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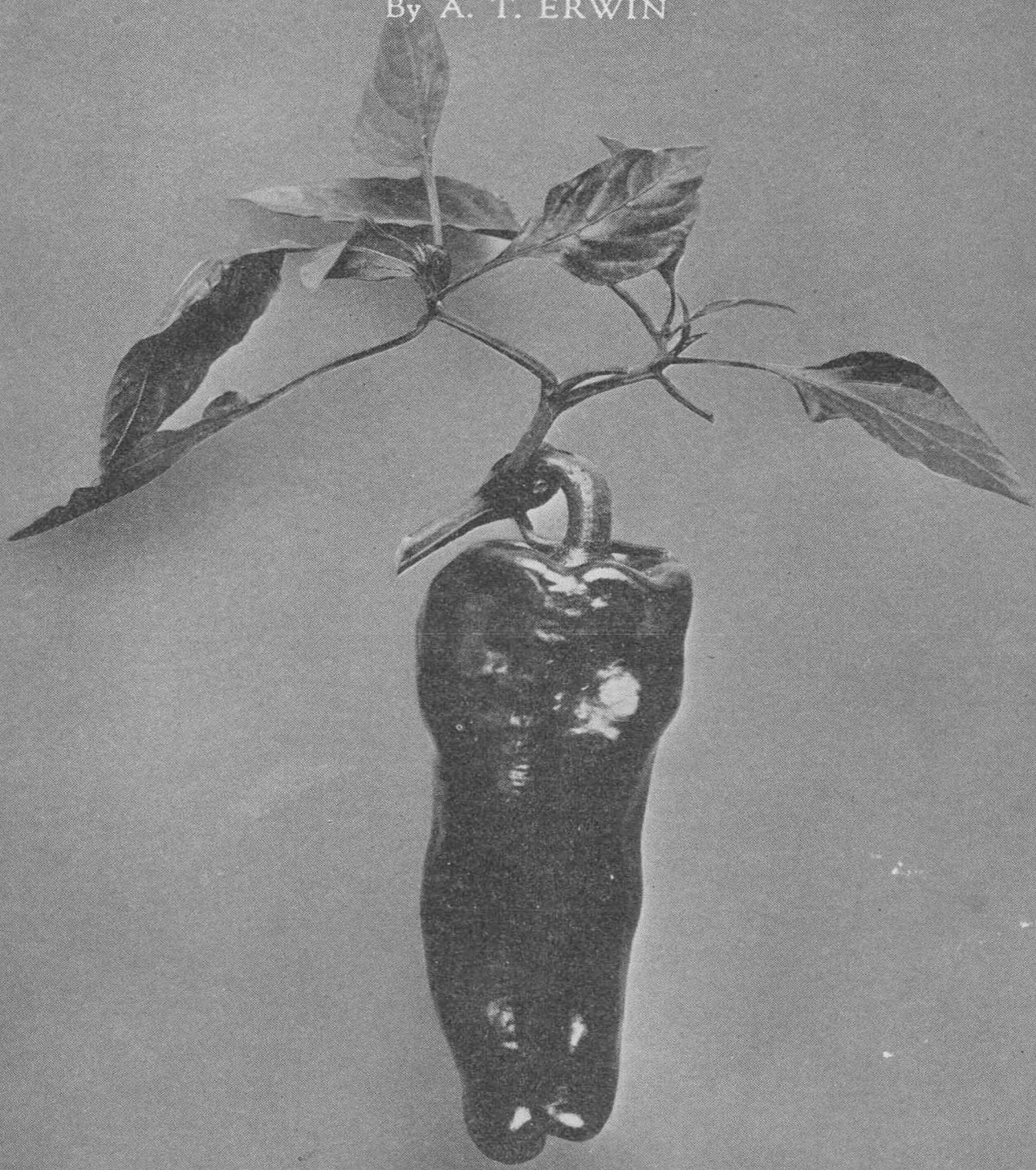
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THE PEPPERS

By A. T. ERWIN



AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
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SUMMARY

Peppers are native plants of tropical America, one of the few vegetables which still abound in the wild state. The earliest mention of them was in a report of Columbus' first voyage.

The garden peppers are regarded as dwarf, early maturing forms of *Capsicum frutescens*. They are either annuals or perennials, according to climatic conditions.

The peppers are both self and cross-fertilized.

The collection of peppers grown in securing the data for this bulletin included over 200 varieties, a large proportion of which were synonyms, secured from the American and European seed trade.

The present day varieties of peppers are classified under seven groups and one subgroup as follows: Tabasco, Cayenne, Cherry, Celestial, Perfection, Tomato, Bell and the subgroup, Yellow Bell.

