPARATIVE INFESTATION OF DIFFERENT WHEAT VARIETIES BY HESSIAN FLY, ALHAMBRA EXPERIMENT FIELD, 1932 AND 1935

Variety	1932		1935		Average	
	Tillers infested	Rank	Tillers infested	Rank	Tillers infested	Rank
	<i>perct.</i>		<i>perct.</i>		<i>perct.</i>	
Brill.....	43.6	4	9.7	4	26.7	3
Fulcaster.....	28.1	1	2.9	1	15.5	1
Fulho.....	33.7	2	21.8	6	27.8	4
Illinois Progeny 2.....	46.7	5	31.7	7	39.2	7
Kawvale.....	54.9	6	8.6	3	32.8	5
Michigan Amber.....	35.9	3	5.9	2	20.9	2
Nabob.....	60.8	7	13.0	5	36.9	6

Enough progress has been made in this work to demonstrate that variation does exist in the locally adapted varieties and that further progress may be made in the near future toward developing varieties of wheat that have not only other desirable characteristics, but also an appreciable degree of resistance to Hessian fly.

The use of resistant varieties can never replace other methods of controlling this insect, especially since timely planting has been demonstrated as productive of maximum yield, but such varieties may be a valuable means of preventing severe losses when long, late falls produce untimely broods of the fly. (4.1 Illinois Natural History Survey)

Liquid P.D.B. Kills High Percentage of Peach Borers

Thru weakening and devitalizing trees, the peach tree borer, the lesser peach borer, and bark beetles annually cause large losses in Illi-

nois peach orchards. Sprays for their control would be applied more generally if they were less expensive than at present. As possible means whereby control at less cost could be obtained, liquid applications of paradichlorobenzene (P.D.B.) and other materials have been given continued study by S. C. Chandler, Illinois Natural History Survey, in cooperation with the Department of Horticulture.

A three-season test for peach borer control was concluded in the fall of 1935. Of the several materials tested, best results were obtained by dissolving P.D.B. crystals in a dormant miscible oil at the rate of 2 pounds to 1 gallon, then diluting with water to make 4 gallons, and applying the solution to the base of the tree at the rate of a pint a tree. The average kill obtained with this material at this strength (three seasons' tests) was 96 percent as compared with 95.4 percent with the regular crystalline treatment. This proved that the kill obtained with the liquid treatment was equal to the regular crystal treatment when used in the same manner, the trees being mounded after treatment. However, the cost of the materials was doubled by use in the liquid form, and this could only be compensated for by speed of operation or use without mounding. The tests in the spring of 1936 were confined to determining the need of mounding after treating with the liquid applications. A 100-percent kill was obtained from the trees that were mounded and 90.5 percent from those not mounded.

Three seasons' tests for the control of the lesser peach borer, which works higher up on the tree where there is no opportunity to treat in the regular manner, showed an average of 82.2 percent kill obtained by P.D.B. in a dormant miscible oil. Two pounds of P.D.B. crystals were dissolved in 1 gallon of dormant miscible oil, and this mixture was diluted with water to make 2 gallons. The diluted mixture was painted on the affected areas. In tests continued in the spring of 1936 P.D.B. was used at twice the former strength. A 100-percent kill was obtained with no injury to date. Further work on these insects is needed. (10.1 Illinois Natural History Survey)

Studies Aid in Economical Control of Plum Curculio

While plum curculio is a serious enemy to Illinois' average annual peach crop of 1,750,000 bushels and often necessitates the expenditure of large sums for spray materials and labor, it is highly susceptible to changing weather conditions. For this reason the destructiveness of the insect varies widely from year to year, and the control measures needed one year may not be needed in another. Studies continued the past year by S. C. Chandler, Illinois Natural History Survey, in cooperation with the Department of Horticulture, kept peach growers informed of the situation with respect to plum curculio and so aided in the economical control of this insect.

In 1935 curculio was light and two sprays were sufficient. In the

spring of 1936, however, it became evident from the jarrings and observations carried on in orchards in southern Illinois that the situation had changed. More curculios were jarred in sprayed orchards than for several years. Notice of this situation was given in the regular weekly radio broadcast on fruit insects, and growers generally increased the number of early sprays. Weather then entered the situation, the excessive heat and drouth preventing most of the beetles from leaving the ground. From this fact it was evident that the natural

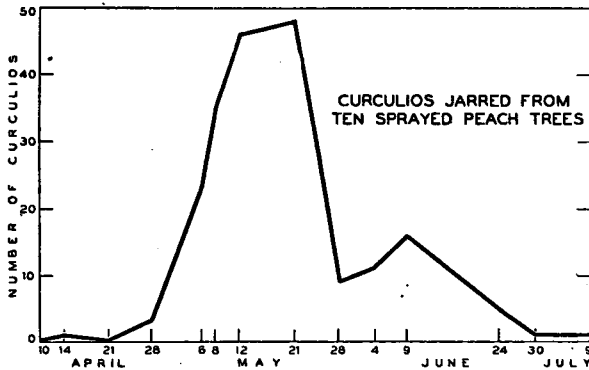


FIG. 28.—FLUCTUATION IN THE 1936 PLUM CURCULIO INFESTATION IN A SPRAYED ORCHARD

The figures are for the number of curculios jarred from ten sprayed peach trees at Carbondale. By keeping growers informed of such changes in the insect situation, investigations by the Experiment Station and the Illinois Natural History Survey reduce the cost of pest control.

increase which usually takes place in the latter part of the season after a heavy early infestation would not appear, and that it would not be necessary to apply arsenical sprays a month before harvest. Fig. 28 shows the rapid rise in the number of curculios in a sprayed orchard and the drop to practically none.

While still in the experimental stage so far as peach insects are concerned, oil dusts have been tested in comparison with the regular arsenical sprays. Plots outlined in the spring of 1935 and checked for curculio in August gave the following results:

Treatment	Peaches examined	Infested with plum curculio per cent.
Oil-dusted plots (average of two plots).....	2 000	1.2
Sprayed twice.....	2 000	.3
Untreated check.....	1 000	6.4

Either of the above treatments would be considered good commercial control. (10.2 Illinois Natural History Survey)

Infestation of Fruit Moth Worst Since Pest Was Found

Seriousness of the oriental fruit moth in Illinois peach orchards has increased to the point where the 1935 infestation was the worst since the pest was first found in the state in 1927. A large number of counts made at harvest time showed an infestation ranging from 8 to 50 percent in the larger peach-growing sections. This growing infestation is all the more serious because of the peculiar manner in which the insect attacks fruit. The worms enter at the stem end or even in the stem. Consequently many wormy peaches go over the grader as No. 1 fruit. In a number of cases the inspectors later catch this fruit and require a change of classification, with a resulting lower price.

Continued attack on this pest has been made in studies under the direction of S. C. Chandler and W. P. Flint, Illinois Natural History Survey, in cooperation with the Department of Horticulture. Tests begun in the spring of 1935 were carried thru the season, the results being noted at peach harvest in August. These tests were conducted to obtain further information relative to the following questions:

1. What control can be secured with oil dust as compared with the regular sprays for curculio and brown rot?
2. Is oil dust applied the latter part of the season as effective as when applied thruout the season?
3. Is dusting from one side of the tree as effective as from both sides?
4. Is the addition of derris in the oil dust of any value?

These questions were not all settled by the tests, but the following facts were brought out:

1. On the basis of results from the check blocks practically 50-percent control was obtained with oil dust. This is less than in other years because of the tremendous numbers of worms that hatched and the fact that the intervals between dusts were too long. Tests with dusts at shorter intervals are planned.

2. Practically no difference could be seen in the control obtained by applications of oil dust thruout the season and by those started a month before harvest, following early applications of spray.

3. Where a pound of dust a tree was applied, $\frac{1}{2}$ pound from each side, no better control was secured than where $\frac{1}{2}$ pound was applied from one side. This result does not seem reasonable and will be checked in further tests.

4. Derris oil dust was of no special value in the control of the oriental fruit moth.

In 1936 there was a decided tendency among growers to begin control operations earlier than previously, which resulted in many repeated requests for information regarding the broods and waves of infestation. This information has been secured thru the help of cooperators

in three orchards and the use of bait traps. More accurate data on the seasonal activity of the insect has been obtained than heretofore. In this connection a test of two common baits was run at Carbondale in June, 1936. Brown-sugar bait in a 30-day trial was found to attract more than twice as many moths as molasses bait.

The work of establishing parasites has been carried on more extensively in 1936. This work is done in cooperation with the U. S. Bureau of Entomology and Plant Quarantine. Forty-six colonies of parasites have already been liberated in 1936. It is hoped these will become established and be of aid in the control of the oriental fruit moth. (10.6 Illinois Natural History Survey)

Parasites Are Fostered as Insect Control Measure

If it were not for the fact that approximately one-third of the different kinds of insects occurring in Illinois depend for their food supply on the other two-thirds of the insect population, it would be far more difficult to produce good crops or to keep trees and flowering plants from damage and disfigurement than it is now. Taking advantage of this fight among insects, the entomologists of the Experiment Station and Illinois Natural History Survey are constantly on the lookout for opportunities to foster and increase it.

In some cases it is possible to stimulate the production of insect-feeding species artificially or to distribute them in parts of the state where they do not exist or where for some reason the plant-feeding species are not keeping up with their hosts. In general, however, little can be accomplished thru the artificial propagation of a native species of parasite or predator. Better results are usually obtained by the introduction of species not occurring in the region affected.

To the end that insects be made to fight each other as much as possible, a careful check is kept on the injurious plant feeders occurring in the state and on the species of insects that are attacking them. If it seems possible to aid in this insect warfare, new species of parasites are brought in for this purpose.

Foreign parasites are introduced only in cooperation with the Federal Bureau of Entomology and Plant Quarantine. Such insects must be studied very carefully both in their native country and under conditions here before being liberated, and it is not possible for the state to carry on this work. During the past three years several new species of parasitic insects have been liberated in Illinois. This work will be continued and enlarged if possible. (21.1 Illinois Natural History Survey)

Oil Dusts Give Good Results in Long Test on Peaches

An important step in the stabilization of peach production in Illinois is to control the oriental fruit moth. However, this must be done in

such a way that the trees are not injured. Lead arsenate and lime sprays are partially effective against the moth, but if injury to the foliage is to be avoided, Experiment Station tests have shown that zinc sulfate must be added to these sprays. Considerable work with oil dusts has been done in a three-year experiment concluded in 1935. Significant results were obtained from the use of these insecticides. This work, which was under the direction of M. D. Farrar, S. C. Chandler, and W. P. Flint, Illinois Natural History Survey, in cooperation with the Department of Horticulture, was carried on in the experimental orchard at Olney.

Four blocks of peach trees were used, three of which, beginning in 1933, were sprayed and dusted, while the fourth had no treatment.

TABLE 39.—1935 RESULTS ON PEACH TREES AFTER THREE YEARS OF TREATMENT FOR ORIENTAL FRUIT MOTH

Treatment of plots for three years		Number of trees in plot	Yield of fruit	Control of oriental fruit moth
<i>Early season</i>	<i>Late season</i>		<i>lbs.</i>	<i>per cent.</i>
Dust: 60 parts hydrated lime, 25 parts talcum powder, 10 parts lead arsenate, and 5 parts Diamond paraffin oil	Dust: 60 parts 300-mesh sulfur, 20 parts hydrated lime, 15 parts talcum powder, and 5 parts Diamond paraffin oil	56	4 657	17.7
3 lbs. lead arsenate, 8 lbs. zinc sulfate, 8 lbs. hydrated lime in 100 gallons of spray	8 lbs. zinc sulfate, 8 lbs. hydrated lime in 100 gallons of spray or 5 lbs. dry wettable sulfur in 100 gallons	54	3 589	21.8
3 lbs. lead arsenate, 6 lbs. hydrated lime in 100 gallons of spray	4 lbs. dry wettable sulfur in 100 gallons of spray	30	527	None
No treatment	No treatment	29	238	None

From the standpoint of tree vigor, growth, and foliage the untreated plot was superior to those receiving any of the treatments. This is a further illustration of the fact that spray treatments of all kinds produce unfavorable reactions in peach trees. Fruit production on the untreated trees, however, was poor. In 1935 when oriental fruit moth was abundant, hardly 20 percent of the fruit remained on the trees until harvest.

Of the treated plots the most unprofitable was that sprayed with 3 pounds of lead arsenate and 6 pounds of hydrated lime early in the season, and with wettable sulfur previous to harvest. By harvest each year practically all the leaves had fallen, and spray injury and sunscald were found on much of the fruit. In 1935 the total crop of this plot was less than one-fourth that produced in each of the two best plots.

Outstanding among the sprayed plots was the one receiving 3 pounds of lead arsenate, 8 pounds of zinc sulfate, and 8 pounds of hydrated lime early in the season and preharvest sprays of either zinc-lime or wettable sulfur. Only traces of spray injury were apparent, the fruit and foliage developed normally, and an excellent crop relatively free from insect damage was produced.

Each year oil dust was in all respects equal to or superior to any of the other treatments. This dust was composed of 60 percent lime, 25 percent talc, 10 percent lead arsenate, and 5 percent oil early in the season and 60 percent sulfur, 15 percent talc, 20 percent hydrated lime, and 5 percent oil late in the season. The dusted trees grew normally, held excellent foliage, and produced an excellent crop of high-quality fruit. The control of oriental fruit moth was practically equal to that of the most effective of the other treatments.

The yields and insect control obtained in 1935 are summarized in Table 39. Out of this experiment, which was designed as a study of the accumulative effect of insecticide and fungicide treatments for peaches, have come the following important facts:

1. Peaches to be profitable must be protected against insects and diseases.
2. Lead arsenate and hydrated lime is not a profitable spray to use on peaches.
3. The use of zinc sulfate with lead arsenate and hydrated lime makes an excellent spray for peaches.
4. Oil dusts are excellent for use on peaches. (10.5 Illinois Natural History Survey)

Oil Dust Is Tried in Study of Catfaced Peach Problem

In some years 10 to 20 percent of the Illinois peach crop, which in 1935 amounted to more than 3 million bushels, is affected by catfacing, an injury which results in scarred, distorted, and lopsided fruit. The greatest damage usually occurs when peaches are a light crop and worth the most.

The insects chiefly responsible for catfacing are the tarnished plant bug and the various stink bugs, or pentatomids. Both are sucking insects and cannot be poisoned. The plant bug is very active and is difficult to hit with a contact insecticide, while the stink bugs are tough and hard to kill even if hit.

Various repellents have been tried, and in the work of the past year a test of oil dust was made. This test was carried on at Carbon-dale under the direction of S. C. Chandler, Illinois Natural History Survey, in cooperation with the Department of Horticulture, in the hope that the oil dust, if applied about blooming time, would repel the insects as they were about to enter the orchards. Two applications were made, April 10 and 15, each being at the rate of 1 pound to a tree.

Jarring the trees one week after the last application showed the same number of insects in each plot, but very few in either. Peaches then dropped badly, and in the final count on June 11 (1936) very light catfacing was found. No data of value could be obtained. (10.3 Illinois Natural History Survey)

Distillate, Soybean Oil Aid in Codling Moth Control

Surveys have shown that orchardists obtaining control of codling moth, the most serious insect enemy of Illinois' extensive apple-growing industry, are those who give careful attention to the details of spraying and general orchard sanitation. In this connection the prevention of infestation by adult moths emerging from orchard crates stored during the winter has been a troublesome problem. Many commercial orchards have from one thousand to five thousand crates in use each year, and unless the moths wintering in them are prevented from flying back into the orchard, much infestation results.

In experimental work carried on by W. P. Flint, S. C. Chandler and M. D. Farrar, Illinois Natural History Survey, it was found that the larvae of codling moths overwintering in orchard crates and like equipment can be killed by dipping, the treatment being given during the winter months before the adult moths emerge. At least 98 percent of the moths failed to emerge when crates were dipped in any one of several mixtures.

The basic dipping mixture used in 1935 was tractor fuel kerosene, or distillate. This, mixed with 5 percent by volume of monochloronaphthalene, killed all the codling moth larvae. The distillate alone killed 99.4 percent, while distillate with 5-percent tar wash (manufactured by Niagara Sprayer and Chemical Corporation) killed 98.8 percent of the larvae. From the untreated crates there was an average emergence of 4.7 moths a crate.

The quantity of oil required for dipping orchard crates depends upon their construction. Heavy crates may absorb a pint of liquid and light ones no more than a fourth as much. Only that portion of the crate harboring codling moth larvae need be dipped.

Soybean Products Show Value in Sprays.—As long ago as 1929 crude soybean oil was being successfully used in sprays in Illinois for the control of codling moth. Rapid expansion of soybean production in Illinois has made the state a center for the development of new uses for this crop, and continued research has revealed additional ways in which soybean products fit into the preparation and use of sprays.

As a sticker for arsenical sprays soybean oil has been found superior to any other material tested. Use of the oil at the rate of 1 to 2 quarts to 100 gallons of spray has greatly improved both the spreading and sticking qualities of arsenicals while causing very little, if any, injury to foliage. Care should be taken not to use soybean oil in exces-

sive quantities or late in the season, as in either case the fruit is likely to have residues that are difficult to remove.

Soybean flour also was used in Illinois orchard field tests in 1935. When mixed with arsenicals in orchard sprays, this flour aids in the deposit of a smooth, even film on the fruit. Results with this material have been so successful that in 1936 Illinois and other experiment stations will conduct extensive tests with it.

Results of preliminary tests indicate that soybean flour may also be useful as an emulsifier. Trees sprayed during the dormant period in 1935-36 with oils emulsified with soybean flour were not injured by the sprays. The properties of soybean flour are such that it may find rather wide use in orchard spray practices. (9.1 Illinois Natural History Survey)

San Jose Scale Survey Saves Orchardists Large Sums

Thousands of dollars were saved to Illinois apple and peach orchardists during the winter of 1935-36 by the annual San Jose scale survey which showed that the severe winter had killed the scale over a large portion of the state, thus making it unnecessary to spray for this fruit enemy over the usual area. The gathering of this information was in charge of S. C. Chandler, M. D. Farrar, and W. P. Flint, Illinois Natural History Survey, and others of the staff.

In the fall of 1935 the annual survey showed a moderate to severe infestation in some part of 33.7 percent of the apple orchards and 45.4 percent of the peach orchards. Growers were notified and urged to spray carefully either in the fall or the following spring before leafing began. With young produced at the rate of 300 a female scale and a brood every 35 days so long as the weather stays mild, San Jose scale increases with great rapidity. This is especially true in the southern end of the state, where the growing season is long.

The winter of 1935-36 entirely altered the situation of the previous fall. Many collections of scale were made at various points thruout the state, and from examination of them it was found that from Carbondale and Harrisburg north nearly 100 percent of the scale had been killed by the severe winter. From those points south the kill varied from 100 to 80 percent, sufficient scale surviving to justify scale sprays in many orchards. Growers were again notified and, taking advantage of the situation, many omitted the dormant spray. From \$75,000 to \$100,000 was saved by Illinois orchardists in this way.

The severe weather that removed the necessity of spraying also in many cases made experiments at Carbondale on the control of San Jose scale inconclusive. Tests were made of methods of control designed chiefly to reduce the expense of spraying. In these tests apple trees were uninjured even tho the methods were applied during an abnormally cold winter. No results of kill of scale could be secured

from the large series of tests because of the severe winterkilling of the scale in all plots. (9.4 and 10.4 Illinois Natural History Survey)

Progress Toward Control of Apple Tree Borer Is Made

An insect enemy of Illinois' 5 million apple trees for which there is now no satisfactory control is the round-headed apple tree borer. At present the principal means of checking this pest is by use of a jackknife and wire, a method that is slow, inefficient, and that may injure the tree as much as the borer. Progress toward finding a better means of control is being made in studies under S. C. Chandler and W. P. Flint, Illinois Natural History Survey, in cooperation with the Department of Horticulture.

Paradichlorobenzene (P.D.B.) applied in the crystalline form as for peach borers has been found to injure apple trees. When it was found that P.D.B. dissolved in a dormant miscible oil caused no injury on peach, however, an attempt to use it for borers on apple was made. Tests were started in an abandoned nursery of four-year-old apples near Godfrey in the fall of 1935. In that year P.D.B. was dissolved in a commercial miscible oil at the same rate as for peach tree borer, 2 pounds to 1 gallon. The solution was then diluted with water in two proportions, 1 ounce to 1 pint and 2 ounces to 1 pint, and painted on the bases of trees showing signs of borers. The weaker solution resulted in a kill of 27.2 percent of the borers and the stronger in a kill of 61.9 percent. No injury resulted.

In the spring of 1936 a stronger mixture was used, 4 pounds of P.D.B. being dissolved in 1 gallon of miscible oil. This was diluted with water to make 2 gallons, each pint thus containing 4 ounces of P.D.B. On the check plot all the borers remained alive, while on the treated trees 63 percent were dead. Again no injury resulted.

It is felt that this control is not good enough, tho perhaps it is as good as that obtained by the jackknife method. It is not known whether something can be found to increase the efficiency of control. Further tests will be made. (9.8 Illinois Natural History Survey)

New Attachment Lowers Cost of Applying Oil Sprays

Considerable saving in the cost of applying oil sprays may be effected thru use of an inexpensive attachment to the spraying rig that has been worked out by M. D. Farrar, Illinois Natural History Survey, and R. H. Reed, Agricultural Engineering, in continued studies of new insecticides and the best ways of applying them. With this attachment, known as an "injector," oil can be used in spray mixtures without the processing formerly necessary to make it miscible with water.

By means of a pipe "T" with two gate valves, the attachment provides a small secondary suction to the spray pump. In this way the oil is drawn directly into the spray mixture, where it is broken up and

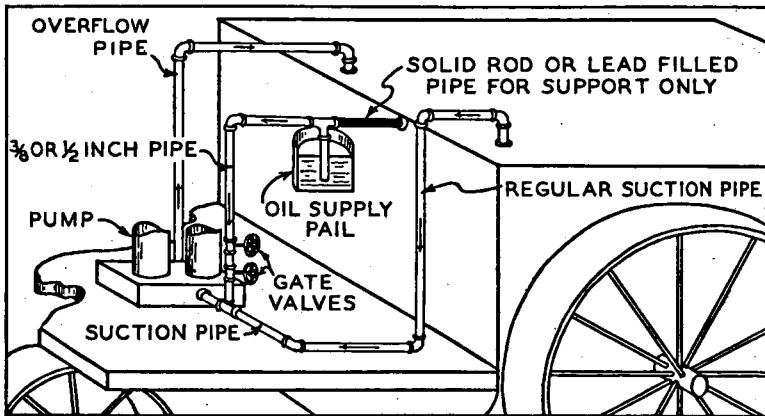


FIG. 29.—“INJECTOR” WHICH REDUCES COST OF APPLYING OIL SPRAYS

This device makes it possible to use oil in spray mixtures without the processing formerly necessary to make the oil miscible with water. A pipe “T” with two gate valves provides a small secondary suction to the spray pump. This draws the oil directly into the spray mixture, where it is broken up and emulsified before it enters the spray tank.

emulsified before it enters the spray tank. Several commercial installations in 1935 proved the practicability of the method in many orchards. Further details of the attachment, with illustration, are given in Circular 447, “Directions for Spraying Fruits in Illinois.” (18.1 Illinois Natural History Survey)

Renovated Strawberry Beds Show Lower Insect Counts

Whether the renovation of strawberry beds is of practical value in southern Illinois, where a large share of the state’s 5000-acre strawberry crop is grown, is a point on which neither growers nor experimenters have been in agreement. Work designed to test and to demonstrate the value of this treatment was carried on the past year by S. C. Chandler, Illinois Natural History Survey, in cooperation with the Department of Horticulture.

Counts of the insect population in renovated and nonrenovated berry patches were made at a selected location in Pulaski county. These counts showed an average of two adult rootworms a square foot in the renovated area, with no strawberry crown borers. In the neglected area there was an average of one adult crown borer a square foot and of twenty adult rootworms. In addition crown borers were found hibernating in brome sedge which had grown up in the nonrenovated area but which was absent from the renovated area. (12.3 Illinois Natural History Survey)

Summer Oils Tested as Preventive of Raspberry Loss

Red spiders, the same mites that destroy and disfigure many ornamental and flowering plants, are responsible for much of the loss of raspberries occurring both in central and southern Illinois. In an effort to find means of reducing this damage, tests of the effectiveness of summer oils in controlling red spiders on red raspberries have been carried on during the past three years. S. C. Chandler, Illinois Natural History Survey, in cooperation with the Department of Horticulture, is in charge.

The season of 1935 was unfavorable to the development of the mites, which thrive in hot, dry weather. There was an abundance of rain the first of the season and evidently enough later to prevent a serious infestation. To determine the increase in mite infestation and the possible control afforded by various treatments, counts were made on plots in Pulaski county maintained by the Department of Horticulture. Fifty leaves were taken at random thruout each of selected plots, with and without treatments of summer oil, and subjected to heat under 100-watt lights for 48 hours, the mites being driven thru the berlese funnel. Five examinations were made during the period from May to September. From the first of August on there was a gradual increase in the number of mites. There were not enough to affect the leaves, however, and in the small numbers found there was no indication that the plots had been treated differently.

Tests on the same plots were resumed in 1936, but no definite results from this work have yet been obtained. Tentatively, three summer applications of 8-8-100 bordeaux with 1-percent summer oil are recommended—one to be made just before bloom, one just after harvest, and the other two to three weeks later. (12.1 Illinois Natural History Survey)

New Copper Sprays Fail to Match Bordeaux on Potatoes

Results of tests conducted at the Cook county branch experiment station the past few years have demonstrated that unless controlled, the potato leafhopper seriously limits the production of potatoes. An average of 50,000 acres of potatoes is grown in Illinois each year, and if the damage of this insect could be avoided, the increased yields, improved quality, and lowered costs of production would benefit both grower and consumer.

In a series of tests carried on the past season by L. H. Shropshire, Illinois Natural History Survey, in cooperation with the Department of Horticulture, several of the newer copper sprays were compared with 4-4-50 bordeaux in the control of the potato leafhopper. While some of these materials showed promise, a 4-4-50 bordeaux spray gave the greatest increase in potato yield of any materials tested.

Bordeaux-sprayed plots stayed green longer and gave higher yields than any other plots. (6.3 Illinois Natural History Survey)

Better Control of Bean Leafhopper Is Expected

In four years out of five the snap beans raised in Illinois are seriously damaged by the bean leafhopper. Thru the application of 3-6-50 bordeaux spray or a 16-84 monohydrated copper-sulfate-lime dust much of the damage by this insect can be prevented. Bean yields in an average season have been doubled by the use of these materials. It is believed, however, that the methods giving these results can be improved. To do so is the object of continued work under L. H. Shropshire, Illinois Natural History Survey, in cooperation with the Department of Horticulture.

Details concerning the application of sprays for control of bean leafhoppers can be found in Circular 437, "Saving Garden Crops From Insect Injury." (7.9 Illinois Natural History Survey)

Forecasts of Insect Outbreaks Effect Large Savings

Every farmer, truck grower, and amateur gardener in Illinois knows from experience that cutworms and armyworms have often been the source of much damage. These insects are present over all the state every year, but in some seasons are more abundant than in others. This is especially true of the armyworm. During many seasons this insect causes no appreciable damage anywhere in the state. In other years it may clean out the crops over large areas unless control measures are applied in time.

Because of the irregularity with which armyworms and cutworms appear, it is highly important if they are to be controlled without unnecessary expense, that their probable abundance be known in advance. To determine the probable abundance of these and other common moths, the larvae of which are destructive to crops, is the purpose of continued studies under W. P. Flint, Illinois Natural History Survey, in cooperation with the Department of Horticulture.

All cutworms are moths in their adult stage, and nearly all of them are attracted by certain kinds of lights or the odors of certain baits. As the moths make their appearance several weeks, or in some cases several months, in advance of the destructive worms, it has been found possible, by maintaining a series of light traps and of bait traps over a period of years, to foretell the coming of armyworm and cutworm outbreaks. This information can always be put out several weeks, and in some cases several months, in advance of the outbreak.

Thru the use of bait traps and of light traps in 1935 it was possible to forecast the general armyworm outbreak occurring that year. Information as to the time the worms would appear was given to the farm bureaus, vocational agriculture teachers, and to the daily and

agricultural press three to five weeks in advance of the outbreak. As a result many farmers were on the watch for armyworms in their fields and were enabled to take prompt action in poisoning them. Farm bureaus and other agencies were also able to provide an adequate supply of effective poisons at the time they were needed. As a result, hundreds of thousands of dollars were saved for Illinois farmers. (19.1 Illinois Natural History Survey)

Greenhouse Cucumbers Are Protected Against Thrips

Large profits from greenhouse cucumbers are seen as the result of experimental work in which the several species of thrips that attack this crop have been successfully controlled. These tiny insects, which materially reduce the yields of greenhouse cucumbers in Illinois, feed by rasping the surfaces of the leaves and sucking up the juices as the plant bleeds. As greenhouse cucumbers are very susceptible to injury by most fumigants, an infestation of thrips once established in the greenhouse is very difficult and expensive to remove.

Their control in experimental work which was carried on by C. C. Compton, Illinois Natural History Survey, in cooperation with the Department of Horticulture, was obtained by means of insecticides of the aliphatic thiocyanate group. These insecticides should be applied at the weakest dilution recommended for thrips by the manufacturer and must be used in conjunction with a good spreader if satisfactory results are to be obtained. Spreaders of the sulfonated amine or sulfonated alcohol types were found to be superior to those containing oil or soap. In order to lessen the possibility of injury to cucumbers by spraying, it is advisable to spray the day following a watering, when the plants are turgid, and preferably on a day when the sun is not shining brightly. It is important to use sufficient pressure to wet thoroly the undersides of the cucumber leaves. Use of a fine nozzle with pressures of 150 to 200 pounds has been found very satisfactory. (8.14 Illinois Natural History Survey)

Control of Cyclamen Mite on Begonias Is Obtained

Were it not for the toll exacted by the cyclamen mite, which attacks not only the plant whose name it bears but also begonia, St. Paulias, and other greenhouse crops, flowers and ornamental plants grown under glass could be produced with far less risk. In some greenhouses of the state, where the cyclamen mite has become thoroly established, it has been almost impossible to grow begonias of the Chatelaine type to maturity and still have them in salable condition.

Studies in the control of this pest have been made by C. C. Compton, Illinois Natural History Survey, in cooperation with the Department of Horticulture. In experiments carried on in commercial greenhouses the past year the cyclamen mite was eradicated on begonias.

This was done thru the use of naphthalene and a proprietary mixture containing halogenated substituted benzene ring compounds combined with certain turpene substances. Tests on the use of these fumigants alone for the control of cyclamen mite on cyclamen has not progressed to the point where definite recommendations can be made. Naphthalene was found to be somewhat cheaper than the proprietary mixture, but is more toxic to greenhouse plants. (8.2 Illinois Natural History Survey)

Better Insecticides for Greenhouse Scale Are Found

Nearly a score of scale insects feed on and are capable of severely injuring ornamental plants in the greenhouses. Control of these pests, despite many recommendations, has remained a problem. Of the fumigants, nicotine or hydrocyanic-acid gas give the most satisfactory results, but as there are many times when conditions do not permit fumigation, a distinct demand for suitable insecticides has arisen. Experimental work designed to answer this need has been in progress under C. C. Compton, Illinois Natural History Survey, in cooperation with the Department of Horticulture.

Tests conducted in Illinois greenhouses during the past year have shown that proprietary mixtures containing aliphatic thiocyanates are more effective than the insecticides commonly used on the scale type of insect. In spraying for scale insects, it is important to reduce the amount of spreader in the spray, as the addition of spreader to the amount most effective for the control of aphids or plant lice has been found to give excessive runoff when applied to most scale insects. Insecticides of the aliphatic thiocyanate group have been found to be quite effective for the control of the larvae of the greenhouse whitefly. Care must be exercised in spraying greenhouse plants with these insecticides to follow the directions of the manufacturer carefully, since there are certain plants upon which they cannot be used and others that may be injured under certain conditions. (8.7 Illinois Natural History Survey)

Red Spider Studies Are Furthered by New Fellowship

. As a group the many different mites commonly called red spiders attack a wide range of plants. Flowering plants, many of the ornamental shrubs, and fruit and shade trees, particularly evergreens, are all subject to damage by these insects. Various methods of control have been developed, but none is entirely satisfactory, especially for trees and shrubs and some of the outdoor flowering plants. A better method of control is badly needed. A continued search is being made under W. P. Flint, C. W. Kearns, C. C. Compton, and M. D. Farrar, Illinois Natural History Survey, in cooperation with the Department of Horticulture.

Aiding in this work is a special research fellowship established the past year by the Crop Protection Institute. This fellowship is supported by the Monsanto Chemical Company, St. Louis, Missouri, makers of many synthetic materials, some of which are being tested as insecticides and miticides. In tests conducted in 1935 some of the synthetic materials gave promise of providing cheaper and more effective control of red spider than anything now known. Intensive work in developing this line of materials will be carried on during the coming year. (13.4 Illinois Natural History Survey)

Pyrethrum-Selenium Combination Controls Leaf Tyers

On roses and chrysanthemums cheap control of the greenhouse leaf tyer and the rose leaf tyer, important insects that attack various cut flowers and potted plants in Illinois greenhouses, may be obtained by combining a pyrethrum spray with the sprays commonly used for controlling the red spider. This has been determined in continued studies of the two insects under C. C. Compton, Illinois Natural History Survey, in cooperation with the Department of Horticulture.

Spray material containing a sulfid of selenium as the active agent, which is widely used against the red spider, was combined with several proprietary insecticides containing pyrethrum. From one-half to one-fourth the dilution of pyrethrum was sufficient to kill the leaf tyers when the spray was applied in combination with the selenium sulfid. (8.3 Illinois Natural History Survey)

Dormant Emulsion Protects Elms From European Scale

European elm scale is spreading rapidly in many sections of Illinois. Serious damage to the beauty and vigor of elm trees from this source may be averted, however, as the result of experiments carried on by M. D. Farrar, Illinois Natural History Survey, in cooperation with the Experiment Station.

These experiments, which were conducted on small trees 15 feet high, have demonstrated that a single spray of 5-percent dormant oil emulsion applied during the dormant season will reduce the scale in infested elms to such a degree that it will be hard to find a year later. Consistent annual spraying on trees isolated from reinfestation might stamp out an infestation. Since it is almost impossible to spray large trees thoroly, however, reinfestation is bound to occur under most conditions.

All elms found in Illinois are attacked by the European elm scale, altho some varieties are reported as lightly infested. Some of the English elms and the American red elm are favored host. The common American elm of cities is readily attacked, but not so severely injured. Some selections of American and Chinese elm are less readily attacked. In some places the scale has escaped to the woodland trees, where there

is little chance to control it. Where it is firmly established, it is doubtful if full control can ever be obtained. (13.5 Illinois Natural History Survey)

Wrappings Protect Newly Set Shade Trees From Borers

Drouth conditions during the past several years have injured some forest and shade trees enough to subject them to attack from wood-boring insects. Little can be done to save the injured forest trees, and they should be removed to destroy breeding places for these insects. In the case of valuable shade trees fertilization will aid in their recovery, altho even these trees are often better removed.

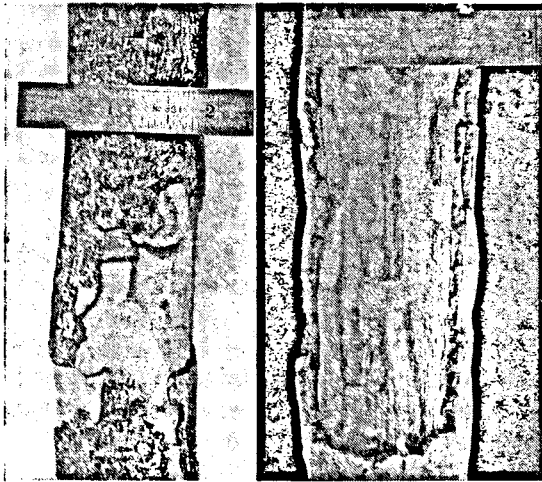


FIG. 30.—DAMAGE TO NEWLY PLANTED SHADE TREES BY THE
FLAT-HEADED APPLE-TREE BORER

This hard maple (*left*) and the pin oak (*right*) show examples of the damage which either killed or severely injured newly set shade trees left unprotected. Practically all damage was prevented by wrapping the trunks of trees.

Newly transplanted shade trees, however, can be easily protected against certain wood-boring insects by wrapping the trunks of these trees, according to findings by M. D. Farrar and W. P. Flint, Illinois Natural History Survey, in studies made in cooperation with the Experiment Station and the State Division of Highways. Some 400 recently transplanted trees were treated in 1935 with various types of wrappings and repellents.

These tests indicate beyond doubt that newly set shade trees should have their trunks protected by wrappings from May to August the first year after transplanting. In the experiments practically no damage

occurred on the wrapped trunks. All wrapping materials tested, including light-proof paper, wrapping paper, newspaper, muslin, and burlap, were found satisfactory. Loops of binder twine held the wrappings in position on the trunks.

In striking contrast to the wrapped trees most of the unwrapped trees were either killed or severely injured by the flat-headed apple tree borer. Contrary to common belief whitewashing of the tree trunks did not prevent damage by borers. A strong soap repellent containing naphthalene also failed to protect the trunks.

Since the materials for wrapping newly set shade trees are so available and inexpensive, there is little excuse for not wrapping the trees for the first year after transplanting. Protection should be given for the critical period of insect activity thru the months from May to August. The necessity of protecting the trees for the second year of growth has not been determined. Experience has shown, tho, that borers seldom attack a vigorous growing tree and that once a tree has become firmly established, it should not need further protection from wood-boring insects. (13.6 Illinois Natural History Survey)

Naphthalene Flakes Give Excellent Control of Fleas

At least some relief from fleas, which for many Illinois families are associated with the summer months and vacations, is in sight as the result of continued work by M. D. Farrar, Illinois Natural History Survey, in cooperation with the Experiment Station. Pets kept about the house bring these pests onto the premises, where they increase during the summer months to enormous numbers. On returning from a summer trip, householders often find the basement and sometimes the entire house, heavily infested with them.

Confirming previous tests, naphthalene flakes gave the best control of fleas under house conditions. When spread over infested floors at the rate of 1 pound to each 100 square feet of floor space, this material has given excellent results. In all tests the crude unrefined naphthalene has been superior to the highly refined product. Altho less available, the crude naphthalene is cheaper and can be obtained thru dealers handling the refined material.

The treatment should be left on the floors three to five days, after which the portion remaining can be removed. (17.5 Illinois Natural History Survey)

Control of Locust Borer Would Help Soil Program

General adoption of soil-conservation measures in Illinois has necessitated many plantings of quick-growing trees on soils where severe erosion is taking place. Black locust has been found to be the most desirable tree for these plantings, first because of its quick growth, and second because of its ability to establish itself under

varying soil conditions, some of which are adverse to the growth of other trees. It is also desirable for the purpose because it is a legume and tends, when grown in badly depleted soils, to build them up.

The fact that it is always attacked by the locust borer, an insect which frequently ruins commercial plantations of locust four to ten years after they are established, constitutes a serious drawback to the planting of black locust. In continued studies in the control of this insect W. P. Flint and M. D. Farrar, Illinois Natural History Survey, in cooperation with the Experiment Station, are searching for combinations of trees which, when grown with the black locust, will prevent serious damage by the locust borer. Mixed plantings of locust and other trees put out in 1935 were partially destroyed by fire the following spring. Some of the plantings are still coming on. It is not yet possible to draw any conclusion as to what mixtures, if any, will be most effective in reducing damage by the locust borer. Such results cannot be obtained for several years. (13.3 Illinois Natural History Survey)

More Effective Control of Ants Is Made Possible

Better control of ants, various species of which are not only annoying in living quarters but also cause considerable loss in stores handling food and in eating places, has been made possible thru work conducted by W. P. Flint, W. E. McCauley, and others of the Illinois Natural History Survey. Studies of the habits of the various house-infesting ants and of poisonous baits effective for their control have been carried on for several years. Some definite results, especially from the use of poisons containing thallium, have been obtained.

Results of this work have been summarized and brought together in Circular 456, "Ants—How to Combat Them." This appeared in June, 1936. (15.1 Illinois Natural History Survey)

New Termite Investigations to Study Soil Treatment

Enormous property losses which termites are causing in Illinois has been called sharply to the attention of property owners thru data collected in rural housing surveys and by other means in representative counties. When, as in at least one county, every farm property had been or was infested with termites, the control of this insect becomes an important economic problem. Even more enormous losses are occurring in urban centers, where property values are being reduced each year by termites.

By proper building construction it is possible to eliminate damage by termites, altho at the present time only a small part of the new construction provides for termite control. Termite-proofing of new buildings costs very little extra, while to control the insects in buildings already infested will always be a much more expensive process.

As an aid to providing cheaper methods of control for the small homeowner, an extensive experiment was started at Urbana in 1935 by W. E. McCauley, W. P. Flint, and M. D. Farrar, Illinois Natural History Survey, in cooperation with the Department of Agricultural Engineering. Particular attention is to be given to chemicals suitable for treating soil about buildings already infested. A practical and satisfactory method of soil treatment would find a wide use under Illinois conditions. This is a logical approach to the problem, since termites must maintain contact with the soil in order to exist. In the new tests more than fifty different treatments are to be compared, several of which look promising. (16.1 Illinois Natural History Survey)

Studies Point to Cheaper Means of Protecting Turfs

Lawns, parks, and golf courses are valuable assets for the maintenance of which Illinois citizens pay many thousands of dollars each year. All are subject to serious damage by insects attacking turfs, and much of the money used in keeping them in a suitable condition goes for the control of these insects or the repair of damage done by them. Studies of these insects have been in progress for a number of years, and as the result of work carried on the past year by C. C. Compton, W. P. Flint, M. D. Farrar, and E. R. McGovran, Illinois Natural History Survey, in cooperation with the Department of Agronomy, means have been found whereby the expense of controlling them may be substantially reduced.

The extent of the damage by insects attacking turfs varies widely from year to year. In some years large areas in many sections of the state are ruined. In other years there is little or no damage. Methods of controlling certain of the more important of these insects, particularly white grubs and cutworms, are known. These measures are needless, however, except in years when the insects are abundant.

Work of the past year consisted mainly in keeping check on the insects thru the use of light traps and of bait traps. While 1935 was the normal year of the three-year cycle for flight of adults of the white grub, weather conditions were such that this insect did not appear in large numbers. This knowledge that the adults of June beetles were not abundant made it possible to omit special treatments of turfs in many cases and thus save expense.

No tests of new materials were made in 1935, but some of the long-time tests on the effect of applications of lead arsenate to pasture turfs were continued. No definite conclusions can be drawn from these tests for several years. To date they look very promising as a possible method of increasing the growth of desirable pasture grasses in the northwestern part of the state where bluegrass suffers severe damage from grubworms. (5.3 Illinois Natural History Survey)

AGRICULTURAL ECONOMICS

Some Farms Average Extra Earnings of \$1,786 a Year

Some north-central Illinois farms were operated enough more profitably than others during the ten years 1925-1934 that the average difference in net earnings a farm would have paid for a fairly good farm. This condition is shown in the results of ten years of records kept by 57 farms enrolled in the farm bureau farm management service in Livingston, McLean, Tazewell, and Woodford counties.

The most profitable one-third of the 57 farms earned an average of \$1,786 more a farm a year during the ten years 1925-1934 than the least profitable one-third of the farms. Each of the farms was under the same management during all ten years. Details are given in Table 40.

