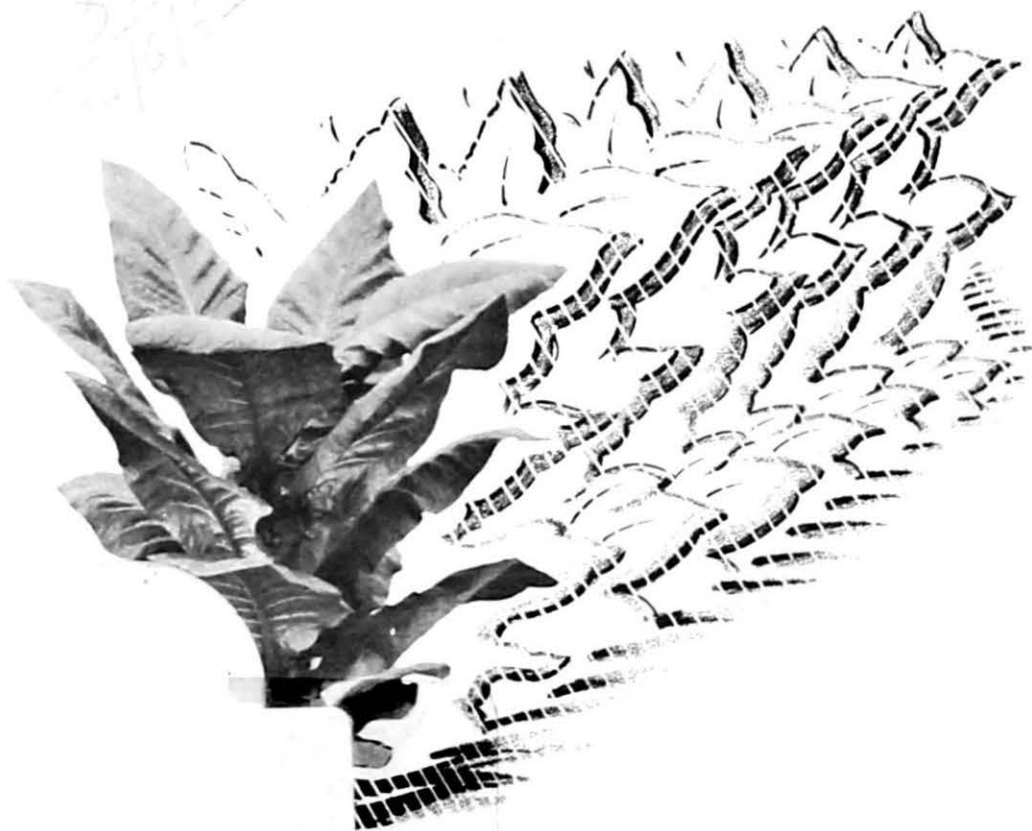


Wisconsin
TOBACCO SOILS
Their Fertility & Management



RAJ EXPERIMENT STATION
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WISCONSIN TOBACCO is produced in two major areas. The area north and west of the Wisconsin River is known as the Northern Wisconsin District. Most of the tobacco in this area is grown in Vernon, Crawford, Monroe, LaCrosse and Richland Counties with scattered acreages farther north in Trempealeau, Dunn and Chipewewa Counties.

The tobacco fields located on the ridges in this area are usually of the Tama and Fayette silt loam types, while those located in the valleys or on the "benches" are usually Waukesha silt or sandy loams.

The Southern Wisconsin District is concentrated in Eastern Dane, with some acreages in Columbia, Rock and

Jefferson Counties. A wide variety of soil types produce tobacco in this area, but the predominant types are the dark prairie Carrington silt loams and the lighter colored Miami silt loams.

Wisconsin tobacco is known as a cigar binder type. The same varieties of tobacco, planted in the two districts, produce tobacco recognized by the U. S. government as two distinct types. U. S. Type 54 is produced in Southern Wisconsin and U. S. Type 55 is produced in Northern Wisconsin.

Wisconsin tobacco is used by the trade in two ways. The better quality crops are used in the cigar trade and the leaf is especially suited for use as the "binder," which is wrapped

*Based on tobacco research conducted at the Wisconsin Agricultural Experiment Station over the past 20 years. Much of this work is reported in detail in Research Bulletins 141, 142, 148, 149 and 153. These studies are being continued and certain of the results reported here have not been previously published.

The writer wishes to acknowledge the generous cooperation of the Soils Department in providing laboratory facilities and personnel for much of the early chemical analyses reported in this bulletin, and for their continued interest and counsel on tobacco soil problems.

Grateful acknowledgement is also made to the more than 40 tobacco growers whose willing cooperation with land and labor made possible the continuance of these studies during the war years and later.

around the inside or "filler" of the cigar to hold it together and shape it.

The poorer quality crops or those with a large proportion of injured leaves are used in the manufacture of scrap chewing tobacco. At the time the leaves are stripped from the stalks on the farm, many crops are sorted into the better grades ("Sorting" or "Binders") to be sold as cigar leaf, and the poorer grades ("Stemming") to be sold for the manufacture of scrap chewing tobacco.

As long as tobacco has been grown in Wisconsin it has been thought, and rightly, that there was no better fertilizer for our tobacco fields than barnyard manure. The economy of the Wisconsin tobacco grower is very closely tied up with the dairy farm and a plentiful supply of animal manure. This tie-up has resulted in the Wisconsin grower having a distinct advantage over the growers in competing areas, because he produces upon his farm a major portion of his tobacco fertilizer.

The Connecticut grower, who produces a cigar type tobacco that competes directly with our Wisconsin tobacco, does not usually have available sufficient animal manures to maintain the organic matter supply in his soil. Instead he depends on a high priced organic form of commercial fertilizer which he must use in one to three tons per acre applications.