Peppers are tropical in their temperature requirements. They do best on a well drained, warm soil that is not too rich in nitrogen, which tends to delay maturity and causes excessive vine growth. It usually takes about 120 to 150 days from the planting of the seeds to maturity of the fruit. The average yield of pepper plants ranged from 11 to 67 ounces of peppers per plant in tests with different varieties at Ames.

Vitamins A, B and C are found in peppers. They compare favorably with many other vegetables in this regard.

The Peppers

By A. T. ERWIN¹

The peppers, though a minor economic group, are a multifarious species of unusual interest from a taxonomic standpoint. This publication deals with a systematic study of the Capsicums, consideration of varieties as related to their group classification, nomenclature and adaptation to Iowa conditions. Attention is also given to the taxonomy, anthesis and fertilization of the Capsicums.

PEPPERS NATIVE TO TROPICAL AMERICA

The peppers are native to tropical America and are one of the few vegetables which still abound in the wild state. They are an historic food plant of South America and were grown by the Olmecs, a tribe preceding the Toltecs.

Safford (29) reports finding dried pods of Cayenne pepper (*Capsicum frutescens*) in the recoveries from the burials in the prehistoric cemetery at Anicon, Peru. The first record of peppers is that of Peter Martyr (23) in the report of Columbus' first voyage. He found innumerable kinds of "ages (peppers), one of them is halfe as long as the length of a man's finger, the other is round . . . they have a hotte kinde of sharpness and biting." In the report of the second voyage the plant was described by the physician of the crew, Chanca (6), by whom seed was apparently first introduced into the old world.

Stade (32), 1537, in the story of his captivity by the natives of eastern Brazil, reports that he found peppers of "two kinds, the one yellow, the other red . . . a small shrub half a fathom high, it is full of pepper which burn the mouth." He also describes a kind "halfe as long againe as the length of a man's finger" and another type "which is round . . . They have a hotte kinde of sharpness and biting."

BOTANICAL CONSIDERATIONS

The garden peppers belong to the order Solanac ae, the nightshade family, and the genus *Capsicum*. The genus comprises a wide range of forms, particularly as to the shape and pungency of the fruit. At one time or another many of these variations have been described as species. Upwards of 100 supposedly good species have been thus described. Linnaeus (19) in his *Hortus Clifforensis*, 1737, describes two species, *C. annum* and *C. frutescens*. Fingerhuth (9), 1832, recognized 25 species and 28 botanical varieties; three of the species and all the botanical va-

¹The author desires to express appreciation to H. C. Irish and Gordon Morrison for helpful suggestions.

rieties were first described by him. Irish (15) in his monograph on the Capsicums reduced the number to two species, namely *C. annuum* and *C. frutescens*, but does not clearly differentiate between the two species. Bailey (3) reduced these two species to a single form, namely *C. frutescens*. A study of the garden varieties presents material evidence in support of this point of view.

In taxonomic characters of leaf, flower and fruit one form intergrades into another. There are wide variations, especially in fruit, and it is but natural to seek an independent origin for each group; yet when the groups are studied in detail an interrelationship becomes evident. In fruit, for example, the elongated merge into a semi-conical and conical. From the conical, of which the Perfection is a good example, there is a shift to the oblate form as in the Tomato pepper. In fact we have found an occasional oblate specimen on plants of the Perfection type where the dominant type is a conical pepper. Linnaeus, who described the two species named above, characterized the one as an annual and the other as a perennial, i.e., frutescent or woody. In the North, however, both species are killed by the winters and conversely, below the frost line both species are perennials.

The author has observed neglected specimens of the garden peppers in southern Florida which were said by the grower to be 5 or 6 years old. Professor W. L. Floyd of the Florida Agricultural Experiment Station advises that in Florida the old plants of the common garden varieties are sometimes cut back and covered with straw or leaves. These plants sprout from the old stump and form a new plant. Likewise, the garden varieties of the North, when grown under glass, live on from year to year as a perennial.

Linnaeus (19) notes, following his description, "mire viriat figura" (wide variations of these two species). Gray (35), in a letter to Sturtevant written at a time when numerous supposedly new species of Capsicums were being described, expressed the opinion that there are only two species in the genus. Sturtevant (34), who had closely observed the cultivated Capsicums, commented, "My studies lead me to believe that the published species are, in the majority of cases, merely forms."