Most of the average difference of \$1,786 a farm a year between the more and less profitable farms was the result of differences in management, both in the way the farms are being handled and the way they have been handled over many years. Very little of the difference could be traced to differences in size of farms or quality of land. Most of the difference was accounted for by farm-management efficiency factors. A difference of 3.7 bushels an acre in yield of corn, 2.4 bushels an acre in yield of oats, and proportionate differences in other crops accounted for \$484 of the total difference. An \$18 difference in return for each \$100 worth of feed fed to productive livestock accounted for \$389; a \$2.63 difference in the value of feed fed per acre of the farm and the increased return secured when this extra feed was fed to livestock accounted for \$253; a difference of 1.7 percent of tillable land in the more profitable crops accounted for \$176; differences of 5 cents a bushel for corn and 9 cents a bushel for wheat accounted for \$157; and differences of 57 cents an acre in miscellaneous expenses, 26 cents an acre in man labor, and 4 cents an acre in horse and machinery costs accounted for \$140, \$64, and \$10 respectively. About 55 percent of the corn and oats produced on these farms was sold as grain.

The farm bureau farm management service is now being conducted in twelve other counties besides Livingston, McLean, Tazewell, and Woodford. A total of 440 farms completed the work in 1935. The project is planned to obtain information that will help all farmers organize and operate their farms more profitably. The greatest value is to men who keep careful records and are assisted in analyzing the results of the records and in following practices based on the facts shown in the data.

The project is under the direction of H. C. M. Case and M. L. Mosher, Agricultural Economics, in cooperation with committees made

up of one man representing the cooperators in each of the counties. W. A. Harrington, as fieldman, has worked with the farmers in Livingston, McLean, Tazewell, Woodford, Henry, Knox, Peoria, and

TABLE 40.—COMPARISON OF MOST AND LEAST PROFITABLE FARMS IN THE FARM BUREAU FARM MANAGEMENT SERVICE IN LIVINGSTON, MCLEAN, TAZE-WELL, AND WOODFORD COUNTIES: AVERAGE OF YEARS 1925 TO 1934

Items	Average of 57 farms	19 most profitable farms	19 least profitable farms
Capital investments, total	\$51 147	\$51 155	\$48 228
Land.....	35 460	36 202	33 148
Farm improvements.....	6 545	5 514	7 084
Livestock, total.....	3 173	3 433	2 913
Horses.....	746	734	808
Cattle.....	1 334	1 469	1 012
Hogs.....	745	954	659
Sheep.....	155	102	257
Bees.....	36	1	15
Poultry.....	157	173	162
Machinery and equipment.....	2 279	2 229	1 996
Feed, grain, and supplies.....	3 690	3 777	3 087
Receipts and net increases, total	\$ 5 344	\$ 6 078	\$ 4 291
Livestock, total.....	2 728	3 567	2 196
Horses.....	395	23	373
Cattle.....	585	885	1 118
Hogs.....	1 313	1 800	1 129
Sheep.....	78	72	2
Bees.....	14	114	119
Poultry.....	106	193	140
Egg sales.....	145	480	315
Dairy sales.....	2 487	1 944	1 629
Feed, grain, and supplies.....	2 107	96	69
Labor off farm.....	92	47	49
Miscellaneous receipts.....	49	424	348
Family living from farm.....	368		
Expenses and net decreases, total	\$ 2 213	\$ 2 097	\$ 2 093
Farm improvements.....	316	272	334
Horses.....	2	1	3
Productive livestock decreases.....			
Machinery and equipment.....	533	525	504
Feed, grain, and supplies.....	48	46	52
Livestock expense.....	240	214	239
Crop expense.....	539	516	443
Hired labor.....	483	474	465
Taxes.....	52	49	53
Miscellaneous expenses.....			
Receipts less expenses	\$ 3 131	\$ 3 981	\$ 2 198
Inventories beginning of year.....	51 147	51 155	48 228
Inventories end of year.....	50 868	50 895	47 936
Change in inventories (loss -).....	- 279	- 260	- 292
Total cash sales a year.....	6 530	7 674	5 267
Total cash expenses a year.....	3 488	3 857	3 125
Cash balance a year.....	3 042	3 817	2 142
Total unpaid labor	\$ 1 095	\$ 1 093	\$ 1 096
Operator's labor.....	886	913	890
Family labor.....	209	180	206
Net income from investment and management	\$ 2 036	\$ 2 888	\$ 1 102
Rate earned on investment (percent).....	3.98	5.65	2.28
Return to capital and operator's labor and management	\$ 2 922	\$ 3 801	\$ 1 992
5 percent of capital investment.....	2 558	2 558	2 411
Labor and management wage (or loss -).....	364	1 243	- 419
Family living furnished by farm	\$ 368	\$ 424	\$ 348
Farm products used in home.....			
Number in family.....	5.1	6.2	4.7
Farm products used per person.....	\$ 72	\$ 69	\$ 74

TABLE 41.—COMPARISON OF TEN YEARS' RECORDS OF FARMS IN FARM BUREAU FARM MANAGEMENT SERVICE IN LIVINGSTON, McLEAN, TAZEWELL, AND WOODFORD COUNTIES

Items	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935
Number of farms.....	210	200	150	380	380	352	190	172	165	168
Size of farm in acres.....	232.1	231.5	234.6	227.6	230.6	237.5	237.4	237.2	254.5	253.7
Rate earned on investment (percent).....	3.43	4.56	6.96	6.86	1.20	-1.13	-1.55	4.11	6.93	6.36
Total investment an acre ¹	\$209.11	\$207.04	\$204.97	\$199.35	\$201.44	\$193.90	\$188.77	\$184.57	\$188.48	\$191.83
Gross income an acre.....	20.74	22.78	27.86	27.17	15.43	9.25	6.84	16.85	22.22	22.32
Total expense an acre.....	13.57	13.33	13.60	13.49	13.01	11.45	9.76	9.26	9.16	10.21
Net income an acre.....	7.17	9.45	14.26	13.68	2.42	-2.20	-2.92	7.59	13.06	12.11
<i>Cash receipts, total.....</i>	<i>\$6 390</i>	<i>\$6 283</i>	<i>\$7 133</i>	<i>\$7 251</i>	<i>\$6 172</i>	<i>\$4 064</i>	<i>\$3 251</i>	<i>\$3 666</i>	<i>\$5 663</i>	<i>\$7 328</i>
Livestock, except dairy and poultry.....	2 958	2 569	2 957	2 881	2 427	1 783	1 402	1 538	1 922	3 126
Dairy products.....	353	380	469	612	583	452	379	372	488	503
Poultry and eggs.....	265	291	341	349	292	228	191	192	261	352
Feed, grain, and supplies.....	2 640	2 850	3 175	3 137	2 592	1 417	1 116	1 366	2 343	2 405
Machinery and equipment.....	101	96	99	168	160	106	98	121	163	293
Labor off farm and miscellaneous ²	73	97	92	104	118	78	65	77	486	649
<i>Cash expenses, total.....</i>	<i>\$3 443</i>	<i>\$3 283</i>	<i>\$3 799</i>	<i>\$3 935</i>	<i>\$3 288</i>	<i>\$2 371</i>	<i>\$1 968</i>	<i>\$1 942</i>	<i>\$2 624</i>	<i>\$4 211</i>
Livestock bought.....	734	630	818	787	480	381	428	311	560	1 104
Feeds.....	346	345	461	456	444	293	192	256	388	548
Machinery and equipment.....	620	607	728	912	775	407	299	412	557	952
Farm improvements.....	257	290	354	394	309	130	93	117	159	375
Livestock, crops, and other expense.....	352	350	365	376	330	301	231	198	265	379
Hired labor.....	634	573	612	564	479	369	300	268	367	520
Taxes.....	500	488	461	446	471	490	425	380	328	333
<i>Cash balance for year.....</i>	<i>\$2 947</i>	<i>\$3 000</i>	<i>\$3 334</i>	<i>\$3 316</i>	<i>\$2 884</i>	<i>\$1 693</i>	<i>\$1 283</i>	<i>\$1 724</i>	<i>\$3 039</i>	<i>\$3 117</i>
<i>Changes in inventories.....</i>	<i>-368</i>	<i>+138</i>	<i>+947</i>	<i>+708</i>	<i>-1 421</i>	<i>-1 462</i>	<i>-1 302</i>	<i>+766</i>	<i>+971</i>	<i>+611</i>
<i>Receipts less expenses.....</i>	<i>2 579</i>	<i>3 138</i>	<i>4 281</i>	<i>4 024</i>	<i>1 463</i>	<i>231</i>	<i>-19</i>	<i>2 490</i>	<i>4 010</i>	<i>3 728</i>
Bushels of corn an acre.....	51.3	42.0	53.0	46.2	36.1	47.9	58.4	35.1	35.3	59.4
Percentage of land in—										
High-profit crops.....	60.1	59.9	60.8	61.4	61.9	64.4	63.7	63.8	56.6	57.6
Medium-profit crops.....	7.4	13.2	15.1	13.9	13.4	12.8	12.0	9.3	14.2	16.1
Low-profit crops.....	32.5	26.9	24.1	24.7	24.7	22.8	24.3	26.9	29.2	26.3
Returns for \$100 feed to livestock.....	\$160	\$135	\$142	\$144	\$126	\$119	\$152	\$128	\$136	\$159
Pounds of pork produced an acre.....	64.0	74.0	76.0	73.7	72.0	83.2	88.4	89.1	67.8	57.3
Pounds of milk a cow.....	.....	.....	.....	6 166	6 574	7 404	7 056	7 312	6 779	6 657
Number of eggs a hen.....	85.4	93.8	92.5	94.0	93.5	102.2	113.4	110.2	110.3	114.0
Hired and home labor for each crop acre.....	\$8.33	\$8.28	\$8.27	\$8.14	\$7.29	\$5.77	\$4.98	\$4.93	\$5.04	\$5.59
Horse and machinery cost for each crop acre.....	5.50	5.52	5.54	5.35	5.07	3.83	2.92	3.01	3.21	3.35

¹Based on \$150 an acre for the better land without improvements. ²Includes AAA payments.

Stark counties. J. B. Cunningham served until October 15, 1935, and was then followed by E. G. Fruin in Grundy, LaSalle, Marshall, Putnam, Bureau, Lee, DeKalb, and Kendall counties.

A comparison of cash receipts, cash expenses, and some other factors for all farms included in the service for each of ten consecutive years in the first area to be organized is shown in Table 41. (203 Agricultural Economics)

Farm Earnings Recover Further From 1932 Low Point

The trend in farm earnings in Illinois continued upward in 1935 and, when inventory increases are considered, reached the highest level since 1930. This was the third year of improvement since the very low level of earnings in 1932. On a strictly cash basis, however, the average net income for the state as a whole was almost the same for both 1934 and 1935. This report for 1935 is based on the analysis of 1,639 Illinois farm-account books which were summarized in the Department of Agricultural Economics under the supervision of P. E. Johnston, J. B. Cunningham, H. C. M. Case, and E. L. Sauer (Table 42). Forty-three farm business reports were prepared for counties or groups of counties, each report based on 30 to 60 individual farm records.

These reports show the earnings, crop yields, livestock efficiency, and operating expenses on the one-third of the farms which were most profitable as contrasted with results from the one-third which were least profitable. A study of these reports over a period of years indicates those farm practices and enterprises which are most profitable for the area.

Individual reports are discussed with each cooperator and the parts of his particular business which are efficient and the parts which are inefficient are pointed out to him. The average of all accounting farms in the area is used as a standard for judging the efficiency of an enterprise or practice on a particular farm.

A large number of records over a period of years show how farm earnings vary from one part of the state to another. They also show how earnings vary from year to year for the different types of farming areas and for the state as a whole.

Farm-income data from farm accounts do not represent average farm conditions. Repeated studies have shown that the average earnings of all farms in an area are lower than for farms included in the accounting service. The accounting farms are larger than average and are operated by farmers who are more efficient than the average.

One thing influencing returns for the past year was the fact that for the state as a whole the combined yields of corn, oats, wheat, soybeans, and hay averaged higher in 1935 than for the ten-year period

1924-1933. Yields were much above average in 1935 for a group of counties in the northeast part of the state and for another area east of St. Louis. They were much below average for a group of counties in the southeastern part of the state and below average for a group along the Illinois river in the west-central part of the state.

Price changes which took place during 1935 favored the livestock rather than the grain farms. In December, 1934, 6.3 bushels of corn were equal in value to 100 pounds of hogs, while by December, 1935, 16.2 bushels of corn had the same value as 100 pounds of hogs. The price of corn and oats was much higher in the 1935 beginning inventory than in the closing inventory, thus causing large inventory losses on those farms with large grain inventories.

As in former years, farm incomes varied from one part of the state to another depending upon productivity of the soils, kind of crops grown, crop yields, and the price of products sold. In this comparison income is measured by the net cash income an acre and is calculated by deducting the value of unpaid labor from the difference between the cash farm income and the cash farm business expenditures.

Earnings for the Chicago dairy area were lower in 1935 than for the average of the period 1930-1934, as shown below. Earnings in all other areas were higher in 1935 than for the average of the five preceding years. Cash incomes are always influenced by crop yields of the preceding year, which accounts for the fact that the cash income an acre was appreciably higher in Areas 7 and 8 in 1935 than in 1934. The net cash income an acre was lower in 1935 than in 1934 for Areas 1, 3, 4, and 5 (Fig. 31). The increase in the price of beef cattle and hogs in 1935 was sufficient to carry the income for Area 2 higher than for any other area in the state.

The net cash income less the value of unpaid labor, for accounting farms, by farming-type areas for the periods 1925-1929, 1930-1934, and 1935, was as follows:

<i>Farming-type area</i>	<i>Average 1925-1929</i>	<i>Average 1930-1934</i>	<i>1935</i>
Area 1. Dairy and truck.....	\$9.90	\$5.55	\$3.33
Area 2. Mixed livestock.....	8.00	4.80	7.62
Area 3. Livestock and grain.....	8.83	4.89	6.02
Area 4. Cash grain.....	8.83	4.35	5.50
Area 5. General farming.....	5.54	3.15	4.22
Area 6. Wheat, dairy, and poultry.....	3.65	1.84	3.37
Area 7. Mixed farming.....	1.36	1.17	3.38
Area 8. Grain and livestock.....	4.07	1.32	4.45

The weighted average net cash income an acre for the state as a whole was slightly lower in 1935 than in 1934, as shown in Fig. 31. The decline in the price of grains in 1935 was sufficient to pull the net income an acre for Area 4 down to \$5.50, as contrasted with \$6.67

for 1934. Earnings for 1934 and 1935 were appreciably above the very low levels of 1931, 1932, and 1933.

The net income an acre is a very significant measure of farm earnings, since over a period of years it tells what the accounting farmers have actually made their farms and equipment worth. This

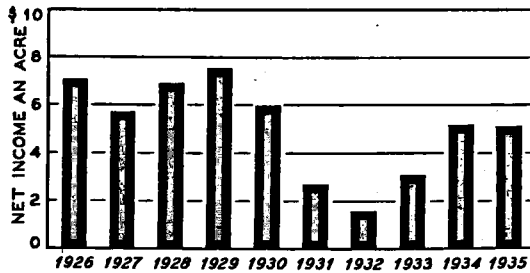
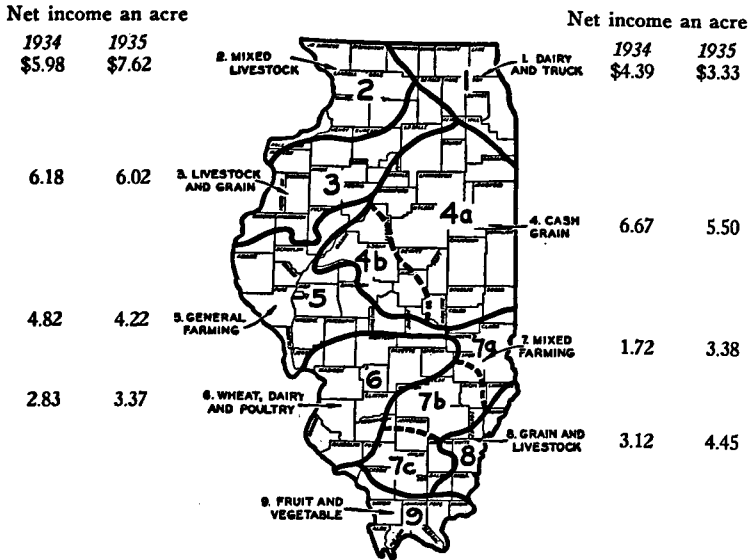


FIG. 31.—NET CASH INCOME AN ACRE, LESS THE VALUE OF UNPAID LABOR ON ILLINOIS ACCOUNTING FARMS BY FARMING-TYPE AREAS FOR 1934 AND 1935 (ABOVE) AND THE STATE AVERAGE (BELOW) FOR 1926 TO 1935

Farm income from one part of the state to another varied, as in past years, depending upon productivity of the soils, the kind of crops and livestock grown, crop yields, and the price of products sold. Inventory changes were not taken into consideration in the above figures. Area averages were weighted by the amount of land in farms to calculate the state average.

TABLE 42.—SUMMARY, BY AREAS, OF BUSINESS RECORDS FROM 1,639 ILLINOIS FARMS, 1935

Accounting items	Boone, DuPage, McHenry, Lake, Cook	DeKalb	Rock Island	Jo Daviess, Stephenson, Winnebago	Whiteside, Ogle, Lee	Carroll	Henry, Stark, Bureau, Marshall- Putnam	Mercer	Warren, Knox
Capital investment, total.....	\$30 181	\$30 110	\$28 376	\$24 623	\$30 113	\$25 394	\$30 898	\$34 569	\$35 948
Land.....	18 190	19 193	17 450	13 908	19 091	15 854	21 464	22 938	25 491
Farm improvements.....	5 824	5 081	4 794	5 425	5 062	4 249	3 892	4 660	4 592
Machinery and equipment.....	1 668	1 384	1 619	1 395	1 499	1 163	1 320	1 284	1 323
Feed and grain.....	1 694	2 058	2 254	1 569	2 054	1 722	2 158	2 483	2 278
Livestock, total.....	2 805	2 394	2 259	2 326	2 407	2 406	2 064	3 204	2 264
Horses.....	427	389	382	371	414	387	352	494	463
Cattle.....	1 892	1 273	1 055	1 372	1 354	1 309	841	1 569	1 090
Hogs.....	184	437	688	383	444	550	676	957	601
Sheep.....	196	178	42	114	112	46	120	85	53
Poultry.....	106	117	92	86	83	114	75	99	57
Income, net increases, total.....	\$ 4 370	\$ 4 898	\$ 4 425	\$ 4 004	\$ 4 206	\$ 4 894	\$ 4 508	\$ 6 587	\$ 4 920
Feed and grain.....	191	553	.....	.....	41	.....	446	.....	930
Labor and miscellaneous.....	56	48	59	85	93	64	73	78	89
Livestock, total.....	4 123	4 297	4 366	3 919	4 072	4 830	3 989	6 509	3 901
Horses.....	20	28	36	13	34	23	26	84	46
Cattle.....	912	1 727	1 195	973	1 487	1 499	1 203	1 937	942
Hogs.....	727	1 429	2 429	1 615	1 560	2 160	2 067	3 781	2 300
Sheep.....	143	126	54	113	124	70	176	137	116
Poultry and eggs.....	276	338	270	257	234	354	249	269	193
Dairy sales.....	2 045	649	382	948	633	724	268	301	304
Expenses, net decreases, total.....	\$ 1 669	\$ 1 302	\$ 1 663	\$ 1 256	\$ 1 259	\$ 1 212	\$ 1 226	\$ 3 044	\$ 1 384
Farm improvements.....	236	223	290	220	227	210	195	282	230
Machinery and equipment.....	475	377	390	365	330	255	343	386	366
Feed and grain.....	.....	.....	435	62	.....	125	.....	1 479	.....
Crop expense.....	232	213	125	167	170	171	183	149	195
Hired labor.....	380	201	189	195	248	203	218	398	289
Taxes.....	250	207	241	177	212	185	223	254	234
Horses.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Livestock and miscellaneous.....	96	81	63	70	72	63	64	96	70
Income less expense.....	\$ 2 701	\$ 3 596	\$ 2 762	\$ 2 748	\$ 2 947	\$ 3 682	\$ 3 282	\$ 3 543	\$ 3 536
Total unpaid labor.....	762	710	679	754	704	701	693	632	681
Net farm income.....	\$ 1 939	\$ 2 886	\$ 2 083	\$ 1 994	\$ 2 243	\$ 2 981	\$ 2 589	\$ 2 911	\$ 2 855

TABLE 42.—Continued

Rate earned on investment (percent).....	6.42	9.59	7.34	8.10	7.45	11.74	8.38	8.42	7.94
Labor and management wage.....	\$912	\$1 909	\$1 172	\$1 299	\$1 247	\$2 215	\$1 574	\$1 676	\$1 572
Size of farm, acres.....	198.6	183.9	191.2	210.3	201.6	182.7	195.3	228.5	235.4
Tillable land (percent).....	80.0	93.5	85.1	72.5	83.0	84.2	89.5	76.1	84.8
Gross income an acre.....	\$22.00	\$26.63	\$23.14	\$19.04	\$20.86	\$26.79	\$23.06	\$28.83	\$20.90
Total expense an acre.....	12.24	10.94	12.25	9.56	9.74	10.47	9.82	16.09	8.77
Net income an acre.....	9.76	15.69	10.89	9.48	11.12	16.32	13.24	12.74	12.13
Percent of tillable land in—									
Corn.....	23.7	30.0	32.8	22.0	31.9	28.1	38.2	36.7	37.0
Oats.....	19.6	23.3	13.5	21.1	22.2	24.2	21.1	9.4	10.6
Wheat.....	.....	.8	2.3	1.1	2.1	.8	.4	1.4	.9
Soybeans for grain.....	2.3	4.1	3.7	.6	4.4	1.6	8.5	2.9	16.6
Other cultivated crops.....	18.7	14.7	7.1	12.3	9.0	7.1	4.1	3.5	2.4
Legume hay and pasture.....	22.4	17.2	24.0	24.1	18.8	20.7	19.5	24.3	19.7
Nonlegume hay and pasture.....	13.3	9.9	16.6	18.8	11.6	17.5	8.2	21.8	12.8
Bushels an acre—									
Corn.....	54.2	57.8	51.1	50.0	51.6	59.0	54.9	48.8	51.1
Oats.....	40.7	52.8	28.5	34.7	42.5	45.1	32.1	33.1	32.9
Wheat.....	15.2	17.9	14.7	15.3	15.8	12.5	22.9	16.3	11.6
Barley.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Soybeans.....	15.1	15.8	14.5	11.1	14.1	22.0	15.1	17.8	19.3
Returns for \$100 of feed.....	\$181	\$192	\$168	\$190	\$176	\$186	\$187	\$175	\$202
Returns for \$100 of poultry.....	246	274	260	262	257	279	296	254	280
Dairy sales from each cow.....	114	94	52	72	74	69	55	54	54
Returns for each litter.....	146	144	139	145	155	160	152	160	142
Investment an acre in livestock.....	14.26	13.92	12.34	11.17	11.64	13.33	11.37	15.50	9.60
Income an acre from livestock.....	20.66	23.21	22.65	18.57	20.03	26.31	20.27	28.12	16.37
Power and machinery cost a crop acre.....	\$ 5.14	\$ 3.59	\$ 4.72	\$ 4.86	\$ 3.66	\$ 3.63	\$ 3.34	\$ 4.34	\$ 3.26
Labor cost for \$100 gross income.....	24	18	19	23	22	18	19	15	19
Labor cost an acre.....	8.12	5.88	6.77	7.59	6.49	6.98	5.91	7.58	5.58
Expense for \$100 gross income.....	52	41	53	50	47	39	43	56	42
Excess of sales over expenses.....	\$1 423	\$1 875	\$2 324	\$1 863	\$2 288	\$2 589	\$1 933	\$2 094	\$2 359
Increase in inventory.....	1 278	1 721	438	885	659	1 093	1 349	1 449	1 177
Value of land an acre.....	\$ 92	\$104	\$ 91	\$ 66	\$ 95	\$ 87	\$110	\$100	\$108
Total investment an acre.....	152	164	148	117	149	139	158	153	153
Number of farms included.....	53	34	30	59	44	30	60	38	30

(Table is continued on next page)

TABLE 42.—SUMMARY, BY AREAS, OF BUSINESS RECORDS FROM 1,639 ILLINOIS FARMS, 1935—Continued

Accounting items	Pike, Brown	Scott	Morgan, Greene	Jersey	Macoupin	Christian	Shelby	Efingham
Capital investment, total.....	\$23 366	\$25 913	\$33 409	\$21 096	\$20 245	\$32 519	\$20 131	\$13 618
Land.....	15 971	20 219	24 424	14 025	12 686	24 347	14 127	7 948
Farm improvements.....	3 282	2 224	3 934	2 796	3 425	3 185	2 301	1 914
Machinery and equipment.....	912	1 162	1 360	1 374	1 303	1 563	960	921
Feed and grain.....	1 083	926	1 765	1 358	1 166	1 971	1 505	1 364
Livestock, total.....	2 118	1 382	1 926	1 543	1 665	1 453	1 238	1 471
Horses.....	376	401	436	439	390	404	387	400
Cattle.....	1 151	520	917	704	850	592	469	786
Hogs.....	445	319	450	270	214	337	232	120
Sheep.....	99	75	57	60	108	40	69	37
Poultry.....	47	67	66	70	103	80	81	128
Income, net increases, total.....	\$4 137	\$3 585	\$4 494	\$3 751	\$3 549	\$4 790	\$2 918	\$2 115
Feed and grain.....	93	75	113	57	126	96	78	96
Labor and miscellaneous.....	4 044	2 509	4 106	2 985	2 905	2 807	1 860	2 019
Livestock, total.....	29	34	50	42	18	38	41	49
Horses.....	1 252	501	1 365	731	776	484	443	574
Cattle.....	2 337	1 643	2 072	1 445	1 004	1 437	764	464
Hogs.....	106	64	103	55	119	37	52	37
Sheep.....	143	146	198	201	331	220	269	448
Poultry and eggs.....	177	121	318	511	657	591	291	447
Dairy sales.....								
Expenses, net decreases, total.....	\$1 313	\$1 170	\$1 484	\$1 079	\$1 161	\$1 453	\$912	\$700
Farm improvements.....	199	116	216	159	174	174	138	106
Machinery and equipment.....	231	280	311	317	311	396	262	124
Feed and grain.....	340	.....	.....	.....	.....	.....	.....	90
Crop expense.....	118	195	236	156	164	209	172	111
Hired labor.....	191	232	395	206	279	319	117	102
Taxes.....	157	290	261	194	161	282	186	105
Horses.....	.....	.....	.....	.....	.....	.....	.....	.....
Livestock and miscellaneous.....	77	57	65	47	72	73	37	62
Income less expense.....	\$2 824	\$2 415	\$3 010	\$2 672	\$2 388	\$3 337	\$2 006	\$1 415
Total unpaid labor.....	691	686	590	811	722	735	689	616
Net farm income.....	\$2 133	\$1 729	\$2 420	\$1 861	\$1 666	\$2 602	\$1 317	\$799

TABLE 42.—Continued

Rate earned on investment (percent).....	9.13	6.67	7.24	8.82	8.23	8.00	6.54	5.87
Labor and management wage.....	\$1 499	\$ 922	\$1 181	\$1 309	\$1 173	\$1 473	\$ 820	\$ 523
Size of farm, acres.....	236.8	245.7	253.0	226.8	222.6	239.3	193.5	215.7
Tillable land.....	68.6	78.6	82.2	83.4	80.7	92.5	91.6	86.3
Gross income an acre.....	\$17.47	\$14.59	\$17.76	\$16.54	\$15.94	\$20.02	\$15.08	\$9.80
Total expense an acre.....	8.46	7.55	8.19	8.33	8.46	9.15	8.27	6.10
Net income an acre.....	9.01	7.04	9.57	8.21	7.48	10.87	6.81	3.70
Percent of tillable land in—								
Corn.....	25.7	32.3	27.4	22.4	17.1	25.0	27.0	15.0
Oats.....	12.4	10.1	11.1	8.9	10.8	8.1	6.7	12.3
Wheat.....	9.8	20.1	22.0	21.4	17.9	13.8	5.9	9.0
Soybeans for grain.....	.5	4.6	5.0	4.4	5.5	31.6	24.0	3.8
Other cultivated crops.....	14.3	7.2	7.2	7.8	9.6	1.6	4.3	11.2
Legume hay and pasture.....	20.2	13.4	16.8	18.4	19.5	8.5	12.5	16.1
Nonlegume hay and pasture.....	17.1	12.3	10.5	16.7	19.6	11.4	19.6	32.6
Bushels an acre—Corn.....	41.8	35.6	37.9	42.3	32.9	50.3	43.2	26.8
Oats.....	31.8	34.5	31.8	25.7	27.6	37.3	24.7	9.3
Wheat.....	13.3	18.7	17.8	20.2	19.7	18.6	20.3	14.9
Barley.....								
Soybeans.....	6.7	11.2	14.4	15.1	19.1	23.7	18.9	10.7
Returns for \$100 of feed.....	\$195	\$196	\$168	\$172	\$187	\$197	\$188	\$174
Returns for \$100 of poultry.....	251	212	268	252	301	232	289	287
Dairy sales from each cow.....	54	34	60	64	72	62	49	51
Returns for each litter.....	178	141	144	166	143	151	143	161
Investment an acre in livestock.....	9.18	5.30	8.00	6.49	7.16	5.17	5.18	5.46
Income an acre from livestock.....	16.96	10.07	16.03	12.98	12.97	11.57	9.40	9.13
Power and machinery cost a crop acre.....	\$ 3.45	\$ 3.10	\$ 3.07	\$ 3.51	\$ 3.57	\$ 2.78	\$ 2.76	\$ 1.88
Labor cost for \$100 gross income.....	20	25	21	26	26	21	26	32
Labor cost an acre.....	7.69	5.48	5.36	6.64	6.56	5.21	5.35	4.80
Expense for \$100 gross income.....	48	52	46	50	53	46	55	58
Excess of sales over expenses.....	\$1 761	\$1 457	\$1 727	\$1 814	\$1 324	\$2 643	\$1 576	\$1 265
Increase in inventory.....	1 063	958	1 283	858	1 064	694	430	150
Value of land an acre.....	\$67	\$82	\$97	\$62	\$57	\$102	\$ 73	\$37
Total investment an acre.....	99	105	132	93	91	136	104	63
Number of farms included.....	32	30	40	32	35	42	30	36

(Table is continued on next page)

TABLE 42.—SUMMARY, BY AREAS, OF BUSINESS RECORDS FROM 1,639 ILLINOIS FARMS, 1935—Continued

Accounting items	Champaign	Edgar, Vermilion	Douglas, Coles, Moultrie	DeWitt, Logan, Piatt	Sangamon	Mason, Cass, Menard	Macon	Adams	Schuyler, Fulton
Capital investment, total.....	\$38 080	\$35 590	\$39 591	\$37 934	\$36 487	\$26 090	\$38 819	\$21 295	\$23 945
Land.....	29 708	26 405	30 302	28 208	27 524	19 506	30 179	14 085	16 191
Farm improvements.....	3 236	3 794	3 451	3 575	3 875	2 701	3 605	3 727	3 707
Machinery and equipment.....	1 407	1 464	1 935	1 381	1 269	1 047	1 588	1 141	1 170
Feed and grain.....	2 384	2 235	2 394	3 192	1 723	1 515	2 288	958	1 213
Livestock, total.....	1 345	1 692	1 509	1 578	1 996	1 321	1 159	1 384	1 664
Horses.....	395	367	415	489	513	547	350	442	382
Cattle.....	529	732	713	688	790	420	453	540	696
Hogs.....	267	412	284	263	524	251	264	269	426
Sheep.....	68	97	35	55	88	22	18	66	110
Poultry.....	86	84	62	83	81	81	74	67	50
Income, net increases, total.....	\$4 787	\$4 519	\$5 112	\$4 545	\$4 419	\$3 290	\$4 374	\$2 870	\$3 284
Feed and grain.....	2 754	1 388	2 157	1 768	737	1 157	2 431	234	186
Labor and miscellaneous.....	70	58	146	67	62	71	109	108	91
Livestock, total.....	1 963	3 073	2 809	2 710	3 620	2 062	1 834	2 528	3 007
Horses.....	26	29	55	37	20	22	25	62	35
Cattle.....	465	984	939	1 048	955	411	330	480	676
Hogs.....	865	1 500	1 248	1 013	2 011	1 076	860	1 509	1 850
Sheep.....	35	49	26	93	109	32	21	75	102
Poultry and eggs.....	271	275	215	270	205	300	255	174	164
Dairy sales.....	301	236	326	249	320	221	343	228	180
Expenses, net decreases, total.....	\$1 417	\$1 478	\$1 684	\$1 628	\$1 646	\$1 094	\$1 520	\$1 051	\$1 028
Farm improvements.....	161	191	228	237	245	143	202	174	186
Machinery and equipment.....	413	405	321	412	363	303	363	340	279
Feed and grain.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Crop expense.....	230	224	326	258	260	178	263	129	152
Hired labor.....	244	312	415	328	419	182	313	166	168
Taxes.....	310	277	336	327	267	236	324	191	191
Horses.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Livestock and miscellaneous.....	59	69	58	66	92	52	55	51	52
Income less expenses.....	\$3 370	\$3 041	\$3 428	\$2 917	\$2 773	\$2 196	\$2 854	\$1 819	\$2 256
Total unpaid labor.....	631	649	635	667	662	707	670	738	684
Net farm income.....	\$2 739	\$2 392	\$2 793	\$2 250	\$2 111	\$1 489	\$2 184	\$1 081	\$1 572

TABLE 42.—Continued

Rate earned on investment (percent).....	7.19	6.72	7.05	5.93	5.78	5.71	5.63	5.08	6.57
Labor and management wage.....	\$1 319	\$1 093	\$1 325	\$ 853	\$ 793	\$ 699	\$ 752	\$ 543	\$ 914
Size of farm, acres.....	241.0	243.5	281.2	251.5	248.8	232.9	240.2	208.4	227.3
Tillable land.....	94.5	92.3	90.9	91.8	91.0	84.5	92.8	74.8	65.9
Gross income an acre.....	\$19.86	\$18.56	\$18.18	\$18.07	\$17.76	\$14.13	\$18.21	\$13.77	\$14.45
Total expense an acre.....	8.50	8.74	8.25	9.12	9.28	7.74	9.12	8.58	7.53
Net income an acre.....	11.36	9.82	9.93	8.95	8.48	6.39	9.09	5.19	6.92
Percent of tillable land in—									
Corn.....	37.1	31.1	29.9	34.9	28.6	32.3	32.7	24.9	27.1
Oats.....	17.9	13.9	11.1	15.9	11.6	13.4	10.5	22.0	15.1
Wheat.....	3.0	8.2	9.0	8.3	12.3	23.1	11.3	10.0	15.7
Soybeans for grain.....	22.4	13.8	25.6	21.2	14.5	5.9	29.1	4.3	7.3
Other cultivated crops.....	2.5	4.6	7.9	.2	3.3	4.7	1.1	6.1	7.5
Legume hay and pasture.....	11.4	19.4	11.4	8.8	13.1	12.7	6.6	19.9	19.5
Nonlegume hay and pasture.....	5.7	9.0	5.1	10.7	16.6	7.9	8.7	12.8	7.8
Bushels an acre—Corn.....	56.5	55.1	48.7	47.3	42.4	41.0	51.2	35.2	38.1
Oats.....	38.3	30.7	35.8	37.3	43.1	30.9	39.1	31.1	31.8
Wheat.....	20.7	20.5	15.1	19.8	19.6	15.3	17.3	15.0	13.3
Barley.....									
Soybeans.....	24.6	24.3	23.9	23.1	17.4	12.9	23.2	13.9	20.3
Returns for \$100 of feed.....	\$203	\$178	\$163	\$184	\$182	\$206	\$204	\$188	\$193
Returns for \$100 of poultry.....	268	286	272	267	225	316	287	239	273
Dairy sales for each cow.....	53	45	61	49	67	57	61	41	39
Returns for each litter.....	140	138	144	151	149	129	143	143	140
Investment an acre in livestock.....	4.61	6.47	4.74	5.93	7.22	4.29	4.05	5.77	6.82
Income an acre from livestock.....	8.04	12.50	9.79	10.63	14.47	8.76	7.53	11.83	13.08
Power and machinery cost a crop acre.....	\$ 2.71	\$ 2.97	\$ 1.81	\$ 2.94	\$ 3.14	\$ 3.05	\$ 2.57	\$ 3.98	\$ 3.38
Labor cost for \$100 gross income.....	18	20	20	21	24	26	21	30	24
Labor cost an acre.....	4.24	4.89	4.30	4.67	5.59	5.08	4.59	6.98	6.17
Expense for \$100 gross income.....	43	47	45	50	52	55	50	62	52
Excess of sales over expenses.....	\$2 479	\$2 108	\$2 742	\$2 544	\$2 155	\$1 481	\$2 299	\$1 063	\$1 585
Increase in inventory.....	891	933	686	373	618	715	555	756	671
Value of land an acre.....	\$123	\$108	\$108	\$112	\$111	\$ 84	\$126	\$ 68	\$ 71
Total investment an acre.....	158	146	141	151	147	112	102	102	105
Number of farms included.....	33	33	34	36	30	49	33	31	30

(Table is continued on next page)

TABLE 42.—SUMMARY, BY AREAS, OF BUSINESS RECORDS FROM 1,639 ILLINOIS FARMS, 1935—Continued

Accounting items	Peoria	McDonough	Henderson, Hancock	Henderson	Will	Will, Kendall	Kankakee	Iroquois	Ford
Capital investment, total.....	\$27 577	\$30 962	\$24 344	\$22 583	\$26 246	\$27 248	\$34 395	\$38 986	\$43 240
Land.....	19 167	21 773	17 139	15 095	17 871	18 373	24 077	28 181	32 852
Farm improvements.....	3 486	3 786	2 954	2 812	4 155	4 450	4 639	5 054	4 243
Machinery and equipment.....	1 382	1 361	947	1 020	1 293	1 383	1 585	1 392	1 666
Feed and grain.....	1 715	2 078	1 513	1 513	1 389	1 459	2 396	2 253	2 643
Livestock, total.....	1 827	1 964	1 791	2 143	1 538	1 583	1 698	2 106	1 836
Horses.....	418	378	388	394	418	398	580	703	651
Cattle.....	728	884	742	998	752	804	730	841	744
Hogs.....	528	576	520	637	163	207	199	311	262
Sheep.....	61	44	78	58	113	77	68	144	64
Poultry.....	92	82	63	56	92	97	121	107	115
Income, net increases, total.....	\$ 4 019	\$ 4 915	\$ 3 396	\$ 3 660	\$ 3 316	\$ 3 683	\$ 4 428	\$ 4 782	\$ 5 608
Feed and grain.....	957	181	143	128	1 025	1 052	2 195	2 017	2 764
Labor and miscellaneous.....	126	66	62	79	75	68	104	64	111
Livestock, total.....	2 936	4 668	3 191	3 453	2 216	2 563	2 129	2 701	2 733
Horses.....	24	62	36	72	42	57	45	86	129
Cattle.....	508	1 340	736	1 084	594	670	550	813	894
Hogs.....	1 636	2 626	1 882	1 830	498	744	592	873	982
Sheep.....	145	63	88	64	53	51	25	107	49
Poultry and eggs.....	303	258	169	162	286	295	381	370	361
Dairy sales.....	320	319	280	241	743	746	536	452	318
Expenses, net decreases, total.....	\$ 1 087	\$ 1 228	\$ 1 037	\$ 1 114	\$ 1 094	\$ 1 176	\$ 1 461	\$ 1 467	\$ 1 431
Farm improvements.....	167	194	140	156	203	220	244	244	260
Machinery and equipment.....	300	340	269	317	356	396	472	405	314
Feed and grain.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Crop expense.....	163	146	137	122	140	160	241	156	177
Hired labor.....	203	266	225	248	156	156	215	289	317
Taxes.....	194	202	206	211	173	182	236	296	296
Horses.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Livestock and miscellaneous.....	60	80	60	60	66	62	74	77	67
Income less expense.....	\$ 2 932	\$ 3 687	\$ 2 359	\$ 2 546	\$ 2 222	\$ 2 507	\$ 2 967	\$ 3 315	\$ 4 177
Total unpaid labor.....	725	687	652	620	720	715	747	727	744
Net farm income.....	\$ 2 207	\$ 3 000	\$ 1 707	\$ 1 926	\$ 1 502	\$ 1 792	\$ 2 220	\$ 2 588	\$ 3 433

TABLE 42.—Continued

Rate earned on investment (percent).....	8.00	9.69	7.01	8.53	5.72	6.58	6.45	6.64	7.94
Labor and management wage.....	\$1 381	\$1 989	\$1 001	\$1 293	\$ 700	\$ 938	\$1 007	\$1 131	\$1 805
Size of farm, acres.....	203.5	218.4	207.2	202.2	177.6	177.4	242.9	254.1	264.0
Tillable land (percent).....	76.7	86.4	78.1	73.5	88.7	88.1	91.0	91.7	94.5
Gross income an acre.....	\$19.75	\$22.51	\$16.39	\$18.10	\$18.67	\$20.76	\$18.23	\$18.82	\$21.24
Total expense an acre.....	8.90	8.77	8.15	8.57	10.21	10.66	9.09	8.64	8.24
Net income an acre.....	10.85	13.74	8.24	9.53	8.46	10.10	9.14	10.18	13.00
Percent of tillable land in—									
Corn.....	32.0	35.3	29.7	38.3	31.9	33.9	33.3	35.0	39.8
Oats.....	14.9	16.2	16.6	15.4	27.6	29.1	23.2	24.9	25.6
Wheat.....	8.1	6.3	4.7	1.6	2.8	1.9	1.2	.1	.....
Soybeans for grain.....	12.6	5.6	10.1	7.8	10.1	8.3	13.9	6.8	7.5
Other cultivated crops.....	7.6	5.8	9.5	6.2	5.7	5.0	6.4	5.3	6.0
Legume hay and pasture.....	15.8	16.0	19.3	21.0	16.6	17.7	14.0	15.7	16.8
Nonlegume hay and pasture.....	9.0	14.8	10.1	9.7	5.3	4.1	8.0	12.2	4.3
Bushels an acre—									
Corn.....	51.3	50.4	45.8	47.2	55.8	57.7	55.0	59.4	59.2
Oats.....	30.2	39.1	31.5	28.0	25.6	32.2	28.5	34.4	33.4
Wheat.....	14.9	15.5	16.1	16.2	19.1	19.0	14.6	6.6	1.7
Barley.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Soybeans.....	19.7	20.8	13.9	14.1	14.4	14.3	20.5	22.9	20.0
Returns for \$100 of feed.....	\$204	\$191	\$189	\$187	\$162	\$175	\$181	\$202	\$211
Returns for \$100 of poultry.....	297	280	235	245	262	256	280	289	267
Dairy sales from each cow.....	54	68	48	46	102	96	72	76	55
Returns for each litter.....	138	142	146	141	146	148	118	136	150
Investment an acre in livestock.....	8.02	9.62	8.17	10.34	8.37	9.04	5.45	7.13	5.89
Income an acre from livestock.....	14.31	21.09	15.23	16.72	12.24	14.13	8.58	10.29	9.86
Power and machinery cost a crop acre.....	\$ 3.63	\$ 3.13	\$ 3.30	\$ 3.82	\$ 3.58	\$ 3.68	\$ 3.54	\$ 2.94	\$ 1.91
Labor cost for \$100 gross income.....	22	19	25	23	25	23	21	21	18
Labor cost an acre.....	6.52	5.88	6.24	6.67	5.87	5.86	4.70	5.19	4.67
Expense for \$100 gross income.....	45	39	50	47	55	51	50	46	39
Excess of sales over expenses.....	\$2 099	\$2 295	\$1 740	\$1 610	\$ 822	\$1 082	\$1 922	\$1 656	\$2 679
Increase in inventory.....	833	1 392	619	936	1 400	1 425	1 045	1 659	1 498
Value of land an acre.....	\$ 94	\$100	\$ 83	\$ 75	\$101	\$104	\$ 99	\$111	\$124
Total investment an acre.....	136	142	117	112	148	154	142	153	164
Number of farms included.....	30	44	44	30	37	44	33	35	51