This high fertilizer cost in the Connecticut area sustains a relatively high price for the cigar binder grades of tobacco. This fact has given the

Wisconsin producer, in times of low stocks of cigar tobacco, a wide spread in price between the lower "Stemming" grades and the higher "Binder" grades. This possible high acre value of the crop has tempted growers to use all available animal manures on the land to be planted to tobacco. Many tobacco growers have thus exploited this tobacco-dairy combination to the detriment of the rest of the farm.

Much has been learned in the past 20 years about the amount of soil fertility needed and the balance of plant nutrients necessary to produce "Binder" quality tobacco in Wisconsin. In considering these problems we must keep in mind that the soil is not an inert material, but is teeming with life and is a dynamic everchanging substance.

The principal questions we must answer are these:

How can a tobacco soil be economically built up to a fertility level and balance of plant nutrients so that it will produce quality tobacco?

How may this be accomplished without exploiting the manure supply on the farm?

Once the desired level and balance are obtained, how can they be maintained economically?

With these questions in mind, let us review some of the results secured from experimental plots and some of the chemical analyses of our tobacco soils and of the tobacco produced on these soils for possible answers.

IS TOBACCO HARD ON THE SOIL?

THIRTY or forty years ago a very common expression among tobacco growers was that soils in certain

of their fields were "tobacco sick." It was generally felt that the soil was run down from having produced sever-

al crops of tobacco. When corn was grown on these soils, however, bumper crops resulted, indicating that the fertility was not depleted.

This was one of the early problems studied by the Experiment Station and it was found that the varieties of tobacco being grown were subject to a fungus disease causing a black root rot. This disease developed on some fields after three or four crops of tobacco had been grown.

As the problem was studied further it was found that cold, wet seasons were more favorable for the development of the fungus in the soil, and that some varieties of tobacco were more resistant to the disease than others. It was also found that if a soil had a certain degree of acidity (pH 5.8 or below), this black root rot disease fungus would not develop and these soils could produce many crops of tobacco.

This old idea that tobacco is hard on the land still persists but it is now known that the question is not one of soil fertility. The common varieties originally grown--"Comstock Spanish," "Havana No. 38," and "Seedleaf"--were susceptible to this disease. Today growers are using root-rot resistant varieties that have been developed by the Experiment Station, such as Havana No. 142, Havana No. 307 and Havana No. 322.

Even though these varieties are resistant, they are not entirely immune to the disease and under some conditions may be stunted by it. It is for this reason that we like to maintain a slightly acid condition (pH of around 6.0 to 6.5) in the tobacco soils. Liming is not recommended unless the soil is very acid, and then only enough to bring the pH up to around 6.0.

PLANT FOOD REMOVED BY TOBACCO CROP

HOW MUCH of the three major fertility elements does the tobacco crop, as compared to other crops, take from the soil? Table I lists the pounds per acre of these three elements removed from the soil by average yields of tobacco and four other crops.

When we compare these figures we find that tobacco is a moderate user of nitrogen, a very light user of phosphorus and a relatively heavy

user of potassium.

The important points to remember are that tobacco uses only a small amount of phosphorus, but must have large amounts of potassium. If we compare tobacco with corn we find that corn uses more nitrogen, much more phosphorus and about half as much potassium. The total of these three elements used by tobacco is 176 pounds, while the total used by corn is 188 pounds.

Table 1.

Plant Food Removed From the Soil by Various Farm Crops

Crop	Acre Yield	Pounds per Acre		
		Nitrogen	Phosphate (P ₂ O ₅)	Potassium (K)
Tobacco	1500 pounds cured leaf	67	13	96
Potatoes	150 bushels	45	20	60
Corn	60 bushels	96	36	56
Oats	35 bushels	50	20	43
Alfalfa	2 1/2 tons	100	43	149

TOBACCO NEEDS HIGH LEVEL OF FERTILITY

THE FIGURES in Table I would indicate that you could grow good tobacco on a soil that produces good corn. Tobacco growers know from experience that this is not necessarily true. They know that a good *yield* might be produced, but the possibility of producing good *quality* tobacco would be small. This is largely due to the short length of time, as compared with corn, that tobacco is growing in the field and feeding from the soil. Because of this fact tobacco requires a high or "luxury" level of fertility to produce the desired quality in the leaf.

Until 1930 little was known about the chemical analyses of Wisconsin tobacco soils. A general recommendation was followed that a fertilizer formula high in phosphorus was need-

ed, because it was known that our soils were low in phosphorus. We knew, also, that barnyard manures were low in phosphorus. A ton of good manure is considered to supply about ten pounds of nitrogen, five pounds of phosphoric acid, and 8.3 pounds of potassium. Accordingly the combination of manure with a 2-12-6 commercial fertilizer was thought to provide about the right balance for the production of tobacco.

We now have chemical analyses of a large number of our tobacco soils and the leaf produced on them over a period of years. This information has changed many of our ideas about the fertility needs of tobacco and has made it possible to develop more accurate fertilizer recommendations for the crop.

WHAT TOBACCO SOILS CONTAIN

IN TABLE 2 we have the average analyses of nearly 200 tobacco soils showing the total nitrogen, available phosphorus, and available potassium.

The Northern District is noted for its "valley" tobacco; and over the years, one of the easily measured points of cigar tobacco quality, the "burning" quality or the ability of the

cured leaf to hold fire, will average about twice as good for the tobacco produced in this district as for that from the Southern District. The reason for this difference is found in the higher content of nutrients, especially potassium, of the tobacco soils of the Northern District.

In the lower half of the table are given the average analyses of 29 old

Table 2.
Average Analyses of Wisconsin Tobacco Soils

Number of fields and area included in average	Pounds per Acre		
	Total Nitrogen	Available Phosphorus	Available Potassium (K)
95 Northern District	3,987	172	520
95 Southern District	3,168	90	328
29 Old Tobacco Fields (Northern District)	4,126	247	643
14 First Year in Tobacco (Northern District)	4,031	62	325

tobacco fields that had raised at least five consecutive crops of tobacco. Several of these fields have raised tobacco year after year for 30 to 40 years.