The lack of a clear-cut line of demarcation between *C. annuum* and *frutescens* on the one hand, and the fact that the garden forms are dwarf perennial forms, leads to the conclusion that we are dealing with but one species. We therefore concur with Bailey that garden peppers all belong to one species of pepper. "I am convinced," states Bailey (3), "that the horticultural kinds are all forms of one species and that the species is shrubby, the herbaceous or so-called annual kinds being races that develop in a short season and do not become woody before killed by frost. In the Capsicum shrubs of the tropics one finds puffy fruit of the

bell-pepper type as well as the slender finger-like and berry-like kinds; and when the northern kinds are grown in the tropics they become shrubs. Leaf variation also has an equal range. I therefore propose to arrange the most significant forms of this multifarious species under *C. frutescens* rather than under *C. annum*. In doing so I accept the second rather than the first of the two names proposed by Linnaeus in Species Plantarum, but when no question of authority or priority is involved, I cannot allow the incident of precedence on pages to obscure a biological fact." Irish (15) concurs in this point of view. "From a further study of the genus Capsicum, I have reached the conclusion that the garden varieties are simply dwarf northern forms of *C. frutescens*."

If one accepts the hypothesis that the cultivated forms represent but one species, the question still remains as to whether the designation should be *annuum* or *frutescens*. According to the American code it would be the former because it takes precedence on the page in Linnaeus' description, but such is not the case in the International code. The use of a term which contradicts the facts of the case by calling a plant an annual which is a perennial is not advisable. We therefore refer to *C. frutescens* all of the garden forms of peppers.

It may be noted that the genetic relationship also points to a single species. Halsted (12) crossed the Birds Eye, a primitive form of *C. frutescens*, with the large podded sweet peppers, *C. annum*, and from this cross secured fertile seeds. The crosses made by Dale between the Coral Gem, *C. conoides* of Fingerhuth, and Anaheim Chilli, which is a variety of *C. acuminatum* by the same author, also produced fertile seed.

The author saved the seed from open pollinated plants grown in the station collection. Ten plants of seed from Perfection gave the following segregates in the next generation: Three plants, fruit similar to the mother; two Bull Nose type, *C. grossum*, Linn.; five Cayenne type, *C. acuminatum*, Fingerhuth.

Fifteen plants from the variety Tomato, *C. grossum*, Linnaeus, open pollinated, gave the following segregates in the progeny: two Cherry type, *C. cerasiforme*, Miller; six Perfection type; two Bull Nose; and four Tomato type, the last three being *C. grossum*.

The plants from which this seed was saved adjoined rows of numerous other varieties; consequently there was ample opportunity for crossing. It will be noted that the segregates include representatives of a number of the important groups of cultivated peppers, forms classed by some authorities as species.

The following crosses were made by Dr. E. W. Lindstrom of the Genetics Section of this station. Red Cherry, a variety of *C. cerasiforme*, Miller, was crossed with the five named varieties of *C. grossum*: Yellow Giant, Prolific Yellow, Golden Queen,

Rainbow and Oshkosh. The Chinese pepper—a form of Cayenne—*C. acuminatum*, was crossed with the Perfection and the Tomato, which also belong to *C. grossum*. Fertile seeds in the F₁ generation were secured from all of these crosses and also in the F₂ and back crosses.

The above evidence, though not conclusive, suggests that these groups bear a close relationship and from a genetic standpoint are forms of the same species.

The genus *Capsicum* was first described by Tournfort. The origin of the term is obscure. According to some authorities it is derived from the Greek root, to bite. In view of the fact that the red pepper is an American plant and is unknown to the old world literature previous to the voyage of Columbus, the above derivation seems doubtful. Another suggestion is that it is derived from the Latin *capsa*, capsule or pod.

THE PEPPERS

Capsicum frutescens, L. Sp. Pl. 189 (1753).

C. frutescens, var. *baccatum*, Irish. 9th Ann. Rpt. Mo. Bot. 99 (1898).

C. annum, L., l.c. 188.

C. annum, var. *abbreviatum*. Irish, l.c. 88.

C. annum, var. *conoides*. Irish, l.c. 65.

C. annum, var. *fasciculatum*. Irish, l.c. 68.

C. annum, var. *acuminatum*. Irish, l.c. 69.

C. annum, var. *longum*. Irish, l.c. 73.

C. annum, var. *cerasiforme*. Irish, l.c. 92.

Herbaceous or semi-woody plants, annual or perennial, 1½ to 4 feet high. The stems more or less angular or channeled, usually enlarged at the nodes, sparingly hairy or glabrous, sometimes purplish, striate; leaves alternate, entire, ovate acuminate, often unsymmetrical; flowers axillary, solitary, or two or three in a fascicle; corolla white, greenish white, light yellow or purple; petals five, connate, rotate to semi-campanulate; calyx varying from pateriform to cup-shaped; stamens five, adnate, dehiscence longitudinal; carpels connate in a two to four-celled ovary; fruit varying from globose to elongated conical; seeds discoid, smooth or subscabrous, embryo peripheric.

In color, peppers range from yellow to deep red. The color pigment is found in the outer layers of the pericarp and, according to Jones and Rosa (16), is due in the yellow varieties to carotin and in the red sorts to a mixture of lycopersicin, xanthophyll and carotin.