(Table is continued on next page)

TABLE 42.—SUMMARY, BY AREAS, OF BUSINESS RECORDS FROM 1,639 ILLINOIS FARMS, 1935—*Concluded*

Accounting items	Clinton, Bond, Montgomery	Madison	St. Clair	Randolph	Randolph, Monroe	Clark, Crawford	Jefferson, Marion, Jackson, Richland, Clay	White, Edwards, Wabash, Saline
Capital investment, total.....	\$16 592	\$16 739	\$19 140	\$13 690	\$15 320	\$18 367	\$ 9 574	\$14 516
Land.....	10 336	10 295	12 359	7 589	9 130	11 100	5 318	9 028
Farm improvements.....	2 496	2 538	2 943	2 641	2 415	2 948	1 531	2 066
Machinery and equipment.....	1 074	1 379	1 049	1 104	1 305	952	757	663
Feed and grain.....	1 307	1 261	1 387	1 290	1 363	1 658	966	1 627
Livestock, total.....	1 379	1 266	1 402	1 066	1 107	1 709	1 002	1 132
Horses.....	401	345	465	362	380	376	363	371
Cattle.....	667	662	557	491	453	797	395	455
Hogs.....	123	139	158	98	145	298	93	145
Sheep.....	63	14	93	20	15	106	38	49
Poultry.....	125	106	129	95	114	132	113	112
Income, net increases, total.....	\$2 843	\$2 879	\$3 084	\$1 983	\$2 324	\$3 633	\$1 482	\$2 144
Feed and grain.....	498	598	545	186	393	.....	.....	41
Labor and miscellaneous.....	72	98	54	48	54	129	54	70
Livestock, total.....	2 272	2 183	2 485	1 749	1 877	3 504	1 428	2 033
Horses.....	9	21	21	42	15	38	38	24
Cattle.....	599	369	340	388	337	742	294	391
Hogs.....	693	550	877	420	610	1 691	387	923
Sheep.....	70	28	115	24	25	143	32	62
Poultry and eggs.....	354	447	536	328	421	561	425	392
Dairy sales.....	548	768	596	547	469	329	252	241
Expense, net decreases, total.....	\$872	\$1 033	\$1 038	\$719	\$837	\$1 477	\$513	\$835
Farm improvements.....	147	158	163	144	129	163	90	130
Machinery and equipment.....	232	276	271	211	277	260	165	218
Feed and grain.....	157	154	181	120	131	428	2	.....
Crop expense.....	157	209	194	83	130	181	78	112
Hired labor.....	126	173	160	113	118	136	84	138
Taxes.....	.....	.....	.....	.....	.....	.....	.....	.....
Horses.....	.....	.....	.....	.....	.....	.....	.....	.....
Livestock and miscellaneous.....	53	63	69	48	52	73	34	46
Income less expense.....	\$1 971	\$1 846	\$2 046	\$1 264	\$1 487	\$2 156	\$969	\$1 309
Total unpaid labor.....	663	616	637	703	689	522	624	509
Net farm income.....	\$1 308	\$1 230	\$1 409	\$561	\$798	\$1 634	\$345	\$800

TABLE 42.—*Concluded*

Rate earned on investment (percent).....	7.88	7.35	7.36	4.10	5.21	8.90	3.60	5.51
Labor and management wage.....	\$867	\$786	\$862	\$268	\$431	\$1 064	\$258	\$443
Size of farm, acres.....	184.9	167.1	178.1	195.4	194.7	213.3	181.0	203.4
Tillable land.....	84.5	82.6	83.6	81.1	81.6	81.3	83.5	84.8
Gross income an acre.....	\$15.38	\$17.23	\$17.32	\$10.15	\$11.94	\$17.03	\$8.19	\$10.54
Total expense an acre.....	8.31	9.87	9.41	7.28	7.84	9.37	6.28	6.61
Net income an acre.....	7.07	7.36	7.91	2.87	4.10	7.66	1.91	3.93
Percent of tillable land in—								
Corn.....	17.1	17.6	21.2	12.3	15.2	22.2	15.4	22.2
Oats.....	15.5	10.8	15.0	9.8	10.3	6.5	5.5	7.2
Wheat.....	19.9	27.4	27.9	29.8	32.2	11.5	14.0	18.6
Soybeans for grain.....	5.0	1.9	1.0	1.2	.8	2.2	1.2	1.8
Other cultivated crops.....	6.5	8.6	4.9	10.9	9.6	12.3	12.2	10.4
Legume hay and pasture.....	18.5	19.2	21.5	28.1	23.5	25.2	25.9	26.4
Nonlegume hay and pasture.....	17.5	14.5	8.5	7.9	8.4	20.1	25.8	13.4
Bushels an acre—Corn.....	40.7	40.8	47.3	29.2	33.9	39.5	26.2	34.1
Oats.....	32.0	31.3	32.0	27.5	28.9	16.5	13.3	14.2
Wheat.....	18.3	19.5	18.3	11.4	13.9	12.6	10.6	11.4
Barley.....	.....	.....	.....	.....	.....	.....	.....	.....
Soybeans.....	17.6	12.7	10.0	13.2	13.1	10.0	6.1	9.4
Returns for \$100 of feed.....	\$165	\$172	\$170	\$148	\$149	\$189	\$180	\$178
Returns for \$100 of poultry.....	264	380	370	309	340	395	340	309
Dairy sales from each cow.....	71	77	82	57	69	49	47	46
Returns for each litter.....	127	138	171	130	128	168	148	151
Investment an acre in livestock.....	6.30	6.70	6.27	4.34	4.50	7.49	4.06	4.47
Income an acre from livestock.....	12.24	12.94	13.83	8.74	9.56	16.25	7.68	9.88
Power and machinery cost a crop acre.....	\$ 3.61	\$ 4.21	\$ 4.37	\$ 3.14	\$ 3.77	\$ 3.39	\$ 3.22	\$ 3.30
Labor cost for \$100 gross income.....	28	27	26	38	34	21	44	31
Labor cost an acre.....	6.26	6.79	6.48	6.17	6.46	6.24	6.56	5.59
Expense for \$100 gross income.....	54	57	54	72	66	55	77	63
Excess of sales over expenses.....	\$1 363	\$1 445	\$1 477	\$969	\$1 225	\$1 632	\$846	\$1 414
Increase in inventory.....	608	401	569	295	262	524	123	-105
Value of land an acre.....	\$56	\$ 62	\$ 69	\$39	\$47	\$52	\$29	\$44
Total investment an acre.....	90	100	107	70	79	86	53	71
Number of farms included.....	52	47	30	37	54	30	42	35

net income figure is not influenced by changes in inventory of either land or equipment. Net income an acre may be capitalized at any desirable rate of interest to calculate the earned value of the property. (202 Agricultural Economics)

Part of Increased Soybean Demand May Be Permanent

Studies of the prices of Illinois farm products are helping to provide a better basis for planning production and marketing programs of Illinois farmers. This work, which is being carried on by E. J. Working, Agricultural Economics, is designed to disclose the important factors which affect prices. Thru such knowledge it is possible to appraise the outlook for prices and to judge the effect of proposed changes in production programs on prices.

In recent years prices of farm products have fluctuated violently. Price studies show that this has been partly because of changes in supplies, but even more important have been changes in demand and the general level of prices. Changes in production are less important in affecting income than in contributing to price changes, for while a large

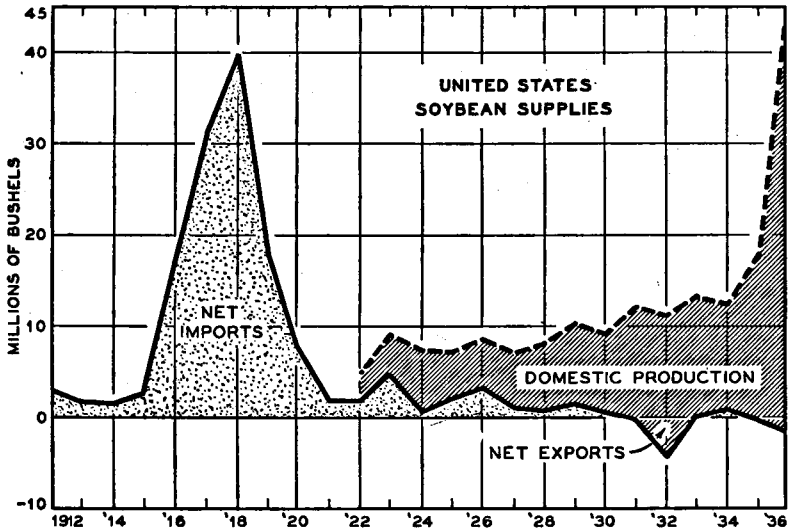


FIG. 32.—SOURCES OF THE U. S. SUPPLY OF SOYBEANS DURING THE PAST TWENTY-FIVE YEARS

Net imports and exports are for the calendar year and include the bean equivalent of oil. Production represents the crop of the preceding year. Total utilization of soybeans in the United States in terms of their oil equivalent during 1936 (from the 1935 crop) will apparently just about equal the peak-year importation of soybeans and soybean oil in 1918.

production tends to reduce prices, it also provides more of the product for sale. Consequently farm income is especially dependent upon the demand for farm products and the general price-level.

Special attention has been given in the past year to studying soybean prices. In brief the study indicates that while much of the increase in demand for soybeans in the past two years has come from conditions which will probably prove temporary, there has nevertheless been a very substantial increase of a permanent nature. Still further growth of this permanent type of demand is expected in future years. The demand for soybean oil by the paint and varnish industry promises to continue to improve in future years and will at least partially counteract the adverse effect of increased supplies of lard and cottonseed oil upon the soybean oil and soybean market within the next few years. Furthermore improved business conditions and the effects of dollar devaluation may also be expected to continue to have a sustaining influence on the soybean market.

It is only during recent years that soybeans have become a cash crop of major importance to Illinois farmers, who are now raising about half of the total crop of the United States. The extent of the increase in soybean production in the United States is shown by Fig. 32. This chart shows year-by-year sources of the United States supply of soybeans, including oil, during the past twenty-five years. Very little soybean oil or other soybean products were used in the United States prior to the World War, but during the war period there was a great increase. This increase was supplied mostly by imports of soybean oil. Following the war, however, soybean oil imports and the amount utilized dropped off abruptly. In 1921 and 1922 imports amounted to an equivalent of less than 2 million bushels of soybeans. In 1921 domestic soybean production amounted to nearly 3 million bushels, or considerably more than the amount imported. Very few soybeans were grown for commercial purposes until recent years. The first year for which reliable production figures are available is 1921. Since that date there has been a rapid growth in the domestic production of soybeans and a rather slow but irregular decline in imports. The total utilization of soybeans in the United States in terms of their oil equivalent during 1936 (from the 1935 crop) will apparently be just about equal to the peak-year importation of soybeans and soybean oil in 1918.

There has been much uncertainty as to the extent to which the increase in the production of soybeans should be carried. Prices of soybeans grown in 1934 and 1935 were maintained at about the same levels as prices for the 1933 crop, in spite of the tremendous increase in acreage and production, but the question remains whether this was the result of a temporary increase in the demand for soybeans or

whether it is to be expected that there will be a permanent increase in the demand.

The study which is now being carried on indicates that the major part of the increase in demand for soybeans which has taken place in the past two years has come from reduced production of lard and cottonseed oil. Nevertheless there has been a very important increase in demand of a nature which will probably prove to be permanent. Furthermore it is likely that there will be a continued increase in demand from this source. Attention may be called in this connection to Fig. 33, which shows the factory consumption of soybean oil in the United States for various major purposes. It will be noted that the

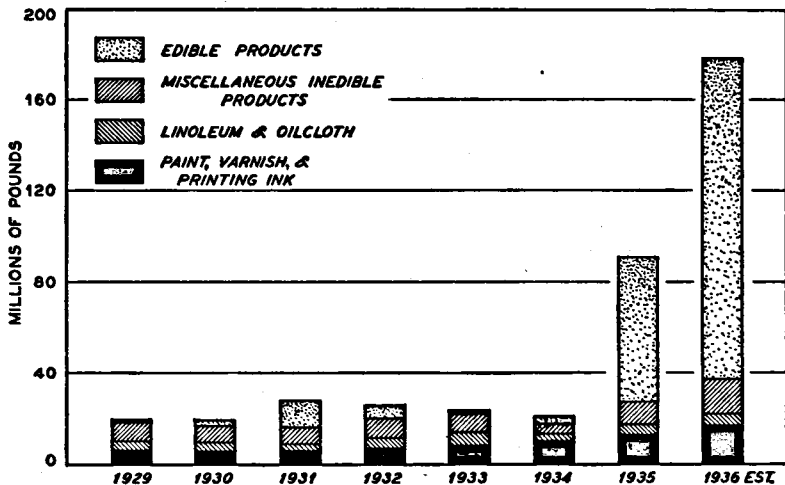


FIG. 33.—FACTORY CONSUMPTION OF SOYBEAN OIL IN THE UNITED STATES FOR VARIOUS MAJOR PURPOSES

The amount used for vegetable shortening and other edible purposes has fluctuated greatly from year to year. To a somewhat less extent the same is true of what have been termed "miscellaneous" uses. On the other hand, there has been a much more steady increase in the amount of soybean oil used as a drying oil.

amount used for vegetable shortening and other edible purposes has fluctuated greatly from year to year. To a somewhat less extent the same is true of what have been termed "miscellaneous" uses in the chart. On the other hand, there has been a much more steady increase in the amount of soybean oil used as a drying oil. These uses include paint and varnish, linoleum, core oil, and printing ink. The steady increase in the consumption for paint and varnish is especially notable. The amount used in this manner has increased from approximately

6 million gallons in 1929 to 13 million gallons in 1935, and preliminary estimates indicate that a further increase will be recorded in 1936.

Fluctuations in the amount of soybean oil used depend very largely upon the changes in the relative prices of various other fats and oils. Thus if the price of soybean oil is low in relation to the price of cottonseed oil, this tends to increase the amount of soybean oil used in vegetable shortenings, the soybean oil being used as a substitute for cottonseed oil. The statistics which have been gathered and analyzed by the Department of Agricultural Economics do not indicate that soybean oil has had its competitive position improved in relation to cottonseed oil for vegetable shortening and oleomargarine. On the other hand, in studying the amount used for paint and varnish, it becomes evident that altho the amount used fluctuates with the relative prices of soybean and linseed oil, there has, nevertheless, been a very marked increase in the amount of soybean oil utilized even in years when soybean prices have not declined as compared with linseed oil prices.

From 1929 to 1932 there was a downward trend in the price of soybean oil in relation to the price of linseed oil. During this period there was a very sharp decline in the total amount of drying oils used in the paint and varnish industry, because of the business depression. However, the amount of soybean oil used in relation to the amount of linseed oil more than doubled, owing largely to the relatively low price of soybean oil. From 1933 to 1935, on the other hand, soybean oil rose in price in relation to linseed oil, and in spite of this rise in price there has been an increase in the amount of soybean oil used as compared with the amount of linseed oil. There has, of course, also been an increase in the total consumption of oil by the paint and varnish industry, owing to the rising level of business activity. These facts indicate that there has been a steady and rapid improvement in the ability of soybean oil to compete with linseed oil during recent years. This has been an important factor in the total increase in demand for soybean oil since 1932. It presumably has been brought about by improvements in methods of using soybean oil in paint and by the fact that some manufacturers have learned better how to make use of the improved methods. (100 Agricultural Economics)

Abnormal Conditions Back of 1935 Soybean Expansion

Soybeans in Illinois in recent years have expanded both as a result of the more general distribution of the crop in the state and of a greater concentration in the heaviest producing areas. The extent of such concentration is shown by the records of crops grown in 1935 on 102 farms in nine counties in the heavy-producing soybean area, according to a study by R. C. Ross, Agricultural Economics. On these farms soybeans occupied 36 percent of the total farm area and 42 percent of the area in harvested crops. In contrast in 1928 and 1929

similar records indicated about 16 percent of the total farm acreage and 20 percent of the harvested crop acreage was in soybeans.

This rapid increase in soybean acreage has come about largely because farmers have substituted this crop for a part of the acreage of other grains. In 1928 and 1929 the acreage of soybeans on farms studied in this area stood second to corn, whereas in 1935 there were more soybeans than corn.

However, this extreme situation in 1935 must be interpreted in the light of unusual conditions. For the years 1930-1934 soybeans harvested with a combine were slightly more profitable than corn on the detailed-cost farms in Champaign and Piatt counties. During the earlier years of this period prices of all crops were at abnormally low levels, and under such conditions farmers are likely to make shifts in crop acreages more rapidly than under normal conditions if such shifts promise an increase in income. In 1934 and 1935 acreages of corn and wheat were limited under the AAA program, giving an advantage in acreage to crops which were not so restricted. Furthermore, the severe chinch bug infestation in 1934 curtailed yields of corn and oats in that year, while the threat in the spring of 1935 of continued severe damage resulted in some shift in acreage from corn and oats to nonsusceptible crops. The severe drouth in 1934 likewise reduced yields of corn and oats to a greater extent than those of soybeans and damaged seedings for 1935 meadows. These conditions influenced many farmers to make maximum reductions in corn acreage under their AAA contracts and to plant much of this acreage to soybeans. They thus obtained both the corn benefit payments and the soybean crop from such land.

Because of the abnormal conditions during these years, neither the relative acreages of corn and soybeans nor their relative profitability during the period of abnormal prices provides an adequate basis for ascertaining the relative positions of these crops during a period of normal relationships. Over a longer period the crop which proves to be the most profitable may be expected to occupy the larger acreage unless the advantage of profit is offset by the limitations of other relationships. (208 Agricultural Economics)

Costs of Production Rising With Better Farm Prices

Cost of producing farm crops in Illinois was materially increased in 1933 and 1934 owing to the very wet spring and early summer of 1933 and to the unusually severe drouth of 1934, which began early in the spring and continued thru the summer. Yields of grain crops were lower than normal in both years, while the yields of hay were affected rather severely by the drouth of 1934. Yields were influenced not only by abnormal weather, but by heavy chinch bug infestation both years. Changes that are occurring in the cost of producing farm products and present methods that give low costs are being brought out in farm-ac-

counting investigations by H. C. M. Case, R. H. Wilcox, and E. B. Colegrove, Agricultural Economics.

These cost studies that have extended over a long period have as their objects: (1) to determine the cost of producing different farm products and the influence of various factors upon the cost of production; (2) to provide a basis for interpreting the less complete records kept by farmers; and (3) for securing information to assist in more economical organization and operation of the farm. This project has extended over a period long enough to permit valuable comparisons to be made between present and prewar methods and their effect upon production during the two periods. Costs of producing selected crops in east-central Illinois in 1933 and 1934 are shown in Table 43.

Except for soybeans and soybean hay the average unit costs a bushel or ton of crop products showed a marked increase in 1934 over those of 1933. While some crops showed a moderate increase in acre-costs, the higher unit costs were caused primarily by lower yields rather than by changes in operating costs. As between individual farms, the differences in cost have been wider than normal as a result of the localization of chinch bug infestation and drouth areas.

TABLE 43.—COST OF PRODUCING SELECTED CROPS IN EAST-CENTRAL ILLINOIS, 1933 AND 1934

Items	Corn		Oats		Soybeans (combined)		Wheat (combined)	
	1933	1934	1933	1934	1933	1934	1933	1934
Growing cost.....	\$5.85	\$6.70	\$2.70	\$2.89	\$4.96	\$5.03	\$3.87	\$4.12
Harvesting cost.....	1.33	1.58	1.96	1.71	1.70	1.95	1.59	1.74
Growing and harvesting costs.....	\$7.18	\$8.28	\$4.66	\$4.60	\$6.66	\$6.98	\$5.49	\$5.86
Taxes.....	1.39	1.15	1.46	1.15	1.30	1.13	1.42	1.17
Interest on land.....	6.91	6.84	6.81	6.72	7.09	6.78	7.00	7.09
Total cost.....	\$15.48	\$16.27	\$12.89	\$12.45	\$15.05	\$14.89	\$13.88	\$14.12
Yield an acre, bushels..	36.3	26.5	25.0	14.7	23.0	26.2	21.8	17.8
Cost a bushel.....	\$.41	\$.60	\$.48	\$.76	\$.65	\$.57	\$.61	\$.78

Items	Wheat (threshed)		Soybean hay		Alfalfa		Red clover	
	1933	1934	1933	1934	1933	1934	1933	1934
Growing cost.....	\$4.82	\$4.74	\$5.83	\$5.51	\$.32	\$1.66	\$.05	\$.69
Harvesting cost.....	2.88	3.19	3.00	3.11	5.07	8.27	4.09	4.22
Growing and harvesting costs.....	\$7.70	\$7.93	\$8.83	\$8.62	\$5.39	\$9.93	\$4.14	\$4.91
Taxes.....	1.36	1.09	1.45	1.15	1.43	1.16	1.39	1.21
Interest on land.....	6.81	6.88	7.01	6.59	6.84	6.83	7.13	7.25
Total cost.....	\$15.87	\$15.90	\$17.29	\$16.36	\$13.66	\$17.92	\$12.66	\$13.37
Yield an acre, bushels..	22.5	18.7	1.6	1.6	2.2	1.9	1.5	.6
Cost a bushel.....	\$.68	\$.78	\$10.56	\$10.14	\$ 5.77	\$8.47	\$ 5.94	\$18.24

One very significant thing that these long-time cost studies show is that during recent years only 58 percent as many man hours and 53 percent as many horse hours are used in growing and harvesting an acre of corn as were used twenty years ago. Improved machinery and methods in wheat production and harvesting show somewhat similar reductions in man labor.

Another characteristic of agricultural production which these cost studies accurately measure is the variation in the quantities of labor, power, machinery, seed, and other materials used upon an acre of the same crop by different farmers in the same community. The

TABLE 44.—AVERAGE AND EXTREME VARIATIONS IN BASIC REQUIREMENTS USED AN ACRE IN CROP PRODUCTION ON 33 CHAMPAIGN AND PIATT COUNTY FARMS, 1933

Items	•Corn	Oats	Soybeans (combined)	Wheat (combined)
Man hours: average of all farms.....	10.2	5.2	5.1	3.6
lowest farm.....	6.1	1.8	2.5	2.1
highest farm.....	15.1	8.7	9.3	5.4
Horse hours: average of all farms.....	30.7	11.7	19.8	12.4
lowest farm.....	24.0	5.0	7.7	5.5
highest farm.....	47.5	21.6	37.1	19.3
	<i>lbs.</i>	<i>bu.</i>	<i>bu.</i>	<i>bu.</i>
Seed: average of all farms.....	7.6	3.1	1.8	1.6
lowest farm.....	5.3	1.2	1.2	1.1
highest farm.....	11.4	5.0	3.1	2.1
Machinery investment: average of all farms....	\$2.85	\$1.26	\$.95	\$4.07
lowest farm.....	1.06	.21	.31	1.87
highest farm.....	8.63	3.76	3.03	5.37
			Soybeans (threshed)	Wheat (threshed)
Pounds of twine: average of all farms.....	...	2.0	1.9	2.5
lowest farm.....	...	.7	1.3	.9
highest farm.....	...	4.0	2.6	3.8

extreme variations in hours of man labor, horse labor, seed, twine, and machinery investment between 33 farms in 1933 is shown in Table 44.

These variations between farms in the same community are caused very largely by differences in methods of preparing the ground and planting the crop, by differences in the weight of straw, and by whether or not farm machinery on the farm is fitted to crop needs. (200 Agricultural Economics)

Costs of Harvesting With Combines Were Low in 1935

Soybeans comprized 75 percent, wheat 17 percent, oats 7 percent, and other grain and seed crops 1 percent of the total of 35,731 acres harvested by 83 combines in 1935, according to a study made by R. C. Ross, Agricultural Economics. Thirteen of these machines were of the power-take-off type, with cutting widths of 5, 8 and 10 feet, while

TABLE 45.—TOTAL ACREAGES CUT, PROPORTIONS OF HOME AND CUSTOM CUTTING, AND AVERAGE HARVESTING COSTS AN ACRE FOR COMBINES OF VARIOUS SIZES AND TYPES IN ILLINOIS, 1935

Size and type of combine	Number	Average acreage cut	Acreage for each foot of cutting width	Proportion of total cutting		Average harvesting cost an acre		
				Home farm	Custom work	Wheat	Oats	Soybeans
<i>Power-take-off</i>				<i>perct.</i>	<i>perct.</i>			
5-foot.....	3	166.5	33.3	61.4	38.6	\$1.32	\$1.30	\$1.37
8-foot.....	6	271.8	34.0	42.3	57.7	1.29	1.45	1.25
10-foot.....	4	389.1	38.9	34.6	65.4	1.39	1.06	1.49
<i>Motor-mounted</i>								
8-foot.....	7	414.2	51.8	33.4	66.6	1.42	1.30	1.42
10-foot.....	24	369.1	36.9	46.1	53.9	1.37	1.51	1.51
12-foot.....	31	455.1	37.9	44.5	55.5	1.48	1.41	1.40
16-foot.....	6	883.5	55.2	16.9	83.1	1.04	1.09	.94

70 were of the motor-mounted type, of 8- 9- 10- 12- 16- and 20-foot cutting widths. Machines in five of these size groups cut an average of between 33 and 39 acres for each foot of cutting width; two groups, the 8- and 16-foot motor-mounted types, averaged 51.8 and 55.2 acres respectively, as reported in Table 45. Of two sizes, the 9- and 20-foot widths, only one record was secured.

While machines of all sizes were used for custom cutting, the proportion of cutting which was performed for pay increased generally with the cutting width. The smaller-sized machines, particularly the 5-foot width, are a better size for the amount of cutting on the average farm than are the larger sizes. The 5-foot machines were first introduced in 1935 and hence had not been fully perfected.

Cutting conditions were generally favorable during wheat harvest, but a considerable proportion of the oats were badly tangled as a result of rust. Soybean harvesting was normal in October, but excessive rain in November delayed harvesting or greatly reduced efficiency of the machines.

Costs of combining varied considerably among machines in each size-group, but in general were low. Costs an acre of wheat, oats, and soybean harvesting fell between \$1.25 and \$1.50 an acre, not including the cost of hauling the threshed grain. These costs were based upon labor rates of 40 cents an hour for combine operators, 30 cents for tractor operators, and 20 cents for other labor. Tractor rates, not including fuel and oil were 30 cents an hour for three-plow tractors and 23 cents for two-plow tractors. Fuel, oil, grease, and repairs were figured at actual cost. Depreciation was based upon the operators' estimates of machine life and average acreages harvested, interest at 6 percent of the average investment value, and shelter at a flat rate of \$5 a year. No charge was made for taxes or insurance.

The acreages harvested represent a marked increase since 1927 and 1928 when the previous study was made. An increase of approximately 10 acres a foot of cutting width reflects improvement in machine construction and an increase in soybean production, making available a larger acreage of crops suited to the combine method of harvesting. (209 Agricultural Economics)

Corn-Hog Data Supply Need for More Land-Use Facts

A more accurate basis for agricultural adjustment programs, for land appraisal, and for other land-use studies and projects is now available as a result of a study of data taken from 120,000 corn-hog contracts under the direction of R. R. Hudelson, Agricultural Economics. These data, which have been compiled with the aid of NYA student help, show the percentage of cropland devoted to corn, wheat, oats, barley and rye, soybeans and cowpeas, grain sorghums, and tame hay in each township of the state. The percentages of farm land in

crops, in pasture, in woods and that classified as wasteland, by townships, have also been derived. Transferred to maps, the data and percentages obtained supply valuable reference material.

Similar data for counties have been available thru the Census. County averages, however, cover up many of the important variations in practice owing to differences in soil, topography, market outlets, and community customs. Townships are less variable and small enough to be quickly examined by an appraiser, assessor, or other worker.

The considerable differences obtaining in the cropping systems of townships within the same county may be illustrated by some of the findings of this study. In Champaign county, for example, land devoted to corn in the different townships varies from about 50 percent of the cropland to about 60 percent. In Madison county the range is from about 30 percent to about 40 percent. Similar figures for wheat show approximate ranges from none to 10 percent in Champaign county and 20 to 40 percent in Madison county. Newer crops such as soybeans and cowpeas show wider ranges. One township in Christian county shows 26 percent of its cropland in these crops, while another township shows 11 percent. In other counties some townships show no soybeans or cowpeas at all.

The land appraiser is commonly expected to compute farm production and income on a basis typical of the community in which the farm under consideration is located. Data such as this project yields will give him a factual foundation for setting up typical cropping systems. It is entirely feasible for him to examine a township to see how the particular farm differs from nearby farms, but to examine a whole county to check with county data is usually not practicable.

No immediate formal publication of the findings of this study is contemplated, but the material has already proved useful for reference, and the project is being continued. It is hoped to supplement the study with additional data from the new soil-conservation program. (213 Agricultural Economics)

Crop Adjustment by Farming-Type Areas Is Studied

What changes in the Illinois cropping system might logically be made to provide for conservation of the soil, and what would be the effect of these adjustments on total volume of crops and on the production of livestock products? With these questions as a basis of inquiry the Experiment Station has cooperated with the Bureau of Agricultural Economics of the U. S. Department of Agriculture, the Program Planning Division of the Agricultural Adjustment Administration, and the Office of Experiment Stations in conducting a study of agricultural adjustment by farming-type areas. The leaders are H. W. Mumford, Administration; H. C. M. Case, Agricultural Economics; and C. L. Holmes and F. F. Elliott, U. S. Department of Agriculture.

This project, which is part of a general study being made by all the state agricultural experiment stations in cooperation with the federal agencies, was undertaken late in 1935. Its findings are based upon the best information then available.

On the basis of a careful analysis of the existing information on soil types and the probable average crop production of the various soil types, calculations were made to determine what would appear to be the best use of land in the interest of conservation and profitable agriculture. As a result of this study, which is subject to further revision and refinement, the following suggestions are offered as desirable adjustments in land use:

1. That of more than 31 million acres in farms in Illinois, 691,000, or 2.2 acres out of every 100 acres in farms in 1929, should be taken out of farms and devoted to timber or recreational uses. About half this land is in the southern thirteen counties of the state, while considerable areas lie along the western side.

2. That small bodies of badly eroded land unfit for pasture purposes, amounting to an average of about one-half acre a farm, be put into farm woodlots to prevent further erosion.

3. That 775,000 acres, or about 2½ percent of the land in farms, be taken out of harvested crop use and put into pasture use. Each 10 acres now in rotated pasture and permanent pasture land would thus be increased to 11 acres. These three suggested readjustments in the use of land would remove 1,600,000 acres from crop use, or an average of 7½ acres of cropland for every 100 in 1929.

4. That the land in hay be increased by 357,000 acres, or about 1 acre for every 10 acres of hay grown in 1929.

5. That corn be decreased 11½ acres for every 100 acres grown in 1929.

6. That oats and mixed grain be reduced 8 acres for every 100 acres grown in the base period of 1929.

7. That wheat acreage of the state be reduced 2.2 acres for every 100 acres grown in 1929, altho there are some farming-type areas in the state where an increased acreage of wheat was believed to be advisable.

8. That 243 acres of soybeans be grown for every 100 acres grown in 1929, which is less than was grown in either 1934 or 1935.

The experience of the Experiment Station, as well as that of the farmers, has also demonstrated the beneficial effects of legume green-manure crops where the legume is plowed under without occupying the land a full year. It is suggested that green-manure crops be increased to a point where all the land used in a crop rotation would have the benefit of a soil-building legume crop at least one year out of five; that is, at least one-fifth of the rotated land be in legume pasture, a legume hay crop, or sweet clover as a green-manure crop each year.

On the basis of these conclusions careful estimates were made of the total production of crops which might be expected at average yields. Then on the basis of this estimate of crop production, a careful analysis was made to see what changes it might bring in livestock production, based on the adjustments farmers ordinarily make in response to changes in the relationship of feed supply and numbers of livestock. It is suggested that cows milked be increased by 76,000, or about 7.4 percent of the number milked in the state in 1929. It is significant that more than this increase in dairy cattle had already occurred by 1935. It is suggested further that the total live weight of cattle and calves produced for sale annually be increased by 509,000 hundredweight, or 8.8 percent. This increase would be the result of the expected increase in the number of dairy cows over the 1930 base number, and an expected increase of 51,000, or 32 percent, in the number of beef cows. This increase in beef cows would take place largely in those areas where the increase in pasture would be greatest, that is, in those areas having serious erosion difficulties. Owing to the reduction in the acreage of corn there probably would be a decrease of 12.5 percent in the number of feeder cattle shipped in from outside the state. In other words, with some increase in the number of beef herds in the state there probably would be a greater proportionate reduction in the number of feeder cattle shipped in to be fed than there would be in the amount of corn produced.

With regard to sheep and lambs, the live weight produced in the state would probably increase by 163,000 hundredweight, or 43.6 percent over the base year of 1930. Any material increase in hay and pasture crops undoubtedly would lead to a considerable increase in native flocks of sheep and to an increase in lambs shipped into the state. Combined, these factors might account for an increase in mutton production of as much as 7,000 hundredweight.

As opposed to these increases in the classes of livestock which utilize considerable roughage, it was suggested that the total hog production of the state might easily decrease by 1,992,000 hundredweight, or 14.7 percent below the 1930 base. The decrease would be relatively greatest in those areas where the decrease in corn acreage was heaviest. The final conclusion as to what would happen to livestock production, provided a good program of soil conservation were carried out, may be summed up in the statement that, owing to the reduction in the weight of hogs produced, the total combined live weight of meat animals probably would be reduced by 1,321,000 hundredweight, or 6.7 percent below 1930. Furthermore, 1930, which was taken as the base period for these calculations, was a year in which both cattle and hogs were at relatively lower points, so far as their total production is concerned, than during either the preceding or following years.

Stated simply, the adjustment in use of cropland as suggested from this study would result in more roughages and less grain feed, which would result in more beef and mutton production and less hog production. This may be explained by saying that an acre in corn will produce more pounds of pork than the same acre planted to legumes will produce of beef or mutton. Thru such adjustments the farmer should have a better stabilized price-level for farm products while still producing a sufficiently large amount of food products. He would also profit thru having a more valuable farm ten years hence than he will have if the processes of soil deterioration are permitted to continue unchecked by good farm practice.

An interesting comparison may be made of the suggestions of this study and that of Administration 2, pages 7-9, which is based on estimates of farmers as to what constitutes desirable agricultural adjustment in the state. (214 Agricultural Economics)

Variations in Power Costs Point Way to Economies

After being curtailed by low farm incomes of the past few years, farmers' expenditures for tractors and other farm machines are now increasing. Furthermore horses continue to command relatively high prices, and there still is an increased interest in horse breeding. As a result of this situation Illinois farmers are greatly interested in questions concerning farm power, the costs of different types of power, and the relationships between the type of power and farm operating costs, farm income, and other farm-management factors.

Farm-account records from central Illinois farms have been studied by P. E. Johnston and J. E. Wills, Agricultural Economics, over the five-year period 1930-1934 in order that the Experiment Station might assist farmers in solving their power problems and in improving the efficiency of their operations. The records studied represent the experiences of a large number of farmers, a total of 6,390 records having been used in the five-year analysis. The number varied from 1,599 in 1931 to 1,045 in 1933. In the analysis these records were divided into three groups according to type of power used: (1) farms using horses but no tractors; (2) farms using horses and standard tractors, and (3) farms using horses and general-purpose tractors. Some of the larger general-purpose-tractor farms also use standard tractors. The records were also divided into eight size-groups, according to the acres of cropland in the farm.

The way in which the different types of power have been adapted to farms of different size is clearly indicated in Table 46. Of the horse farms almost exactly 50 percent had less than 120 crop acres, as compared with 17.5 percent of the standard-tractor farms and but 10.5 percent of the general-purpose-tractor farms. Of all farms with less than 120 crop acres, 52 percent used horses only, 41 percent were

TABLE 46.—DISTRIBUTION OF CENTRAL ILLINOIS FARM-ACCOUNT RECORDS ACCORDING TO SIZE OF FARM AND TYPE OF POWER, FIVE-YEAR AVERAGE, 1930-1934

	Percentage of records from—		
	Horse farms	Standard-tractor farms	General-purpose-tractor farms
Size of farm			
40 to 79 crop acres	20.5	3.8	1.2
80 to 119 crop acres	29.9	13.7	9.3
120 to 159 crop acres	27.0	23.5	17.8
160 to 199 crop acres	12.0	22.5	18.5
200 to 239 crop acres	5.7	16.5	16.0
240 to 279 crop acres	2.4	9.4	13.5
280 to 319 crop acres	1.3	4.9	7.1
320 and more crop acres	1.2	5.7	16.6
Total number of records	1 639	3 703	1 048
Acres a farm	186.1	247.9	294.4
Crop acres a farm	127.3	185.8	225.8

standard-tractor farms, and 7 percent were general-purpose-tractor farms. Of all farms with 280 or more acres in crops, only 6 percent did not use tractors, 58 percent used standard tractors, and 36 percent used general-purpose tractors.

Man-labor costs, horse costs, and machinery costs for each acre of crops vary greatly with the size of farm, and it is necessary to compare costs on farms of similar size if the influence of the type of power is to be correctly analyzed. The combined man-labor, horse, and machinery costs for each crop acre for the accounting farms studied are given in Table 47.

There has been a tendency for the total of these operating costs to be lowest on the horse farms and highest on the standard-tractor farms. Horse costs have been consistently highest on the horse farms and lowest on the general-purpose-tractor farms, being about twice as high on the former as on the latter. Machinery costs have been consistently highest on the general-purpose-tractor farms and lowest

TABLE 47.—COMBINED MAN-LABOR, HORSE, AND MACHINERY COSTS FOR EACH CROP ACRE ON FARMS OPERATED WITH DIFFERENT TYPES OF POWER (6,390 Central Illinois Farm-Account Records, 1930-1934)

Crop acres a farm	Costs on horse farms	Costs on standard-tractor farms	Costs on general-purpose tractor farms
40 to 79	\$16.66	\$16.62	\$17.55
80 to 119	12.17	12.73	12.92
120 to 159	10.04	10.83	10.59
160 to 199	8.90	9.49	9.07
200 to 239	8.40	8.63	8.44
240 to 279	6.85	8.00	8.01
280 to 319	6.78	7.57	6.85
320 and more	5.90	7.43	6.76

on the horse farms, being more than twice as high on the former as on the latter. Combined horse and machinery costs have been highest on general-purpose-tractor farms and lowest on horse farms. Man-labor costs, including the value of the labor of the operator and of the farm family, have been lowest on the general-purpose-tractor farms, but there has been very little difference in labor costs on horse farms and standard-tractor farms. This situation clearly indicates the advantage that the general-purpose tractor has over the standard-type tractor in replacing labor as well as horses on corn-belt farms. On most Illinois farms the cost of labor is greater than the combined costs of horses and machinery. Yet tractor farms as a group, and particularly standard-tractor farms, have not reduced their labor and horse costs as much as they have increased their machinery costs. Many tractor farmers have not taken full advantage of the opportunities afforded by their tractors in reducing costs for labor and for horses.

Wide variations occur in the costs of labor, of power, and of machinery from farm to farm in the same area, even where the same type of power organization is used and on farms similar in size. This points to the needs of having a power organization that is adapted to the individual farm; of avoiding an excess of power and of labor so that each power or labor unit may be used effectively; and of giving proper care to horses, tractors and other farm machinery, and equipment.

Analysis of earnings on these central Illinois farms reveals no significant difference in the net incomes of horse and of tractor farms. The slightly higher costs on the tractor farms have been offset by a higher gross income. This higher gross income on tractor farms has come largely from more livestock on the tractor farms and from a slightly greater proportion of the land in those crops that have yielded higher returns. (201 Agricultural Economics)

Tenancy Need Not Lead to Unprofitable Agriculture

Increasing farm tenancy, sometimes viewed as a sign of declining agriculture, need not necessarily mean that the land is less profitably managed than it is under an owner-operated system. Of the 95,000 or more tenant farms in Illinois, for instance, many are operated as profitably as those under the direction of owner-operators. This is indicated by an analysis which H. C. M. Case and Joseph Ackerman, Farm Management, have made of records from an average of more than 200 farms a year, many of the records being from the same farms, for a ten-year period.

The study was of farms typical of the best farming section of central Illinois. The farms were divided according to the years in which the records were made and into the four groups according to

the type of tenure: those operated by owners, those partly owned by operators, those whose tenants were related to the landlord, and those whose tenants were unrelated to the landlord. Earnings on the total farm investment were 3 percent, 3.7 percent, 3.2 percent, and 3.8 percent respectively. This shows that the men who owned only part of their land and the tenants who were unrelated to the landlord made the largest returns. A more careful analysis of the data shows that one of the chief differences in the net earnings was the more efficient use of labor, power, and equipment on the partly owned and tenant-unrelated farms. It is to be expected that among the owner group there are more older operators who have acquired their farms thru long years of work and are not exerting themselves as are the young men representing both the part-owner group and the tenant-unrelated group. One disadvantage of both the owner-operated and the tenant-related group was that the acreage farmed was smaller than in either of the other two groups.

Analysis of these records shows that the same factors usually found to affect farm earnings in any composite group of farms also applied to the groups studied on the basis of land tenure. Importance of giving careful attention to the organization and operation of the farm is thus again emphasized.

Among the operators of the farms included in this study, all of whom have kept careful records, one would expect to find farming of a better average grade than in a cross-section study of all the farms in a community. In general it was found that tenant farms are not more profitable than the owner-operated farms, when all farms in a given area are considered. In this study, however, which was made of the better farms in the area, it was found that there was no reason why tenant lands cannot be operated as profitably as owner-operated farms when the proper type of leases and arrangements are entered into by landlord and tenant. The disturbing fact in tenancy is that many poorly supervised farms, altho perhaps showing good current earnings, are following soil-depleting systems of farming. (205 Agricultural Economics)

Upward Trend in Use of Rented Land Is Given Study

Trends in land use are not only of direct economic importance, but also are often indicative of conditions deeply affecting the social structure. In Illinois the use of rented land by operators has shown an upward trend. Details of this trend and of conditions associated with it are being brought together in a continued study of land tenure and transfer under C. L. Stewart, Agricultural Economics.

Separation between ownership and operatorship of farm land in Illinois advanced considerably prior to 1880, was intensified between

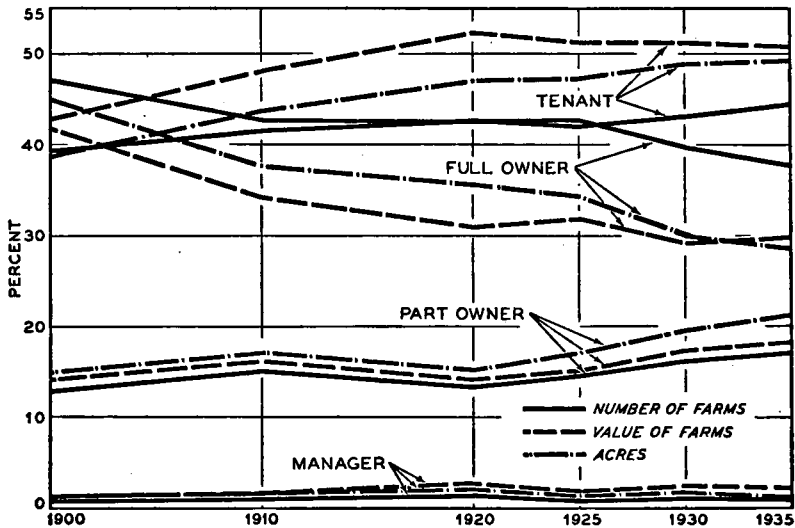


FIG. 34.—TRENDS IN VALUE OF ILLINOIS FARM REALTY, NUMBER OF FARMS, AND NUMBER OF ACRES EXPRESSED IN PERCENTAGES OF STATE TOTAL FOR FULL OWNERS, PART OWNERS, TENANTS, AND MANAGERS, 1900-1935

Counting part-owner realty as half rented and half owned, operation under lease was at all-time highs from 1920 to 1935, and operation by owners at all-time lows.