For comparison the average analysis is also given of 14 fields that had been in rotation for several years and had just returned to the first year of tobacco in the rotation. These two groups were selected from the 95 Northern District soils given in the upper part of the table.

The high average analysis for available phosphorus and potassium on the old tobacco fields represents that "luxury" level of fertility needed for

tobacco, and explains why, in Wisconsin, the best quality tobacco is usually produced under a system of continuous culture.

The low available phosphorus on the first year tobacco fields explains why the use of a 2-12-6 formula gives good growth response on fields new to tobacco, but does not show up so well on the old tobacco fields. In fact, if fertilizer applications show up strikingly on the growth of tobacco on an old field, it is an indication that the field has not yet reached that luxury level of fertility needed to produce quality binder tobacco.

FERTILIZER NEEDED TO MAINTAIN SOIL FERTILITY _____

TO TRY TO LEARN what fertilizer practice would best maintain or build soil fertility under continuous tobacco cropping, a ten year experiment was set up in 1929 on the East Hill Farm at Madison. These plots were located on a typical Miami silt loam soil that had been used as a sheep pasture for many years and was in a good state of fertility.

In Table 3, the analysis of this

soil at the start of the experiment showed it to contain 3000 pounds per acre of total nitrogen, 140 pounds of available phosphorus, and 477 pounds of available potassium. If we compare this analysis with that of the tobacco fields in Table 2, we see that it compares favorably.

The fertilizer treatments given in the first column were applied to the same duplicate plots each year. The

Table 3.

Effects of Different Fertilizer Treatments on Soil Fertility After Ten Crops of Tobacco 1929 - 1938

	Pounds per Acre			
	Ten Year Av. Yield	Total Nitrogen	Available Phosphorus	Available Potassium (K)
At Start 1929		3,000	140	477
Fertilizer Applied Each Year				
40 Tons Mamre	1,835	4,120	358	951
20 Tons Mamre	1,772	3,105	182	637
1000 pounds 4-10-6	1,873	2,110	167	258
10 Tons Mamre	1,642	2,475	127	404
500 pounds 4-10-6	1,575	2,220	134	387
10 Tons Mamre Plus 500 pounds 4-10-6	1,725	2,560	137	387
No Fertilizer	1,518	2,183	104	214

average yield per acre of the cured leaf over the ten year period is given in the next column.

On the "No Fertilizer" plots and those with the smaller fertilizer applications, high yields were maintained for about three years. Then the yields began to decline and at the end of the experiment the "No Fertilizer" plots produced a yield of only 1100 pounds, while the heavy manure plots were still producing high yields.

The soil analyses are of soil samples taken at the end of the ten year period. After producing ten crops of tobacco we find that the annual 40 ton application of manure increased the total nitrogen content of the soil by $\frac{1}{3}$, more than doubled the available phosphorus, and doubled the available potassium. The 20 ton annual application of manure maintained and slightly increased the total soil fertility. The ten ton manure treatment was not enough to maintain soil fertility. Commercial fertilizer alone at the rates applied did not maintain soil fertility except for available phosphorus. The only plots that dropped appreciably in available phosphorus were the "No Fertilizer" treatments.

There appears to be an inconsistency in the results of the soil analyses from the 1000 pound and 500 pound per acre commercial fertilizer applications. Even though twice the application of nitrogen and potassium was made, the total nitrogen and available potassium analyses are less for the 1000 pound treatment than for the 500 pound. During the ten year period the 1000 pound fertilizer plots produced half a ton more of cured leaf and over half a ton more of stalks than the 500 pound treatment. By stimulating the growth and not supplying enough fertility to compensate

for this increased growth this treatment actually brought about depletion of the soil faster than the smaller rate of application.

On the basis of the net value of the tobacco produced—that is, the value of the tobacco minus the value of the manures and commercial fertilizers applied—we find that over the ten year period the 20 ton manure applications produced a net return of \$77 per acre per year more than that produced by the "No Fertilizer" treatment. The 40 ton manure applications, and the ten ton manure plus 500 pounds commercial fertilizer applications produced net returns of \$57 and \$53 respectively higher than the "No Fertilizer" plots. The ten ton manure applications, and the applications of commercial fertilizer only gave net returns over the "No Fertilizer" treatments of about \$25.

The tobacco produced on these plots and also that from other plots where heavy applications of manure alone were used over a period of years, developed more damage such as pole sweat and stem rot in the curing shed. This damage is undesirable and can be largely avoided by the use of less manure supplemented with commercial fertilizer.

Shed burn appeared to a greater extent on tobacco from the low fertility plots.

From the results of this ten year experiment we may draw these conclusions:

1. Over a period of years heavy applications of manure are wasteful.
2. To maintain a satisfactory level of fertility under continuous culture, an annual application of 12 to 15 tons of manure plus 800 to 1000 pounds of commercial fertilizer is

necessary. If the level of soil fertility needs to be built up, heavier applications of both manure and com-

mercial fertilizer will be needed for a period of three to five years.

EFFECTS OF PHOSPHORUS ON YIELD AND QUALITY _____

FROM 1938 through 1942 a series of tobacco fertilizer plots were maintained at the Vernon County Farm, one mile north of Viroqua. These plots were located on a field that had not produced tobacco for ten years. The soil type is typical of the dark prairie silt loam found between Viroqua and Westby. These soils are known to produce good yields of relatively poor quality tobacco, especially after they have been in rotation a few years. The soil analysis of this field was 5000 pounds per acre of total nitrogen (high), 75 pounds of available phosphorus (low), and 187 pounds of available potassium (low).

In Table 4 the effects of superphosphate fertilizers on yield and quality of the tobacco are described. The superphosphate was applied alone and in combination with sulphate of potash. These commercial fertilizer treatments are compared with like treatments supplemented with ten tons of manure.

In each case (both with and without barnyard manure) the 1000 pound application of 16% superphosphate produced the largest yields. The addition of sulphate of potash to the

formula did not increase the yields, and where heavy applications of potash were applied alone, we actually had a reduction in yield as compared with the "No Fertilizer" plots.

The numerical figures given under "quality index" are ratings which will be used in other tables and are the result of carefully sorting each leaf of the tobacco from a plot into 13 different classifications. The figure given in the table is the result of giving each leaf classification an arbitrary numerical value, multiplying that value by the percentage (by weight) of leaf in that classification, and adding the resulting figures for the entire plot. If every leaf produced on a plot was a fancy binder of light color, the quality index would be 1,000. Such a quality index would be impossible for all of the leaves of a tobacco crop.

We might compare this quality index to the batting average of a baseball player. If the player hits every time at bat, his average would be 1.000. This is possible if he is up to bat only once or twice, just as one or two leaves of tobacco could rate a quality index of 1,000, but if

Table 4.
Phosphorus Effect on Yield and Quality of Tobacco -- Vernon County Plots
Average 1939 and 1940 Crops

Fertilizer Applied Per Acre	Yield Cured Leaf	Quality Index
10 Tons Mamre plus 1000# 0-16-0	2,286	.243
10 Tons Mamre plus 1000# 0-16-20S	2,184	.348
10 Tons Mamre plus 1000# 0-0-20S	2,121	.375
No Mamre -- 1000# 0-16-0	2,173	.188
No Mamre -- 1000# 0-16-20S	2,104	.322
No Mamre -- 1000# 0-0-20S	1,794	.289
No Fertilizer	1,812	.184

we take a season's average a batter has to be good to bat .400. We find that a quality index of .500 represents an excellent quality binder leaf crop, and the division between the binder and stemming grades falls at an index of about .350.

In Table 4 it is interesting to note that the quality index of the tobacco from the "superphosphate only" applications, both with and without manure, are the lowest of any of the treatments, except of course the "No Fertilizer" plots.

Where potash is added in the manure series, increases in quality

are very apparent. The "superphosphate only" treatments produced tobacco plants that showed potash starvation symptoms on the lower leaves shortly before topping time.

On this same field it took five years of fertilizing with 20 tons of manure plus 800 pounds per acre of a 3-9-18S fertilizer before a good leaf burn was produced. Along with this fact it should be noted that in the area where this treatment was applied, the soil analysis was about 228 pounds per acre of available potassium at the start, while after five years of treatment it analysed 498 pounds.

EFFECTS OF POTASH ON QUALITY AND BURN OF TOBACCO _____

IN A SERIES of plots at Utica, near the center of the largest acreage in Dane County, an attempt was made to determine the balance of phosphorus and potash we should have in our tobacco fertilizer analysis to produce an improvement in the leaf quality and especially in the burn. These plots were located on an old tobacco field typical of the dark silt loam prairies of Eastern Dane County. This particular field had not been producing good quality tobacco. The soil analysis was 4800 pounds per acre of total nitrogen (high), 65 pounds of available phosphorus (low), and 374 pounds of available potassium (medium).

In Table 5 the average results of duplicate plots are given to show the effect of increasing the amounts of potash in the fertilizer on the weight of cured leaf per acre, the quality index, and the seconds burn of the tobacco produced. Each of the five treatments received 18 tons of manure per acre. The different plots received 800 pounds per acre of a standard fertilizer with the amount of potash varied from 0 to 27%.

The potash was supplied as sulphate of potash. The figures on burn represent the average of 60 tests made on 20 middle-of-the-plant leaves selected from 20 plants grown on

Table 5.
Effect on Tobacco of Added Potash in the Fertilizer
(Utica Plots -- 1942 Crop)

Fertilizer Applied Per Acre	Yield Cured Leaf	Quality Index	Seconds Burn
18 Tons Manure plus 800# 3-9-0	1,956	.368	3.5
18 Tons Manure plus 800# 3-9-9S	2,068	.412	4.4
18 Tons Manure plus 800# 3-9-18S	2,108	.445	6.4
18 Tons Manure plus 800# 3-9-27S	2,020	.418	6.6
18 Tons Manure Only	1,900	.418	3.5
No Fertilizer	1,615	.281	2.0

each plot. A test was made at the tip, middle and base of each leaf. To make a test a cured leaf is stretched out and held against a red hot electric wire until it is ignited; it is then removed and the number of seconds it will continue to glow is counted by the aid of a metronome set for a one second beat. All burn data given in this bulletin are for unsweated tobacco.

The data in Table 5 are for the 1942 crop. The plots had been fertilized with the same treatments in 1940 and 1941 and had grown a crop of tobacco each of those years. Notice that with each increase in potash the yield and burn made regular increases up to the point where the potash percentage was double the phos-

phate percentage in the fertilizer. The quality shows a similar trend, but is not so consistent in following the increase in potash.

When the potash is increased to 27% in the formula, there is no increase in the yield and quality, and the slight increase in the burn is not enough to pay for the cost of the extra potash applied.

On this field, which was in a fair state of potassium fertility, the 3-9-18S formula at 800 pounds per acre along with 18 tons of manure gave a balance of fertility that increased the yield, quality and burn to a good binder crop and at the same time built up the available soil potash in a three year period.

THE EFFECT OF CHLORIDES ON LEAF-BURN

IT HAS BEEN KNOWN for almost a century that chlorides of any salt applied as a fertilizer would have a detrimental effect on the burning quality of the tobacco produced. In 1885 a pamphlet was published here in Wisconsin by F. W. Coon, editor of the Wisconsin Tobacco Reporter at Edgerton, in which he quotes statements telling about the wonderful growth of tobacco after the application of common table salt, but warning that it is very harmful to the burning quality of the tobacco. Common table salt is sodium chloride, while the cheaper potash fertilizer is potassium chloride.

Chlorine belongs to a group of elements that are usually found in plants, but it is not known to be absolutely necessary for the growth and development of the plant. The tobacco plant seems to take it up in unlimited quantities in proportion to the amount available in the soil. Small

amounts of chloride seem to have a beneficial effect on the growth of the tobacco in the field, and if the potash content of the leaf can be maintained at five to six times the chloride content, the burning quality of the tobacco will be good.