1890 and 1900, and entered another period of intensification about 1925. Evidences of the growing extent of the separation afforded in Census data (Fig. 34), in courthouse records, and in reports to state officials by insurance companies and other financial institutions have been examined in the light of information as to type of farming; value of products; amount of general and special taxes on farm real estate; extent of recent tax delinquency; the level, trend, and dependability of gross and net returns; and the market valuation of the property.

Values represented by Illinois farm ownership have undergone two notable periods of change. The products from an acre of land would buy about three times as much in 1910 as in 1850, considering the United States as a whole. In Illinois they would buy thirteen times as much. After 1910 the purchasing-power valuation of farm real estate in the United States kept advancing until 1914, moved to levels below those of 1910 between 1914 and 1920, and has hovered near the 1910 level in recent years. After showing a tendency to return toward the high levels of the period immediately before the war, the purchasing-power valuation of real estate, particularly in Illinois and other corn-belt states, showed further decline. In Illinois in 1933 the pur-

chasing-power valuation was below the 1910 level and not much above the very low 1900 level. Since 1933 there has been about as much increase in valuation of farm real estate as of prices of cost-of-living commodities both in the nation and the state. The detailed aspects of these changes in purchasing-power valuations in the various parts of Illinois are being studied in the light of information recently made available to the Experiment Station.

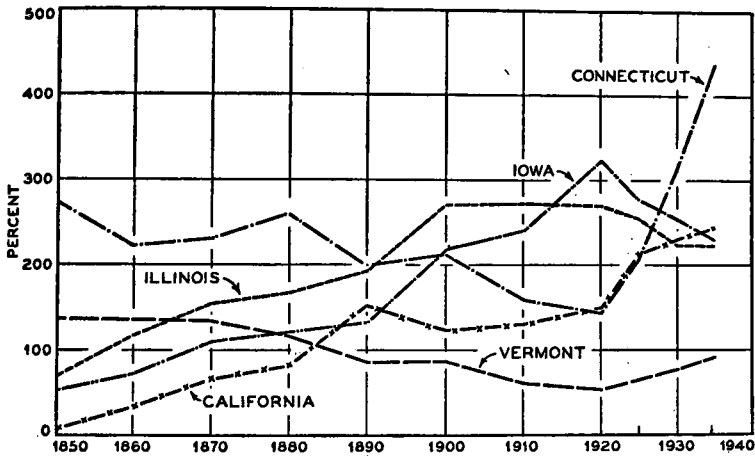


FIG. 35.—AVERAGE VALUATIONS OF FARM LAND AND BUILDINGS AN ACRE IN SELECTED STATES EXPRESSED IN PERCENTAGES OF UNITED STATES AVERAGES, 1850-1935

Acres-values in California were below the national average thru 1880, but much above from 1925 on. Connecticut has led all states in upward movement since 1925. Recently Illinois values are again rivaling Iowa values.

Changes in average valuation of farm real estate an acre from one year to another, and especially from one Census date to another, have made it difficult to measure the shifting position of the realty in one state in comparison with that of another or that in one part of the state with that of another part. Expressing state average valuations an acre in terms of national averages for each Census from 1850 to 1935 reveals some striking developments. Valuations an acre in Illinois were 75 percent of the national average in 1850; 120 percent in 1860; between 270 and 275 in 1900, 1910, and 1920; and between 220 and 225 percent in 1930 and 1935, or about one-tenth higher than in 1890. Iowa's average valuation was below that of Illinois until 1910, markedly higher than Illinois in 1920, and in 1935, after fifteen years of marked decline, it was still between the 1900 and 1910 levels. In

contrast with the downward movement of realty valuations an acre in Illinois and Iowa in terms of national averages since 1920, some states exhibit an upward movement. Connecticut, Massachusetts, Rhode Island, New Jersey, and California, largely because of effect of cities, have had their valuations sustained since 1920 better than other states

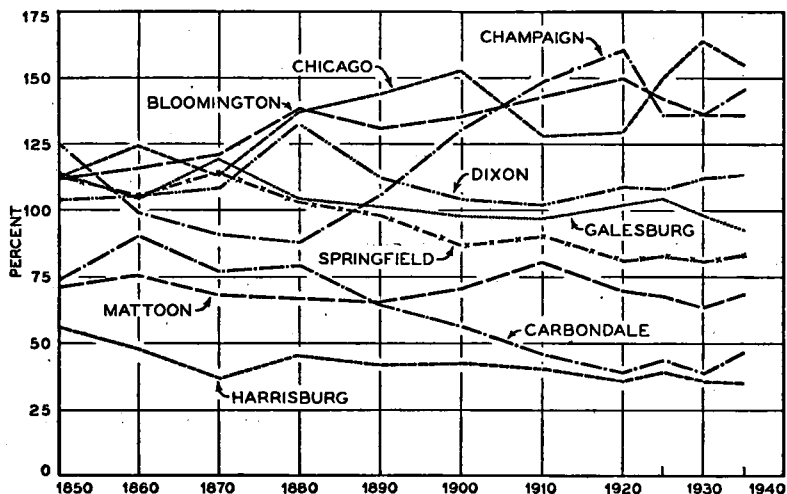


FIG. 36.—DISTRICT AVERAGE VALUATIONS OF ILLINOIS FARM LAND AND BUILDINGS AN ACRE EXPRESSED IN PERCENTAGES OF STATE AVERAGES, 1850-1935

In 1880 the Bloomington and Chicago districts were above the state average by more than 35 percent. From 1925 on the state average has been exceeded 35 to 65 percent in three districts: Bloomington, Champaign, and Chicago. Trends in the Galesburg, Springfield, Carbondale, and Harrisburg districts were downward.

(Fig. 35). In the East North-Central division, Michigan and Wisconsin have scored gains in terms of the national averages since 1920, and Ohio and Indiana since 1930, but Illinois has reflected a relative loss of position, less marked than that of Iowa but more than that of South Dakota, Minnesota, or Missouri.

Within Illinois the land-valuation map has changed markedly since 1850 (Fig. 36). The Bloomington and Chicago districts were above the state average in 1880 by more than 35 percent. From 1925 on, the state average has exceeded 35 to 65 percent in three districts—Bloomington, Champaign, and Chicago. In contrast with the upward trends noted for these districts are downward trends in the Galesburg, Springfield, Carbondale, and Harrisburg districts.

The proportion of farm land operated by persons other than owners since 1900 has been highest in the Champaign, Bloomington, and Gales-

burg districts. As one goes from counties in which high percentages of tenancy are found to counties having low percentages of tenancy, he moves from counties of high average valuations an acre to counties of lower valuations. When the percentage of all farms operated by full tenants was correlated with the valuation of farm real estate an acre, all of the 102 counties except Cook, DuPage, and Lake being included, the following positive coefficients were obtained: 1880, .25; 1890, .66; 1900, .78; 1910, .82; 1920, .86; 1925, .83; 1930, .85; and 1935, .79. Between real-estate valuation a farm and tenancy the coefficient in 1880 was .22; 1890 to 1930, .68 to .89; and 1935, .79. Between valuation of land only a farm and percentage of farms operated by tenants, the coefficient in 1910 was .86; 1920, .85; 1925 and 1930, .88. Between percentage of farm land operated under lease by tenants and part-owners and valuation of land only a farm, the correlation coefficient in 1925 was .87 and in 1930, .89; for the same dates the correlation with percentage of farm land in harvested crop was .89 and .90.

Date after date until 1930 there was increasingly closer correlation between land leasing and land valuations as between Illinois counties. Increase of tenancy between 1930 and 1935 in a number of southern Illinois counties where land valuations were relatively low was marked, whereas there was less increase and some actual decrease in tenancy in counties where land valuations had been relatively high. Decreases in valuation of land in absolute amounts and in terms relative to national and state averages have not resulted in decreased tenancy. The search for explanations goes hand in hand with collection of data on an annual basis for counties and minor civil divisions. Collection of data on farm-land tax delinquency in Illinois has continued in 101 counties. Considerable use has been made of this material by the Illinois State Planning Commission specialists, particularly in preparing its "Report on Land Use in Illinois." (300 Agricultural Economics)

Trucking Service of Livestock Cooperatives Is Studied

Experience has shown that the choice of a suitable system of trucking service, together with its proper management, has an important bearing on the general success of cooperative marketing and shipping associations. Information relative to the advantages, disadvantages, and management of the different systems in use is greatly needed. Such information is being obtained by R. C. Ashby and W. J. Wills, Livestock Marketing, thru a study of organized trucking by Illinois livestock cooperatives.

Facts concerning the trucking service of nine organizations were gathered in preliminary work carried on the past year. Of the nine organizations included, two were county livestock marketing associations operating concentration points, one was a county-wide shipping association, and six were largely local shipping associations. Five of

the organizations operated association-owned trucks. In two associations the managers owned and operated the trucks. In the remaining instances the trucking service was furnished on a contract basis.

One of the organizations adopted its present trucking setup in 1931, three adopted their present system in 1932, two in 1933, one in 1934, and one in 1935.

In general the systems in use are proving satisfactory. The old custom of using the cooperative as a lever to force a better deal outside still crops up. Since the associations establish and observe fixed rates for service, private truckmen can underbid them on full-load consignments, leaving the lower revenue jobs to the association trucks. Two associations reported specific difficulty in these matters.

While the number of cooperative livestock shipping associations has decreased rapidly in recent years, three factors could quickly change this situation. These are:

1. General adoption of local livestock truck pickup service by the railroads.

2. Granting by the railroads to the terminal markets of the same in-transit rate privileges now available at innumerable local markets.

3. Governmental regulation of motor transportation, with resultant uniformity of truckage rates and, sooner or later, probably higher rates.

More general development of organized truck service by farmers' associations appears to be a thoroly sound procedure. (61 Agricultural Economics)

Cost Figures on Livestock Trucking Being Obtained

More and more of the 207 million dollars' worth of livestock and livestock products produced annually in Illinois is going to market by truck, but the field within which motorized transport is most effective is still not clearly defined. Introduction of federal supervision of motor carriers may materially modify the situation. So may a general adoption of pickup service by the railroads. Accurate cost figures would help to establish the particular place of livestock trucking. They would also aid truckmen in conducting their business more effectively and in collectively meeting the problems resulting from public control and probable regulation of rates.

Figures on livestock trucking costs are being obtained in studies begun the past year by R. C. Ashby and R. J. Eggert, Livestock Marketing. Truckmen were contacted at country points and at the three principal livestock markets in Illinois (Chicago, East St. Louis, and Peoria), and those sufficiently interested to agree to keep records as outlined were provided with record books developed especially for the purpose. In all, record books were supplied to some 130 truckmen.

During May, calls on all cooperators were attempted, the purpose

being to assist them in the project, to encourage them to keep up their record books, and to discuss with them their various trucking problems. Altho a number were not at home, 112 were talked with. Of these, 40 were keeping the records. As a result of the calls 28 others signified their intention of giving the books another try. Forty-four of the truckmen visited had definitely given up keeping the cost records, and of these a large proportion had lost or misplaced their books.

To many it may seem that a discouragingly small percentage of the original cooperators are keeping up their records. Truckmen's hours and conditions of work, however, are not conducive to the keeping of records, even simple ones. In view of those hours and conditions, the showing may even be considered good. (62 Agricultural Economics)

Long-Time View Needed of Effects of Direct Selling

The trend toward decentralization of livestock selling continues, whereas livestock buying becomes more centralized. The result is to place Illinois farmers, who during recent years have produced an average of almost 66 million dollars' worth of hogs annually, in an increasingly weaker bargaining position in the selling of those hogs. In this connection R. C. Ashby and R. J. Eggert, Agricultural Economics, at the request of two local livestock markets, are making an analysis of sales of hogs from those markets direct to packers. Other aspects of local livestock markets also have received attention during the past year.

Heretofore attention to this problem has in most instances been confined too completely to the immediate comparative price and to the short-run viewpoint. A broader and longer-time view is imperative. It is shortsighted policy to test marketing effectiveness solely by comparative price thru centralized selling as opposed to sale thru decentralized channels, important as immediate price may be. Experienced market men recognize that as the number of sellers is increased in relation to the number of buyers, the bargaining position of the sellers is definitely weakened. Moreover as the number of selling points is increased, fewer buyers are able to continue trying to buy at many points. Buying competition thus tends to be weakened. (63 Agricultural Economics)

Both Poultry Profits and Costs Increased in 1935

The income to labor on 36 Illinois poultry farms as a result of 1935 operations was approximately double that in 1934 and well above that of 1932 and 1933. This study of poultry costs by R. H. Wilcox, Agricultural Economics, and L. E. Card, Poultry Husbandry, continues to show the effect of those factors having the greatest bearing on income and expense. These factors are: number of eggs a hen,

TABLE 48.—COST OF PRODUCING EGGS AND PULLETS ON ILLINOIS POULTRY FARMS, 1932-1935

Items	1935, average of 36 flocks	1934, average of 37 flocks	1933, average of 20 flocks	1932, average of 21 flocks
Birds in laying flock.....	422	430	510	510
Pullets produced.....	330	326	360	354
Eggs a hen.....	131	126	131	140
Receipts and net increases a flock.....	\$1 473.17	\$979.15	\$1 076.57	\$1 137.60
Expenses and net decreases a flock.....	1 030.39	780.25	753.05	864.24
Receipts less expenses.....	442.78	198.90	323.52	273.37
Income to labor, other costs subtracted.....	\$ 522.53	\$279.04	\$ 419.89	\$ 352.00
Egg cost a dozen.....	\$.17	\$.15	\$.13	\$.14
Cost of rearing a pullet.....	.58	.37	.45	.46
Profit a hen.....	.76	.14	.37	.25
Returns an hour of labor.....	.62	.23	.38	.30
Net cost a hen.....	1.80	1.59	1.31	1.58
Feed cost a hen.....	1.22	.86	.61	.66
Egg receipts a bird.....	2.56	1.72	1.67	1.82
Capital invested a bird.....	2.50	2.66	2.44	3.05
Hen mortality, percentage.....	21.8	21.0	20.9	27.0
Returns from each \$100 worth of feed...	\$ 162	\$ 116	\$ 160	\$ 137

feed cost for a dozen eggs, capital invested, and mortality. Any one of these factors when out of balance with the rest of the poultry enterprise can cause poor results.

The object of the study is: (1) to obtain facts regarding the management of farm and commercial poultry flocks in the state and (2) to secure fundamental basic requirements of feed, labor, and miscellaneous cost items in farm and commercial poultry production. A summary of egg costs and other figures for the past four years are given in Table 48.

During the fourth year of the field work in this project cooperation among poultry producers in the northern portion of the state was secured. This made it possible on October 1, 1935, to place a total of 126 poultry cost-account books in the state. From these records the poultrymen have the basic information covering their yearly operations which will make it possible for them to analyze the year's business and then make changes in methods of production where they seem warranted. (212 Agricultural Economics)

Effect of Transportation on Egg Quality Is Shown

For each of the years from 1925 to 1934 Illinois farmers and poultrymen produced an average of more than a billion and a half chicken eggs. An average cash income of more than 20 million dollars a year was received for these eggs. With proper attention to marketing, however, it is believed that the income from Illinois eggs can be substantially increased. To this end, and with the cooperation of commercial egg producers in certain sections of southern Illinois, a study of

such basic factors as market destination, method of transportation to that market, and effects of production practices upon egg quality from farm to market is being carried on. R. C. Ashby, Livestock Marketing, and L. E. Card, Poultry Husbandry, are in charge.

During May, June, and July, 1935, eight experimental shipments of Illinois eggs were forwarded to the New York market. In five instances shipments by rail and by truck were compared. The rail shipments were in less than carload lots. All shipments were given U. S. grades at the local shipping point and were similarly graded upon arrival at New York.

Less-than-carload shipments by rail involved nine handlings of the eggs en route as compared with four handlings by truck shipment; six days were required for market delivery as compared with three days by truck; and the marketing cost was materially higher by rail than by truck. Owing to the greater time in transit, the eggs shipped by rail graded appreciably lower on arrival at New York. In the rail shipments 49.1 percent of the eggs graded U. S. Extras, whereas 89.6 percent of the eggs in the truck shipments rated U. S. Extras.

However, one producer's eggs showed 71.5 percent U. S. Extras in rail shipments on arrival at New York. Production practices were found to be an important factor in quality of eggs at destination, especially where delays occurred in transit.

Significant differences were found in initial quality of eggs from different flocks, particularly in eggs from flocks in confinement and from flocks allowed farm range. This difference was noted in size of eggs, condition of white, and in yolk color.

A feature of the project was a producers' meeting at Olney on July 23 at which samples of the eggs shipped to New York on July 19 were on display and which the growers present were invited to candle—to see for themselves the differences in quality. They had been brought from New York to St. Louis by plane, then to Olney by automobile, the day of the meeting.

The project is being continued during the summer of 1936 but on a broader basis. Improved service on rail shipments has been arranged. The initial 1936 shipment upon arrival in New York showed no difference in quality of eggs as between rail and truck transportation. (81 *Agricultural Economics and 1092 Animal Husbandry*)

Cost Studies Reveal Why Orchard Profits Increased

The fruit enterprise on 41 Illinois farms on which cost records were kept in 1935 showed an average net profit of \$975. For a similar group of farms there was an average net loss of \$88 a farm in 1934, a net profit of \$640 a farm in 1933, and a net loss of \$141 a farm in 1932. Cost studies conducted by P. E. Johnston, *Agricultural Economics*, and V. W. Kelley, *Horticulture*, to determine the reasons for these and sim-

ilar variations indicate that the increased profits were the result of better yields without a corresponding increase in costs.

The productive apple trees in 1935 produced an average of 3.6 bushels a tree, while the average yield for 1934 was only 1.5 bushels a tree. The average production for peach trees was 1.8 bushels a tree in 1935, but only one-half bushel in 1934. Fruit sold by Illinois farmers in 1935 was valued at about \$9,700,000, whereas that sold during the three-year period 1931-1933 had an average annual value of \$5,400,000.

For purposes of this study the orchards were divided into two groups, the first consisting of 22 orchards of 40 acres or more and the second of 19 orchards of less than 40 acres. The average profit in 1935 for the larger orchards was \$1,423 and for the smaller orchards \$457.

The larger orchards averaged 68.3 acres, had \$17,146 invested in the enterprise, and had a gross income of \$6,495 a farm. Operating costs totaled \$5,072 a farm, or \$74.25 an acre.

The smaller orchards averaged 18.8 acres, had \$4,491 invested in the orchard and equipment, and had a gross income of \$1,820 a farm. The average cost was \$1,365 a farm, or \$72.63 an acre.

There was a direct relationship between the yield of fruit and costs and profits. The ten orchards which had yields of apples of more than 5 bushels a tree had spray costs which averaged \$24 for each 100 trees and an average profit of \$1,259 a farm. The eight orchards with apple yields of a bushel or less a tree had an average spray cost of \$7 each 100 trees and an average profit of \$501 a farm.

The price of apples dropped sharply during the latter half of 1935, whereas the prices paid by farmers for commodities bought declined but little. In June of 1935 the farm price of apples in Illinois was \$1.35 a bushel, or 29 percent above the prewar level. The price in July dropped to 60 cents a bushel, or to 58 percent of the prewar level. Prices were low during the fall marketing season and greatly reduced the profit from the orchards. The low prices at picking time were responsible for the heavy movement of apples into storage. On the cooperating farms the average selling price for apples was slightly less than 60 cents a bushel, whereas the average price received for peaches was \$1.03 a bushel.

Comparisons between the large and small orchards show that expenses an acre were less on the small farms, but that the expense for 100 bushels of fruit was larger. Fruit yields were higher on the larger farms, but the price received a bushel was higher on the smaller farms. The gross income an acre was slightly higher on the smaller farms. The net profit an acre was larger for the smaller orchards, but the net profit a farm was less than for the larger orchards. (204 Agricultural Economics)

Lower Fruit Costs Are Aim of Packing-Shed Studies

A very large percentage of the apples, peaches, and pears produced in Illinois, which in 1935 totaled 11 million bushels, are handled thru packing sheds. Costs of packing in different sheds are known to vary widely. Since these costs ultimately become a part of the price the consumer must pay for the fruit and of the price the producer must have in order to remain in business, their reduction to the lowest possible point is highly desirable. To analyze the costs of packing and to devise means for reducing them has been the object of studies carried on by J. W. Lloyd, Fruit and Vegetable Marketing.

Results of these studies indicate that in many instances a rearrangement of the shed equipment would make possible a better coordination of the various operations so that the fruit could move steadily from the receiving door to the refrigerator car, truck, or storage room without congestion or delay at any point. Provision for the expeditious handling of facer fruit and disposal of culls would greatly facilitate the work in many sheds. Installation of roller or chain conveyors to eliminate the hand carriage of fruit would reduce the labor in a number of sheds. (23 Agricultural Economics)

Ways to Lessen Losses in Shipped Peaches Are Shown

Losses of more than 10 million dollars a year occur as a result of deterioration and damage of fruits and vegetables on the way to market. Much of this loss could be prevented by proper handling and particularly by rapid cooling of the products shipped under refrigeration. Factors influencing the rate of cooling of peaches packed in various containers have been under investigation in studies conducted by J. W. Lloyd and S. W. Decker, Fruit and Vegetable Marketing. These studies have been completed and the results were published in October, 1935, as Bulletin 418, "Factors Influencing the Refrigeration of Packages of Peaches."

The studies showed that the rate at which the fruit in a bushel basket cools is largely dependent upon the difference between the temperature of the air about the fruit and the temperature of the fruit. Peaches packed in an unlined ventilated bushel basket cooled in half the time required by those in a standard lined tub bushel basket. Wrapping of the fruit in paper greatly retarded the cooling.

Results of these studies indicate that radical changes in methods of preparing fruit for shipment may be necessary before current losses are sufficiently curtailed. (21 Agricultural Economics)

Precooling of Peaches for Rail Shipment Is Studied

A considerable part of the Illinois production of peaches is transported by rail, 20,881 carloads having been shipped in this manner

during the past ten years. It is to the advantage of both producer and consumer to have this fruit transported without damage. In continued studies under J. W. Lloyd and S. W. Decker, Fruit and Vegetable Marketing, special attention has been given to precooling as an aid in better preserving the quality of peaches intended for railway shipment.

Because of truck competition in the transportation of peaches to all nearby markets, rail shipments are now going to the more distant markets. The peaches thus do not reach the consumer until several days after they are picked. The weather is usually hot at the time Illinois peaches ripen, and prompt cooling is essential if they are to be carried safely to distant markets. Peaches packed in standard bushel containers, loaded into refrigerator cars, and shipped under standard refrigeration cool very slowly. Tests made under laboratory conditions had shown that peaches packed in a ventilated package cooled more than twice as fast as those packed in a standard bushel container. Arrangements were therefore made to test the rate of cooling of peaches in the two types of packages when loaded into refrigerator cars and subjected to two methods of precooling.

With one type of precooling equipment, the temperature of the fruit in the ventilated baskets was reduced 17.3 degrees in 3½ hours, while that of the fruit in the standard baskets was reduced only 11.2 degrees, a difference of 6.1 degrees in favor of the ventilated package. Inspection of the fruit upon arrival in the market showed that the peaches in the ventilated packages were in firmer condition than those in the standard packages. With the other type of precooling equipment, the average temperature of the fruit in the ventilated packages was reduced 17.9 degrees in 7 hours, while the temperature of that in the standard packages was reduced 14.1 degrees. In the above tests standard liners were used in both types of packages. In another test the temperature of the fruit in the ventilated packages, without liners, was reduced 10 degrees more than that of the fruit in the standard-lined containers during a six-hour cooling period.

The past season was the first year that commercial precooling companies worked on carloads of peaches in Illinois. Except for the twelve cars used in the tests by the Experiment Station, all the peaches were packed in standard bushel containers with standard paper liners. Results of the tests show that in order to secure the benefits of prompt cooling of Illinois peaches loaded into refrigerator cars for shipment, some marked modifications of even the most advanced commercial practices used in the state the past season will be necessary. Either colder air than that provided by the types of precooling equipment employed in the past season's tests must be brought into contact with the load of fruit, or a greater volume of cold air must be forced thru the load, or thoroly ventilated packages must be used. It is probable

that the use of ventilated packages combined with one of the other specifications mentioned would be most effective.

Colder air or a greater volume of cold air could be provided by enlarging the capacity of the precooling equipment. In order to adapt the ventilated package to the most effective use under modern packing-house methods, it will be necessary to use a new type of liner that will obstruct the air movement as little as possible and yet be sufficiently rigid to hold the fruit in place while the packing form is being exchanged for the basket in the up-side-down method of packing. An open-mesh liner made of the same sort of material as onion and orange bags has been tested in an experimental way and offers much promise.

If truck shipments of Illinois peaches continue to take larger and larger percentages of the crop, it will be more necessary than ever to take special precautions with all carload shipments by rail to fortify their carrying quality, so that they may reach the more distant markets in satisfactory condition. Precooling will probably have to become the regular commercial practice. The use of ventilated packages equipped with thoroly ventilated liners will undoubtedly be necessary to provide effective precooling without unreasonable delay in shipment. (22 Agricultural Economics)

Consumer Demands Are Pointed Out in Produce Study

Produce from thirty-six states appeared on the Peoria market between July 1, 1934, and June 30, 1935. In addition imported bananas and pineapples were present in large quantities, constituting more than 42 percent of the carlots of fresh fruits unloaded at Peoria.

These facts, which were obtained in studies carried on by J. W. Lloyd and S. W. Decker, Fruit and Vegetable Marketing, are illustrative of the important changes in the marketing of fresh fruits and vegetables that are being brought about thru improved methods of packing, processing, and transportation. They are also indicative of the competition that growers who are producing fruit and vegetables for local markets must meet if they are to continue in business on a profitable basis. It is believed that these men could increase their income thru more earnest efforts to meet the demands and desires of consumers. The nature of these demands and how they may be met more effectively are being brought out.

Produce coming to the Peoria market from distant regions is, as a rule, rigidly graded and packed, while no standard is in common use among local producers. This makes it possible for retailers to handle the produce from distant regions more effectively and on a smaller margin than that required for handling local produce.

A consumers' survey indicates that, regardless of family income, about 70 percent of the vegetable supply is purchased as fresh vegetables. More than 85 percent of the fresh fruit and vegetable supply is

purchased from retail stores, about 6 percent from street peddlers, and the remainder direct from farmers and open markets.

The tendency of consumers to buy all fresh produce in small units is reflected in the purchases of retailers and wholesalers. This condition is favorable to placing produce from a large number of producing areas upon a given market. It has greatly reduced the market for such crops as stored cabbage and topped carrots and has greatly increased the demand for other crops such as green beans and new potatoes.

The quality of fresh produce stocked by retail stores in the various parts of town does not vary greatly. However, the variety of fresh produce stocked may vary greatly, depending upon the family income of the store's patrons.

The retail price on a given quality of produce was found to vary greatly within the city. The wide difference in price was frequently caused by some stores using the item as a leader when others were carrying it as a profit-making item or as a service item. (24 Agricultural Economics)

Transportation Changes Would Net Dairymen 3 Million

In 1934 consumers paid about 150 million dollars for dairy products produced in Illinois. Out of this amount farmers received 58 million dollars, while costs of transportation, processing, marketing, and distribution took about 92 million dollars. On a proportionate basis farmers received about two-fifths, while costs of distribution absorbed the other three-fifths of what consumers paid for these products. Out of the various steps in the distribution process, transportation is probably most susceptible to control by producer groups. It is estimated that Illinois farmers in 1934 paid about 12 million dollars for transporting milk and cream from farms to markets where these products were processed or manufactured.

With these facts in mind, R. W. Bartlett, Agricultural Economics, has made a careful analytical study of the costs to farmers of transporting milk from farms to receiving plants in the St. Louis milkshed.

That savings up to 25 percent of total hauling costs and greater economic stability of transportation can be brought about by certain changes in the transportation system is indicated by preliminary analysis of the data obtained in this study. Changes necessary to effect these savings include: (1) reducing the distance that milk is hauled by eliminating duplication and overlapping of routes; (2) increasing the volume a load with present seasonal production; (3) increasing the volume a load by reducing the range in seasonal production; and (4) the diversion of more milk to country plants.

The greatest opportunity for effecting savings and bringing about economic stability in transportation of milk in the St. Louis milkshed lies in reducing the mileage that milk is hauled and in increasing the

volume a load. A practical question which arises is how and by whom can this be accomplished.

One answer to this question was found in the operations of the producers' association in Dayton, Ohio. This association commenced a rerouting program in the spring of 1930 and completed it in the early part of 1931. Results of this program were summed up by C. W. Lawrence, general manager of the Miami Valley Cooperative Milk Producers' Association, as follows in a paper, "The Cooperative Control of Hauling."¹

"After the northern section had been rerouted in the fall of 1930, the southwest and east sections of our milkshed were rerouted, making the program complete. The total of 17 trucks (out of a total of about 47) were eliminated, and the hauling rate was reduced on an average of almost ten cents a hundred pounds, which meant a saving of more than \$50,000 to the farmers the very first year that this rerouting was accomplished."

Some of the factors relating to the transportation of milk in the Dayton, Ohio, area are summarized in Table 49 from information and maps obtained thru the courtesy of Mr. Lawrence.

TABLE 49.—SUMMARY OF FACTORS RELATING TO TRANSPORTATION OF MILK FROM 506 FARMS TO CITY PLANTS, DAYTON, OHIO, 1930-1931

Items	Before trucking routes were revised, 1930	After trucking routes were revised, 1931	Net change
			<i>perct.</i>
Number of routes	14	9	-36
Round-trip mileage of all routes.....	847 miles	526 miles	-38
Average daily volume a truck.....	1 835 pounds	2 855 pounds	+56
Average rate for 100 pounds of milk.....	40 cents	30 cents	-25
Average daily income of each trucker.....	\$6.81	\$7.74	+14

Since the producers' association in the Dayton market accomplished one of the things desired in the St. Louis market—a lowering of the hauling rate—careful analysis was made of a selected area in the Dayton milkshed to ascertain how this was done, with the producers' association cooperating in the study. The rerouting program in this selected area was found to have resulted in: (1) eliminating 5 of the 14 hauling routes; (2) a net reduction of 38 percent in the round-trip mileage; (3) a net increase of 56 percent in the average volume of milk a truck; (4) a net reduction of 25 percent in the average hauling rate paid by producers; (5) a net increase of 14 percent in the average income a trucker; and (6) an hour earlier delivery of milk to distributors' plants. This helped producers to deliver milk in better condition, particularly during the summer months.

¹Paper given at the annual meeting of the National Cooperative Milk Producers' Federation, 1935.

Opportunities for reducing mileage, increasing the volume a load, and decreasing hauling costs to farmers in the St. Louis milkshed are as great as, if not greater than, those that existed in the Dayton milkshed. The average volume of milk a load in the St. Louis country-plant areas in 1933-34, for example, was 1,321 pounds daily, whereas that for the more efficient routes in the area exceeded 2,855 pounds, the average of the selected revised routes in the Dayton area. The more efficient routes in the St. Louis area were operating under average conditions as to proportion of earth roads and volume of milk available a mile.

A saving of about \$250,000 annually to farmers in the St. Louis milkshed would result from a 25-percent reduction in their hauling costs. Not less important in bringing about greater economic stability would be an increase in the daily income to haulers. At least part of the troubles in the St. Louis country-plant areas during the past few years were caused by discontented haulers whose labor and operating costs were higher than their incomes.

With an estimated total hauling cost of \$12,000,000 annually, a saving of \$3,000,000 in hauling costs for dairy products in Illinois would result from a 25-percent reduction in these costs. This indicates the importance which can be attached to the problem of effecting savings in transportation of dairy products. (1 Agricultural Economics)

Costs of Producing Milk in Chicago Area Are Studied

More up-to-date figures on the cost of producing milk in northern Illinois than are now available are expected to result from a study begun in January, 1936, by R. H. Wilcox and P. E. Johnston, Farm Management, and C. S. Rhode and J. G. Cash, Dairy Husbandry. No authoritative figures of the kind have been collected in this area since 1928.

The objectives of this study are: to determine milk production costs in the Chicago fluid-milk area and in adjacent areas in northern Illinois; to secure data by means of which analysis can be made of the methods of producing milk and of the causes for the variation in production costs from farm to farm; and to secure data for such an analysis of the farm business as will show the relation of the dairy enterprise to the organization of the farm.

Cow testers for seventeen dairy herd-improvement associations in the area assisted in obtaining the cooperation of dairymen and are helping to keep the cost records. Approximately 100 dairy cost records were obtained during the winter of 1935-36. (207 Agricultural Economics)

AGRICULTURAL ENGINEERING

Farmers on Experimental Line Use More Electricity

Rapid extension of electrical service to Illinois farmers, stimulated both by the nationwide rural-electrification program and the return of more favorable economic conditions, has increased the need for accurate figures on the use of current on representative farms. Such information is being obtained in continued studies under E. W. Lehmann and A. L. Young, Agricultural Engineering.

A noteworthy increase in the average amount of energy consumed by cooperators served by the experimental power line established in 1925 was found in 1935-36. Consumption on the farms of the eight cooperators during the year is shown in Table 50. Data for consumption by ranges and refrigerators are not quite complete because of the burning of the residence of Cooperator 3. Meters for use on these pieces of equipment on this farm have not been available since last August. A small building was used as a temporary home until about December 1, when the new house was completed.

The total consumption, 25,450 kilowatt hours, by the eight cooperators slightly exceeds the former high consumption of 24,866 used in 1930-31, when ten cooperators were using current. The average a customer the past year was 3,181 kilowatt hours as compared with the previous high of 2,487 in 1930-31. The consumption for the year by individual cooperators varied from 2,103 to 5,273 kilowatt hours. The total monthly consumption by the eight cooperators varied from 1,710 in June to 2,682 in April. The high April consumption is in accord with records of other years, this being the month when normally considerable extra current is used in the operation of brooders. Usually the lowest monthly total is for some one of the winter months.

In 1935-36 consumption was lower than usual in both June and July because two farms, those of Cooperators 3 and 4, on which new houses were being constructed did not use the normal amount of current in either refrigerator or range. Consumption during the winter months was somewhat higher than in past years because two of the cooperators were using water heaters, one (Cooperator 2) starting in September and the other (Cooperator 10) in January. These two heaters used 3,468 kilowatt hours, or about 13.5 percent of the total. Had both been used thruout the year, they would have increased the total considerably.

Apparently the lower rates as compared with previous years have somewhat encouraged increased use of ranges. Consumption by Cooperator 1 increased from 1,276 to 1,479 kilowatt hours, Cooperator 5 from 353 to 870, Cooperator 7 from 0 to 587, and Cooperator 8 from

TABLE 50.—MONTHLY AND TOTAL CONSUMPTION OF ELECTRICAL ENERGY FOR DIFFERENT PURPOSES ON COOPERATING FARMS, 1935-36
(Kilowatt hours)

Cooperator	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Customer total
Total used													
2.....	205	218	258	476	509	516	489	450	471	590	566	525	5 273
3.....	226	416	382	464	288	256	347	358	351	395	277	490	4 250
4.....	124	190	275	279	229	185	229	218	217	204	194	202	2 546
5.....	185	284	270	151	212	265	175	120	138	123	122	270	2 315
6.....	225	210	208 ¹	205	200	214	77	80	63	100	447	74	2 103
7.....	404	370	410	376	228	308	220	254	403	158	122	265	3 518
8.....	159	212	226	175	149	134	147	134	97	129	503	219	2 284
10.....	182	166	192	153	161	175	189	332	330	346	451	484	3 161
Total.....	1 710	2 066	2 221	2 279	1 976	2 053	1 873	1 946	2 070	2 045	2 682	2 529	25 450 Average 3 181
Used by ranges ²													
2.....	135	128	118	136	153	144	93	75	97	142	117	141	1 479
4.....	0	0	0	115	61	30	40	29	47	33	45	57	457
5.....	69	132	138	142	103	83	38	25	33	25	26	56	870
6.....	130 ⁴	132	145	150	144	56	3	3	2	9	11	10	795
7.....	0	82	150	147	58	33	29	25	12	0	0	51	587
8.....	32	85	107	65	1	3	15	15	6	12	4	15	360
10.....	20 ¹	22	38	32	9	12	10	9	11	11	9	13	197
Total.....	386	581	696	787	529	361	230	182	206	232	212	343	4 745 Average 593

TABLE 50.—*Concluded*

Used by refrigerators ^a													
2.....	0	28	54	35	31	25	18	21	14	30	26	39	321
4.....	0	0	45	39	36	44	24	35	34	39	31	39	366
5.....	108	172	149	106	73	56	15	0	0	0	13	190	882
6.....	30 ¹	32	29	23	18	6	16	20	17	22	23	25	261
7.....	136	162	165	128	0	1	0	0	0	0	0	41	633
8.....	65 ¹	79	66	61	61	37	0	32	39	49	54	57	600
10.....	45 ¹	48	44	30	21	14	9	8	6	15	21	34	295
Total.....	384	521	552	422	240	183	82	116	110	155	168	425	3 358 Average 383
Used by 5-horsepower motors													
2.....	11	8	10	10	24	13	3	10	9	6	18	3	125
3.....	15	73	99	90	21	13	4	0	0	51	46	85	497
4.....	22	1	8	11	15	21	14	26	27	18	17	10	190
5.....	0	0	0	0	1	17	0	0	0	0	0	0	18
7.....	0	0	0	0	0	24	0	0	0	0	0	0	24
8.....	16	9	7	7	16	20	26	8	4	8	12	9	142
10.....	26	48	44	30	21	14	9	8	6	15	21	34	276
Total.....	90	139	168	148	98	122	56	52	46	98	114	141	1 272 Average 159

¹Estimated consumption; meter not attached or attached during only a portion of the period. ²Cooperator 3 used both a range and a refrigerator during a portion of the year, but no record was obtained of the current consumption. The monthly totals and customer averages are for the group from which data were collected.

120 to 360. Cooperators 3 and 4 also used much more current, but consumption of the previous year was abnormally low because their homes were destroyed by fire. Cooperator 6 also used considerably more current than during the previous year. However, consumption on this farm in 1935-36 was perhaps abnormally high, since during a portion of the time, while a new house was being constructed, the family lived in temporary quarters and did all the cooking on the electric range.

If the consumption of the refrigerator in the home of Cooperator 3 is estimated as 450 kilowatt hours, the total consumption by eight refrigerators the past year was 3,808 as compared with 4,946 in 1934-35. However, the total hours of use of refrigerators was greater in 1935-36 than in the previous year. Cooperator 2 used a new machine constantly after it was installed in July, whereas in the previous year the old one was turned off entirely for six months. Cooperator 4 had a new machine in use from August thruout 1935-36, whereas the previous year none was used. Cooperator 8 also used a refrigerator more months in 1935-36 than in the previous year. Cooperators 5, 6, and 10 used their refrigerators about equally in the two years. Cooperator 3 used a refrigerator six months in 1934-35 and about ten months in 1935-36. Cooperator 7, on the other hand, used a machine only five months in 1935-36 as compared with twelve in the previous year.

The reduction in total consumption by refrigerators was therefore apparently the result of use of new machines. The new machine used by Cooperator 2 averaged slightly more than 28 kilowatt hours a month for the eleven months' use in 1935-36, whereas in the previous year the old machine averaged 151 kilowatt hours a month for five months' operation. The old machine used by Cooperator 6 averaged 56 a month in 1934-35, whereas the new one in 1935-36 averaged 22 a month. A new refrigerator used by Cooperator 10 averaged about 25 a month in 1935-36, whereas an old machine averaged 69 in 1934-35. Cooperator 7 installed a new 6-cubic-foot refrigerator about May 1, 1936. This machine used 41 kilowatt hours in May, as compared with an average of 147, which the old one used during four months (June to September) the previous summer. The only old refrigerator now in use on the line is that used by Cooperator 5. It used 190 kilowatt hours in May, 1936, and averaged 134 for June to September in 1935.

Tests on the use of light in insect control were continued in cooperation with the Illinois Natural History Survey, and sterilizer tests were continued in cooperation with the Department of Dairy Husbandry.

A pneumatic (air blast) grain blower installed in a commercial grain elevator near the University was tested to determine the reason for its excessive power consumption. It was found that the motor driving the fan required 48 horsepower to elevate the grain. A minor

change was made in the duct system and the fan replaced with one of more nearly correct design. The revised installation elevated grain somewhat faster than the original fan at a motor input of slightly less than 20 horsepower. (404 Agricultural Engineering)

Septic-Tank Studies Aid Modernization of Farm Homes

With farm homes being modernized at a rapid rate, there is strong demand for septic tanks requiring less attention. While some serve eight or ten years without being cleaned out, others must have the accumulated sludge removed more frequently. How often a septic tank must be cleaned depends much upon its size and design, and in continued studies of sewage disposal by E. W. Lehmann, Agricultural Engineering, in cooperation with A. M. Buswell, Illinois State Water Survey, efforts are being made to determine the correct design for given sets of conditions.

Studies of the accumulation of sludge in the three experimental septic tanks on the University farm have been continued the past year. Measurements made approximately twice a month indicated a downward trend in the accumulated contents from June until about December, when there was an upward trend in the accumulation. Possibly this was caused by the kinds of materials discharged into the tanks or by the temperature change. The accumulated sludge in Tanks 1 and 2 in 1935-36 was much less than that in 1934-35 (Table 51).

Tank 1 has been operating very efficiently for the past ten years. During the past year three adults were using the tank. Except for one time when ice formed on the tank, observations were made twice each month on the sludge accumulation.

Tank 2 has been operating with good results. Two adults and seven children have been using this tank. Except for one time when the 2-inch iron-pipe outlet drain was clogged, the tank has been very efficient. This small drain was a part of the original experimental equipment for collecting the effluent, and it had not been replaced with a larger outlet until this spring.

Tank 3 has been in continuous operation for the past ten years, serving two families, a total of about seven adults, in two households. The sludge content having increased each year until the tank was approximately full, the tank was emptied June 3, 1936, and immediately put back into operation. There was comparatively little odor from the material pumped out of the tank. During the past year the outlet drain became clogged, and no accurate data were secured. A broken tile causing the clogging in the outlet drain was replaced.

About the first of June observations were made on the sludge accumulation in the outlet tile from two of the tanks. In the outlet of Tank 3, about 15 feet from the tank, 1½ inches of sludge had accumulated; about 50 feet out, 1 inch. The tile was carrying about 1 inch of

TABLE 51.—RELATIVE EFFICIENCY OF THREE TWO-CHAMBER SEPTIC TANKS OF DIFFERENT CROSS-SECTIONS AS MEASURED BY ACCUMULATION OF SLUDGE OVER A PERIOD OF TWELVE YEARS

Tank	Tank dimensions		Number of persons	Sludge accumulated									
	Depth	Width		1931	1932	1933	1934	1935	1936	For each person a year			
										1924 to 1931	1931 to 1933	1933 to 1935	1935 to 1936
1.....	<i>ft.</i> 5	<i>ft.</i> 2.4	3	<i>cu. ft.</i> 25.44	<i>cu. ft.</i> 31.59	<i>cu. ft.</i> 31.51	<i>cu. ft.</i> 41.28	<i>cu. ft.</i> 34.2	<i>cu. ft.</i> 29.90	<i>cu. ft.</i> 1.16	<i>cu. ft.</i> 1.01	<i>cu. ft.</i> .45	<i>cu. ft.</i> -1.43
2.....	4	3.0	9	44.00	42.84	51.55	56.04	69.0	56.53	2.86	1.88	1.81	-1.38
3.....	3	4.0	7	69.29	77.76	83.43	88.16	110.0	Filled up	.96	.71	2.21	....

water. Tank 1 outlet had collected only a very slight, almost negligible, amount of sludge. It was carrying no running water.

It may clearly be seen that septic tanks of a recommended size will operate for many years without any expense other than first costs and with little or no attention. (501 Agricultural Engineering)

Use of Gasoline Lessens Oil Dilution in Tractors

Excessive dilution of crankcase oil in tractors when low-grade fuels are used, together with much of the wear on engine parts, can be reduced by the use of gasoline. This is a fact brought out by continued studies of the factors affecting the lubricating qualities of crankcase oils under the supervision of R. I. Shawl, Agricultural Engineering.