On another series of plots at Utica an application of ordinary 3-9-18 corn fertilizer was made. Corn fertilizer differs from a tobacco fertilizer in that the potash is in the "muriate" or "chloride" form instead of the sulphate form. Potash as it is taken from the mine is in a crude "muriate" form. The purified muriate salt must be given an additional chemical treatment to produce the sulphate form, and this makes the cost about \$10 to \$15 a ton more.

Naturally, unless there is a good reason, the manufacturers will make the mixed fertilizers from the cheaper more abundant supply of muriate of

Table 6.
Chloride Content and Burn of Leaf Fertilized With Different Amounts of
Chlorides - Utica Plots

Fertilizer Applied Per Acre C. F. 800 Pounds	% Chloride			Seconds Burn			Av. Soil (K)
	1940	1941	1942	1940	1941	1942	1942
3-9-18M (Muriate) 1940							
3-9-18S (Sulphate) 1941-42	2.85	0.49	0.23	1.4	1.5	3.0	548
3-9-18 1/3M 2/3S 1940-41-42	0.95	1.15	1.53	2.3	1.3	1.9	505
3-9-18S 1940-41-42	0.26	0.16	0.17	5.9	1.6	4.9	370
33 Tons Manure 1940-41-42	0.94	0.85	1.08	5.2	2.0	10.8	668
No Fertilizer 1940-41-42	0.24	0.15	0.16	3.7	1.3	1.7	313

potash. So unless there is an S after the potash figures in the formula, or unless it is specifically stated that the potash is in another form, all of the common fertilizers you buy will have the potash in the cheaper "muriate" or "chloride" form.

In Table 6 a comparison is given of how different amounts of chloride of potash applied as a fertilizer affect the chloride content and burning qualities of the leaf over a three year period.

These plots were located on the same field at Utica as those in Table 5. Their object was to learn what a 3-9-18M formula, with all the potash in the "muriate" or "chloride" form, would do to the burning quality of the tobacco, and how long that effect would last if the regular tobacco 3-9-18S formula was used on the soil in following years.

In comparison with this treatment a second treatment had a formula with one-third of the potash in the muriate form and two-thirds in the sulphate form.

A third treatment had the regular 3-9-18S tobacco formula, with all the potash in the sulphate form.

The fourth treatment was a heavy application of 33 tons of barnyard manure.

The amount of chloride in the

leaf and the burning quality of the tobacco indicate that under the conditions of this experiment most of the chlorides applied were taken up by the tobacco and adversely affected the burning quality of the leaf. The results obtained from the heavy manure application show that even though the chlorides were increased, the potash applied was enough so that the available potassium, especially the third year, counterbalanced the detrimental effect of the chlorides on the burn.

The burn of the tobacco from all of the plots on this field was poor in 1941. This was caused by a very dry growing season. The treatments in Table 5 had produced tobacco with almost 3.5% potassium in 1940, but in 1941 it dropped to about 2.3%. In 1942, however, a year of good rainfall, these same plots produced tobacco with about 3.75% potassium.

This point emphasizes the effect of a dry season on the quality of the crop. In a dry season there is no leaching of the nitrogen and chlorine, elements which, if in excess, are detrimental to the general quality as well as the burning quality of the leaf. Also in a dry year the potassium is less available to the plants, and we find the crop has a lower potassium content even though the potassium may be in the soil.

This balance between the chlo-

rides and potassium is important in its effect on the burning quality of the tobacco, and in order to understand the problem of improving the burning quality of the crop it is necessary to realize that the balance between the two, instead of any exact percentage of either in the leaf, determines the effect on burn.

During the war years, detailed plots were abandoned and demonstrations were set up on about 20 farms throughout the two tobacco growing districts. It was thought that demonstrations could now be made of how the quality, especially the burning quality, of the tobacco crop could be improved by the use of tobacco fertilizers and sulphate of potash. The

plan was to apply regular tobacco 3-9-18S and sulphate of potash in strips cross-wise of the rows on demonstration fields.

The whole field was to be fertilized completely with manure and commercial fertilizer as the grower planned for his crop. The demonstration strips were then extra, over and above, the regular fertilizers. The regular tobacco 3-9-18S was purchased and applied at two rates of 500 and 1000 pounds per acre. The sulphate of potash, because it is a fine powder and would not flow properly in the drill, was mixed with just enough 20% superphosphate so that it would flow at the regular rate. This mixture gave a formula of 0-7-33S.

Table 7.
Average Results of Four Fertilizer Treatments on the 1945 Tobacco Crop on Four Vernon County Farms

Fertilizer Applied Per Acre	Pounds Per Acre Cured Leaf	Available Potassium Pounds Per Acre	Percentage Potassium In Leaf	Seconds Burn
1000# 3-9-18S	2058	613	4.3	1.4
500# 3-9-18S	2030	525	3.8	1.9
500# 0-7-33S	1936	580	3.7	4.9
No Extra	1892	424	3.5	4.9

The data given in Table 7 are the results obtained on the 1945 crop, the third crop produced on the plots receiving these treatments each year, and are the average of these treatments on four Vernon County farms. As was expected the fertilizers increased the yields. The available soil potassium and the potassium content of the leaf were increased by the fertilizers. Yet the burn was good on the plots which had no extra fertilizer and on the 0-7-33S treatment, but was poor on those which had the 500 pound 3-9-18S treatment and even lower on the 1000 pound application. Approximately the same results were obtained on these same plots in 1946.

The commercial fertilizers used on these plots in 1945 and 1946 were al-

so used in greenhouse tests, where they greatly reduced the burn as compared with similar 3-9-18 mixtures made up in the laboratory using a commercial grade of sulphate of potash as the potash source.

In cooperation with the State Fertilizer and Feed Laboratory these three fertilizers were analysed. The commercial 3-9-18S fertilizer used in the greenhouse and on the demonstration plots analysed 5.6% and 6.2% chloride, while the mixture made up in the laboratory analysed 1.1% chloride. The sulphate of potash used in compounding the laboratory 3-9-18S analysed 2.3% chloride.

A search of the Wisconsin fertilizer regulations revealed that there was no regulation of the amount of chlorine

in the tobacco fertilizers. Although it was more or less taken for granted that a tobacco fertilizer would be compounded of sulphate of potash, there was no requirement that it must be. Due to the war conditions and the increased demand for all types of fertilizer, the production of sulphate of potash had almost stopped. Some manufacturers discontinued tobacco fertilizer production or restricted production to the amount they could produce from available supplies of sulphate of potash. Other manufacturers substituted muriate of potash for sulphate of potash that they normally used in tobacco fertilizers.

Through the Wisconsin Tobacco Dealers and Growers Association, which had consulted with the Experiment Station on how to stop the sale of corn and grain fertilizers for use on tobacco fields, a request was made to the State Department of Agriculture and Markets for a hearing on the regulation of the chlorine content of tobacco fertilizers.

After the hearing a new regulation was put into effect on February 1, 1948, which protects the buyer from obtaining a fertilizer for tobacco that has a high content of chlorine. The new regulation requires that no fer-

tilizer be sold for use as a tobacco fertilizer unless its brand name or label clearly indicates that it is suitable for such use and its label bears a statement of maximum chlorine content, which shall not exceed two per cent (2%).

Subsequent analyses of the chlorine content of the tobacco leaf and soil samples from these demonstration plots indicated that the major factor in the poor burn obtained from the 3-9-18S fertilizers was excessive chlorine. Two of these Vernon County fields have been selected because both produced tobacco of high potassium content and yet the burn of the tobacco produced by the same treatment varied greatly. Table 8 gives the soil and leaf analyses for potassium and chlorides, along with the burn of the cured leaf produced in 1945 on these two fields. The soil treatments are the same as those in Table 7 and a question mark is placed after the 3-9-18S formula, because we now know that these fertilizers actually contained 6% chloride.

The available soil potassium analyses show that these fields have that luxury level of fertility that was mentioned earlier. The leaf analyses, all of them near 5% of potassium, show

Table 8.

Comparison of Leaf-Burn and the Chloride and Potassium Content of the Tobacco with the Available Chloride and Potassium in the Soil (2 Vernon County Farms, 1945)

Fertilizer Applied Per Acre	Pounds Per Acre in Soil				Per Cent in Cured Leaf				Seconds Burn	
	Available Potassium (K)		Available Chlorides		Potassium (K)		Chlorides			
	Farm B	Farm J	Farm B	Farm J	Farm B	Farm J	Farm B	Farm J	Farm B	Farm J
1000 lbs 3-9-18S (?) *	834	887	87	78	5.4	5.2	1.9	2.8	2.7	1.6
500 lbs 3-9-18S (?) *	872	850	52	78	5.1	5.3	1.5	2.3	3.8	1.6
500 lbs. 0-7-33S	864	720	23	47	4.5	5.1	0.4	1.1	11.8	3.4
No Extra Fertilizer	820	588	14	44	4.9	4.7	0.4	1.2	13.3	3.3

* Although these fertilizers were labeled as containing potash in the sulphate form, they actually contained 6% of chloride.

that the crop took up that luxury level of potassium.

The greatest differences appear in the chloride analyses of both the soil and the leaf. On the "No Extra Fertilizer" plots there is a difference of 30 pounds of chlorides in the soils of Farm B and Farm J. This was due to the fact that on Farm B no commercial fertilizers had been used on this field for the past four years except on the plot areas. On Farm J, 400 to 600 pounds per acre had been applied annually to the field for several years.

The chloride content of the soil increased slightly with the applications of 0-7-33S, but increased very greatly with the applications of the 3-9-18S (?). The chloride content of the leaf is roughly proportional to the soil chlorides. Where the available soil chlorides are about 20 pounds per acre, the leaf chlorides are less than 0.5%. Where the soil chlorides approach 50 pounds, the leaf chlorides are 1 to 1.5%. Where the soil chlorides are above 70 pounds, the leaf chlorides are 2% or above.

A free burn of 11 and 13 seconds was obtained on only two of the eight plots. These were both on Farm B. The same treatments on Farm J gave only a passable burn of three seconds. Where the 3-9-18S (?) was applied, the burn was proportionately reduced on each farm.

These figures further emphasize the fact that the burning quality of the tobacco is due mainly to the balance of the potassium content of the leaf (which improves the burn) with factors harmful to the burn (chlorides, in this case).

Other soils and leaf analyses of greenhouse and field tests indicate that about 30 to 50 pounds of chlorides per acre may be added annually to average Wisconsin tobacco soils in the farm manures and commercial fertilizers without great injury to the burning quality of the tobacco produced, provided the soils do not already have more than 25 or 30 pounds of available chlorides and the season has a normal amount and distribution of rainfall.

If the soil is sandy or has a low available potassium content (less than 500 pounds per acre) and the season is below normal in rainfall, additions of 50 pounds of chlorides per acre may produce poor burning tobacco.

If the season is above normal in rainfall and the soil is sandy or has good subsoil drainage, relatively large applications of chlorides will be leached from the soil by midseason and the chloride content of the leaf may be low. The poor subsoil drainage of such soil types as the Clyde silt loam may be a factor in the retention of the chlorides in the root zone of the tobacco crop, so that if tobacco is grown on these soils special care must be taken not to apply excessive chlorides.

The ordinary application of farm manure and commercial fertilizer may put 40 to 60 pounds of chlorides on tobacco fields. With the tobacco fertilizer regulations now in effect we know that its chloride content will not exceed 2%. In every 100 pounds of this fertilizer there will be applied two pounds of chlorides. In 1000 pounds we would apply 20 pounds of chloride.