Many of the present tractor engines are being made with much smaller clearances between their working parts, for which reason a much lighter-bodied oil (usually SAE 20) is necessary if the oil pump is to supply each part with sufficient oil. When low-grade fuels are used, the lighter-bodied oils are often thinned out rapidly by the unburned fuel that works past the pistons into the crankcase, and in order to offset this thinning, many farmers have been using the heavier grades of oil.

Field tests were made on a 11½-year-old tractor, with new sleeves

TABLE 52.—COMPARISON OF OILS USED IN A GASOLINE-BURNING TRACTOR WITH NEW OILS OF THE SAME KIND, 1935

Oil	Hours oil was used in the engine	Seybolt viscosity in seconds ¹		SAE viscosity ²	Percentage dilution
		100° F.	210° F.		
No. 1, new.....	...	300	53	20	...
No. 1, used.....	105	202	49	..	4.5
No. 2, new.....	...	360	57	20	...
No. 2, used.....	145	296	54	..	5.0
No. 3, new.....	...	330	56	20	...
No. 3, used.....	166	253	51	..	4.0
No. 4, new.....	...	320	56	20	...
No. 4, used.....	137	247	52	..	4.0
No. 5, new.....	...	368	57	20	...
No. 5, used.....	144	249	51	..	3.75
No. 6, new.....	...	371	55	20	...
No. 6, used.....	189	263	50	..	3.0
No. 7, new.....	...	351	53	20	...
No. 7, used.....	147	240	49	..	3.0

¹The viscosity, or body, of an oil is given as the number of seconds it takes 60 cc. of it to run thru a standard opening at a given temperature. ²The Society of Automotive Engineers has recommended that all new oils listed as light, medium, heavy, etc., be given a viscosity number, which allows a certain definite range in number of seconds viscosity at 130° F. and 210° F. This system standardizes the body of all brands of oil for any grade.

and pistons, burning gasoline and using light-bodied SAE 20 oils. The laboratory tests of these oils before and after their use are shown in Table 52. These oils, all of which were of high quality, were used more than 100 hours in every case. The performance of all was exceptionally good. The viscosity of the used oils at 210° F. was changed but little from that of the new oils, and the average crankcase oil dilution was 4 percent for seven oils tested. In 1931 this same tractor, with new sleeves and pistons, burning kerosene and using SAE 40 oil showed an average of 36 percent dilution for seven oils that were tested. In 1934 this same tractor, with badly worn sleeves and pistons, burning kerosene, and using SAE 50 and 60 oil showed an average of 32 percent dilution of the oil in the same number of hours of use.

Results of these oil tests indicate that high-quality crankcase oils can be used with safety for 100 hours without draining when gasoline is used as a fuel in the tractor, provided the air cleaner and oil filter are serviced according to directions.

Tractor and automobile engines should be lubricated with the lighter oils, as recommended in the instruction books, until the engine begins to use oil too rapidly or until the oil becomes diluted too rapidly where low-grade fuels are used. (405 Agricultural Engineering)

High-Compression Tractor Shows Economies in Fuel

A number of the owners of the 85,000 tractors in Illinois in 1935 were greatly interested in the use of high-compression engines and rubber tires as a means of increasing their tractor power and reducing the acre-cost of operation of these machines. Studies made by R. I. Shawl, Agricultural Engineering, on a 11½-year-old tractor show that by raising the compression of the low-grade, fuel-burning engines and by the use of 70-octane gasoline, the belt horsepower of this engine was increased more than 30 percent along with a definite saving in the fuel consumed for each belt horsepower hour.¹ Continued tests on a set of rubber tires showed that these tires were in good condition and were working efficiently after three years of continuous use, totaling 3,400 hours of work.

For the purpose of the high-compression engine tests, the Department of Agricultural Engineering decided to use a two-plow, general-purpose, kerosene-burning tractor on which it had been keeping cost records for the past 11½ years. In 1935 this tractor, which had been operated for 7,393 hours, was changed into a high-compression engine,

¹The fuel used in pounds a belt horsepower hour is the usual method of comparing the fuel economy of different-sized engines. This is determined by dividing the pounds of fuel used an hour by the belt horsepower of the engine. The approximate weight of a gallon of gas is 6.10 pounds and of distillate 6.95 pounds.

burning 70-octane gasoline. This change was made by equipping the tractor with new sleeves fitted with 8,000-foot altitude pistons, a cold-gasoline manifold, and the cold type of spark plugs for burning gasoline.

The brake horsepower tests of the original type of kerosene engine and the Agricultural Engineering laboratory test of the same model engine with high compression are shown in Table 53.

TABLE 53.—BELT HORSEPOWER TESTS OF HIGH- AND LOW-COMPRESSION TRACTOR ENGINES

Engine	Fuel	Belt horsepower	Fuel consumption for each horsepower hour
Nebraska test Low compression.....	Kerosene	20.05 maximum	lbs. .716
Illinois tests ¹			
High compression.....	70-octane gasoline	10.73	.98
High compression.....	70-octane gasoline	15.37	.76
High compression.....	70-octane gasoline	19.72	.663
High compression.....	70-octane gasoline	24.89	.642
High compression.....	70-octane gasoline	26.45	.637

¹A check run of this series of tests with different loads has not been conducted.

The Illinois high-compression test showed 32 percent more horsepower than indicated in the Nebraska official test for this model of tractor and a fuel saving of 12.4 percent. The nonadjustable carburetor on this engine prevented any fuel adjustments being made. The calculated compression ratio of the engine for low-grade fuel was 4.13:1 and for the high-compression engine 5:1.

This tractor with the high-compression engine completed 1,074 hours of general farm work during 1935, giving excellent service during the entire period. It was felt safe to use the extra power provided by the high-compression engine in the old tractor, because it was equipped with rubber tires which greatly reduced the shocks to gears and other working parts.

Raising the compression of the tractor engine will not make the tractor an economical unit to operate unless the tractor is operated at its optimum load a large percentage of the time. Apparently the use of rubber tires on this tractor made this possible.

The average gasoline consumption of this high-compression tractor for the year 1935 was 1.67 gallons an hour, and the greatest fuel consumption at any time was 2.27 gallons an hour while pulling the 6-foot wheatland disk, which was considered a maximum load. The average kerosene consumption of the tractor for the 10½ years previous to 1935 was 1.44 gallons an hour. These figures show a difference of 16 percent in fuel consumption on the hourly basis between the 10½-

year average of 1.44 gallons and the 1.67 gallons for 1935, but when this difference is considered on the basis of the fuel consumption for each acre of work done, the high-compression tractor shows some advantage in fuel economy.

A continuation of the studies on the cost of operation of this 11½-year-old tractor, as related to length of life, shows that the cost has gradually decreased as the total estimated hours of work are increased. The average cost for the 10½-year period thru 1934 was 51.7 cents an hour. Detailed cost figures for the 11½-year period follow:

Depreciation for 8,464 hours tractor work at 8.5 cents an hour ¹ ...	\$719.44
Interest on investment, 6% of $\frac{920 + 65.71}{2} \times 11\frac{1}{2}$ years ²	340.06
Fuel, oil, and grease	
530 gals. gasoline (1924-1935) at 16 cents.....	84.80
1,796 gals. gasoline (1935) at 10 cents.	179.60
10,117 gals. kerosene at 12 cents.....	1,214.04
440 gals. crankcase oil at 75 cents.....	330.00
73.5 gals. transmission oil at 55 cents.....	40.15
461 lbs. grease at 12 cents.....	55.32
Repairs (cost of material only).....	780.53
Farm labor overhauling tractor, 550 hrs. at 50 cents.....	275.00
Expert labor overhauling tractor, 13 hrs. at \$1.25.....	16.25
Implement dealer labor overhauling tractor, 74.5 hrs. at \$1.....	74.50
Tractor chores, 443 hrs. at 30 cents ³	132.90
Total taxes on tractor to date.....	12.35
Housing tractor to date.....	46.00
Total cost of operating tractor 8,464 hours.....	\$4,300.94
Average cost of operation of tractor an hour for 11½ years..	.508

¹The life of the tractor is estimated at 10,000 running hours, or approximately 714 hours a year for fourteen years. Depreciation is figured on \$920 — \$65.71, or \$854.29. ²Cost of tractor was \$920 including freight. The \$65.71 represents the estimated value of the tractor at the end of 14 years. ³Tractor chores consist of greasing, changing oil, filling with water, fuel, and oil, and cleaning spark plugs.)

(303 Agricultural Engineering)

Plow Users Obtain Good Results From Covering Aids

While the principal purpose of plowing is to improve the physical condition of the soil, it is important for other reasons. As an operation in which the plant growth and manure, commonly referred to as trash, is covered, good plowing facilitates other work and aids in insect control. Clean plowing has given more effective control of the European corn borer, for example, than any other single method yet developed.

As continued by A. L. Young and R. I. Shawl, Agricultural Engineering, in cooperation with Thayer Cleaver, U. S. Bureau of Agricultural Engineering, the investigation of mechanical methods of fighting the corn borer has in recent years become a general study of plows and plow equipment, with emphasis on attachments to provide good trash coverage and to aid in securing better control of insects, crop diseases, and weeds. During the past year further studies have been made of

disk jointers and trash guides as used by seven cooperating farmers on their own plows. Most of the equipment used was similar to that originally patented by the U. S. Department of Agriculture. A modified and somewhat simpler trash guide also was given a trial. This equipment was used in covering cornstalks; soybean, oat and wheat stubble; straw after combining; and timothy and clover sod.

All farmers who have used this equipment are enthusiastic as to the possibilities of the disk jointers. Those who have used the trash guides long enough to learn how to adjust and operate them have found them very satisfactory. The modified trash guide is more easily adjusted and is perhaps more likely to receive immediate approval of users than the one originally developed.

Altho no actual measurements of the amount of trash and crop debris left on the surface of the plowed ground were made, it was evident that the coverage was much better than that obtained before this equipment was placed on the plows. Work in previous years has indicated that the disk jointers and trash guides have given better covering than can be secured by the use of standard rolling colters, moldboard-type jointers, and covering wires, and it is thought that adjustment and maintenance will be easier for the average operator. Further information concerning this equipment and plowing problems in general may be obtained from the recently issued Circular 450, "Better Plowing." (304 Agricultural Engineering)

Mechanical Checks on Soil Washing Being Perfected

Topsoil on more than 12 million acres of rolling cultivated land in Illinois is being depleted and carried away by erosion. A good portion of this land can be greatly benefited and erosion losses checked by the use of terraces and contour farming in conjunction with other recommended soil-treatment and cropping practices. This is being observed by E. W. Lehmann and R. C. Hay, Agricultural Engineering, in their studies on the use of terraces and other mechanical means of controlling soil erosion.

Three problems frequently encountered in terracing are: (1) difficulties arising from poorly planned terrace systems with inadequate outlets; (2) failure of terraces as a result of not adapting farming methods to the terraces; and (3) failure of terraces owing to lack of maintenance.

Considerable thought and judgment are needed in planning and laying out terrace systems, judging from the results of the current studies. Poorly planned terraces and terrace outlets have in most cases been unsatisfactory. Frequently, sodded outlets can be located, graded, and seeded a year or more in advance of the terrace construction. The use of concrete dams in outlets provides permanent control, but frequently is difficult to justify from an economic standpoint.

The most satisfactory terrace grades range from 1 to 4 inches in 100 feet, with all terraces more than 300 to 400 feet long constructed to a variable grade. In certain exceedingly porous soils, such as sandy loam and deep loess, level terraces with closed ends are performing satisfactorily. However, it is recognized that level terraces have a very limited place in Illinois. In pastures small level terraces and contour furrows blocked at intervals for protection against erosion of seedbeds for new seedings and for moisture conservation are being given numerous trials in various sections of the state. They have also proved to be a very economical method of controlling hillside gullies having small watersheds.

Little maintenance of terraces is needed when plowing, planting, and cultivating of crops are done on the contour. Furthermore contour cultivation tends to reduce erosion between terraces. Because of crooked, winding rows and point rows, farming on the contour is considered a difficult practice. The most commonly used methods of contour farming are the key terrace system, in which one terrace is used as a guide for all the rows on the slope, and a modified plan for strip cropping wherein the point rows are taken up by small grain or hay crops and corn planted only in the long-row strips.

With contour farming, maintenance of terraces farmed on the contour in a good crop rotation is a small item, yet quite an essential one. Breaks in the ridge must be repaired promptly and channels must be kept open. Observations on terraces that have been performing satisfactorily for twelve to fourteen years indicate that terraces properly farmed and maintained provide permanent protection against erosion losses. (201 Agricultural Engineering)

Smaller Combines Make Satisfactory Record in Tests

Because certain manufacturers were introducing, or at least experimenting with, combines smaller in size and lower in first cost than those marketed in the past, studies of these small machines were made during the summer and fall of 1935 in cooperation with the Bureau of Agricultural Engineering, U. S. Department of Agriculture. Tests similar to those during the period from 1925 to 1931 were made by A. L. Young and R. I. Shawl, Agricultural Engineering; and W. M. Hurst, W. R. Humphries, and Thayer Cleaver, U. S. Department of Agriculture.

In general it was found possible to do quite satisfactory work with these smaller combines. In some wheat and in nearly all oat fields in which tests were made, more grain than is desirable was left in the straw and chaff, but in part this was the result of heavy and badly lodged crops. In such fields the larger combines also lost more than normal amounts. In soybean fields losses were not excessive, but the smaller machines seemed to split a somewhat higher percentage of

the beans than did the larger ones. In general the operators of the smaller machines were the less experienced.

Total harvesting and threshing losses for all tests made averaged 10.7 percent for wheat, 25.4 for oats, and 9.3 for soybeans. Threshing losses, or losses in straw and chaff, averaged respectively 5.8 percent, 19.2, and 2.7. Hardly enough tests were made on large combines in wheat and oat fields to compare them with the smaller ones. During soybean harvesting seven larger combines were tested as against fourteen smaller ones. The average total loss for large machines was 9.6 percent as compared with 9.1 percent for the small machines. The average cutter-bar, or harvesting, loss was 6.1 percent for the larger machines as against 7.2 percent for the smaller ones, but threshing losses averaged 3.8 percent for the larger machines as compared with 1.8 percent for the smaller machines when combining soybeans. Threshing losses were exceptionally low for the small machines when combining soybeans, but in oat fields tended to be considerably higher than for the larger machines. In the combining of wheat there seemed to be no great difference between the large and small machines. Cutter-bar, or harvesting, losses averaged about the same for large and small machines for all crops combined. (401 and 402 Agricultural Engineering)

Artichoke Tests Clearing Way for Advent of New Crop

If Jerusalem artichokes are to be widely introduced and grown as one of the new crops of Illinois, satisfactory methods of harvesting and washing them will have to be developed. During the past year, therefore, E. W. Lehmann and R. I. Shawl, with other staff members in Agricultural Engineering, have continued the development and use of the artichoke digger with which they have been experimenting.

The time of digging artichokes varies greatly with weather conditions. Fall digging is done as late as possible in order that the tubers may make a maximum growth. However, late fall and early spring rains cause soggy field conditions which not only delay the time of digging, but also increase the difficulty of digging and the separation of the artichokes from the dirt, all of which adds greatly to the cost of harvesting. Studies made on the growth of tubers in 1935 show that they are sometimes in the ground to a depth of 10 inches, which means that a great amount of dirt must be handled if the majority of the tubers are to be reached.

The engine-operated modified potato digger and the sorting table used during 1935 were rebuilt for greater strength during the past year, but the machine would not handle satisfactorily the large amount of damp earth necessary if most of the tubers were to be reached. Lighter soils that clean readily from the tubers decrease the time and labor of harvesting. The small size of the tubers the past year increased the

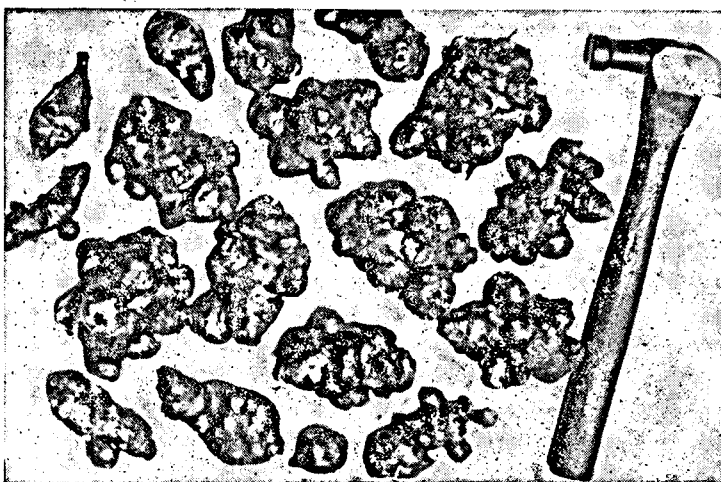


FIG. 37.—VARIATION IN SIZE AND ROUGHNESS OF JERUSALEM ARTICHOKES
Harvesting troubles were increased by many of the small tubers falling thru the slats of the digger before passing over the sorting table.

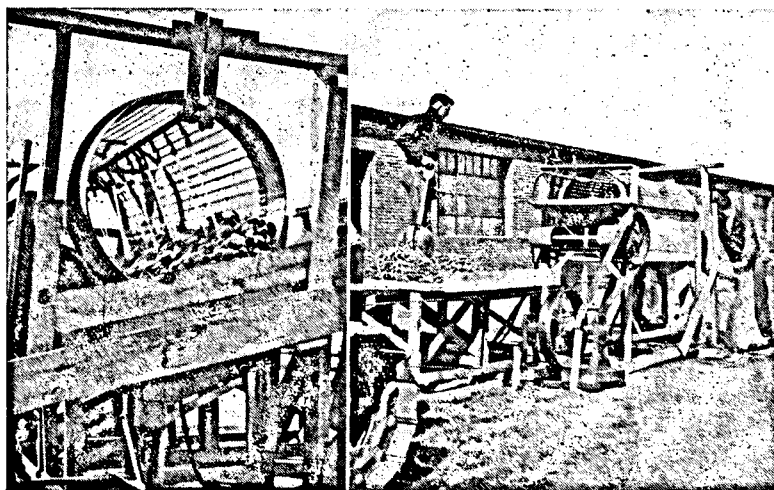


FIG. 38.—REVOLVING CYLINDER EQUIPPED WITH LOW-PRESSURE NOZZLES
FOR CONTINUOUS WASHING OF ARTICHOKES

Fifty pounds of artichokes grown in clay soil could be washed and bagged in about four minutes with this machine. After spilling over the baffle board, the tubers were inspected on the wooden chute, the improperly cleaned ones returned for rewashing, and the remainder bagged.

difficulty of harvesting, because many of them fell thru the slats of the digger before passing over the sorting table. The variation in the size and roughness of the tubers is shown in Fig. 37.

The large quantity of dirt which often sticks to the tubers makes it necessary that they be washed if they are to be used commercially. This washing is difficult because of the irregular shape of the tubers. In 1936 R. H. Reed, Agricultural Engineering, tested a commercial rotary vegetable-washing machine having a slatted drum 6 feet long and 2 feet in diameter to determine its adaptability to the washing of artichoke tubers. Artichokes grown in clay soil could be satisfactorily washed at a total operating and equipment cost of approximately \$2.15 a ton. Had the artichokes been grown in soil which washed off more readily, the cost would have been less, with the minimum figure approximately 70 cents a ton for those requiring little cleaning.

The washer shown in Fig. 38 was used as a continuous-feed washer by installing an adjustable baffle over the discharge end to keep about 100 pounds of tubers in the drum at all times. After spilling over the baffle board, the tubers were inspected on a wooden chute. All improperly cleaned tubers were returned for rewashing and the rest bagged. Under these conditions and for artichokes grown in clay soil, it required approximately 4 minutes to wash and bag 50 pounds.

A flat-type nozzle discharging 4 gallons of water a minute at a pressure of 27 pounds a square inch in a flat, continuous stream was more effective than other types of nozzles. Eleven of these nozzles were placed 6 inches apart to form a continuous stream of water requiring the use of 44 gallons of water a minute. The washer appeared to clean the tubers best at a drum speed of 40 to 44 revolutions a minute, altho some tubers were bruised at this speed.

The only structural changes that appeared necessary to adapt the machine to the washing of artichokes were an increase in the size of the drain pipe to care for the long trash found in artichokes and the moving of the drain pipe to the center of the machine to facilitate the carrying away of the very large amount of soil washed off the tubers. (403 Agricultural Engineering)

New Methods of Drying Hay and Grain Are Tested

So many important advantages result from improved methods of drying and storing hay and grain, such as better quality, better prices, and better germination of seed, that a vastly greater application of such methods appears certain. If the most satisfactory results are to be obtained at minimum cost, numerous problems, some of which involve the use of artificial heat and of new machines and methods, must be worked out. Several of these drying problems have been attacked in further studies under E. W. Lehmann and R. H. Reed, Agricultural Engineering, and W. L. Burlison and George H. Dungan, Agronomy.

An attachment to an ordinary mower, similar in principle to the large hay-crushing machine used in 1932, was tested to determine its adaptability to handling soybeans as well as alfalfa and red clover. The crusher handled soybean plants except for the stems which lay crosswise at the end of the roll and clogged on the bearing support. A circular rotating saw blade was attached to the end of the roller shaft, as shown in Fig. 39, as a means of determining whether a

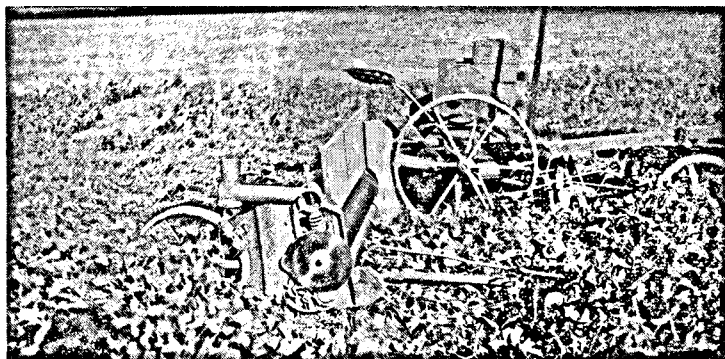


FIG. 39.—HAY CRUSHER WITH EXPERIMENTAL DIVIDER TO KEEP STEMS FROM CLOGGING BEARING SUPPORT

The circular rotating saw blade attached at the end of the roller shaft demonstrated that a rotary cutter built into the machine at or near this location would eliminate the trouble caused by the stems lying crosswise at the end of the roll and clogging the bearing support.

rotary cutter built into the machine at or near this location would eliminate the trouble encountered. This proved to be a very satisfactory type of divider. It was found that the mower, with crusher attachment, could be pulled by an ordinary farm team on soybean ground, altho the load was such that during hot weather a change of teams during the day would be desirable.

Soybean hay cut with an ordinary mower was placed on tripod supports, such as are used frequently in the southern states. It was found that eight to twelve man-hours an acre were required to build the stacks. Altho the curing weather was unusually favorable, it was felt that the smaller amount of moldy hay and the greater percentage of green hay in the stacks as compared with ordinary cocks capped with cloth was a distinct advantage. Several stacks were left standing during the fall rains. These were in excellent condition when torn down. Thus it is evident that small, specially constructed stacks may be valuable both as a curing method and as a field storage method.

As another phase of the forage harvesting study several tons of

first-cutting alfalfa hay were chopped and put into a tight wooden silo. As the weather at the time of harvest was such that the hay contained 32 percent moisture, it was known that neither baling nor chopping and handling by the ordinary method would prove satisfactory. It was found that the chopped hay around the side of the silo had molded but had remained sufficiently cool to prevent charring.

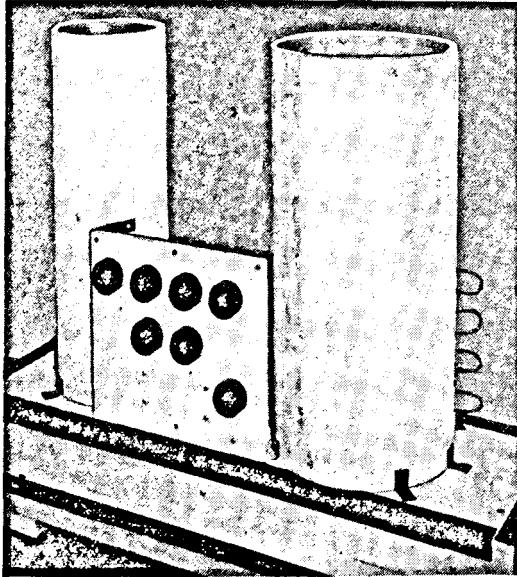


FIG. 40.—TUBE DRYER FOR DETERMINING THE MOISTURE CONTENT OF GREEN GRASS SOON AFTER MOWING

This equipment was especially designed for use in pasture-grass feeding experiments. Air heated to 260° F. and blown thru the grass sample at a velocity of 1 foot a second would dry small-stemmed plants, such as grasses, alfalfa, and red clover, to a constant weight in 1¼ to 1½ hours.

The entire center of the hay below the top surface had charred black but had given no threat of an open fire.

In cooperation with the Department of Animal Husbandry, the "tube dryer" shown in Fig. 40 was designed for use in a pasture-grass feeding experiment in which it was necessary that the moisture content of the green grass be known soon after cutting. It was found that air heated to 260° F. and blown thru the grass sample at a velocity of 1 foot a second would dry small-stemmed plants, such as grasses, alfalfa, and red clover, to constant weight in 1¼ to 1½ hours. In

order that this high temperature might be used without the material being scorched by exposure to the heater, specially wound electric heaters were designed for a wire temperature of 350° F. in still air. (601 Agricultural Engineering and 534 Agronomy)

Further Studies of Spraying-Plant Design Are Made

Stationary spraying plants have an obvious advantage in making it possible to apply sprays under weather conditions unfavorable for the use of portable spray outfits. Under conditions found in some states they have also substantially reduced the cost of spraying as compared with the cost with portable sprayers. However, while individual pieces of the equipment of stationary plants have reached a high state of mechanical development, other parts will require much improvement. Information on which to base improvements in design is being obtained in continued studies under E. W. Lehmann and R. H. Reed, Agricultural Engineering, and H. W. Anderson and R. L. McMunn, Pomology.

At low velocities much of the suspended solid material used in spraying solutions will settle out and be deposited temporarily or

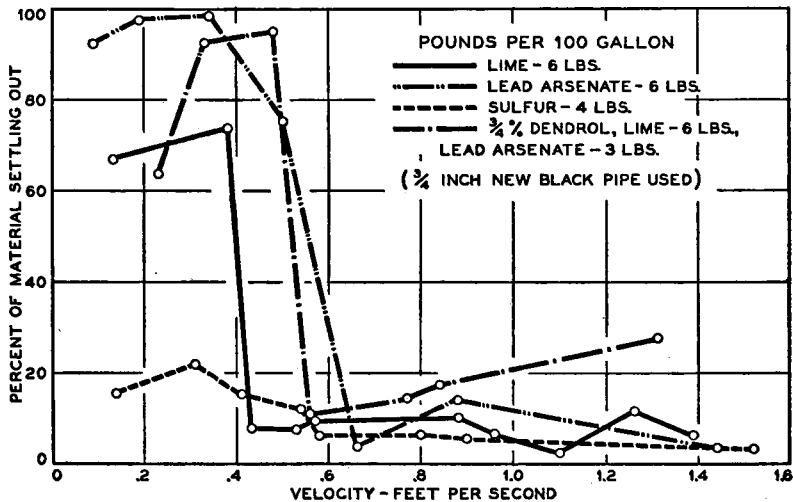


FIG. 41.—PERCENTAGE OF SUSPENDED SPRAY MATERIAL SETTLING OUT OF SOLUTION AT DIFFERENT FLUID VELOCITIES

The very rapid increase in the amount of suspended spray materials which settles to the bottom of a ¾-inch distributing pipe as the fluid velocity is decreased from .6 to .4 feet a second indicates that the former is the minimum velocity for which a distributing system should be designed. The fact that this velocity is at the lower limit of the turbulent flow range indicates that turbulence is necessary to maintain a uniform spray material concentration.

permanently in the bottom of the distributing pipes, as shown in Fig. 41. From the results shown, this settling appears to become a very serious problem at an average velocity of .4 to .6 feet a second. Friction loss tests indicated that this range is for a Reynold's number,¹ for the particular pipe and solution, of 2,500 to 4,000. As the lower limit of turbulent fluid flow is normally considered as a Reynold's number of about 3,000, the results of this study indicate very strongly that stationary spraying plants must be designed to operate at all times somewhat above the critical region, if they are to operate successfully with suspensions of solid spray materials.

As the loss of head, or friction loss, in a stationary spraying plant is proportional to the square of the average fluid velocity and only directly proportional to the friction factor, which decreases slightly for higher velocities, it is desirable to design a plant for as low a velocity as possible. The studies made tend to indicate that the lower limiting velocity may be less than the value previously used. (406 Agricultural Engineering)

Heat Loss in New Apple-Washing Machine Is Studied

As a result of recent regulations severely limiting the amount of lead and arsenic that may be present on apples moving in intrastate, interstate, and international commerce, a large share of Illinois' average annual apple crop of more than 4 million bushels must be washed. In order that the washing machines may remove the residue satisfactorily under practically all conditions, it will be necessary for many of them to be equipped with heating systems capable of maintaining the washing solution at 90° to 110° F.

To provide information for the correct design of these heating systems has been the object of a study by R. H. Reed, Agricultural Engineering. In this work the newest underbrush flood-type of washing machine has been tested to determine its heat loss. Tests have also been made to find a suitable metal pipe for use as submerged radiator or heating coils in acid washing solutions or for a coating for ordinary steel pipe that would protect it under such conditions.

The large size underbrush flood-type washer having a washing-solution tank 56½ inches wide and 81½ inches long was found to have a heat loss, while in operation but without apples being washed, of 1,795 B.t.u. an hour for each degree Fahrenheit difference in temperature between the washing solution and the outside air. This was at the rate of 56.3 B.t.u. for each square foot of exposed tank area.

The total amount of heat required to maintain the washing solution at 110° F. during operation would be 192,800 B.t.u. an hour. This

¹Reynold's number is the dimensionless ratio:

$$\frac{\text{inside pipe diameter in feet} \times \text{average fluid velocity in feet a second}}{\text{kinematic viscosity in square feet a second}}$$

figure is based on a temperature of 40° F. for the outside air and the apples with the machine operating at full capacity while set for the shortest immersion time likely to be required under Illinois conditions. Specific information for the design of heating systems for this as well as other washers on the market at the present time is given in Circular 457, "Heating Systems for Apple-Washing Machines."

The most desirable types of heating systems require the use of metal pipes in the acid solution. In a prolonged immersion test the past winter sixteen different types of acid-resisting paint on black steel pipe, three different types of pipe made of metal alloys, and a steel pipe enameled (glass-coated) on the outside were used. Of the twenty specimens tested, two coated with different types of paint, one made of monel metal alloy, and the enameled (glass-coated) pipe resisted the action of the heat and acid sufficiently long to warrant their use as radiator or heating coils. (407 Agricultural Engineering)

Studies of Farm-Waste Gas Plants Are Continued

In view of the benefits that would follow if gas for heating and cooking could be produced from farm wastes in a practical manner, every possible means of developing and perfecting the process should be fully investigated. Consequently, despite the fact that the volume of gas yet obtained has been impracticably small in proportion to the amount of material that must be handled, study of the process has gone on. A. M. Buswell, Illinois State Water Survey; E. W. Lehmann, Agricultural Engineering; and E. E. DeTurk, Agronomy; in cooperation with the Departments of Animal Husbandry and Agricultural Economics, are in charge. Detailed results are given in Table 54.

At the beginning of the year (July 1, 1935) the experimental plant, which consists of two gas tanks of different sizes, was being operated under practically normal conditions. Shredded corn fodder was fed during the summer and fall period, and a series of tests was made. During the first test period (July 1 to 7) 335 pounds of material were fed into the large tank (A), with a gas production of 1,108 cubic feet, or 3.31 cubic feet to the pound of material fed, the average tank temperature being 85.5° F. The greatest yield of gas recorded was during the six-day period August 12 to 17, when 220 pounds of material were fed, with a gas production of 1,372 cubic feet, or 6.25 cubic feet a pound fed, the average tank temperature being 84.1° F.

The test-period results cannot be regarded as final. Altho the material fed and the gas production are measured for a given period, the gas is not produced by the particular material fed during that period. Several days must elapse before the material is digested. For this reason and because new material in varying amounts was fed each day, the test-period results have little significance. The cubic feet of gas produced for each pound of material fed, for the 72 days which the

TABLE 54.—RESULTS FROM OPERATION OF LARGE AND SMALL TANKS FOR PRODUCTION OF GAS FROM FARM WASTES, 1935
(Shredded corn fodder used in all tests.)

Test period	Material fed	Material fed a day	Gas produced	Gas produced a day	Gas from each pound material fed	Material removed	Average inside temperature	Average outside temperature
Large tank (A)								
<i>July</i>	<i>lbs.</i>	<i>lbs.</i>	<i>cu. ft.</i>	<i>cu. ft.</i>	<i>cu. ft.</i>	<i>lbs.</i>	<i>° F.</i>	<i>° F.</i>
1- 7, 7 days.....	335	47.9	1 108	158	3.31	404.25	85.5	84.6
<i>August</i>								
1- 3, 3 days.....	330	110	1 135	378.3	3.44	383	85.7	90.7
5- 9, 5 days.....	550	110	1 604	320.8	2.92	643	85.4	87.5
12-17, 6 days.....	220	36.6	1 372	228.6	6.25	410	84.1	81.1
19-24, 6 days.....	550	91.6	1 621	270.1	2.95	666	83.3	79.9
26-31, 6 days.....	605	100.8	2 202	367.0	3.64	493	81.4	75.6
<i>September</i>								
3- 7, 5 days.....	440	88.0	1 491	298.2	3.39	906	73.6	67.9
9-10, 2 days.....	165	87.5	503	251.5	3.05	281	75.5	71.8
Small tank (B)								
<i>July</i>								
1- 7, 7 days.....	102	14.6	205	29.1	2.00	181	85.5	84.6
<i>August</i>								
1- 3, 3 days.....	35	11.7	94.2	31.4	2.69	21	85.3	90.7
5- 9, 5 days.....	120	24.0	181	36.2	1.51	92	84.2	87.5
12-17, 6 days.....	45	7.5	177.5	29.6	3.94	96	83.1	81.1
19-24, 6 days.....	90	15.0	239.8	39.9	2.68	144	84.4	79.9
26-31, 6 days.....	90	15.0	222	37.0	2.47	57	83.4	75.6
<i>September</i>								
3- 7, 5 days.....	75	15.0	130	26.0	1.73	111	76.9	67.9
9-10, 2 days.....	30	15.0	52.7	26.3	1.76	52	78.4	71.8

plant was run, was 3.13. Except for the one period August 12 to 17, mentioned above, this is a fair average.

The amount of material fed during the fall was increased from 50 pounds daily to 110 pounds, with only a small variation in the amount of gas produced a pound fed. Only 112 pounds of coal were used during the entire period of operation.

Measurements have been continued during the year to determine what portion of the material fed into the tank is destroyed in the fermentation process. The loss in nitrogen content, the element which gives to the tailings removed from the tank their chief manurial value, has also been studied. These studies were carried out during a run of 86 days (June 17-September 10, 1935). The actual operation time, because of a 14-day period when no material was fed, was 72 days.

During this period the total dry weight of the material fed was 3,207 pounds, while the tailings removed amounted to 924 pounds, dry weight. The recovery of undigested material was thus 28.8 percent, indicating that 71.2 percent had been destroyed during fermentation except for such portions as may have remained in the tank in excess of the amount present at the beginning of the run. The variation in degree of packing in the tank with changes in feeding or manner of turning the cylinder may result in considerable variation in the amount of solids in the tank at any given time. Consequently the percentage recovery of dry matter for any given run is only an approximation.

The nitrogen contained in the material fed into the tank totaled 50.4 pounds for the 72 days, and of this amount 18 pounds, or 35.7 percent, was recovered in tailings. The foregoing statements regarding causes of variation in dry matter recovered apply also to nitrogen. The nitrogen which is not recovered in tailings is retained in the tank liquor in the form of ammonium salts, urea, and possibly other chemical forms.

Summarizing, it may be said that the tailings resulting from the gas-fermentation process have lost practically all the constituents which would make them a fly nuisance and have a definite, tho not a high, manurial value owing primarily to the nitrogen content.

During the same period the small tank (B) was operated. From July 1 thru July 7, 102 pounds of shredded corn fodder were fed, with a gas production of 205 cubic feet, or 2 cubic feet a pound fed. The period from August 12 thru August 17 yielded the most gas. Forty-five pounds of material were fed, with a gas production of 177.5 cubic feet, or 3.94 cubic feet a pound. A daily average of 15 pounds of shredded fodder was fed during the fall, with an average of 2.35 cubic feet of gas a pound fed, the average for the entire period being 2.22. This figure is to be compared with the 3.13 of the large tank. On September 10 the plant was closed for the winter.

The plant was not operated until May 25, 1936, when the cylinder of the large tank was lined with a No. 12-mesh wire screen, so that

finely ground soybeans could be fed into it. The object of the summer operation is to determine the maximum possible gas production from soybeans. The tank was put into operation May 29 and was up to operating temperature June 1. It was primed with old tailings, and nothing else was fed until June 8, when 10 pounds of finely ground soybeans and 20 pounds of chopped straw were fed daily. Gas production in appreciable quantity was recorded June 15. From this time on, the gas production increased rapidly. Both outside and inside temperatures were recorded. Samples of tailings, liquor, gas, and feeding material were taken daily and analyzed by the cooperating departments. No practical use has been made of the gas. However, enough was produced so that it could have been utilized. (101 Agricultural Engineering and 124 Agronomy)

Improved Incomes Permit Increased Farm Building

Outlays for improvements were increased 42 percent in 1935 by Illinois' account-keeping farmers. With this trend has come an increased demand for farm-building plans such as are being developed by W. A. Foster, Agricultural Engineering, in his studies on the modernization of old buildings and the proper design of new structures.

Some new plans were added to the blueprint service, including three new farmhouse plans, one remodeling plan, several swine-equipment plans, and others. In addition some of the older plans were revised and material bills added to plans already in circulation.

The small-house study was continued with a series of simple low-cost plans made suitable for the resettlement units.

The Experiment Station's blueprint service of nearly 350 plans of all types of farm buildings is supplemented by the Midwest Plan Service of 120 plans. The interest in poultry housing and equipment continues strong, with a renewed interest in swine housing, barns, and grain-storage buildings. The rural housing problem is still active with many groups contributing to its promotion, including the FHA, REA, other government agencies, and private material interests.

Surveys and economic studies reveal the great need of better housing and grain storage on the farm. Better sheltering and housing for equipment and livestock also are desirable. (700 Agricultural Engineering)

Ventilation of Shed-Roof Poultry House Is Improved

While prices have favored the production of poultry this past year, flock owners have not been able to make the most of the market unless they had buildings for housing their birds adequately. Severe weather conditions of the winter of 1935-36 called attention to the importance of correct housing for poultry at all times. The need for good floor construction and a means of ventilating the Illinois shed-roof house when the open front is closed have been especially urgent.

In continued studies of poultry housing under W. A. Foster, Agricultural Engineering, and L. E. Card, Poultry Husbandry, the ventilation problem has been solved by the development of a simple, inexpensive, and easily installed outlet flue of canvas construction. This flue is homemade and simple in operation.

The blueprint service covering poultry housing and equipment continues popular in Illinois and adjoining states. The Illinois shed-roof house has proved successful in distant states, as indicated by requests for plans and circulars. (703 Agricultural Engineering)

Weed Problem Is Attacked From Engineering Angle

The total annual weed cost to farmers of America has been estimated at 3 billion dollars. The annual loss to farmers in southern Illinois because of garlicky wheat alone is estimated at \$300,000. Indiana estimates its loss from the same cause at 2 million dollars. Loss to the livestock industry in Illinois because of noxious weeds is estimated at more than a million dollars.

As indicated by these estimates, the weed problem is both extensive and serious. Attack upon it in as many effective ways as possible is greatly needed, and under the direction of C. W. Veach, Agricultural Engineering, with the guidance of an advisory committee, a study of certain engineering phases of weed control is being made. The advisory committee consists of J. J. Pieper, Crop Production, chairman; E. W. Lehmann, Agricultural Engineering; and M. J. Dorsey, Pomology.

Included in this work is a detailed study of the physical characteristics of seeds; a study of seed-cleaning machines; and, in cooperation with the Department of Agronomy, field studies on the control of weeds, with special attention to field bindweed.

A small laboratory in which the physical characteristics of seeds may be studied under controlled conditions is being completed, and seed-cleaning machines representative of practically all types have been obtained for test purposes. Reliable methods for determining certain characteristics of seeds are in the process of development. Field experiments on the control of weeds by tillage, covering, burning, chemicals, and hoeing are being carried out in cooperation with the Department of Agronomy.

Inasmuch as weeds may be controlled either by planting weed-free seed or, if the soil is infested with weeds, by proper methods of field control, the general weed problem is being attacked along both lines. The study of the physical characteristics of seed is basic to a study of seed cleaning.

Other phases of weed control are being investigated by L. V. Sherwood of the Department of Agronomy. A summary of this work may be found in the report of Agronomy Project 541A, pages 63-64. (305 Agricultural Engineering)

HORTICULTURE

Apple-Breeding Studies Now Include 338 New Types

As a result of further advancements in apple-breeding studies during the past year there are now 338 promising types remaining in the studies which J. C. Blair and M. J. Dorsey, Plant Breeding, are conducting with the technical assistance of J. S. Whitmire to develop new and improved varieties.

These studies have been carried on continuously since 1908, and during that time more than 46,000 seedlings have been grown from the successful combinations. At the end of the 1935 season fruits of 15,832 of the apple seedlings had been described. The 338 promising types now remaining are the best of 489 that have been under observation. There are in the nursery at the present time 2,902 hybrid seedlings ready to be put out for further testing.

Aside from the technical descriptions of the varieties coming into fruit during the past year, summaries of the inheritance of size have been made in thirty-six of the different crosses. Special attention has been given also during the year to revising the points covered in the technical descriptions. Selected varieties have been assembled for future crosses, emphasis being given in the selections of the trees to be grown in tubs to some of the characteristics in commercial varieties which seem to be needed most in the newer creations. Among these may be mentioned high quality, firmness of flesh, color, and earliness of production.

Seedlings in the test plots came thru the unusually severe winter of 1935-36 without very much injury. A test winter of the severity of the past one is always valuable in breeding work, because individual seedlings in those progenies which lack winter hardiness are eliminated. (201 Horticulture)

Test Trees Show Results of New Apple Pruning

The 4 million apple trees of bearing age in Illinois are far from being the type that is desired, because of the conventional system of training that has been used on them. The typical old tree has a vase shape and is entirely without a central leader. The main branches are crowded and separated by narrow angles. Heavy pruning is necessary when the tree is mature. However, such pruning does not overcome the faults inherent in the tree. It may, in fact, contribute to its breakdown. Studies of the growth of apple trees of various ages and experimental work by W. A. Ruth, Pomology, are developing methods of heading young trees by which these difficulties can be avoided. Three successive plantings of young trees have been made in which

the results of previous work have been applied. The last planting is now eight years old and is at a stage where the significance of certain growth habits can be estimated.

Fig. 42, showing a Golden Delicious and a Duchess, illustrates certain of these habits. Both trees were set out when one-year whips.



FIG. 42.—PRUNED DUCHESS AND UNPRUNED GOLDEN DELICIOUS
SHOWING CERTAIN GROWTH HABITS

The pruned Duchess (*left*) shows the weak growth of the terminal part of a branch which has been blown into the tree and the strong growth of the lateral part toward the wind. The unpruned Golden Delicious (*right*) shows characteristic strong growth from the end of the unpruned whip, strong growth on the side toward the prevailing wind, and weak growth on the opposite side.

The Golden Delicious has never been pruned. The Duchess was trained by heading back and "summer tipping" and the early removal of undesirable laterals. These trees grew on a site entirely exposed to the strong prevailing southwest winds.

The unpruned tree in Fig. 42 illustrates the tendency of the whip to develop its strongest laterals near the end, even if it is not headed back. It also illustrates the strong tendency of an unpruned whip to

produce strong branches on the side toward the prevailing wind and weak branches on opposite sides.

The pruned tree in Fig. 42 illustrates two other growth characteristics that should be taken into consideration in heading trees that are exposed to a strong prevailing wind. One of these is the gradual suppression of growth on terminals of branches blown into the tree. The other is the strong upright growth of laterals arising on such branches. Both characteristics are illustrated by the branch starting in the lower right center of the picture. The terminal part of this branch, which started its growth toward the southwest, has been blown into and almost thru the tree. Nevertheless, a southwest branch has been provided by a lateral growing vertically and in that direction. There seems to be no adequate reason for removing the part of the branch blown into the tree, in view of the fact that it will add to the growth of the tree as a whole.

The experiment at this stage brings out the fact that the framework branches must be selected when the tree is fairly young. It also shows that later growth counteracts early bending by a prevailing wind. (107.1 Horticulture)

Growers May Save on Apple Fertilizers in Some Years

Fertilizing of Illinois' 4 million apple trees of bearing age is becoming more complicated as variations in the soil, seasons, and nitrogen carriers are studied. Further efforts to clear up some of these complications have been made in continued studies by M. J. Dorsey and R. S. Marsh, Pomology. For the 1935 season a report was published in the Proceedings of the American Society for Horticultural Science, Vol. 33, 1935, pages 142 to 144, under the title, "Soil Nitrate-Nitrogen Determinations Following the Applications of Calcium Cyanamide and Nitrate of Soda to the Surface of the Soil Under Apple Trees During Dry and Normal Seasons."

It is evident now that commercial orchardists may profitably omit or greatly reduce the inorganic nitrogenous fertilizer applications in the spring of some years, owing to seasonal factors that favor high nitrate-nitrogen levels in the soil during the late summer and early fall of the preceding year.

In addition the residual influence of previous fertilizer applications and other soil-management practices are factors to be kept in mind if such a recommendation is made to growers. Recently the question has been raised as to the probability of overfertilizing apple trees in the Midwest with applications of nitrogenous fertilizers, and this preliminary study suggests such may be the case in some years.

Finally the data indicate that soil nitrates may be present in greater amounts for certain periods of the year where calcium cyanamid is used than where sodium nitrate is used. (101.2 Horticulture)

Deep Cultivation Not Dangerous in Olney Orchards

Not all of Illinois' apple crop, which has averaged almost 5 million bushels during the past two years, is produced under the same conditions. Orchard soils in the Olney section, for instance, are a special problem. The soil, which is a gray silt loam on tight clay, is very wet in the spring after prolonged periods of heavy rainfall. On the other hand the surface strongly repels water after it dries out in the summer. Rooting is shallow, but prolonged saturation does not kill the roots. Further studies therefore have been made by W. A. Ruth, Pomology, of the responses of bearing Jonathan and Grimes apple trees to some of the more important nitrogenous fertilizers and to certain soil treatments on the Experiment Station orchard at Olney.

Several conclusions can be drawn, the most important of which is that deep cultivation, either in the spring or summer, is not in itself a dangerous practice. On the contrary it is a benefit if the soil is left in clods to collect water. It can also be concluded that on this type of soil seasonal conditions have more effect upon flower production than does the fertilizer treatment.

Fertilizers being studied are sodium nitrate, ammonium sulfate, and cyanamid. They are applied in the spring and fall. The more important soil treatments are spading to a depth of 4 or 5 inches, which severs a large proportion of the finer roots; and trenching under the peripheries of several trees, which severs all of the outer roots. Both treatments are repeated annually, the spading in the spring and in July, and the trenching in July only. Because work in this orchard several years ago showed that small depressions conserved a significant part of the rainfall even on slight slopes, the spaded surfaces are left rough.

With the exception of a very few trees the entire orchard bloomed very heavily in 1935. There was no relationship between the fertilizer treatment and the amount of bloom. Bloom in 1934 and again in 1936 was very light, so that the orchard is in a state of almost complete alternation. This alternation is to be attributed to an undetermined combination of factors. A part of the few trees that bloomed in 1935 bloomed again in 1936. The remainder failed to bloom. Some of the trees that bloomed in 1936 were in low spots where soil water would collect. Because the spring and early summer of 1935 were very wet, it can be said that blossom formation did not require a dry soil. Judging by the past, when complete alternation has set in only to disappear from unknown causes, it can be assumed that the present almost complete alternation will not persist.

Contrary to the expectations when spading under the trees was started, this severe treatment of the surface roots has benefited the trees. Also contrary to expectation, trenching under the peripheries of

the tops, which has cut off only a comparatively small part of the root system, has reduced growth to almost nothing. (101.3 Horticulture)

Light Pruning Brings Earlier Returns From Apples

More than 4 million dollars' worth of apples have been produced in Illinois during each of the past two years, but the trees which grew these crops have gone thru an early nonproductive period of several years, which has run up production costs and reduced the margin of net profit. Anything which will shorten this nonproductive period without endangering future production is to the advantage of the grower. Twelve years' results have now been collected in the experiment by V. W. Kelley, Horticulture Extension, to determine what degree of pruning was best for bringing apple trees into profitable production at an early age. Light, moderate, and heavy pruning were compared with no pruning, beginning at the five-year period. Annual records were made of tree growth, bloom, production, and fruit size.

In 1935 when the trees were seventeen years old, the average total yields of the different plots were: lightly pruned, 5.9 bushels; moderately pruned, 5.5 bushels; heavily pruned, 4.7 bushels; and not pruned, 7.4 bushels. Yields of picked fruit more than 2 inches in diameter for the treatments were: lightly pruned, 3.7 bushels; moderately pruned, 3.3 bushels; heavily pruned, 3.4 bushels; and not pruned, 4.1 bushels. There was a rather heavy drop of fruit before harvest. No size records were taken on the drops.

Records to date indicate that after the framework is formed, young apple trees should be pruned lightly until they have the bearing habit established. A general thinning thruout the top definitely postpones production and materially decreases yields. Cuts should be limited to corrective pruning, such as the removal of water sprouts, crossing branches, and an occasional lateral in particularly crowded areas. Altho pruning has decreased the yield of marketable fruit thruout the experiment, the percentage decrease was less after the trees came into bearing. There has been no economic advantage in fruit size as a result of pruning these young trees. About half the trees in the heavily pruned blocks were killed by cold weather during the winter of 1929-30. (107.2 Horticulture)

Weak Bordeaux Fails to Keep Apple Diseases in Check

Illinois' apple crop cannot be protected from diseases by weak bordeaux mixtures. A combination of lime sulfur and flotation sulfur must be used in the prebloom sprays, followed by straight flotation sulfur in post-bloom applications. This has come out of further experiments by H. W. Anderson, Pomological Pathology, to test new materials or combinations of known fungicides for control of common fruit diseases.

The 1935 spraying experiments were designed primarily to secure a safe sulfur fungicide for general recommendation to the growers and to test the feasibility of using a weak bordeaux mixture for control of apple scab. The main experiments were conducted in an orchard near New Burnside, in Johnson county.

Growers who had been using liquid lime sulfur for the control of scab had found that serious damage occurred under certain weather conditions. Some growers had experimented with a weak bordeaux mixture and had secured fair results. Experiments of the Station in the past with a stronger bordeaux mixture had proved that this mixture is not safe on apples in the early part of the season, owing to the fact that there was serious russetting of the fruit. Little information was available as to the effect of weaker dilutions, either on apple-scab control or on russetting.

The 1935 spraying experiments proved that a weak bordeaux not only failed to control apple scab, but also was unsafe because of its tendency to russet the fruit. It was found, however, that a mixture of lime sulfur and flotation sulfur containing half the standard concentration of each satisfactorily controlled scab without serious injury. Experiments in past years had proved that a wettable sulfur obtained from coal in gas manufacture had exceptional fungicidal value because of its finely divided state. This material is known as flotation sulfur. It is not toxic to the foliage and consequently can be substituted for lime sulfur in the control of apple scab. Since this sulfur is somewhat more expensive than lime sulfur, an effort was made to find a combination of these two types of sulfur which would give satisfactory control of scab, avoid injury to the foliage, and yet be economical. The results as reported are now being made the basis of recommendations to growers. (113.1 Horticulture)

Methods and Benefits of Apple Thinning Being Studied

In 1935 Illinois produced 5,603,000 bushels of apples, but in 1936 the prospect was for a crop of only 1,270,000 bushels. Not all the factors entering into this wide variation are in the control of growers, but one factor of quality which is in their control is thinning. Studies were started last year by M. J. Dorsey and R. L. McMunn, Pomology, to determine: (1) the time of most effective thinning in relation to size of fruit and yield; (2) the place of thinning in relation to pruning as a means of maintaining yield and increasing size of fruit; (3) the place of thinning in correcting the biennial bearing habit of certain apple varieties. Because of frost injury, scab infection, and light crops, the experiment could not be carried on as contemplated. Prospects for a crop in 1936 indicate that certain phases of the thinning work can be carried on during the spring and summer.

The apple normally produces five blossoms in each cluster. None

or all of these flowers may be pollinated and set. When there is a heavy set, the crop is so large that very few of the fruits reach marketable size owing to the natural drop which occurs in three more or less definite periods. With a heavy set, however, these natural drops usually do not reduce the crop enough so that the tree can size up the fruit. Thinning, then, must supplement these natural drops to a greater or lesser extent. Since the biennial bearing habit is induced to a greater or less extent by the quantity of fruit produced, thinning will be used as a means of correcting this characteristic. It has been determined that there is a fairly definite relationship between the number of leaves and the number of fruits on the tree for the different sizes. This condition will be checked under Illinois conditions with several varieties of different ages growing under different cultural treatments. (107.6 Horticulture)

Spray-Removal Studies Aid Growers in New Problem

One of the newer problems of Illinois growers in keeping down the cost of producing their average annual crop of 2½ million bushels of apples and at the same time giving consumers a product of higher quality is the removal of spray residues in conformity with recently imposed regulations. Practically all commercially grown apples now be washed, because no generally applicable substitute has been found for lead arsenate, the spray which leaves the objectionable residue. The problem will become even more serious in the immediate future than it has been in the past. Starting with the season of 1936, the State Department of Agriculture will enforce the "tolerances" on lead and arsenic, heretofore applied by the federal Food and Drug Administration only to fruit in interstate commerce. Fortunately several important new results have been secured by W. A. Ruth, Pomology, assisted by D. S. Brown, in the studies they are making of residue removal.

One question which has always interested fruit growers has been the proportion of spray residue in the calyx and stem ends. It has been their contention that residue so located was of much less consequence than residue on the cheek of the apple, because it would seldom be eaten. Of more immediate and practical importance is the amount of residue left on the apples by each application of spray. Some results bearing on both questions, which were secured with Transparents in the entomology plots in the Heaton orchard at New Burnside, are reported in Table 55.

It can be concluded that only the calyx spray of lead arsenate can be applied to Transparents without exceeding the lead tolerance of .018 grain a pound. However, if the residue in the calyx and stem ends were not considered, two additional applications could be made.

Sodium silicate applied as a removal spray while the apples were

ent cover crops reduce or increase certain of the elements. Analyses will also include selected material from trees.

The tests are to be conducted in the Experiment Station orchard at Urbana. In this orchard there are trees of ages varying from six to nineteen years and including the varieties Willow, Stayman, Grimes, Delicious, Jonathan, and Winesap. Soil cultural treatments, including the use of cover crops, are being laid out across the orchard so that all varieties will be included in a single treatment and also trees of different ages will be included within a single treatment. (101.5 Horticulture)

Search for Desirable Resistant Pear Is Continued

No pear has been found as yet which has the required desirable market qualities and which at the same time is resistant to blight and leaf spot. Search for such a pear is being conducted by H. W. Anderson, Pomological Pathology, in an orchard of various species and varieties. The purpose of this experiment is to secure a commercial pear which is not only highly resistant to these diseases, but which also will withstand the climate of central and northern Illinois and produce a fruit of superior market quality.

Many of these pear trees bore fruit in 1935, but none proved to be of exceptional quality. The experiment is being continued with the hope of making crosses and securing hybrids which will have the desirable qualities and at the same time be resistant to blight. Experiments planned for this purpose in 1936 were given up because of the general killing of the pear blossoms of the desirable commercial varieties. (110.2 Horticulture)

Severe Winter Shows Need of Better Peach Varieties

Almost complete destruction of the 1936 Illinois peach crop by the record cold winter of 1935-36 has again emphasized the urgency of developing superior varieties as one means of stabilizing this industry, which in some recent years has brought growers more than 2 million dollars. Breeding projects looking to the development of improved varieties have been carried forward during the past year by J. C. Blair and M. J. Dorsey, Plant Breeding, with the technical assistance of J. S. Whitmire. Special attention was given to making technical descriptions of the seedlings at the Olney farm which bore fruit and in assembling material for the future crosses.

There are now in the test plots, as a result of previous work, 154 seedlings from the 1929 crosses, 869 from the 1933 crosses, and 247 from the 1934 crosses. Good germination was secured from the seeds of the 1935 crosses which are now in the nursery row. The parents entering into the crosses made in 1929 were Gage × Elberta and J. H. Hale × Elberta. In 1933 the combinations included Elberta × Gage,

Gage × Elberta, J. H. Hale × Gage, J. H. Hale × Elberta, Elberta × Canadian Queen, Elberta × Markberta, Elberta × South Haven, Gage × Early Elberta, and Gage × Canadian Queen. In 1934, on account of the extensive killing of fruit buds during the winter, the crosses were limited to Elberta × Gage and Elberta × Lemon Free. In 1935 the combinations included Heath Cling × Marigold and South Haven × Heath Cling.

Material assembled for future crosses includes some of the newer varieties coming into promise which seem to possess to a higher degree such characteristics as firmness of flesh, high quality, and hardness. The outstanding of these variety selections which are now growing in tubs include Rio Oso Gem, Fertile Hale, Hope Farm, Candoka, Halberta, Hardee, Markberta, Polly, and Sun Gold. (202 Horticulture)

Cover Crops Impossible for Old, Closely Planted Trees

Stabilizing Illinois' peach crop involves not only the growing of superior varieties, as discussed in the foregoing report, but also proper orchard fertilization, cover crops, and cultivation.

Further experiments in this line by M. J. Dorsey and W. A. Ruth, Pomology, at Olney have demonstrated that probably not much can be done beyond the seventh or eighth year with closer planting distances in keeping up the organic matter of the soil by growing a cover crop. In other experiments at Olney it has been demonstrated that peaches can be grown successfully, at least during the early years, without summer cultivation in the tree row.

The cover-crop experiment was conducted in a block of older trees that were in their eighth year. Here in the summer of 1935 a cover crop of cowpeas was sown. The season was favorable for fruit last year, and the trees were in full production. It seemed increasingly evident, as has been previously reported, that as the growth of the trees gradually expands with time and fills up the space in the rows, the difficulty of getting an adequate cover-crop growth to keep up the organic content of the soil is increased. The trees not only shade the cover crop to a greater and greater extent, but also the demand of the tree for moisture increases with time, so that unless the season is exceptionally favorable, the cover-crop growth is reduced accordingly.

In another block of five rows of trees now five years old, formerly seeded to sweet clover in earlier tests but seeded to Korean lespedeza in 1934, the growth between the rows was cut over with a mower nine times during the summer. There was enough of this growth to mulch half of the trees. Doubtless the previous crops of sweet clover turned down have been a big factor influencing the vigor of the native weeds between the rows, particularly crab grass. It was necessary to mow in order to keep the native weeds from completely crowding out the lespedeza. With this treatment there seemed to be a good stand of

Peach Thinning After June Drop Again Improves Crop

Peach growers are limited in what they are able to do about the quantity of peaches from one year to the next, as shown by the fact that the crop during the past five years has varied from as much as 4,300,000 bushels in 1931 to 188,000 bushels in 1932. Definite control can, however, be kept on size of peaches and hence on quality through sound and careful thinning even after the June drop has taken place. This has again been demonstrated in investigations by M. J. Dorsey and R. L. McMunn, Pomology. Continued studies during the 1935 season showed that thinning after the June drop can be relied upon to give increased size of fruit.

The experiments were conducted in a block of Gage-Elberta in the Experiment Station orchard. Although thinning was not started until after the normal June drop and was timed at ten-day intervals up to within three weeks of harvest, those trees that were thinned at the later date sized up their fruit as well as trees thinned at an earlier date. However, this past season was ideal from the standpoint of sizing up the crop, there being plenty of soil moisture during the ripening period. This was shown by the fact that unthinned trees sized up the crop about as well as trees which had been thinned. On the unthinned trees, however, the fruits were slightly smaller than on any of the thinned trees. Thinning did not appreciably reduce the quantity of fruit except in the two blocks thinned later in which the trees were slightly smaller and thus could not be expected to carry as much fruit as the larger trees which were thinned at earlier dates.

In this experiment a slight variation from the normal procedure was followed. In some of the past thinning experiments distance between fruits has been used as a factor in determining the quantity to leave on the tree. In the Gage block this past year the total load on any one tree was reduced to between 1,000 and 1,200 fruits. Fruits were removed from the nonvigorous shoots and all shoots less than 5 inches long. This concentrated most of the fruits on the more vigorous shoots. Very little stress was given to spacing fruits on the longer shoots. On account of the winter killing of buds and the type of fruiting of Gage, the fruits were more or less concentrated on the basal part of the shoot. Because of the type of thinning that was practiced, most of the fruits were concentrated on the basal half of the shoots, often as close as 2 or 3 inches apart. The number of the fruits on the shoot, however, was reduced to a point where the shoots could size up the fruit. In other words, the fruits were left at those points which were physiologically dominant and removed from weaker points on the tree. This method of thinning has its advantage in that at one single thinning practically all the fruits are removed that must be taken out to give size to the remaining fruit.

Late thinning again showed that a greater number of fruits injured

by insects, bruised, or undersized could be removed more easily as the season advanced. (107.5 Horticulture)

Spray Tests Bring New Economies in Fruit Production

Back of the 6 million dollars' worth of apples and peaches produced in Illinois during the past two years is the expenditure of thousands of dollars for sprays and dusts to control various insects and diseases. Unless these materials are of the right kind and are properly applied, costs of production will be increased, market quality of the resulting crop will be poorer, and net returns to growers will be reduced.

Out of peach- and apple-spraying experiments conducted during the past year by the Department of Horticulture in cooperation with the Illinois Natural History Survey have come several findings of importance both to producers and consumers. First, it has been demonstrated that it is unsafe to use less than 6 pounds of copper sulfate in each 100 gallons of spray for peach leaf curl. Second, none of the experimental work has substantiated the belief of some investigators that zinc sulfate in peach sprays is an effective fungicide and bactericide. Third, zinc sulfate cannot be used as a lead-arsenate corrective in apple sprays. Fourth, results in apple-spraying experiments in 1935 were considered complete enough to warrant reducing the amount of zinc sulfate from 6 to 2 pounds for each 100 gallons of spray, thus materially reducing the cost to the grower.

Peach-spraying experiments in 1935 included: (1) control of peach leaf curl, (2) control of oriental fruit moth, and (3) additional experiments on the role of zinc sulfate as a corrective for lead arsenate.

The experiments on peach leaf curl were conducted by S. C. Chandler, Illinois Natural History Survey, at Carbondale. The object of these experiments was to determine the minimum concentration of copper sulfate that would give effective control of leaf curl. Experiments in the past had indicated that the standard formula contained more copper sulfate than was necessary for control. If this were true, a reduction in the amount of copper sulfate would mean a decided saving to the peach growers. On the other hand, failure to control severe leaf curl conditions would cause a heavy loss. The formulas used in these experiments were bordeaux 8-8-100, 6-6-100, and 4-4-100, all with 3 percent oil emulsion. An unsprayed check had 24.5 percent leaf curl. The 8-8-100 and 6-6-100 formulas reduced this to about 1 percent, while the trees sprayed with the 4-4-100 had about 6 percent leaf curl. From these results it is evident that it is unsafe to use less than 6 pounds of copper sulfate to 100 gallons of the spray.

Neither the results of the past year's work nor those of any other year at this Station have substantiated the claims of some workers that zinc sulfate is an effective fungicide and bactericide. In certain parts of the world, including many sections of the United States, it has

proved very satisfactory as a remedy for some physiological diseases, none of which as yet have been identified in this state. Apparently Illinois soils have enough available zinc to permit proper plant development. As was pointed out in last year's report, the real value of zinc sulfate in the Illinois peach-spray program is to prevent spray injury from applications of lead-arsenate-lime sprays. These sprays should never be applied to peaches in Illinois without the addition of zinc sulfate. This point is now well established by research in Illinois and other states.

Growers who have observed the beneficial results of zinc sulfate in peach sprays have requested investigations of this material in apple sprays. Consequently studies were outlined to yield information on these questions: (1) Is zinc sulfate effective in controlling apple scab? (2) Does it prevent injury to apples from lead-arsenate-lime spray as it does to peaches? (3) Does it cause russet on susceptible varieties as does copper sulfate? (4) Does it reduce the effectiveness of lead-arsenate-lime and oil sprays in the control of codling moth? And (5) what is its effect upon the residue load of sprayed fruit?

These experiments on apples in 1935 were conducted on Ben Davis at Urbana under the direction of H. W. Anderson, Pomological Pathology. It was found that: (1) while zinc sulfate had mild fungicidal value toward apple scab, it did not give commercial control of this disease; and (2) zinc sulfate gave as severe russetting as did bordeaux mixture. These results eliminated the possibility of using zinc sulfate as a corrective in apple sprays.

In experimental work in the laboratory it was found that relatively small amounts of zinc sulfate decidedly reduced water-soluble arsenic. This indicated that the concentration used in the field contained much more zinc sulfate than was actually necessary. From 1932 to 1935 a series of tests were run to determine the minimum amount which would give adequate protection in the field. These results were considered complete enough after the 1935 experiments to warrant the reduction of the zinc sulfate from 6 pounds to 2 pounds in each 100 gallons, thus materially reducing the cost to the grower. (110.5 and 114 Horticulture)

Cold Caused Some Damage to Peach and Apple Wood

Despite the record-breaking cold weather during the winter of 1935-36, damage to the trunks and crowns of Illinois' 9½ million peach and apple trees was not especially severe. This has been observed by M. J. Dorsey and H. W. Anderson, Pomology, in connection with their studies of root and collar rots of fruit trees.

In the apple in addition to the breaking away of the bark which has been reported in previous seasons, there have been rather frequent instances this year of trunk splitting. The wood seems to be cracked

deeply, and in many of these breaks the bark is not separated at the edges as is so commonly the case. In instances of this kind healing will take place without serious injury. The trunk injury, however, is not always associated with the splitting, and as growth comes on in the spring, the loosened bark breaks as a result of the drying, with the typical healing taking place on the wood and on the bark as well. The injury this year seems to be worse on smaller trees, altho in some instances cracks were opened up in the older trees, especially where there has been pronounced "ribbing."

In addition to this type of injury there has been some direct killing of trees, especially in the northern and western sections of the state. In Calhoun county Black Twig seems to have been injured most in some of the orchards, the tops and main limbs having been almost completely killed in a few instances. Duchess seems to have been injured worse this year than usual in the western part of the state. In some of the trees of this variety which are "going out," there appears to be a combination of winter injury coupled with a canker-like growth of some fungus. On account of the snow protection there does not seem to have been much injury to the roots proper, altho in certain spots here and there over the state apple trees had considerable difficulty in making the normal spring growth. All told, however, the injury to the apple is much less than might have been expected during a winter when the temperatures were low for so long. Older trees have suffered more injury than younger, but crotch injury is common in the young orchards.

Injury to the peach has been confined for the most part to twig and limb killing, especially in older trees. In the northern part of the peach district, however, where the low temperatures seem to have caused most damage, the bark splitting became more evident as growth came on in the spring. The loosened bark on the south and southwest side of the trunk was evident earlier in the season, as indicated by the hollow sound when the bark was tapped with some hard instrument. It began to crack and peel back, as might be expected, about the first of May. Crotch injury, so noticeable other years, has not been so much in evidence this year, even in the older trees. An interesting feature of the peach injury in the northern part of the district this year has been the fact that the leaf or wood buds on the twigs have been killed but not always the twigs. As growth came on this spring, many of the buds, particularly on the younger trees, seemed still to be alive, but since the growing points were all killed on them, further development was not taking place.

There appears to be but little root injury to the peach this year, altho there will be considerable loss as a result of the winter injury where the ground is also inclined to be wet and lacking in aeration. The outstanding feature of the injury to the peach this year seemed to

be the greater killing in the older trees, particularly where crop production was heavy last year. In one orchard South Haven, supposedly very hardy, was completely killed, while Elberta made a fair response, on an average, of two to three dozen growing points a tree. (110.6 Horticulture)

Record Winter Reveals Hardest of Fruit Varieties

Illinois' fruit crop, which during the past two years had averaged more than 6¼ million dollars annually, suffered heavy damage during the record cold winter of 1935-36. These losses can be minimized in future years thru results of comparisons such as R. L. McMunn, Pomology, is making of the hardiness and other qualities of different fruit varieties for Illinois.

Temperatures as low as 20 degrees below zero in the variety test orchards at Urbana put the hardiness of different varieties to severe test. All peach varieties suffered severe winter injury. Not only were all the fruit buds of the peach killed by the low temperatures, but also most of the leaf buds were killed on practically all varieties. Severe injury was done to the wood on both the trunks and larger limbs in all varieties. Supposedly hardy varieties suffered the same as the more tender ones. Such damage happens far too often in the northern two-thirds of the state to warrant commercial planting even of the more hardy varieties of peaches farther north than the accepted commercial belt. For small home plantings those varieties which are supposedly more hardy in fruit bud than Elberta should be given preference over the more tender varieties. A few of the newer varieties would include Buttercup, Marigold, Massasoit, Meteor, Rosebud, Valiant, and Vedette. These varieties have been tested in the variety plantation and have proved to be somewhat more hardy in fruit bud than Elberta.

The severe winter again showed that it is unprofitable to plant sweet cherry and Japanese plum in central and northern Illinois. Fruit buds in all varieties of these fruits were killed. Sour cherry suffered 50 to 70 percent fruit-bud killing, depending upon the variety, with the Montmorency showing less bud killing than did any of the other varieties. Just before bloom the live, unopened flowers on sour cherry were practically all killed by a temperature of 22° F.

Apples, European plums, and Damson plums also were damaged by this temperature, and all showed a light set of fruit.

Low temperatures during the winter, however, did not injure the fruit buds of apples, European plums, and Damson plums, or those of the native American plums to any appreciable extent. These kinds of fruits, along with the sour cherries, can be depended upon to withstand lower winter temperatures than the peach, sweet cherry, and Japanese plum and therefore should be given preference in plantings in the northern half of the state.

These tests in the variety orchards are being carried on to test not only the hardiness of fruits, but also to determine their adaptability, disease and insect resistance, productiveness, and their worth for growers thruout the state. As new varieties are introduced, they are checked against older varieties to determine their worth both from the commercial and home standpoint. (106 Horticulture)

Cherry Trees on Mahaleb Root Stock Have Best Yield

Cherry trees growing on Mahaleb root stock to date are superior among those being compared by M. J. Dorsey and R. L. McMunn, Pomology, in their experiments to overcome some of the hazards of cherry growing in this state. A comparison is being made of standard varieties on Mazzard, Morello, and Mahaleb stock.

In the planting of Early Richmond and Montmorency on Mahaleb and Morello root stocks, those trees on Mahaleb at the present time are larger and have produced more fruit than those worked on Morello, altho, as previously noted, the trees on the Morello stock began to bear earlier. At this time, however, the larger size of the trees on Mahaleb stock more than makes up in potential production for the earlier bearing of the Morello trees. The size of the trees on Morello undoubtedly has been influenced by the dwarfing habit of the Morello root stock.

It is too early to make definite recommendations to Illinois growers on the length of life of the varieties on the two respective root stocks. It is interesting to note, however, that during the severe winter of 1935-36 neither root stock was injured to any appreciable extent. However, the tops of trees of the Morello stock were severely injured.

With Lyons, Seneca, and Montmorency, which are being compared when worked on Mahaleb and Mazzard root stock, none of the trees have come into production to date. At the present time there is little or no difference in tree size between those on the two stocks. An interesting feature of these trees this year is their recovery following the extensive killing of the young leaves after they had started growth in early spring. (122 Horticulture)

Severe Winter Tests Hardiness of Grape Varieties

An average of \$190,000 worth of grapes annually already are being grown in Illinois, and on favorable sites they may be grown in all sections of the state. With the increasing interest in grape culture, varietal tests are being continued in charge of A. S. Colby, Pomology. The extremely cold winter of 1935-36, with sub-zero temperatures as low as -22° F., resulted in injury to many grape varieties. However, varieties on which practically no injury occurred and which may be listed as hardy include: Bacchus, Beta, Janesville, Marion, and Worden.

Varieties with light injury include: Berckmans, Caco, Champagne, Clinton, Colerain, Concord, Delaware, Diamond, Dracut Amber, Early Victor, Etta, Fredonia, Gaertner, Geyer, Hartford, Hubbard, Ives, King, Lindley, Lucille, Lutie, Martha, Moore, Moyer, Noah, Ontario, Pocklington, Regal, Winchell, Woodruff, and Wyoming.

Varieties moderately injured include: August Giant, Campbell, Carmon, Dunkirk, Eaton, Eclipse, Geneva, Golden Muscat, Green Early, Herbert, Isabella, Niagara, Norton, Salem, and Vergennes.

Varieties severely injured include: Agawam, Barry, Brighton, Catawba, Champion, Dutchess, Empire State, Eumalon, Goethe, Goff, Iona, Lady Washington, and Urbana. (105 Horticulture)

Economical Control Worked Out for Grape Leafhopper

Grapes are grown in nearly every county in Illinois with nearly two million vines in the state. The size and quality of the crop is seriously curtailed unless some control measures are taken against grape leafhoppers, one of the most common and widely distributed insect pests of this fruit.

Excellent control of grape leafhoppers was secured in the Station vineyard in 1935 by burning over the dead grass and other litter between the rows in late April, followed by one application of bordeaux-nicotine-sulfate spray in late June when most of the young nymphs had appeared on the undersides of the grape leaves. This problem is being dealt with in studies carried on by A. S. Colby and R. S. Marsh, Pomology, and M. D. Farrar, Illinois Natural History Survey.

Unless timely and careful attention is given to the control of grape leafhopper, this insect under ordinary conditions builds up a tremendous carryover population during the summer and early fall. The adult leafhoppers live over winter in dead grass and other litter in fence corners, hedgerows, headlands, and other protected places and emerge in early spring, laying their eggs on the grape leaves in May and June.

In an effort to kill the overwintering adults before egg laying commenced, the Station vineyard was burned over on April 22, 1935, when the vines were still dormant. Dead grass and litter were raked away from the base of the vines before burning, and the fire was kept in control while the burning was done. No serious injury to the vines was observed.

The last week in June, 4-4-50 bordeaux, to which was added nicotine sulfate 1-600, was applied, using especial care to cover the lower leaf surfaces. The application was timed to coincide with the completion of egg hatching, before the young nymphs had reached maturity as indicated by wing development.

Observations at intervals thruout the summer and fall indicated

very little leafhopper injury, the insects being scarce and hard to find. The foliage was healthy; the fruit crop heavy, well ripened, and of high quality; and the current season's growth excellent, with promise of good bearing wood for 1936.

In check plots nearby the injury was extremely severe with from ten to fifty leafhoppers to the leaf; 75 to 100 percent of the foliage dried and brown; and most of the fruit failing to ripen, with poor color, low sugar content, and covered with insect feces. Much of the crop was unsalable and was left on the vines. The season's growth was weak with no promise for the 1936 crop. (112 Horticulture)

Strawberry Resistant to "Brown Stele" Is Located

At least one variety which is resistant to the destructive "brown stele" disease of strawberries and which is suitably adapted has been located as a result of experiments which H. W. Anderson, Pomological Pathology, and A. S. Colby, Small Fruits, are making to protect the state's half-million-dollar strawberry industry against this disease. This variety is Aberdeen. Two other varieties, Red Heart and Mastodon, also proved to be resistant to the disease, but the Aberdeen variety was the only one suited to conditions in Edgar county, where the tests were conducted and where the brown stele disease has become prevalent during the past few years.

Experiments leading to the finding of resistant varieties were prompted by the fact that it had become common experience for strawberry growers to have profitable crops on a farm for a few seasons and then find that the yield was decidedly reduced over a period of years and that it was difficult to renew the patch after the first bearing year. This condition may be caused, not by depletion of the soil, but by certain parasitic fungi which become established in the soil. The brown stele disease, for instance, one of the most destructive root diseases, had become established in the strawberry section of Edgar county. This county was formerly known as one of the most productive areas in the state, a reputation gained from the excellent Premier berries raised. Unfortunately this variety is especially susceptible to the disease.

Three years of investigation were necessary to establish the cause of this disease and explain why it was more destructive in that area than in other sections of the state. The fungus causing the disease was one which was favored by soil with a high water-holding capacity. Certain areas in most of the beds in Edgar county were a clay soil which held the water after adjoining areas were completely dried. It was found that the fungus became established on the roots in this area and spread to better-drained parts of the beds.

No effective method of treating the soil for control of this disease was considered practical. The only other method of control was to

secure a variety or varieties which were resistant. Such varieties had to be adapted to market demands and to climatic conditions of this section of the state. In 1934 a patch was selected which had a previous history of severe root rot and in it twenty-four varieties were planted for comparison and tests. First indications of the resistance of these varieties was obtained during the 1935 season, as has already been reported.

Further tests are being made to determine the degree of resistance of the Aberdeen variety. In 1935 it was found to be quite susceptible to leaf spot, which might make it necessary to spray for this disease, a practice not followed by most strawberry growers in Illinois.

In 1935 Colby made crosses between the Aberdeen and the Mastodon, both resistant to the disease, with the hope of securing seedlings which would show superior qualities from a market standpoint and yet be resistant to the disease. In addition hybrid plants from other sources are being tested on the wilt-infested soil of this section.

Additional facts are being secured concerning the distribution of this particular root rot in this and other states. (110.8 Horticulture)

Better Gooseberries May Open New Market for Farmers

One of the undeveloped markets for Illinois farm products that the Experiment Station is trying to open up is that for gooseberries. The small, green, sour gooseberries commonly found on the market prevent the more general use of a potentially important small fruit. Only a few acres are grown in Illinois. More people would eat gooseberries, both fresh and preserved, if varieties of better quality were available.

Further work in eliminating undesirable seedlings in the gooseberry breeding project being carried on by A. S. Colby, Pomology, has resulted in the selection of certain promising individuals. These seedlings are an improvement over the commonly grown varieties, the bushes being comparatively free from spines and resistant to the leaf-spotting diseases and bearing fruit of medium to large size and of good quality.

Certain of the Station seedlings which carry factors for resistance to the leaf spots are undesirable from other standpoints, such as fruit size and presence of spines. Seedlings of greatest promise have resulted from crossing Carrie and Poorman. Others of possible value in breeding work include Chautauqua, Spinefree, and Transparent. (115.1 Horticulture)

Promising Purple Raspberries Being Further Tested

Purple raspberries are not extensively grown in Illinois, owing primarily to lack of market demand because of their dark red or purple fruit color and relative softness of the berries. This fruit, however,

offers an excellent opportunity for small-fruit growers to diversify their plantings if better varieties could be secured. A search is being made by A. S. Colby, Pomology, thru the crossing of red and black raspberries, to find potential purple varieties resistant to disease and bearing firm fruit of attractive appearance and good quality.

Promising seedlings of Quillen (black) fertilized with June, Latham, and Newburgh (red) pollen are now on second test. During the course of the experiments it has been noted that certain purple seedlings propagate only by tip layers in the field, while others reproduce both by suckers and tips. Studies were made of these characteristics. Further tests are necessary with the most promising seedlings before their value as potential new varieties can be determined.

Under field conditions most red raspberries propagate only from suckers and black raspberries from tip layers. Hybrids between these two species, commonly known as purples because of their fruit color, are notable for the variability exhibited in certain plant and fruit characteristics. Purples are said to propagate generally by tip layers. Two different methods of asexual reproduction, that is, by suckers and layers, appeared as one of the bush characteristics in certain groups of purple seedlings.

Counts of the various hybrid progenies propagating both by suckers and tip layers are summarized as follows:

<i>Progeny</i>	<i>Total plant population</i>	<i>Number of plants which suckered</i>	<i>Number of suckering plants forming layers</i>
Quillen × Golden Queen.....	29	7	5
Quillen × Latham.....	94	27	22
Quillen × June.....	108	8	8
Quillen × Starlight.....	129	21	19

It is not easy to explain the reproductive behavior of these seedlings. Their genetic constitution is complex. The pollen parents are heterozygous. However, Quillen was used in all cases as the female, or pistil, parent. Quillen is evidently homozygous for tip-layering as a method of reproduction, since no individuals were found reproducing from suckers in a population of 579 resulting from selfing that variety. There were five parent plants. Suckering, then, as a method of reproduction in the progenies must have come from the pollen parent in the crosses involved, indicating that there is a close relationship between suckering and tipping.

With Golden Queen, Latham, and Starlight there is the possibility of a simple monohybrid character involved, since approximately 25 percent of the plants sucker. Quillen × June progeny, however, with only about 7 percent which sucker, do not fall into this class and evidently have a more complex type of inheritance.

Progeny of Quillen × Ranere are of especial interest in that in an examination of 89 seedlings not one was found to be reproducing from

suckers, while 56 plants, or 62 percent of this group, had the characteristic bush habit of *R. occidentalis* and set tip layers naturally without placing the turions in the soil. Since Quillen is apparently pure for lack of ability to reproduce from suckers while Ranere is normally propagated by suckers, suckerlessness is apparently a dominant character in this case.

The relative difficulty in propagating the purple raspberry is a factor of importance in commercial plant production. In general, vigorous tip layers are probably most easily secured from young plants set the preceding spring. In fruiting plantations the time of fruit ripening has an important bearing upon the date when the plants will begin to root at the tips of their turions. Since the purples as a group mature their fruit rather late, it is relatively difficult to secure vigorous, well-grown tip layers in a bearing patch. Partly because of this fact some nurserymen carry thru these weak layers for a season in the nursery row and feature such stock as "transplants."

It has been noted in the work at this Station that a number of the most promising purple seedlings, some of which have a relatively late ripening season, are propagated with unusual difficulty at the tips. Since several of these show a tendency toward suckering, this characteristic may be of some value as a second method of reproduction. By this means a greater number of plants may be secured in a shorter time under field conditions than would otherwise be possible, and the cost of stock thus cut down. (115 Horticulture)

Control of Raspberry Pests Lessens Winterkilling

A consistent spray program to control anthracnose and red spider and thereby lessen winterkilling of the bushes is essential to successful production of red raspberries in southern Illinois. This is becoming more evident from the results of experiments which H. W. Anderson, Pomological Pathology, and K. J. Kadow, Horticultural Pathology, are making to determine the relationship between winterkilling and control of insects and diseases. Previous to the experiments the acreage of red raspberries, an important crop in southern Illinois, had been markedly reduced thru failure to recognize and control the cause of winterkilling.

Results of these experiments indicate that the factors involved in winterkilling vary from season to season. In some years defoliation in midsummer as a result of leaf diseases appeared to be responsible; in other years red spider was the worst offender in stunting the plants.

Striking results were obtained in 1935 from sprays applied in 1934 for the control of red spider. In these experiments three plots were significant. Table 56 gives the results on winter injury and total yield in 1935. It is evident that the chief factor in the control of winter injury was the red spider infestation, since the sprays were applied

TABLE 56.—REDUCTION OF RED-RASPBERRY WINTERKILLING THRU CONTROL OF RED SPIDER, 1935

Sprays used	Date of application	Canes alive to top	Canes half alive	Pints of fruit picked
None.....	.....	<i>perct.</i> 9	<i>perct.</i> 34	<i>perct.</i> 145
1-percent summer oil, bordeaux 8-8-100....	July 31	69	19	376
1-percent summer oil, bordeaux 8-8-100....	July 31, September 1	81	13	499

too late to secure effective control of the leaf spots which were of little importance in this season. In 1935 red spider infestation was very light, and no marked reduction in winter injury was secured from spraying for this mite. (112.1 Horticulture)

Rainy Season Changes Previous Truck-Crop Results

Soil conservation, low-cost production, and quality products are a special problem in the case of cabbage, onion sets, sweet corn, and pickle cucumbers, which are among the most important truck crops grown in northern Illinois. In the past, fertility for the production of these crops has been maintained largely by the use of barnyard manure, which has now become relatively scarce and expensive. To meet this condition an experiment has been continued at the Cook county branch experiment station by J. W. Lloyd and J. P. McCollum, Olericulture, to determine the effects of certain commercial fertilizers on the production of these four crops. The crops are grown in rotation on a series of plots receiving various fertilizer, barnyard manure, and cover-crop treatments. In view of the fact that rainfall for 1935 was far above the average for the locality in which this experiment was conducted, results obtained were quite different from those of some of the previous years.

Cabbage over a number of years has responded most favorably to applications of organic matter supplemented with commercial fertilizers. However, as indicated by the data for 1935 in Table 57, this crop did not show a large response from either cover crops alone or from barnyard manure supplemented with a complete fertilizer. Large increases were obtained by the use of manure alone and by complete fertilizer treatments with cover crops. Deficiencies in nitrogen and phosphorus were responsible for large decreases in yield of this crop.

The 1935 results indicate that manure can be completely replaced by commercial fertilizers and cover crops for the production of onion sets. When manure is used during a wet season, an application of available nitrogen is necessary to promote early growth and thereby increase the yield. Highest yields were obtained from a 4-8-4 fertilizer

TABLE 57.—EFFECT OF VARIOUS FERTILIZERS UPON YIELD OF TRUCK CROPS IN COOK COUNTY, 1935

Fertilizer treatment	Amount	Acre-yield of marketable product			
		Cabbage	Onion sets	Sweet corn	Pickle cucumbers
	<i>lbs. or (tons)</i>	<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>
<i>With cover crops</i>					
4-8-4.....	1 000	7 000	12 880	.....	10 920
None.....	.....	2 920	9 760	.....	10 680
<i>Without cover crops</i>					
4-8-4 and manure.....	1 000 (10)	6 080	18 360	5 480	9 600
Manure.....	(20)	6 760	14 400	5 240	11 960
None.....	.....	2 400	11 120	5 680	12 600
<i>With cover crops</i>					
0-8-4.....	1 000	12 640	16 400	7 240	.....
4-8-4.....	1 000	14 400	18 360	8 560	.....
6-8-4.....	1 000	15 040	15 600	7 800	.....
4-0-4.....	1 000	13 200	13 640	7 800	.....
4-4-4.....	1 000	14 560	16 240	8 240	.....
4-12-4.....	1 000	16 320	15 960	7 280	.....
4-8-0.....	1 000	15 360	14 160	7 080	.....
4-8-6.....	1 000	17 120	13 920	7 760	.....
None.....	.....	11 880	14 560	7 040	.....

and from manure supplemented with a 4-8-4 fertilizer, the yields from these two treatments being the same.

Unlike the results obtained for sweet corn during drier years, those of 1935 did not show increases in yield from applications of barnyard manure. The highest yield was obtained from a 4-8-4 fertilizer used where cover crops were plowed under.