MANURES MAY BE HIGH IN CHLORIDE

IN THE PAST we have assumed that the barnyard manure we applied to our tobacco fields contained on the average 0.5% chloride in the dry matter. If we calculate the amount of chloride on the basis of the wet manure, with the average barnyard manure containing about 80% moisture, we would find that a ton will contain about two pounds of chloride. If we apply 15 or 20 tons of manure per acre, we will apply 30 or 40 pounds of chloride.

Many farmers measure the manure application by the number of loads hauled on an acre. Our manure spreaders vary in size, the usual sizes being rated as 60 bushel, 80 bushel and 100 bushel. A bushel of average manure will weigh 50 to 60 pounds. A person could roughly calculate the tons of manure applied as one and one-half tons for a 60 bushel, two tons for an 80 bushel, and two and one-half tons for a 100 bushel spreader load. If the capacity of the spreader is not known, a rough measurement of the length, width, and depth of the box will give the cubic foot volume, which divided by 1.24 will give the approximate ca-

capacity in bushels.

In 1941, analyses of eight samples of manure gave a chloride content of 0.49% of the dry matter. In 1949, 20 samples averaged 0.57%, and on a number of the farms from which the samples were collected, where large quantities of commercial fertilizers were being used, the chloride content was much higher. More samples were collected in 1950 on which definite information was obtained about the use of fertilizers on the entire farm.

From the State Fertilizer and Feed Laboratory, tonnage figures show that for 1937-38-39 Wisconsin farmers annually used 44 thousand tons of commercial fertilizer. The average tonnage used each year in 1947-48-49 was 368 thousand tons, or almost eight and one-half times more than ten years before.

The analyses of the manures collected in 1950 are given in Table 9. The average analyses are grouped according to the amount of commercial fertilizer used on the general farm crops and according to the tobacco growing district in the state in which

Table 9.
Average Analysis of Manures Produced on 50 Wisconsin Tobacco Farms 1950

District	Number of Samples	Average Tons Commercial Fertilizer Used	Pounds in 20 Tons Wet Manure	
			Chloride	Potassium
Manure on Farms using <u>less</u> than five tons commercial fertilizer each year				
Southern	14	2.2	36.5	131
Northern	10	1.8	30.3	103
Total	24	2.1	33.9	119
Manure on Farms using <u>more</u> than five tons commercial fertilizer each year				
Southern	15	10.7	50.4	144
Northern	11	6.4	45.7	131
Total	26	8.9	48.3	138
Manure storage (From above farms using <u>more</u> than five tons commercial fertilizer)				
Pen Barn	6	9.2	83.5	222
Yard Pile	20	8.8	39.8	117

the farms were located.

There is an indication that less fertilizer is used on the Northern District farms; this is especially evident in the group of farms that use more than five tons of fertilizer per farm.

The average chloride content of the dry matter of the 50 samples was 0.56%. The range of chloride content was from 0.22 to 1.84%. The average potassium (K) content of the dry matter was 1.77% and the range was from 0.72 to 3.67%. The per cent of a nutrient in the dry matter of the manure does not give a true picture of the problem, because the percentage of moisture in these manures varied from 70.1 to 85.3%. To indicate the amount of nutrients that would be applied with an average application of the manure to an acre of land, the pounds of chloride and the pounds of potassium in 20 tons of the wet manure are given.

On the basis of the wet manure content there is 42% more chloride and 17% more potassium in the manures produced on farms using more than five tons of commercial fertilizer than in those from farms using less than five tons of fertilizer.

From the more-than-five-ton group of farms, there were six farms that produced and kept the manure in pen barns. In comparison with the other 20 farms of this group, the pen barn manures contained 110% more chloride and 90% more potassium.

These figures indicate that increasing amounts of commercial fertilizers containing chlorides are being used on many Wisconsin tobacco farms. This element is readily absorbed from the soil by most farm crops, and often is present in substantial amounts in the harvested portion. Where these crops are fed to

livestock, large amounts of chloride may be present in the manure. The more progressive the farmer is in the use of commercial fertilizer on his farm, and the better care that is taken in the preservation of the nutrients in the manure, the greater the quantity of chlorides the manure may contain.

On these farms, if the practice is followed of using most of the available manure on the tobacco crop, there is the possibility of funneling chlorides used on other crops on to tobacco fields where they are not wanted.

On small farms where tobacco is the chief cash crop, it may pay to use only the low chloride tobacco fertilizers on all the crop land in order to reduce the chlorides in animal manures so that the usual 20 to 30 tons to the acre may be applied annually to the tobacco fields. The tobacco crop will take up a large proportion of the chlorides applied to the soil if they are not leached out of the root-zone of the plant by heavy rains. Although the figures indicate that usually there is also more potassium in the manures that contain high amounts of chlorides, it is important to remember that up to half of the potash applied to the heavier silt loam soils (typical tobacco soils) becomes fixed and is not readily available to the crop.

From available data it would seem that for the production of better burning tobacco in Wisconsin it would be far more economical to control the amount of chloride applied to the tobacco soils than to attempt to build the available potash in these soils high enough to overcome the detrimental effects of the chlorides. Some growers intentionally leach the manure produced on the farm by spreading it out in low, widespread piles for sever-

al weeks before putting it on the tobacco field. This practice may leach the chlorides, but it will also leach the nitrogen and potassium as well. From a conservation standpoint such

a practice could not be recommended. Such a practice would be a wasting of the farm manure value and most certainly would prove very costly.

MAINTAINING SOIL ORGANIC MATTER

IF A GROWER finds that moderate or heavy applications of manure are producing poor burning crops of tobacco, he may have to devise other ways of building or maintaining the organic matter in his tobacco soils.

One of the best ways of doing this is by sowing winter rye as a cover crop in the fall and plowing it under as a green manure in the spring. It is best to sow the rye the last half of September. Too early a sowing may cause too heavy a growth in the fall so that it will winter kill.

If a cover crop is used, these precautions are necessary. Do not allow the rye to grow above 15 to 20 inches tall before plowing in the spring. If it is allowed to grow too large, especially on fields that are low in available nitrogen and phosphorus, the same detrimental effect may be produced on the following tobacco crop as the plowing under of a heavy sod on land of low fertility.

The soil bacteriologists explain this effect of plowing under of excessive quantities of green organic matter in this way:

The kinds of bacteria and fungi that make up the populations in the soil are affected by the past cropping history and the fertilizer practices that have been followed. If no great amount of green organic matter has been plowed under for a number of years, the bacteria and fungi that decompose this material will be small in

number. If a large amount of green manure is then turned under, the population of these kinds of bacteria and fungi must at once be built up in great numbers to accomplish the job of decomposition.

These fungi and bacteria require for their growth large quantities of nitrogen and phosphorus. If tobacco is planted on a soil at this particular time, there will be for these nutrient elements a direct competition between this rapidly growing population of soil fungi and bacteria and the tobacco crop. If the soil is low in fertility "sod trouble" may develop. If the soil is high enough in fertility to supply the necessary nutrients to the tobacco crop and the developing soil organism at the same time, no detrimental effect will be noticed on the growth of the tobacco.

By repeated turning under of small quantities of green manure the soil organism population necessary for its decomposition is built up so that larger and larger quantities may be plowed under without bad effects on the growth of the tobacco crop.

It is not a good plan to let the rye produce too large a growth in the spring for another reason. The rye at that rapid development stage uses great quantities of water, and the soil may become too dry for the plowing under of the rye or the later transplanting of the tobacco if a dry weather period should develop the latter part of May or the first part of June.

A cover crop of rye not only supplies organic matter to the soil, but helps to reduce wind and water erosion.

TOBACCO SOIL ANALYSIS SERVICE NOW AVAILABLE _____

DURING THE SPRING of 1950, upon the request of the tobacco growers' organizations, a special analytical service for tobacco soils was made available by the State Soils Laboratory. Because of the chloride determination it is necessary to have at least a pint of soil for this analysis. A complete analysis for soil acidity, available chlorides, potassium, and phosphorus may be obtained for a fee of \$1.75. A copy of the instructions for taking these samples, along with a fill-in space for information needed about the cropping and fertilizer history of the field, and instructions on how to package and address the sample will be found attached to this bulletin. More copies may be obtained from your county agent's office or through the Tobacco Pool or Association offices.

MANAGEMENT OF WISCONSIN TOBACCO SOILS IN BRIEF _____

1. Continuous culture of tobacco is recommended as the best method of obtaining and maintaining the "luxury" level of fertility needed to produce quality tobacco.

2. If disease or soil erosion make rotation necessary,

- a. Plan the rotation two or three years in advance
- b. Never follow sod with tobacco
- c. Use manure and *tobacco* fertilizer on corn for two years after sod before planting the field to tobacco
- d. Use old fertile tobacco fields for tobacco one or two years without barnyard manure
- e. Do not use the tobacco crop, with its heavy applications of manure and commercial fertilizers, for two or three years to build up the fertility of a field, and then rotate the tobacco and start the process all over again on another field

3. To build a soil of ordinary fertility to a "luxury" level of fertility, 20 tons or more of manure plus 1000 to 1500 pounds per acre of a 3-9-18 tobacco fertilizer will be needed each year for three to five years.

4. After available phosphorus has reached 100 to 150 pounds per acre and available potassium has reached 500 to 700 pounds per acre, less manure along with the tobacco fertilizer will maintain the soil fertility and produce better quality tobacco.

5. Common corn or grain fertilizer with the potash in the chloride form should *never* be used on Wisconsin tobacco soils.

6. If burning quality of the crop is poor,

- a. Available soil potassium may be too low (see point 3 above)

- b. If available potassium is more than 500 pounds per acre, chlorides may be high. In this case:

Use less manure and more 3-9-18 tobacco fertilizer. Then sow rye as fall and winter cover crop, because if the manure application is reduced, organic matter may get low. Precaution: Do not let rye grow *more than* 15 to 20 inches high before plowing under in spring, especially on a soil of low fertility.

Request for Chlorine Test

Give the Following Information Concerning the Field or Fields from Which the
Samples were Taken

Field	Number of Samples from this Field	Present or last Crcp	Crop to be Planted	Past Manure and Fertilizer Treatment					
				Manure		Fertilizer			Has the field been Limed
				Loads per A.	Year Applied	Fertilizer Analysis	Lbs. per A.	Year Applied	

Remarks regarding any special difficulty _____

Fold the top of the bag over and tie it securely. Pack the bag or bags tightly in a strong cardboard box and mail or express package prepaid to:

Tobacco Investigations
 Dept. of Horticulture
 College of Agriculture
 Madison, Wisconsin

Fees--The fee for a complete test on your soil will be \$1.75 for each sample. This includes chlorine at \$1.00, available potassium at 50¢, pH and available phosphorus at 25¢. Mail the fee to the above address.

To whom should the report be sent?

Name _____ Address _____

Taking Soil Samples for Chlorine Test

1. Samples should not be taken except when the field is in a plowable condition.
2. If the field is not uniform, separate samples should be taken for each variable area.
3. Samples from 2 different fields should not be mixed.
4. The final sample from each area should represent the top 6 inches of soil and should consist of smaller samples taken from 8 to 10 places in the field.
5. Samples should be collected in a *clean* paper bag. A 6 or 8 pound bag of heavy paper is desirable.
6. The final sample from the field or area should consist of between 1 and 2 quarts of soil. This amount of soil is necessary in order to make the analyses.
7. After the samples have been collected, spread them out to dry at normal temperature. Do not dry in an oven or on a hot stove.
8. After the samples have been dried, return them to the bags. Each bag should be marked with your name and address and also the field identification. Keep a record of this identification so that you will know which sample represents which field when you get your report.
9. Fill in the information called for in the preceding table, fold the sheet and place it in the bag with the sample. We need this sheet to identify your soils.