In view of the fact that severe infestations of cucumber beetles destroyed the stand on some of the plots of pickle cucumbers, complete records were not obtained for 1935. Altho this crop is ordinarily very responsive to fertilizers, the incomplete data shown in Table 57 indicate that it was not in 1935. (315 Horticulture)

Fertilizing Tests Completed.—Tests which have been conducted at the Cook county branch experiment station for eight years by J. W. Lloyd, Olericulture, on the fertilizing of ten market garden crops have been completed and the results published in Bulletin 421, "Substitution of Commercial Fertilizers for Manure in Vegetable Production." (316 Horticulture)

Spring-Plowed Green Manure May Lower Truck Yields

In view of the increasing high price and scarcity of manure it is becoming more important to rely upon cover crops as a source of soil organic matter in growing truck crops. However, with an intensive system of cropping it is usually not practical to use the entire season for growing cover crops. They must be grown during the fall or early spring when the land is not being used for a cash crop. In order to find

the best kind of cover crops with regard to the production of organic matter and the yield of the following crops, tests with a number of fall and winter cover crops have been started at the Cook county branch experiment station by J. W. Lloyd and J. P. McCollum, Olericulture. The fall cover crops include oats, barley, soybeans, buckwheat, and rape. Winter cover crops include rye and vetch, vetch, and sweet clover. These crops are followed by snap beans and pickle cucumbers.

Results of the one year's tests do not justify definite conclusions. They indicate, however, that when large amounts of green manure are plowed under about May 1 the yield of crops planted soon thereafter may be reduced. With cover crops plowed under in the fall, there seems to have been no decrease in the yield of beans and cucumbers the following season. On some of the plots there was perhaps a significant increase. (337 Horticulture)

Heavy Early Cutting May Permanently Harm Asparagus

In a nine-year-old asparagus plantation a plot that had not been cut until the second year and was cut only lightly the second and third years yielded half again as much in 1935 as asparagus that had been heavily cut from the first year. Heavy cutting the first year not only was reflected in a decreased yield in 1935, but also in a decrease in the average size of spears and hence in the market quality of the crop. In general the results in 1935, which are reported in Table 58, were similar to those of previous years. This experiment has been conducted by J. W. Lloyd and J. P. McCollum, Olericulture, at the Cook county branch experiment station since 1926 to show the effect of severe cutting in early years on subsequent yields of asparagus. It has now been demonstrated that young asparagus plantings may be permanently injured in proportion to the severity of cutting. The studies were prompted by the fact that growers commonly find it difficult to wait until new asparagus plantations are well established before beginning to cut a crop. (317.2 Horticulture)

Nitrogen Fertilizers Prove Boon to Asparagus Crop

Present fertilizing practices among asparagus growers are likely to be changed with consequent gains in lower production cost and a higher-quality product as a result of experiments conducted since 1931 at the Cook county branch experiment station by J. W. Lloyd and J. P. McCollum, Olericulture. Altho asparagus is a highly important truck crop in northern Illinois, little definite information has heretofore been available as to best methods of fertilizing the crop.

Results obtained in 1935 and reported in Table 59 show that the crop was very responsive to nitrogen, except when this material was applied in excessive quantities. Altho some phosphorus and potassium seemed to be beneficial, a large amount of each is not needed. Ferti-

TABLE 58.—YIELDS OF ASPARAGUS IN RELATION TO SEVERITY OF CUTTING, 1935
($\frac{1}{2}$ -acre plots)

Number of weeks cut each year ¹				Yield of spears						
				No. 1		No. 2		Total		Average weight of marketable spears
1927	1928	1929	1930	Number	Weight	Number	Weight	Number	Weight	
0	0	4	6	1 110	<i>lbs.</i> 133	1 245	<i>lbs.</i> 72	2 616	<i>lbs.</i> 210	<i>lbs.</i> .0869
0	4	6	8	1 021	123	1 078	62	2 345	190	.0880
4	6	8	8	879	107	875	49	1 985	161	.0891
0	2	4	8	1 231	151	1 224	72	2 693	228	.0908
2	4	8	8	1 104	134	1 032	61	2 348	199	.0912
6	8	8	8	850	97	963	56	1 998	157	.0845

¹Uniform cutting of eight weeks after fourth year.

TABLE 59.—COMPARATIVE YIELDS OF ASPARAGUS UNDER DIFFERENT METHODS OF FERTILIZING, COOK COUNTY, 1935
($\frac{1}{40}$ -acre plots)

Fertilizer treatment ¹	Marketable shoots		Average weight a shoot	Total	
	Number	Weight		Number	Weight
		<i>lbs.</i>	<i>lbs.</i>		<i>lbs.</i>
2-8-4.....	1 130	86.0	.0761	1 256	96.1
4-8-4.....	1 264	97.8	.0774	1 386	107.6
6-8-4.....	1 398	106.8	.0764	1 569	120.5
8-8-4.....	1 192	101.0	.0847	1 302	109.8
4-4-4.....	1 279	100.7	.0787	1 396	110.0
4-12-4.....	1 209	97.8	.0809	1 334	107.8
4-16-4.....	1 119	88.8	.0794	1 245	98.9
4-8-2.....	1 312	102.0	.0777	1 462	114.0
4-8-6.....	1 379	106.9	.0775	1 531	119.1
4-8-8.....	1 130	91.2	.0807	1 238	99.8
4-8-6.....	1 103	87.1	.0790	1 196	94.5
4-8-6.....	1 139	87.8	.0771	1 263	97.7
None.....	1 175	87.0	.0741	1 333	99.7

¹The first ten treatments were applied in July, the eleventh in April, and the twelfth one-half in April and one-half in July.

lizer applied after the cutting season was over gave much better results than fertilizer of the same composition applied before the cutting season began or than split applications applied before and after the cutting season. (317.1 Horticulture)

Superiority of Some New Vegetables Proved in Tests

With Illinois producing more than 10 million dollars' worth of truck crops and farm gardens annually, new varieties of vegetables are constantly being introduced. Some show particular adaptations for certain regions or certain uses. Others have no special merit for the given set of conditions. To assist commercial vegetable growers in northern Illinois in determining the relative merits of certain varieties of vegetables, tests have been continued at the Cook county branch experiment station by J. W. Lloyd and J. P. McCollum, Olericulture. In 1935 the tests were confined to tomatoes and cabbage.

Results of the tests show the superiority of certain of the newer varieties and suggest their possible substitution for some of the sorts now commonly used.

Reliable information on tomato varieties adapted to the fertile soils and short season of northern Illinois has been especially urgent following the large increase in the production of this crop in that region during recent years. Results of the 1935 tests as shown in Table 60 indicate that, in general, largest yields were obtained from relatively early varieties. Outstanding were the Early Baltimore and Prairiana varieties developed by the Department of Horticulture. Altho the former variety yielded a smaller percentage of early fruit than did the John Baer, there was very little difference between the total amounts

TABLE 60.—COMPARISON OF DIFFERENT TOMATO VARIETIES IN NORTHERN ILLINOIS, 1935

Variety	Acre-yields of fruits maturing during—			Average weight a fruit
	First half of season	Second half of season	Entire season	
	<i>tons</i>	<i>tons</i>	<i>tons</i>	<i>lbs.</i>
No. 500.....	.56	7.13	7.69	.40
Prairiana.....	.99	9.56	10.55	.24
Illinois Pride.....	.93	7.27	8.20	.38
John Baer.....	2.80	5.34	8.14	.26
Marglobe.....	1.63	7.02	8.65	.31
Greater Baltimore.....	1.20	8.24	9.44	.33
J. T. D.....	1.91	7.73	9.64	.31
Early Baltimore.....	2.65	9.98	12.63	.31
Rutgers.....	.98	7.94	8.92	.38

of early fruit produced by each. In 1934 the varieties tested showed considerable difference as to resistance to cracking. In 1935 all varieties cracked severely. However, the J. T. D., as in the previous year, showed more resistance to cracking than did any of the other varieties in the test.

Variety tests with cabbage, as reported in Table 61, have revealed some varieties that were 100 percent resistant to the serious disease of yellows, whereas the check plants with which they were compared were all killed by the disease. Use of resistant varieties is the only practical control for this disease. So far it has been difficult to get varieties having the desired market qualities and also resistance to the disease. Since a number of resistant strains have been recently introduced, it was thought advisable to test them out in this region along with a few of the better-known varieties. In view of the difference in time required for the maturity of the various strains, it was impossible

TABLE 61.—RESISTANCE OF DIFFERENT VARIETIES OF CABBAGE TO YELLOWS IN NORTHERN ILLINOIS, 1935

Variety	Total number of plants	Diseased plants	
		Number	Percentage
Wisconsin Hollander No. 8.....	154	126	81.8
Wisconsin Ballhead.....	151	0	0.0
Penn State Ballhead.....	146	146	100.0
Bugner.....	154	142	92.0
Wisconsin All Seasons A.....	146	27	18.4
Wisconsin All Seasons B.....	149	10	6.7
Globe.....	153	12	7.8
Marion Market.....	155	4	2.6
All Head Select.....	152	4	2.6
Resistant Early Copenhagen.....	154	0	0.0
Jersey Queen.....	147	3	2.4
	142	1	0.7

to get a comparison of yield and quality of each. However, accurate records were taken on the number of diseased plants, as is shown by the data in Table 61. (318 and 319 Horticulture)

More Hybrids Soon Available to Sweet-Corn Growers

Popularity of sweet-corn hybrids as a means of reducing the costs and increasing the quality of sweet-corn production continues to increase in Illinois, the leading state in the growing of this crop. So many different types of hybrids are being requested by market growers and canners that the breeder is hard pressed to fill the demands. Pioneering work which the Experiment Station did in the development of improved hybrids is paying increasing dividends to the grower, the processor, and the consumer as the growing of hybrids is expanded.

The Country Gentleman hybrids which the Experiment Station released to the canning trade in Illinois in 1933 are now in commercial production. One of the largest canners in the state has discarded open-pollinated Country Gentleman entirely and is confining production to the crosses released by the Station. Careful tests have convinced this company that such a step is profitable both for the growers and for the company.

These Country Gentleman crosses, along with a Narrow Grain Evergreen cross, will be distributed generally by several seed companies for planting in 1937. Unfortunately getting crosses into production is a slow and tedious process, and the seed trade is not overly well prepared to grow them. The Station is attempting to control the purity of the crosses by means of supplying hand-pollinated seed each year. In 1935 W. A. Huelsen, Olericulture, in charge of this project, personally rogued the increase plots growing in Connecticut, Idaho, and Iowa in order to prevent mixture with outside types.

Further breeding work in 1935 consisted of making numerous crosses between desirable types of yellow sweet-corn inbreds for the purpose of securing crosses to supplement Golden Cross Bantam. In addition a very large number of Country Gentleman and Narrow Grain Evergreen inbreds were crossed in order to improve further those crosses already released. A large number of crosses between Narrow Grain Evergreen and Country Gentleman inbreds indicates that these are of the nature of an outcross, giving larger yields than crosses between inbreds within either variety. Such outcrosses are believed to have a future, as indicated by the large increases in yields shown in Table 62. In the best combinations increased yields are accompanied by considerable increases in the individual ear weights, which means that the ears of these crosses are much larger than in the checks.

In addition Table 62 gives the yields of crosses between various strains of Narrow Grain Evergreen inbreds Nos. 13 and 14. These crosses all produce heavier individual ears, and the increases where

TABLE 62.—COMPARATIVE YIELDS OF SWEET-CORN CROSSES WITHIN THE VARIETY AND BETWEEN VARIETIES

(Yields and ear weights are expressed as percentages of Narrow Grain Evergreen, which was used as a check. The basic figures from which percentages were derived were averages of five replications.)

Cross	Unhusked ears		Prime husked ears		Total yield of prime cut corn
	Yield of marketable corn	Weight of ear	Total yield	Weight of ear	
Narrow Grain Evergreen X Country Gentleman					
	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>
13 X 1	101	124	110	114	124
13 X 3	108	105	119	124	133
13 X 8	104	99	129	106	157
13 X 9	109	105	140	111	144
13 X 15	86	97	120	98	125
14 X 1	97	123	109	132	120
14 X 3	108	104	115	115	138
14 X 5	113	106	114	98	124
14 X 8	103	110	114	98	146
14 X 9	84	100	94	84	105
14 X 15	98	104	119	109	131
Narrow Grain Evergreen crosses					
14 X 13	101	118	113	120	131
13 X 14	105	122	121	126	110
14 X 13	105	118	119	119	131
14 X 13	97	121	105	123	108
14 X 13	102	123	125	136	142

the best strains of inbreds are used are very large. The best combinations between Nos. 13 and 14 will be available to the public for 1937 plantings. (308 Horticulture)

Rate of Planting Has Marked Effect Upon Sweet Corn

With the constant improvement in cultivating implements there is a tendency to plant sweet corn more closely. Distances of 42 by 42 inches were the rule a few years ago, but now growers are planting as closely as 30 by 30 inches. In many instances there is a return to the old method of planting in drill rows. There seems to be considerable justification for closer planting, as yields seem to be greater, but experimental evidence to confirm this point has been lacking.

Rate-of-planting studies being conducted by W. A. Huelsen, Olericulture, are now in their fifth year, and a summary of all the results show that the two late-maturing varieties, Country Gentleman and Narrow Grain Evergreen, require radically different planting rates. Size of plant and productiveness are not criteria for determining the proper stand. Rate of planting has a measurable effect upon yield, height, number of suckers, and earliness of silking. Thick planting increases height, reduces suckers, delays maturity, and may reduce yields.

TABLE 63.—FIVE-YEAR AVERAGE ACRE-YIELDS OF HUSKED MARKETABLE EARS OF SWEET CORN OF TWO VARIETIES PLANTED AT DIFFERENT RATES, 1931-1935

Variety and planting rate	Yields at different distances between plants in row			
	42 inches	40 inches	38 inches	36 inches
<i>Country Gentleman in check rows</i>	<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>
2 kernels a hill	3 515	3 434	3 838	3 809
3 kernels a hill	3 660	3 924	3 804	3 894
4 kernels a hill	3 714	3 975	3 466	3 551
5 kernels a hill	3 503	3 673	3 206	2 894
<i>Country Gentleman in drill rows¹</i>				
8 inches between plants	3 562	4 087	3 984	4 257
14 inches between plants	3 529	4 372	4 149	4 391
20 inches between plants	3 022	3 931	3 807	4 103
<i>Narrow Grain Evergreen in check rows</i>				
2 kernels a hill	3 999	4 396	4 663	4 665
3 kernels a hill	4 680	4 877	5 003	5 219
4 kernels a hill	4 845	5 052	4 878	5 049
5 kernels a hill	5 017	4 804	4 701	4 637
<i>Narrow Grain Evergreen in drill rows¹</i>				
8 inches between plants	4 435	5 083	5 256	5 431
14 inches between plants	4 202	5 064	5 206	5 406
20 inches between plants	3 676	4 404	4 595	4 629

¹Four-year averages, 1933 omitted.

Results of the experiments in Table 63 show that with Country Gentleman nothing is gained by planting more than three kernels a hill. At plantings of 38 by 38 and 36 by 36 inches, two kernels a hill are enough. In Narrow Grain Evergreen five a hill gave the highest yields at 42 by 42 inches, four a hill at 40 by 40 inches, and three a hill at the closer distances. Narrow Grain Evergreen, which is the taller and ranker growing variety, reacts more favorably to heavier planting than does the smaller Country Gentleman.

There is evidence of a distinct relationship between distance between rows and plants a hill. As the distance between rows decreases, the optimum number of plants a hill also decreases, as is shown in Table 63. Thus in Narrow Grain Evergreen at 42 by 42 inches, five a hill is the best rate, but at 36 by 36 inches, three a hill gives the highest yields. In Country Gentleman there is a similar, but much less distinctive trend. It should be noted that the highest check-row yields in each column of the Narrow Grain variety differ only by about 200 pounds. In Country Gentleman the trend is similar, but there is a marked decrease in yield with the check rows at 42 by 42 inches.

In the drill-row plantings in Table 63, 14 inches between plants is the best distance for Country Gentleman. It is obvious that 42 inches between rows is too far apart, as shown by the large decrease in yields. There is, however, no particular advantage in planting the rows of Country Gentleman closer than 40 inches, as the yield does not increase when the distance between rows is reduced to 36 inches with the plants spaced 14 inches apart in the row. In Narrow Grain Evergreen

8 inches between plants is as good as 14 inches, the closer planting causing no decrease in yields. At the same time Narrow Grain Evergreen may be planted to advantage in rows as close as 36 inches, as the yields are highest at that distance.

Maturity records obtained in 1935 by means of silk counts show that silking is definitely delayed as the number of plants a hill increase. With five plants a hill maturity is about three days later than with two a hill. There was also a delay of three days in maturity with plants in drill rows 8 inches apart as compared with those 20 inches apart. The distance between rows showed no effect on maturity.

There was a marked decline in the number of suckers as the number of plants a hill increased. A similar decrease was noted in the drill plantings, the plants 8 inches apart showing fewer suckers than those 14 or 20 inches apart. The distance between rows shows similar trends, the wider plantings having more suckers.

Increasing the number of plants a hill or decreasing the distance between plants in rows also increases the height of the plants noticeably. However, the distance between rows does not seem to have any material effect upon height.

It is evident that the rate of planting has a very material effect not only on the type of plant growth as indicated by number of suckers and total height, but also upon maturity and finally on yield. The results indicate that Country Gentleman is much more selective in its requirements than Narrow Grain Evergreen and that it will pay the grower to set his planter to drop at the proper rate when planting sweet corn. The distance between rows should not be excessively wide or narrow. (335 Horticulture)

Nitrogen Salts for Sweet Corn Not Needed in Illinois

Nitrogen-carrying commercial fertilizers are almost always recommended for sweet corn in the eastern states, as commercial nitrogen is known to give substantial yield increases. In Illinois, however, nitrogen salts are known to give erratic responses. It usually is advisable for the grower to use them sparingly unless experimental results have clearly shown their value. Sweet-corn yields may be seriously impaired by nitrogen applications under certain conditions.

Four years of experimental work show that the use of commercial nitrogen in the form of calcium nitrate, sodium nitrate, and sulfate of ammonia is not justified, as the increased yields were either negative or too small to bear the cost of the treatment. Five additional forms had previously been tested and found ineffective.

The experiments conducted by W. A. Huelsen, Olericulture, consist of five replications of each treatment. Results in Table 64 give the averages for the four years 1931, 1932, 1934, and 1935. Each plot, including checks, received a basal application of 100 pounds of 0-16-6

TABLE 64.—EFFECT OF NITROGEN SALTS APPLIED AT SUCCESSIVE INTERVALS TO COUNTRY GENTLEMAN SWEET CORN RECEIVING A UNIFORM BASAL TREATMENT OF 100 POUNDS OF 0-16-6 AN ACRE

Nitrogen carrier	Time applied	Percentage increased or decreased (-) yield over adjacent check plot			
		Un- husked ears	Prime husked ears	Prime cut corn	Prime husked ears a ton
		<i>perct.</i>	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>
Calcium nitrate.....	At planting.....	.56	-.78	-.38	-1.00
	25 days after planting.....	1.63	-.50	-1.48	-1.66
	50 days after planting.....	-2.11	.70	3.52	4.16
	75 days after planting.....	-.60	-.21	1.82	.17
Sodium nitrate.....	At planting.....	-1.23	.70	-.19	.16
	25 days after planting.....	-.82	-2.24	-3.41	-.34
	50 days after planting.....	.12	1.35	2.47	1.01
	75 days after planting.....	.69	.96	-.75	.51
Sulfate of ammonia.....	At planting.....	-2.21	-2.98	-3.98	-2.14
	25 days after planting.....	.22	.15	.40	.84
	50 days after planting.....	3.03	6.69	4.08	1.30
	75 days after planting.....	-1.92	1.03	-.09	3.97

an acre applied in parallel strips 8 inches long at each side of the hill at planting time. Where nitrogen was applied at planting, the respective nitrogen salts were added to the 0-16-6 at the rate of 4 pounds of nitrogen an acre, bringing the mixture to 4-16-6. At 25, 50, and 75 days after planting the nitrogen was added at the same rate, but as a side-dressing around the hill. However, each plot received only one of the nitrogen treatments, excepting the checks, which received only the 0-16-6.

According to Table 64 applications made 50 days after planting give the largest increases in yield, sulfate of ammonia being the most effective. However, these increases are nominal. Applied at planting time, nitrogen caused small decreases in yield with sulfate of ammonia in the lead.

It is obvious that commercial nitrogen does not pay when used either as a side-dressing supplementary to, or as a part of, a typical phosphorus-potash fertilizer applied around the hill. (306 Horticulture)

Superior Tomato Varieties Overcome Seasonal Hazards

The season of 1935 was another poor one for the tomato grower, especially in northern Illinois, and yields were very low. Altho rainfall was fairly ample and the weather not extremely hot, low yields as in the drouth year 1934 were chiefly the result of a poor set of fruits. This was followed by excessive cracking of the fruits during the ripening period. There has not been a good tomato crop in Illinois for a

number of years, and close observation of the causes leads to the belief that yields may be materially improved even in adverse seasons if better-adapted varieties can be secured.

Breeding experiments by W. A. Huelsen, Olericulture, indicate that the three new tomato varieties—Prairiana, Early Baltimore, and Illinois Pride—introduced in 1936 by the Experiment Station will prove to be superior to many of the varieties now used in the state.¹ In addition these three varieties were bred for resistance to Fusarium wilt, now prevalent thruout Illinois. A fourth new resistant variety which will be called Illinois Baltimore, received final tests in 1935 and will be available to the public for planting in 1937.

TABLE 65.—COMPARISON OF SEVERAL NEW TOMATO VARIETIES ON WILT-INFESTED SOIL, ON BASIS OF AVERAGE YIELDS OF FIVE REPLICATIONS OF FIFTEEN PLANTS EACH

Year and variety tested	Acre-yields of marketable fruit			Grading distribution		
	U. S. No. 1	U. S. No. 2	Total	U. S. No. 1	U. S. No. 2	Culls
<i>1934</i>						
Illinois Baltimore.....	1.83	3.95	5.78	22.2	48.0	29.8
Marglobe.....	1.56	2.39	3.95	26.9	41.1	32.0
<i>1935</i>						
Illinois Baltimore.....	1.22	4.48	5.70	16.0	58.8	25.2
Marglobe.....	.82	4.54	5.36	11.3	62.8	25.9
Marhio.....	.83	3.59	4.42	14.0	60.1	25.9
Marglobe.....	.86	4.75	5.61	11.3	62.8	25.9
Rutgers ¹.....	.91	3.64	4.55	16.1	64.3	19.6
Pritchard ¹.....	.84	5.58	6.42	9.6	63.8	26.6
Rutgers ²	1.47	3.92	5.39	21.5	57.5	21.0
Pritchard ²	1.31	5.21	6.52	14.0	55.7	30.3

¹On gravelly silt loam. ²On black clay loam high in fertility.

The 1935 yields of Prairiana and Early Baltimore have been compared with those of Pritchard on both heavy and light soils in Illinois and the advantages of these two new varieties reported in Circular 448 "New Wilt-Resistant Tomato Varieties for Field and Greenhouse." Yields of Illinois Pride have been compared with those of Marglobe in the same circular.

In Table 65 the 1934 and 1935 yields of the new Illinois Baltimore are compared with those of Marglobe. In 1934 Illinois Baltimore gave substantially larger yields than Marglobe, but under the less adverse conditions of 1935 the total yields of the two varieties were about the same. However, Illinois Baltimore produced more U. S. No. 1 fruits, owing largely to its greater resistance to cracking. Illinois Baltimore

¹Yield tests of these varieties at the Cook county branch experiment station are given in Table 60.

is a strain of Greater Baltimore, having been selected out of Indiana Baltimore for the purpose of securing a strain of Baltimore resistant to *Fusarium* wilt. Illinois Baltimore has the same vine and fruit characters which have made Greater Baltimore and Indiana Baltimore so popular, but unlike these strains, it can be grown on wilt-infested soil. The gradings given in Table 65 show that in both 1934 and 1935 Illinois Baltimore was superior to Marglobe, which has high-quality fruits. The large percentages of culls in Table 65 are explained on the basis that all the fruits in the field were picked and graded.

The two new varieties—Rutgers, introduced by the New Jersey Experiment Station, and Marhio, introduced by the Ohio Experiment Station—were also tested for adaptability to Illinois conditions, and results from them are included in Table 65. Marhio is definitely inferior in yield to Marglobe, out of which it was selected. Rutgers yielded much less than Pritchard, but the quality of the fruits was high as indicated by the higher percentages of U. S. No. 1's.

Extensive breeding work was also done with greenhouse tomato varieties, and the new varieties, Long Calyx Forcing, Urbana Forcing, and Sureset Forcing, were introduced along with Lloyd Forcing and Blair Forcing, which have been in commercial use for several years. Full descriptions and yield data of all these new introductions appear in Circular 448. (322 Horticulture)

Soil Treatment Found Which Helps Hothouse Tomatoes

Another of the markets that is opening up for Illinois growers and on which the Experiment Station is working is that for vine-ripened hothouse tomatoes. They are in demand because their quality is superior to that of immature outdoor stock shipped to Illinois markets from southern producing regions. Unfortunately greenhouse men who are not experienced in the growing of tomatoes are encountering many difficulties in trying to supply the demand. One of these problems is the proper fertilizing of greenhouse soil for the profitable production of this important crop. Studies made in an attempt to determine the most effective method of fertilizing greenhouse tomatoes have been continued by J. W. Lloyd, Olericulture.

The past year the best yield in the spring crop was secured from the plot treated with top-dressings of sodium nitrate and muriate of potash in addition to a basic treatment of manure and superphosphate. In the fall crop, also, plots in which top-dressings of sodium nitrate and muriate of potash were involved were among the best yielders. However, the increased yields, as compared with the average yields of the check plots, were not so marked as in some of the earlier tests.

As is usual with greenhouse tomatoes the yield in the spring crop was very much greater than in the fall crop. The highest yielding plots

in the spring produced practically three times as much fruit as the highest yielding plot in the fall, or approximately 10½ pounds a plant as compared with 3½ pounds a plant. (329 Horticulture)

New Lima Bean Varieties Bred to Set Pods in Drouth

Altho the corn belt contains extremely fertile soils and has an equitable climate, there are equprisingly few crops which are very successful. Sweet corn is the most widely successful vegetable crop grown in Illinois, and consequently the state leads all others in its production. Other vegetables would probably be just as successful were it possible to breed varieties adapted to the climate. Among the vegetables which have the most frequent crop failures is the lima bean. Paradoxically this is also one of the most highly drouth-resistant crops grown in the state, but while the plant will survive the most severe drouths with ease, it fails to produce pods except in occasional favorable seasons. Few growers will attempt to plant lima beans because

TABLE 66.—ACRE-YIELDS OF HAND-PICKED SEED OF BABY POTATO LIMA COMPARED WITH HENDERSON BUSH CHECK, 1935

Strain of Baby Potato	Yield	Henderson Bush (check)	Increase over check
	<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>
455-26	1 361	1 174	187
455-27	1 512	1 174	338
455-28	1 398	1 174	224
455-29	1 549	1 022	527
455-30	1 440	1 022	418
455-31	1 360	1 022	338
455-32	1 476	1 095	381

crop failure occurs most of the time. However, it would be a very profitable crop if normal yields could be obtained. The problem resolves itself into a question of securing a type which can set pods under adverse conditions.

In 1935 more than 75 selections and crosses were under test. The large-podded Henderson Bush described in the Forty-Eighth Annual Report was again successful, and seed has been sent to growers for extensive tests in 1936. In addition a distinctly new variety to be called Baby Potato lima has been bred, and seed of it is now being multiplied in California for trials in 1937. In Baby Potato lima, W. A. Huelsen, Olericulture, has succeeded in combining the plant characters of the early-maturing, productive Henderson Bush with the bean characters of the true potato lima. As its name implies, Baby Potato lima has a small bean like Henderson, but is much thicker. The pods, altho small, are extremely plump and the beans are crowded very thickly, giving them the familiar angular shape of the large potato lima. However, the pods instead of being fleshy are paper thin, and

shelling is very easy. In flavor the beans are exceptionally sweet, on the order of the large potato lima.

In 1935 the Baby Potato lima consistently yielded more than the Henderson Bush lima, which is the only productive standard variety raised in Illinois and which is used entirely by canners. The yields in Table 66 are for hand-picked seed. The increases are all the more significant, as only the earliest types will mature seed at Urbana. It is believed that Baby Potato will find a definite place in Illinois, both as a canning and a market variety. Viner tests will be conducted with it in 1936, and numerous samples will be canned. (336 Horticulture)

Vegetable Disease Studies Will Reduce Heavy Losses

One of the most limiting factors in vegetable production in Illinois is not soil depletion or lack of markets, but plant diseases. Studies being made by K. J. Kadow, Horticulture, on the more important and destructive diseases attacking vegetables point the way to much better stands of vegetable plants and greatly reduced losses from disease.

During the past season an intensive survey was made of diseases attacking cabbage and related crops in Illinois, and recommendations regarding the control of these diseases have been prepared for publication. Studies in the control of "damping-off" have been continued to a point where definite recommendations can soon be made. Different treatments are needed for different vegetable crops in order to control this trouble, which is a much more general and serious problem than most vegetable growers realize. (320 Horticulture)

New Studies Solving Problems of Horseradish Growing

Illinois has two of the few areas in which the highly specialized crop of horseradish is grown extensively. If this industry is to thrive and supply consumers with a high-quality product, there are many problems bearing on methods of fertilizing, time of planting, methods of storage, and control of diseases which must be solved. Studies of these problems are being made by J. W. Lloyd, J. P. McCollum, and K. J. Kadow, Olericulture.

In a test of horseradish fertilizers best results were obtained with a 4-16-6 fertilizer applied at the rate of 1,000 pounds an acre. Unfortunately yields in 1935 were very low. Consequently the differences between the various treatments were not so great as might be expected with a normal yield.

In 1935 the highest yield was obtained from a May 1 planting and the lowest from the June 1 planting. Altho horseradish is commonly planted early in the spring, planting is sometimes delayed until the first of June. Since a number of crops must be planted as early as possible in the spring, it would be unwise to plant horseradish at the same time as these crops unless its yield and the quality were increased. In

the test to determine the effect of the time of planting upon the production of horseradish, plantings were made April 1, May 1, and June 1.

Other tests have shown that good control of nematodes can be secured by storing the horseradish sets in such a way that the temperature gets down to 10° F. for at least a few hours. The danger is in giving the stored sets too much rather than too little protection. When uncontrolled, nematodes may cause losses varying from 1 to 15 percent of the horseradish crop. The organisms are carried over from year to year by infested sets.

Attempts to control white rust, the most serious disease of horseradish, by spraying with bordeaux mixture were not entirely satisfactory, owing to lack of sufficient adhesive properties of the bordeaux when used alone. Additional work is being done to provide a more uniform and durable spray coverage.

Various chemical treatments of horseradish sets before they were planted, in attempts to control root diseases, all proved harmful and therefore are not to be recommended.

In these studies several bacterial root rots have been definitely correlated with the "lifting" process, and their control cannot be expected as long as this practice is continued. (334 Horticulture)

Four-Year Bench Soil Yields as Well as New Soil

Florists are showing increased interest in the practice of using bench soil for more than one season. It is true that the changing of soil or sterilization may be necessary where the previous crop has been subject to disease or insect pests. Also in some cases the soil may contain excessive amounts of lime and various soluble salts as a result of the use of hard water and concentrated fertilizers. It is possible, however, to use bench soil repeatedly for the production of crops of acceptable commercial quality.

Soil in which several florist crops had been grown over a period of three years was compared again for the fourth season with new soil in an experiment conducted by F. F. Weinard, Floriculture. The order in which one crop followed another was varied each season, the planting order the fourth year being the same as the first year. The relative development of the different crops on new and old soil is shown below. There were no marked differences in the time in which the crops came into bloom.

<i>Crop</i>	<i>New soil</i>	<i>Old soil</i>
Carnation (1 variety)	10.4 flowers a plant 22.3-inch stems 3.1-inch flowers	10.3 flowers a plant 21.2-inch stems 3.1-inch flowers
Chrysanthemum (16 varieties)	34-inch stems 4.3-inch flowers	25.2-inch stems 4.2-inch flowers
Freesia (5 varieties)	29.5-inch stems 8.3-inch flower spikes	25.8-inch stems 8.3-inch flower spikes

Gladiolus (5 varieties).....	51.8-inch stems	64.4-inch stems
	12 flowers a spike	10.1 flowers a spike
Larkspur (2 varieties).....	47.9-inch stems	44.1-inch stems
Snapdragon (2 varieties).....	34-inch stems	33.7-inch stems
	6.6-inch flower spikes	6-inch flower spikes
Stock (3 varieties).....	28.3-inch stems	21.7-inch stems
Sweet pea (1 variety).....	5.4-inch stems	5.1-inch stems
	1.7 flowers a spike	1.7 flowers a spike

(403 Horticulture)

Comparison of Numerous Types of Peonies Completed

The single and Japanese peonies are not so commonly grown as the double forms, but they are nevertheless deserving of wider planting for landscape use and for cutting as well. Japanese peonies, particularly, display a variety of form and color, and the numerous blooms are held erect in all kinds of weather. Comparisons of numerous types have now been completed in studies conducted by F. F. Weinard and H. B. Dorner, Floriculture, to obtain adequate descriptions and to correct errors in naming.

The list of outstanding single varieties includes the following: *White*—Katori nahiko, Le Jour, Marguerite Dessert, Queen of the Belgians, Snow Sprite. *Light pink*—E. St. Hill, Kelway's Luck, Kinsui, La Fiancee, La Fraicheur, Mischief, Schwindt, Shirley Walker. *Dark pink*—Catherine S. Fox, Colonel Poe, Josephine, L'Etincelante, Mr. Thim, Nagasaki, Somerton, Success, Venus. *Red*—Adwadji, Balliol, Black Beauty, Black Magic, Darkness, Departing Sun, Florestine, Harriet Olney, Kewanee, Lord Kitchener, Mafeking, May Reid, Mellin Knight, Peter Oleson, Petit Louis, Presto, Red Queen, Stanley, The Moor, Tom Tinker, Toreador, Veloutine, Winnebago Chief.

A similar list of Japanese varieties includes: *White*—Fujimine, Golden Dawn, Hakodate, Isami Jishi, Jan van Leeuwen, Lemon Queen, Margaret Atwood, Shaylor's Sunburst, Toro-no-maki, White Queen, Zanzetsu. *Light pink*—Albatross, Faust, Mr. G. F. Hemerik, Yokohama. *Dark pink*—Ama no Sode, Antwerpen, Attraction, Duchess of Bedford, Gunpooro, Hawa, Makitatelyama, Meigetsuko, Pride of Remington, Tamatbako, Tarantelle, Tokio. *Red*—Akashagata, Empress of India, Flamboyant, Fujajo, Instituteur Doriat, Kameno kerogama, Kino kimo, Kochomai, Mikado, Noonday, Onahama, Ruigegno, Some Ganoko, Soshi, Surugu, The Dragon, Torpilleur. (414 Horticulture)

Stem-Rot Disease Controlled by Sterilizing Soil

Among growers who plant *Euphorbia fulgens* as a bench crop, considerable losses have been experienced from a stem-rot disease, caused by *Fusarium* sp. Inasmuch as the conditions favoring the disease were not known, an experiment was conducted by F. F. Weinard and S. W. Hall, Floriculture, using different cultural methods. The best results in controlling the disease were obtained where cuttings were trans-

ferred directly into sterilized potting soil and then into bench soil which had been sterilized with steam.

No plants were lost from the first lot, propagated February 19 and grown thruout in steamed soil. From another lot, propagated March 1 and grown in similar soil, 10 percent were lost up to August 23. In the same period 23 percent and 59 percent of the plants grown in unsterilized soil died. Sterilizing the bench soil and not the pots and potting soil prevented the disease to some extent, but the results indicated that at least a part of the plants grown under such conditions became infected at an early stage of growth. Successful control accordingly will depend upon the use of sterilized sand and soil at all stages. (408 Horticulture)

Productiveness of Rose Varieties Shows Wide Range

Roses are the leading flower crop under glass. While color, substance, length of stem, and keeping quality are all considered in evaluating the varieties to be grown, the number of flowers produced in a season is always of primary importance. Productiveness of fourteen commercial varieties of forcing roses was determined in an experiment conducted by F. F. Weinard, Floriculture.

Plants of eleven varieties were two years old, while the plants of three other varieties—Better Times, Mrs. F. D. Roosevelt, and Token—were in their first year. There were 100 plants of each kind, and they were grown under uniform conditions in the same house. The average from all varieties was 25 flowers a plant from the first of September thru the following May. One variety averaged as many as 30 flowers a plant, while another produced but 12. From 16 percent to 32 percent of the season's crop, depending on the variety, was cut during the winter months, December thru February. Plants of the more vigorous varieties produced an average of 30 feet or more of flowering wood during the season. Flower production and stem length for the different varieties were as follows:

<i>Variety</i>	<i>Average number of flowers a plant</i>	<i>Average stem length in inches</i>
Better Times.....	19.8	15.6
Briarcliff.....	23.2	13.9
Double White Killarney.....	30.2	10.0
Hollywood.....	27.8	10.1
Joanna Hill.....	23.5	16.3
Mary Hart.....	30.7	12.8
Mrs. F. D. Roosevelt.....	26.5	13.3
Premier Supreme.....	31.2	18.6
Senior.....	21.3	16.1
Souvenir.....	26.5	10.4
Sterling.....	20.8	14.2
Talisman.....	30.2	12.6
Token.....	12.8	11.5
Yellow Joanna Hill.....	25.2	14.4

(415 Horticulture)

Carnations Do Best Spaced 8 by 8 Inches or 11 by 6

The yield from carnations is markedly affected by the spacing of the plants. At the same time the grower is interested in obtaining as large a return from each square foot of bench space as possible, consistent with the quality demanded by his market. The problem was investigated for two seasons by F. F. Weinard, Floriculture. A summary of the data obtained in the second year follows, the figures representing the results from three of the best commercial varieties—Senator, Pink Abundance, and Spectrum.

<i>Planting distance</i>	<i>Flowers a plant</i>	<i>Flowers a square foot</i>
12 inches by 12 inches.....	19.4	19.4
10 inches by 10 inches.....	16.2	24.1
12 inches by 8 inches.....	16.0	24.0
8 inches by 8 inches.....	13.4	29.6
11 inches by 6 inches.....	13.5	29.2
6 inches by 6 inches.....	8.7	34.9

Yields a plant decreased with the space allotted to each plant, while the flowers cut from each square foot increased. While there may be some advantages in cultivating where more space is allowed between the rows, the total space allowed seemed to be the more important factor so far as production was concerned. Stem lengths and flower diameter were little affected by the rate of planting. Observation and measurements of stem strength indicated that 6 inches by 6 inches is too close for the development of flowers of good quality. However, 8 inches by 8 inches or 11 inches by 6 inches permit satisfactory development of the plants. These results agree closely with results obtained the previous season. (416 Horticulture)

HOME ECONOMICS

Vitamin-E Sufficiency Does Not Stop Nursing Failure

Selection of diets most favorable to the proper nursing and development of the young is a matter of much importance from the standpoint of both human and animal nutrition. Further information bearing on the subject has been obtained in a continued study of the dietary requirements for successful lactation in the rat. This study is being carried on by Julia Outhouse, Home Economics.

Results obtained in 1934 and 1935 indicated that the purified diet plus yeast, cod-liver oil, and wheat-germ oil was not adequate to allow mother rats to nurse their young. The feeding of oats, hydrogenated cottonseed oil, and lettuce to the mothers insured against the death of the offspring during the first week of life and promoted the flow of milk in amounts sufficient to induce normal growth of the rats during the first three weeks of life. In the absence of these supplements the young exhibited some symptoms which have been described as occurring in the absence of vitamin E. Inasmuch as this substance had not been fed in the amounts suggested by Evans and Burr, it was decided to investigate the lactation response of the rats to the diet to which large quantities of vitamin E were added.

During pregnancy, therefore, the rats were given daily approximately 150 milligrams of an ether extract of wheat germ. This was increased at the time the litter was cast to include approximately 125 milligrams for each baby rat. The animals were allowed to nurse litters of six rats only.

During nine months eight female rats fed the purified diet supplemented by yeast and cod-liver oil and the larger amount of wheat-germ oil cast a total of only seven litters, or less than one litter for each rat. In every case the mothers failed to suckle their young, with the result that the young rats made poor growth and died at an early age. From the results of this study it is concluded that the failure of the mother rats to nurse their young has not been caused by a lack of vitamin E. The experimenters are still uncertain as to the nature of the galactagogue in cottonseed oil, oats, and lettuce that promotes the flow of milk. (7 Home Economics)

More Vitamin A Found in Dark Orange Kernels of Corn

Dark orange kernels of corn were found, in tests conducted the past year, to contain more carotene than pale yellow kernels from the same sample. The tests, which were made in continued work to determine the relative vitamin-A value of several varieties of yellow corn, were carried on by Julia Outhouse and Milicent Hathaway, Home Economics.

The second study, in which five young college women participated, differed from the other in that a fourth period, in which sucrose was again fed, followed the third, or the lactose-feeding period. No milk solids were fed.

Chemical analysis of the food eaten and the residue excreted from the body was made for calcium and magnesium.

Data for the first study indicate that the calcium retention for three of the four women was increased during the period of lactose ingestion. Magnesium retention was influenced in the same direction but not to the same extent. The analyses for the second study have not been completed.

The studies to date indicate that the albino rat and the human subject react alike to the ingestion of moderate amounts of lactose, that is, by retaining more of the bone-building element, calcium, and possibly more magnesium. (30 Home Economics)

Starch Study Is Aimed to Increase Food Use of Corn

If more corn could be used as human food, farmers of Illinois, the second largest corn-producing state, would share in the benefits of an increased market outlet. However, recommendations for the use of more corn in the diet must be based upon facts, and in a continued effort to establish such a basis Sybil Woodruff and Majel M. MacMasters, Home Economics, have attempted to separate the important constituents of corn. This is done so that the physical and chemical behavior of the different constituents can be studied with a view to finding the desired larger uses.

Most of the effort of the past year has been directed toward a separation and study of the starch. The starch of commerce in this country is cornstarch, and the technology of its manufacture is well established. Results of previous years have indicated, however, that the usual factory methods involve treatment with sulfurous acid sufficiently severe to alter the physical behavior of the starch and therefore, very probably, its chemical nature, too. For this reason all cornstarch used for these experiments has been very carefully prepared by treatment with water alone from known varieties of corn.

Several results obtained during the year are traceable to the fact that much of the corn was frosted before wholly mature. Whether because of this fact or not, starch obtained from this frosted corn behaved somewhat differently from last year's cornstarch of the same kind. It was found that the starch was separated from the corn kernel less easily this year than last, probably because of physical differences in the kernels produced in the two growing seasons. In previous years photographs were used to show differences between commercial cornstarch and that made in the laboratory without chemical treatment with respect to its holding the shape of a gel. This year

a mechanical device called a gel-strength tester has been employed for the purpose of determining whether gel structures of different starches are of equal firmness.

Starches were made the same as in previous years, all processes being carried out in the absence of sulfurous acid, which is always used in commercial manufacture. Reid Yellow Dent corn was the only variety used this year, as no Champion White Pearl surviving

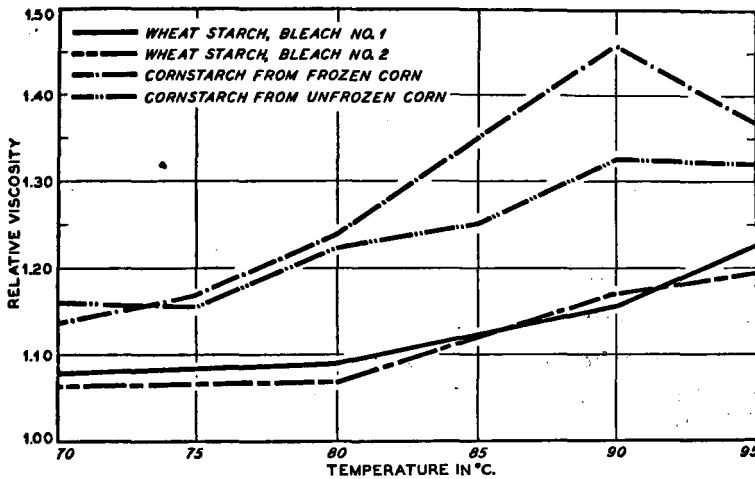


FIG. 43.—VARIATION UNDER DIFFERENT TEMPERATURES OF RELATIVE VISCOSITY OF CORN AND WHEAT STARCHES

Mechanical injury from freezing has been shown to produce changes which may influence the practical uses of starch. For instance the viscosity of a 2-percent suspension of starch from corn which had not been frozen differed, tho irregularly, from that of corn which had been harvested while it still contained 27 to 32 percent moisture and placed at once to freeze at a temperature of -18° to -20° F.

the frost was obtainable. Gels containing 5 percent starch and gelatinized at 95° C. did not leave the mold clean, as they had done in years before, tho freezing the corn had not noticeably altered the ability of its starch to form a gel. A gel-strength tester, measuring the millimeters of water pressure required to force a plunger thru the surface of the gel, gave results far from satisfactory, but agreeing in general with the subjective observation that gels made with commercial cornstarches were less firm than those of cornstarch made in the laboratory. It is hoped that with improvement in technic this instrument will yield valuable results.

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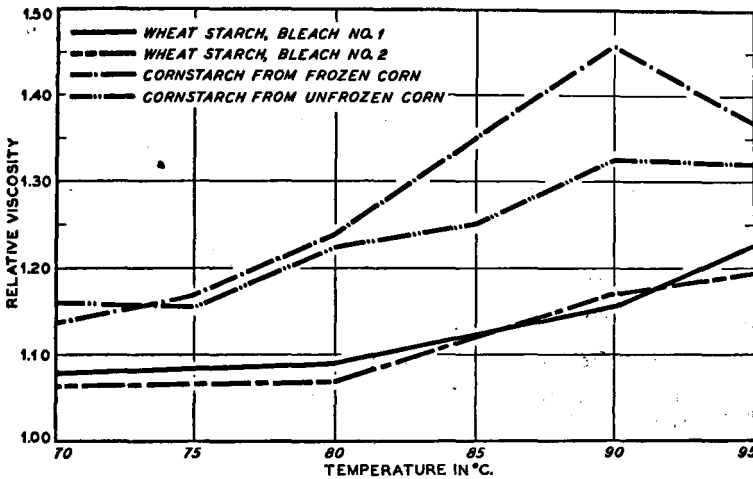


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viscosity of a 2-percent suspension of starch from corn which had not been frozen differed, tho irregularly, from that of corn which had been harvested while it still contained 27 to 32 percent of moisture and placed at once in a cold room, the temperature being -18° to -20° F. Fig. 43 shows these differences, together with the viscosity curves for two wheat starches. Mechanical injury from freezing has been shown to produce changes which may influence the practical uses of the starch.

Frozen corn kernels were found to be injured enough so that moisture was imbibed more readily than by unfrozen kernels. They had not ceased absorbing water until the thirty-second day of soaking in distilled water at a refrigerator temperature of 3° to 4° C. On the basis of the original amount of dry corn, the amounts of water absorbed at different intervals expressed in percentage were:

	<i>Frozen corn</i> perct.	<i>Corn not frozen</i> perct.
1 day.....	30	28
5 days.....	55	50
10 days.....	66	57
32 days.....	74	68

(105 Home Economics)

Starch Behavior Under Different Conditions Is Studied

Starches and starch-rich foods constitute a large fraction of the calories in the diet of American people. The thickening power of starches gives them a place in food preparation which is unique. There are many factors which may influence the thickness of boiled starch pastes and in turn the uses to which they can be put. Starches are seldom used in food preparation in the total absence of sugar, salt, and such ingredients as milk or fruit juices, both of which are rich solutions of chemical salts. Irregular thickening of starch in the presence of such substances may occur, as has been shown in the current year's work in one of the foods projects.

In studies of wheat and corn starches, Sybil Woodruff and Majel M. MacMasters, Home Economics, have noted that the addition to starch pastes of sugar and ordinary table salt, in quantities which may be used for seasoning purposes, changed both viscosity and gel-forming power. Wheat-starch paste had a lower viscosity than cornstarch, as indicated in Fig. 43 of Project 105. It is also shown there that cornstarch began to swell and increase in viscosity at a lower temperature than wheat starch. Wheat starches made from flours which had been bleached by five different treatments apparently had been too little changed by the chemical process to have shown effects in either viscosity or gel-forming power.

Measurements of viscosity were made in a Stormer viscometer

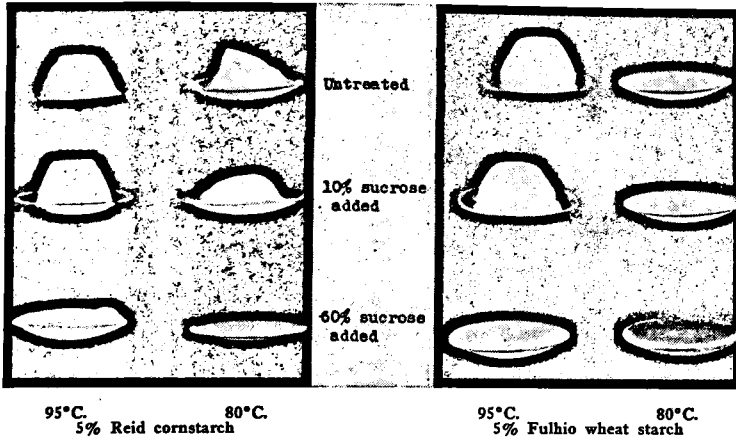


FIG. 44.—EFFECT OF SUCROSE ON GELATION OF STARCH

Neither corn nor wheat starches could hold a gel when as much as 60 grams of sucrose was added to each 100 grams of starch suspension. Ten percent of sucrose affected them little, if any.

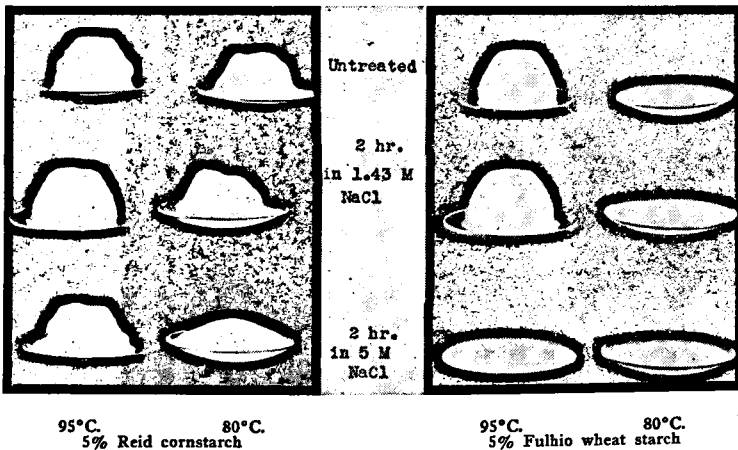


FIG. 45.—EFFECT OF SODIUM CHLORIDE ON GELATION OF STARCH

A 5-molal concentration of sodium chlorid, which was not much more than might be used for condimental purposes, caused both the wheat and the cornstarch gels to flatten out. That of the wheat starch flattened more than the one made of cornstarch.

employing suspensions containing 2-percent starch. The pastes were first gelatinized in flasks, then transferred to the viscometer cup and maintained at the temperature of gelatinization during the reading of viscosity. Additions of sodium chlorid affected viscosity in a less regular manner than they did gel-forming power. Table 67 illustrates what happened when sugar was added. The 10-gram amount is about

TABLE 67.—EFFECT OF CHEMICALS ON RELATIVE VISCOSITY OF STARCHES

Chemical added	Concentration of solution added	Relative viscosity at 80° C.	
		Cornstarch	Wheat starch
None.....	.....	1.32	1.21
K-citrate.....	.04 molal	1.31	1.21
K-citrate.....	.08 molal	1.36	1.25
Sucrose.....	10 grams ¹	1.42 ²	1.30 ²
Sucrose.....	60 grams ¹	1.26 ²	1.19 ²

¹This amount was added to 100 grams of starch suspension. ²Corrected for viscosity of sucrose solution.

such quantity as would be used in a slightly sweet pudding. The 60-gram quantity represents a very sweet pie filling or similar mixture. It will be seen that small amounts of sugar increased viscosity of the starch suspension, whereas large amounts diminished it, in comparison with a paste containing no sugar. It is a common practical observation that excessively sweet mixtures do not thicken as expected. The effect of potassium citrate was studied because it is a salt present in milk in generous amounts. Only a .08-molal concentration (which is a very small amount) was required to bring about a significant increase in viscosity. The larger amounts of both sodium chlorid and potassium citrate produced discoloration of the starch pastes.

The ability of the cooked paste to hold a well-molded form was also influenced by sugar and salt. Gels containing 10 and 60 percent sucrose were photographed after they had been turned out of molds. Fig. 44 shows that both corn and wheat starches could not hold a gel shape when as much as 60 grams of sucrose was added to each 100 grams of starch suspension. Ten percent sucrose affected them little, if any. Sodium chlorid in the largest proportion, which was not more than might be used for condimental purposes, caused both starch gels to flatten out, that of wheat starch flattening more than the one made of cornstarch. This is shown in Fig. 45. (103 Home Economics)

Bleaching Process Aids Quality of Soft-Wheat Flours

Practically all commercial wheat flours on the present-day market have been treated by a chemical process designed to produce artificially some of the changes which would otherwise occur slowly with natural

aging. Properly aged flour has better baking qualities than new, or green, flour. The treatment consists of adding a chemical which changes the hydrogen-ion concentration and the physical properties of the flour when it is wetted. At the same time it bleaches the yellow color of the flour, and for this reason the whole treatment has commonly been called bleaching. The beneficial effects of bleaching are of importance in both hard-wheat and soft-wheat flours. Commercial millers regard the optimum methods of bleaching the two kinds of flour as different.

In a study of Illinois wheat flours and their behavior in baking Sybil Woodruff, Home Economics, and others of the Department have tested the influence of five different bleaches on a patent grade of soft-wheat flour milled especially for this project from certified Fulhio wheat. Measurements of viscosity have been made, because this property is one to which many workers have looked as a means of distinguishing quickly between flours without making the usual lengthy baking tests. The viscosity procedure used in this work successfully showed differences in protein content of flours, but did not indicate differences which were undoubtedly caused by the action of various bleaches. Such effects of bleaches were demonstrated satisfactorily, however, by cake-baking tests.

One lot of the flour was bleached in the mill by the treatment ordinarily used by that mill for the trade. Four other portions were sent to the laboratories of a manufacturer of flour bleaches, where each was treated differently, the kind and amount of bleach being varied. Special bleach A was thought in the bleaching laboratory to correspond approximately to the treatment given in trade practice.

The bleaches were used in the following amounts to the barrel of flour:

Bleached in mill— 14 gms. Agene (NCl₃) and .6 gm. Novadelox (benzoyl peroxid)
Special bleach A— 3 gms. Agene and .5 gm. Novadelox
Special bleach B—4.5 gms. Agene and .75 gm. Novadelox
Special bleach C—6.0 gms. Agene and 1.00 gm. Novadelox
Special bleach D— 28 gms. Beta Chlora (chlorine containing .5 percent nitrosyl chlorid) and .5 gm. Novadelox

Viscosity tests made in a Stormer viscometer on flour-water suspensions gave readings for relative viscosity ranging from 1.37 to 1.42 for the one kind of flour bleached in different ways. The protein content of the flour was 9.79 percent. One brand of flour containing 8.18 percent protein gave a relative viscosity of 1.31 and another brand of hard-wheat flour with a protein content of 12.78 percent read 1.60 in viscosity. These results were interpreted to mean that differences brought about by bleaching treatments were not detectable by viscosity measurements, as were variations in the protein content.

It was demonstrated by cake-baking tests that the different bleaches measurably altered the flour. Three formulas of quite different nature

showed this. Formula 1, judged by home baking standards, gave a rather poor product with all flours, while the ill effects of any one flour were exaggerated in this series. Formula 2 was one frequently used in homemade cakes and its proportions were such that any flour, either soft or hard wheat, could be used with fair success. Formula 3 was richer than either of the other two, and for this reason was well adapted to soft-wheat flours but not to hard-wheat flours. The poor quality of unbleached flour was very apparent in this series. The absence of bleaching was responsible for inability of the cake to hold its shape; on cooling the cake sank in the center and had a fallen soggy texture.

The average scores of six bakings for each of the three formulas are given below. A score of 93 by the rigid standards of judging was considered to be very high.

	<i>Fulhio patent</i>	<i>Formula 1</i>	<i>Formula 2</i>	<i>Formula 3</i>
Unbleached.....	67	84	72	
Bleached in mill.....	78	87	88	
Special bleach A.....	70	84	..	
Special bleach B.....	78	83	89	
Special bleach C.....	80	81	..	
Special bleach D.....	80	88	89	

Flour bleached in the mill and special bleach B gave good and very comparable results. Laboratory bleaching on a small scale probably accounted for the smaller amount of Agene used in the latter case. The treatment in C was excessive and the resulting cakes dry. Bleach D was considered to give a superior cake in all three formulas. These baking tests were performed so many months after milling that the unbleached flour might have been expected to have overcome some of its defects thru natural aging. However, it still was far from good. It appears that with present standards of quality in homemade cakes, chemical treatment can be relied upon to improve the quality of a flour for this purpose. (101 Home Economics)

Studies of Soybeans as Human Food Are Continued

From present indications the use of soybeans as food may be expected to increase along with their development for industrial purposes. Manufactured products of soybeans already appear in the usual diet to some extent, while in cases of allergies to such foods as wheat flour and cow's milk, soybeans have a particular place. Lately the superior availability of the iron of soybeans for hemoglobin regeneration in rats has had special attention. Their unique composition gives them higher nutritive value than competing foods so far as calories, protein, and fat are concerned. Mineral and vitamin content need more extensive study than has been made up to the present before accurate comparisons can be offered for these points of nutritive value.

Soybeans as green vegetables offer great promise as a food. They

have an attractive green color, contain enough sugar to resemble peas in sweetness, and are ready for use in September when vegetables are not always so plentiful. If there is one factor which will interfere with the successful introduction of soybeans as food, it is their flavor. There is considerable difference, however, in the flavor of different varieties, and from the several hundred which are known, it should be possible to select those which will be more acceptable to American

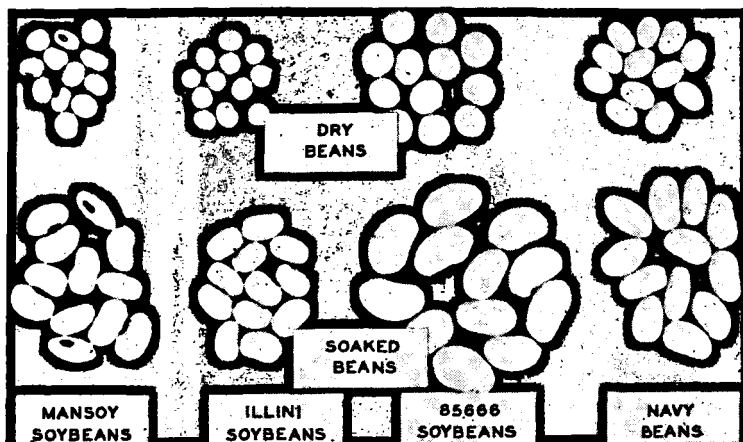


FIG. 46.—RELATIVE SIZE OF THREE VARIETIES OF SOYBEANS, BEFORE AND AFTER SOAKING, COMPARED WITH NAVY BEANS

Edible variety 85666 and Illini are two of the six varieties which have been chosen as having superior qualities for edible use. The four others are 81044-1, 81780 late, 87615, and Higan Mame.

people. Two departments of the Experiment Station have been engaged for several years in making selections of suitable types for food purposes. During the current year the Department of Agronomy has grown and the Department of Home Economics has tested ninety-five varieties for palatability and other factors. Part of these have been vegetable, or edible, types, so called because they are used as food in the orient; the remainder have been field types, accepted as being valuable for forage, seed, and industrial purposes.

In the studies of soybeans as human food by Sybil Woodruff and Helen Klaas, Home Economics, six varieties have been chosen as having superior qualities for edible use. Only one of the six, Illini, is a variety now being grown generally in the state. The other five, which are vegetable types, are better adapted to the purpose than is Illini, which is small in comparison, as shown in Fig. 46. The five

varieties were selected on the basis of their acceptability as green and dry vegetables and of the nature of the flour they would produce.

In palatability tests flavor, color, size, general appearance, and field characteristics have been taken into account in giving first rank to vegetable types 81044-1, 81780, 85666, 87615, Higan Mame, and to the field type, Illini. It was a pleasing coincidence that the varieties which were considered most palatable also gave very high yields in the field. On the basis of palatability 32 of the 95 varieties were rated good, 43 fair, and 20 poor.

Several of the vegetable varieties were analyzed in both the green and mature states and showed no marked differences in proximate composition. All analyses were reported on the basis of 7 percent moisture content for comparisons. In Table 68 are shown figures for two

TABLE 68.—COMPOSITION OF TWO VARIETIES OF SOYBEANS AT SEVERAL STAGES OF DEVELOPMENT
(Calculated to moisture basis of 7 percent)

Variety	Degree of maturity for edible use	Protein	Fat	Ash	Carbohydrates	
					Total ¹	Fiber
<i>Green soybeans</i>						
81044-1, A.....	Premature	37.95	14.51	5.05	35.49	4.31
B.....	Satisfactory	36.44	13.44	4.63	38.49	3.72
C.....	Satisfactory	38.82	14.28	4.64	35.26	3.51
D.....	Satisfactory	39.73	15.79	4.92	32.56	3.59
E.....	Overmature	41.61	14.27	4.89	32.23	3.43
Illini, A.....						
B.....	Premature	37.30	13.11	3.83	38.76	4.43
C.....	Satisfactory	38.11	14.17	3.97	36.75	4.25
D.....	Satisfactory	39.29	16.54	3.91	33.26	4.11
E.....	Overmature	38.22	17.49	4.03	33.26	4.06
<i>Dry soybeans</i>						
81044-1.....	Mature	39.85	16.84	5.01	31.30	4.11
Illini.....	Mature	36.33	18.15	4.75	33.77	4.75

¹By difference.

varieties analyzed at several stages of development. An interesting point brought out by them is that most of the constituents have been laid down, and in about the final proportion, by the time the green beans are ready for table use. As they mature, the beans lose moisture and change in color, becoming either light tan, black, brown, or mottled.

Twenty varieties of yellow-colored soybeans were made into flour after the beans were preheated to remove their strong flavor. The flavor of the flour was better in the case of some beans than others, the poorest flavor coming in certain field beans which are now commonly used for flour purposes. The laboratory-made flours absorbed more water than some of the commercial soybean flours tested. This is a rather important point in view of the fact that soybean flour is used in some kinds of food manufacture because of its water-absorbing

capacity. All flours examined in the laboratory, whether commercial or experimental in origin, acquired unpleasant stale flavors after being stored three to four weeks. This reversion of flavor is a problem which the manufacturer has not yet solved successfully. (104 Home Economics)

Planned Spending Is Means of Obtaining Family Goals

Careful planning, coupled with home accounts kept in cooperation with the Experiment Station, has enabled account-keeping families to attain some of the goals in life. Thru studying and analyzing its own spending and saving and comparing them with a somewhat similar group average, each family has been helped to view its own situation and to evaluate its needs and desires. Studies of the records under Ruth Crawford Freeman, Home Economics, are also resulting in data useful in analyzing habits of consumption for different income groups and sizes of family and for establishing indexes by which different standards of living may later be measured.

Of the 300 home-account records received from thirty-one counties, 278 were sufficiently complete to use in this report. Two hundred sixteen were farm family records and 62 were records of town families.

An average of 15.7 percent more realized income was available for the 216 Illinois farm families in 1935-36 than for the 231 farm families keeping accounts in 1934-35. The increased money available made possible the purchase of modern conveniences in the home, labor-saving equipment, automobiles, college educations, and vacation trips. It would appear that choices in spending are being weighed in terms of satisfactions in living for the family.

The amount of increase in income was even greater if only the cash available for family use is considered. This amount of cash was 20 percent higher in 1935-36 than in 1934-35. This does not necessarily mean 20 percent increase in net income from the farm and other sources, but refers to the cash income that was available for living and family saving after farm investments, notes, and interest were paid. In 1935-36, 47 percent of the 216 farm families had a money value of living and savings of more than \$1,500, while only 40 percent of the 231 farm families keeping accounts in 1934-35 had such a realized income.

Whether the family was owner or tenant and the number of acres owned had a more definite influence on the money available for living in 1935-36 than in the immediately preceding years. In the group of families with less than \$1,500 realized income, 41 percent of the families owned part of the land they operated, with 80 acres the modal number owned. In the group with more than \$1,500 realized income, 51 percent of the families owned part of the land operated by them,

with 160 acres the modal number owned. Previous to this year this difference was not so apparent, because the owner families were burdened with mortgages. Many of these families were able to pay off or reduce the mortgage payments or to refinance them thru federal loans.

Life-insurance payments and other investments absorbed 9 percent of the income realized by the 216 farm families in 1935-36, as shown in Table 69, the percentage being the same as for the 231 families keeping accounts in 1934-35. The actual amount was higher, \$140 a family as compared with \$131 in 1934-35. The increased savings were used mainly for life-insurance premiums, which were nearly one-fourth more in 1935-36 than in 1934-35. In the lower realized-income groups the main type of savings was life insurance. However, the largest families in this group had less protection, a fact indicating that the income would not stretch sufficiently to include much for savings.

The average amount paid on debts by the 216 families in 1935-36 was \$115 in addition to \$51 interest paid. In the highest realized-income group, \$2,500 and more, an average of \$553 a family, was paid on the principal of notes and mortgages, besides \$84 interest.

The average total food cost a family for the 216 farm families in 1935-36 was 16 percent higher than for the 231 farm families in 1934-35. As the cost of food increased only 9 percent, the families were either consuming more food or buying a more expensive type of food. The purchased food records show that these families have been buying a more expensive type of food; they had refrained for the past several years from buying such foods as fresh fruit and also foods considered in the luxury class, such as olives. With more money to spend, they have purchased more food in both these classes.

A considerable part of the increase in total money value of food consumed has come thru the increased use of home-raised foods. With better gardens the families used more fresh and home-canned vegetables and fruits. It is rather surprising to see that the egg consumption a family in 1935-36 was reduced and meat consumption increased altho meat products have been relatively high in price. An average of ten dozen fewer eggs a family of four was consumed by the account-keeping families in 1935-36 than in 1934-35. This may be accounted for by the reduced stocks on hand owing to the drouth and high price of feed. The money value of home-produced meats, vegetables, and fruits, both fresh and canned, a family in 1935-36 was \$188 in contrast to \$124 a family in 1934-35. In money value the food produced on the farm in 1935-36 amounted to 64 percent of the total, the same proportion as in the previous year.

The per-capita cost of purchased food, not including raised food, for farm families according to realized-income groups, appears in Table 70. The range is from \$37 a person in the lowest income group

TABLE 69.—AVERAGE DISTRIBUTION OF REALIZED INCOME OF 216 ILLINOIS FARM FAMILIES IN 1935-36

Realized-income group	Number of families in group	Number of members a family	Total money value of living and savings (realized income)	Savings		Foods ¹ purchased and raised	Operating	Shelter ²	Clothing	General expenditures ³
				Life insurance	Other					
\$ 500 to \$ 999.....	20	2.9	\$ 846	\$ 36	\$ 6	\$362	\$ 64	\$200	\$ 56	\$122
1 000 to 1 499.....	94	3.9	1 250	78	3	496	87	242	104	240
1 500 to 1 999.....	53	4.2	1 760	128	17	606	123	343	155	388
2 000 to 2 499.....	27	4.7	2 197	150	16	660	162	441	194	574
2 500 and more.....	22	5.5	3 110	299	141	763	219	486	274	928
Average.....	..	4.2	\$1 645	\$117	\$ 23	\$558	\$116	\$313	\$141	\$377
Percentage.....	..	...	100	9		33	7	19	9	23

¹Purchased food, meals out, and retail money value of raised food included in these totals. ²These totals include the year's use value of the farm dwelling, cash repairs, furnishings, and equipment. ³General expenditures include auto, health, recreation, education, church, gifts, and personal, for all members.

TABLE 70.—AVERAGE CASH COST OF LIVING A PERSON IN 216 FARM FAMILIES, 1935-36

Realized-income group	Number of families in group	Per-capita cash expenditures	Purchased food	Cash operating	Shelter		Clothing	Auto and other transportation	Health	Recreation	Education	Church, community welfare, and gifts	Personal
					House repairs	Furnishings							
\$ 500 to \$ 999.....	20	\$131	\$37	\$18	\$ 3	\$13	\$19	\$16	\$ 7	\$ 4	\$ 4	\$ 6	\$4
1 000 to 1 499.....	94	165	40	20	6	12	27	23	10	4	8	10	5
1 500 to 1 999.....	53	231	51	27	8	19	36	30	18	6	14	14	8
2 000 to 2 499.....	27	287	53	33	14	25	41	41	21	9	23	19	8
2 500 and more.....	22	359	60	38	14	32	49	40	28	13	41	32	12

TABLE 71.—AVERAGE DISTRIBUTION OF CASH EXPENDITURES OF 216 ILLINOIS FARM FAMILIES IN 1935-36¹

Realized-income group	Number of families in group	Total cash expenditures	Purchased food and meals out	Cash operating	Shelter		Clothing	General cash expenditures				
					Cash repairs and fire insurance	Furnishings and equipment		Auto and other transportation	Health	Recreation and education	Church, community welfare, and gifts	Personal for all members
\$ 500 to \$ 999....	20	\$380	\$106	\$ 52	\$ 9	\$ 37	\$ 56	\$ 47	\$ 22	\$ 23	\$ 18	\$10
1 000 to 1 499....	94	643	156	77	24	45	104	90	39	50	38	20
1 500 to 1 999....	53	982	217	115	33	81	155	127	75	85	62	32
2 000 to 2 499....	27	1 361	254	155	66	120	194	195	98	150	92	37
2 500 and more....	22	1 990	332	211	80	172	274	223	155	299	178	66
Average.....	...	\$929	\$197	\$107	\$36	\$75	\$141	\$122	\$65	\$94	\$63	\$29
Percentage.....	...	100	21	12	4	8	15	13	7	10	7	3

¹This table does not include life-insurance premium payments and savings nor noncash commodities furnished by the farm.

—\$500 to \$999—to \$60 a person a year in the \$2,500-and-more income group.

Operating expenditures for these 216 farm families in 1935-36 (Table 69) took a slightly lower percentage of the total realized income than they did in the preceding year, but the families seem to be gradually acquiring more modern conveniences in the home. This may or may not increase the operating costs. Only one-fourth the group have modern homes, if modern is defined as including a furnace, electric or gas lights, and running water under pressure.

The expenditures for shelter, which are shown in Tables 69, 70, and 71, include those for housing, furnishings and equipment, and the estimated rental value of the farm dwelling. Expenditures for fixing up the farm home continue to be made on about the same scale as shown in the 1934-35 records. Altho, on the average, only \$36 a family was spent in 1935-36, this was a decided increase from the \$10 a year in 1932-33. At present most of the expenditures are for repair and upkeep rather than for major improvements. Inside paint, varnish, wallpaper, and general repairing are the most prevalent items of expenditures. Two running-water systems, four houses wired for electricity, two furnace installations, and several new porches were reported. These show the trend toward major improvements when money is available.

Furnishings and equipment expenditures recorded in the home-account books of 1935-36 show a decided increase over the previous year (Table 71). Besides many replacements such as dishes, curtains, sheeting, blankets, and repair of furniture, many large pieces of furniture and equipment were purchased. Fifteen refrigerators were bought by the group during the year, ten of these being electric and five ice. In the order of the total number of this type of purchases in all account books summarized, the items recorded in the home accounts of 1935-36 were: refrigerators, stoves, radios, mattresses, suites of furniture, washing machines, and pianos.

The amount of money used by the farm families for clothing is gradually increasing from the low point in 1932-33. A total of \$141 a family (Table 71) was spent by these 216 farm families in 1935-36, but this was still only 9 percent of the realized income—the same percentage as in 1934-35. The per-capita cost was definitely influenced by the realized-income level (Table 70). In the analysis of the allotment of the clothing money to the different members of the family, it appears that much of the increase over the amount spent in 1934-35 has taken place in clothing expenditures of homemakers in the realized-income levels of more than \$1,000. Table 72 gives, by realized-income level, the average clothing cost by sex and by age-group for children. These data include only the original cost of clothing, no allowance being made for gifts of garments or for garments worn by children of the family other than those for whom originally purchased.

TABLE 72.—CASH CLOTHING EXPENDITURES FOR 216 FARM FAMILIES KEEPING HOME ACCOUNTS IN 1935-36

Realized-income level	Husbands	Wives	Preschool age		Grade-school age		High-school age	
			Boys	Girls	Boys	Girls	Boys	Girls
\$500 to \$999.....	\$15	\$28	\$11	\$ 7	\$13	\$12	\$24	..
1 000 to 1 499.....	25	38	10	14	17	20	27	\$40
1 500 to 1 999.....	35	49	20	11	21	23	40	66
2 000 to 2 499.....	36	66	14	11	22	27	46	63
2 500 and more.....	50	80	19	25	25	27	53	76
Average of group.....	\$31	\$47	\$14	\$14	\$20	\$22	\$39	\$58

It would appear that on the average it costs more for the wife or older daughter to be as well dressed as the husband or older son on the same income level.

General expenditures in 1935-36 (Table 73) show an increase of 30 percent over those of 1934-35. This increase is exceeded only by that of furniture and equipment. The increase in transportation and educational expenses is the most noticeable in this group.

Transportation expense, which is mainly automobile expenses, has increased owing to the purchase of new cars. Seventeen percent of the 216 families either purchased a new car or traded for a later model. Twenty-nine new cars were purchased and eight cars were traded for a later model.

Educational expenditures increased more in the two higher income groups. From the group of 216 farm families there were 23 children in college in 1935-36, but the 23 are only about half the children past high-school age in these families.

Health expenditures were higher, as recorded for these families studied in 1935-36, than those recorded for the families studied in 1934-35. There was a surprising number of large expenditures for surgical operations, which raises the question as to whether this is a part of the toll of the depression.

Recreational expenditures for these 216 farm families have increased, altho the increase is mainly in the \$2,500-and-more realized-income group. A fairly large proportion of the families in all groups had some type of vacation trip, generally taken in the car.

Church and community-welfare contributions increased over previous years. No increase, however, was apparent in church giving.

Thus it would appear that with more money available for these farm families for living and savings, they have been interested in home improvement, inside and out, in better automobiles, and a general distribution of the money to gain more joy in living. They have not overlooked their savings program, for the majority held their life

TABLE 73.—AVERAGE DISTRIBUTION OF GENERAL EXPENDITURES BY 216 ILLINOIS FARM FAMILIES, 1935-36

Realized-income group	Number of families in group	Total general expenditures	Auto and other transportation	Health	Recreation	Education	Church and community welfare	Gifts	Personal for all members
\$ 500 to \$ 999.....	20	\$122	\$ 47	\$ 22	\$13	\$ 10	\$ 9	\$11	\$10
1 000 to 1 499.....	94	240	90	39	17	33	20	21	20
1 500 to 1 999.....	53	388	127	75	26	59	36	33	32
2 000 to 2 499.....	27	574	195	98	42	108	58	36	37
2 500 and more.....	22	928	223	155	73	227	127	57	66
Average.....	...	\$377	\$122	\$ 65	\$28	\$ 66	\$ 39	\$28	\$29
Percentage.....	...	23	7	4	2	4	2	2	2

insurance even during the years of minimum incomes. Payments of principal on notes and mortgages is increasing their net worth, as is the money going back into the farm business in the form of limestone, new tractors, and other equipment and improvements. (201 Home Economics)

Four-Year Records Show Changing Consumer Habits

A knowledge of trends in spending and of adjustments to changing income is important not only to the sociologist and historian, but also to the individual consumer. Many items in the family budget need to be purchased yearly, while others such as painting the house, buying overcoats, and the purchase of an automobile necessitate expenditure less often. These infrequent expenditures can be better considered and given proper weight if trends in spending under differing conditions are known.

For the purpose of ascertaining recent trends in family expenditures, Ruth Crawford Freeman, Home Economics, has analyzed a group of home accounts kept for a period of years by the same families. Records of 84 Illinois farm families for the four years 1932-1935 were available and used in this study.

Fig. 47 shows the comparative utilization of the realized income, which averaged \$1,349 in 1932, \$1,470 in 1933, \$1,622 in 1934, and \$1,849 in 1935. This trend of increasing realized income was true for 69 percent of the 84 families. For 5 percent of the families the realized income was less, for 5 percent it was about the same for all four years, and for 21 percent of the families the realized income fluctuated during the four-year period.

When the group was divided into thirds, according to realized-income level, it was found that thirteen of the families remained in the high third for all four years.

Utilization of the realized income by the 84 families showed an increase in all divisions of spending, but a decline in savings in 1935. The decline was not in the amount of money paid for life-insurance premiums, which increased from an average of \$125 a family in 1932 to an average of \$134 in 1935, but in other types of savings. It is not surprising that some of the other savings have declined, for in some cases they were made for specific purposes such as education of children or for home improvement.

The interesting finding from the food costs for these identical families when grouped by thirds was that the average daily cost of food per adult unit for the families in the low third was less than the daily cost per adult unit for the other two groups for all four years. Also this low third had used a higher percentage of raised food for all four years. So it would appear that in certain realized-income levels—in this case \$905 in 1932 to \$1,232 in 1935—there was a trend to con-

trol the cost of purchased food even with increasing income. But it is a surprise to see that food costs of the middle and high groups advanced so much more rapidly than the price-level change.

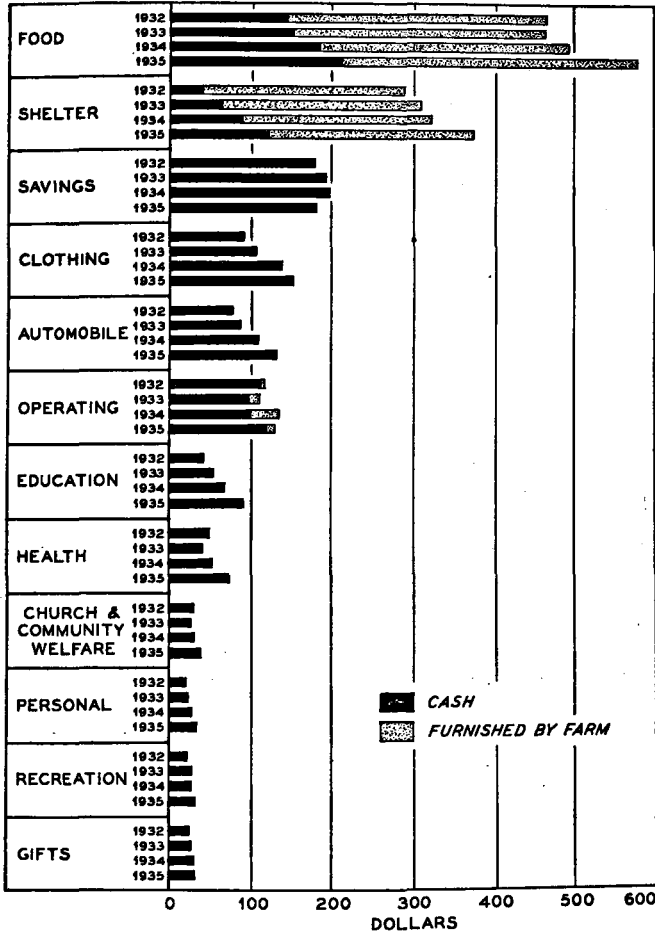


FIG. 47.—DISTRIBUTION OF MONEY VALUE OF LIVING AND SAVINGS BY 84 IDENTICAL ILLINOIS FARM FAMILIES FOR FOUR YEARS, 1932-33 TO 1935-36

Utilization of the realized income by the 84 families showed an increase in all divisions of spending but a decline in savings in 1935. However, the decline was not in the amount of money paid for life-insurance premiums, for these increased from an average of \$125 a family in 1932 to an average of \$134 in 1935.

The other divisions of expenditures which showed the greatest increase from 1932 to 1936 were shelter, transportation, and clothing.

If only the cash items of shelter, including repairs and furnishings, are considered, three times as much was spent for such items in 1935 as in 1932. In 1934 there was a trend for repairing the home which continued in 1935, but more money was spent in 1935 on equipment for the home than for repairs.

The most frequent major piece of equipment purchased in the home in 1934 was a stove, generally an oil stove or some type of gas stove. In 1935 the trend changed to electric stoves, tho still many gas stoves were purchased. Likely the opportunity to get electric service has influenced the type of stove purchased.

Refrigerators and washing machines were also among the pieces of major equipment frequently purchased by these families in 1935.

Even tho these identical families have used very little credit for buying for the home in the past, there seems to be a definite trend in 1935 to buy stoves, refrigerators, and washing machines on a payment plan. But large purchases, such as an automobile, are made at the time the crop is sold and are cash transactions.

As to the trend for purchasing automobiles for these families over the four-year period, none were purchased in 1932, one in 1933, eleven in 1934, and sixteen in 1935. Thus only one-third of the families of this group have had a new car or a later model during the four-year period, which may be taken as showing the need for longer-time records if the distribution cost of a new car or replacement allowance a year is to be known.

The records showing increased clothing costs in 1935 seem to indicate that the families bought more items of clothing but, with the exception of shoes, they did not pay a higher price an item. Since leather goods did not increase in cost in 1935, it would appear a better-quality article was purchased.

Many more coats and accessories were purchased in 1935 by these families than were purchased during the previous three years. (202 Home Economics)

THE YEAR'S PUBLICATIONS

BULLETINS

* Nine Bulletins were issued during the year, totaling 484 pages. All Bulletins record the investigational work of the Station. Some are immediately useful to those engaged in the production or marketing of agricultural products; others report economic and social phases of rural life; others are technical and of interest mainly to fellow investigators.

Value of Present-Day Swine Types in Meeting Changed Consumer Demand. Bulletin 415. By Sleeter Bull, F. C. Olson, G. E. Hunt, and W. E. Carroll. 40 pp.

Lespedeza in Illinois. Bulletin 416. By J. J. Pieper, O. H. Sears, and F. C. Bauer. 52 pp.

Fertilizer Requirements of Sweet Corn. Bulletin 417. By W. A. Huelsen and M. C. Gillis. 88 pp.

Factors Influencing the Refrigeration of Packages of Peaches. Bulletin 418. By J. W. Lloyd and S. W. Decker. 28 pp.

Inheritance of Resistance to Bacterial Infection in Animals: A Genetic Study of Pullorum Disease. Bulletin 419. By Elmer Roberts and L. E. Card. 32 pp.

Seed Treatments for the Control of Certain Diseases of Wheat, Oats, and Barley. Bulletin 420. By Benjamin Koehler. 80 pp.

Substitution of Commercial Fertilizers for Manure in Vegetable Production. Bulletin 421. By J. W. Lloyd and E. P. Lewis. 36 pp.

Prices of Illinois Farm Products From 1931 to 1934. Bulletin 422. By L. J. Norton and T. R. Hedges. 76 pp.

Forces Affecting Participation of Farm People in Rural Organization—A Study Made in Four Townships in Illinois. Bulletin 423. By D. E. Lindstrom. 52 pp.

CIRCULARS

Circulars are extremely varied in character. They may be small leaflets of advice, more extensive pamphlets on recommended agricultural practices, or manuals of instruction. They may even report tentative results of experiments, tho the reporting of finished results is the province of the Bulletin, as noted above. Nineteen Circulars were issued during the year in the combined Station and Extension series.

Recent Developments in the Utilization of Soybean Oil in Paint. Circular 438. By W. L. Burlison. 8 pp.

Fertilizer Treatments for Sweet Corn. Circular 439. By W. A. Huelsen and M. C. Gillis. 12 pp.

Feeding the Dairy Herd. Circular 440. By W. B. Nevens. 52 pp.

Fowl Cholera (Hemorrhagic Septicemia of Fowls). Circular 441. By Robert Graham. 8 pp.

Agricultural Outlook for Illinois in 1936. Circular 442. 32 pp.

Practical Sanitation for Apple Orchards. Circular 443. By M. D. Farrar, S. C. Chandler, H. W. Anderson, and V. W. Kelley. 24 pp.

Seed Treatments for Farm Crops. Circular 444. By Benjamin Koehler. 20 pp.

Sweet-Curd Cottage Cheese—Directions for Manufacturing With an Enzyme. Circular 445. By P. H. Tracy and H. A. Ruehe. 12 pp.

A Manual of Group Discussion. Circular 446. By Lyman Spicer Judson. 184 pp.

Directions for Spraying Fruits in Illinois. Circular 447. By W. P. Flint and H. W. Anderson. 28 pp.

New Wilt-Resistant Tomato Varieties for Field and Greenhouse. Circular 448. By W. A. Huelsen. 20 pp.

Avitaminoses in Animals. Circular 449. By Robert Graham, H. H. Mitchell, and Viola M. Michael. 16 pp.

Better Plowing. Circular 450. By Thayer Cleaver and R. I. Shawl. 40 pp.

Growing Tomatoes in Illinois—Problems in Producing for Market and Canning. Circular 451. By W. A. Huelsen. 28 pp.

A Manual for 4-H Poultry Club Members. Circular 452. By H. H. Alp and E. I. Pilchard. 32 pp.

Strawberry Culture in Illinois. Circular 453. By A. S. Colby. 52 pp.

Diseases and Insect Pests of Cabbage and Related Plants: Identification and Control. Circular 454. By L. H. Shropshire and K. J. Kadow. 48 pp.

Vegetable Exhibitions—Their Planning and Management. Circular 455. By Lee A. Somers. 28 pp.

Ants—How to Combat Them. Circular 456. By W. P. Flint and W. E. McCauley. 8 pp.

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¹Resigned November 30, 1935.

Soil Survey Analysis

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¹Resigned December 1, 1935.

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 W. A. Ruth, Chief, Pomological
 Physiology
 A. S. Colby, Chief, Small Fruit
 Culture
 H. W. Anderson, Chief, Pomologi-
 cal Pathology
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HOME ECONOMICS*(College and Station Research)*

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 ciate, Home Accounts

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INCOME AND EXPENDITURES

Expenditures

For Soils and Crops experiments, including the Soil Survey.....	\$129 113 86	
For Livestock investigations.....	132 314 62	
For Horticultural investigations, including Floriculture and Olericulture.....	68 020 20	
For Dairy investigations.....	50 821 10	
For Agricultural Engineering investigations.....	16 863 59	
For Agricultural Economics investigations.....	60 992 05	
For Home Economics investigations.....	12 113 41	
For Industrial Agriculture investigations.....	1 530 68	
For Administration.....	34 512 54	
For United States Bankhead-Jones (undistributed)...	<u>19 222 30</u>	
Total expenditures.....		<u><u>\$525 504 35</u></u>

Sources of Expended Funds

From Federal appropriations

Hatch fund.....	\$14 001 27	
Adams fund.....	15 000 00	
Purnell fund.....	60 223 43	
Bankhead-Jones (research) fund.....	<u>19 222 30</u>	\$108 447 00

From State appropriations

Budget appropriation by Board of Trustees.....	353 604 03	
From departmental sales.....	50 738 86	
From gifts from private sources.....	12 714 46	
Total.....		<u><u>\$525 504 35</u></u>

For a more detailed statement of receipts and expenditures, see printed report of the Comptroller, University of Illinois, for 1935-36.

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SUPPLEMENTARY LIST OF PROJECTS

Projects listed below have been included in previous annual reports but are not included in the main body of the report this year. On some of them the final report was made in the Forty-Eighth Annual Report and, accordingly, they will not be included in subsequent reports. The remainder of the projects in this list are those for which no new results are available for publication at this time.

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