CAPSAICIN GIVES PEPPERS PUNGENT QUALITY

The pungent quality of peppers is due to an acrid substance, which was discovered by Thresh and named capsaicin. Capsaicin

is a volatile alkaloid, soluble in alcohol. The pods also contain an oleo-resin and fatty matters. The percentage of capsaicin varies widely. Micko (23) found that "*C. fastigiatum* contained 20 times as much capsaicin as *C. annum*."

Generally speaking the percentage of capsaicin or pungency is inversely proportional to the size of the fruit. The pungency is most pronounced in the smallest-fruited forms such as the Tabasco, while only traces are found in the thick-meated, large-podded forms such as the Tomato pepper.

The percentage of capsaicin is also apparently influenced by the soil and climatic factors. According to Gathercoal and Terry (11) "African Chillies are the most pungent. The degree of pungency is as follows: Mombassa Chillies, 50,000 to 100,000; Zanzibar Chillies, 40,000 to 50,000; Japanese Chillies, 20,000 to 30,000."

The domestic production of chillies for pharmaceutical purposes has been suggested but has not proved satisfactory on account of their lack of pungency.

A number of investigators have studied the capsaicin in the Capsicums. Its formation has been attributed to the epidermal cells of the partition walls and placentas of the fruit. Some have reported that it is localized in placentas and seeds, while others find it also in the pericarp, especially in the epidermis of the pericarp. Since there is a lack of agreement among investigators concerning the origin and location of the capsaicin in the Capsicums, a brief study of it was undertaken by Dr. J. N. Martin, morphologist, Iowa State College, who reports as follows.

"By means of sections stained with various reagents to make the capsaicin visible, its distribution and the modification of cells in relation to it were followed from flower stage to mature fruit. The only cells appearing specialized are the inner sub-epidermal cells of the ovary wall. In the flower stage they are conspicuous for their size, contain starch and much capsaicin. These specialized cells are limited to the ovary wall or shell of the pod. The sub-epidermal cells of partition walls and placentas are normal in size and show no indications of having special functions. Throughout the development of the fruit no cells in the placentas or partition walls manifest any glandular function as described by some previous workers. The capsaicin was found most abundant in the enlarged sub-epidermal cells, but was also abundant in nearly all the cells of the ovary wall, which are especially well supplied with chromatophores. Aside from the enlarged sub-epidermal cells of the ovary wall, no cells glandular in either appearance or function were found. Apparently the formation of capsaicin is a function of the ovary wall in general, and the greater concentration of the substance in the placentas and seeds in the later stages of the fruit is a matter of transportation to the most important centers of growth."

FLOWERS SECRETE NECTAR

The secretion of nectar and the visitation of insects is very closely associated with pollination. In a preliminary report on the Capsicums (8) the author suggested that the Capsicums were self-fertile. Inconspicuous non-fragrant flowers and the absence of insects during a period when the flowers were setting freely seemed to support this point of view. These observations were made during the summer of 1930, a year of extreme drouth and high temperatures. In the summer of 1931 it was noted that numerous insects visited the flowers. It was also observed that the flowers, especially of the primitive types, if inspected early in the morning contained drops of a liquid which appeared to be nectar. Since nothing is found in the literature as to the Capsicums being a nectar-bearing flower, the author requested Dr. J. N. Martin, who has made some studies of the morphology of nectar-bearing flowers, to coöperate in this phase of the study (22). The nectar drops were noticeable at definite places on the petals. The drops were most noticeable on the middle line of the petals at the top of the corolla tube. A hand lens showed each drop to be definitely related to a pore in this region of the petal. Less noticeable amounts of liquid were observed between the back of filaments and corolla. The behavior of bees and the sweetish taste of this liquid indicated it was nectar and that the flower possesses some kind of secreting mechanism. On the inner surface of each petal, grooves are found. These grooves extend down the corolla tube some distance. They are deepest at their upper end, reaching almost to the mid vein of the petal. When secreting is in progress, these grooves serve as tubes and their openings at the upper end are the pores through which much of the nectar reaches the surface of the petal. A test for sugar showed an abundance of sharp pointed crystals resembling most the osazones of dextrose.

The flowers of the Capsicums are visited by various insects. A number of catches were made by Claude Lounsberry. These were submitted to Dr. H. M. Harris of Iowa State College for identification. Dr. Harris reported the insects to be as follows: Honeybee, *Apis mellifera* L.; the digger bee, *Melissodes rustica* Say.; solitary bee, *Agapostemon virescens* Fabr.; and the hover fly, *Eristalis latifious*.

These insects, notes Dr. Harris, may have some part in the pollination of the peppers. In addition to the ones named above, he also found in these catches some 25 other species, mostly of beetles and butterflies, which appeared to be casual visitors only.

ANTHESIS IN CAPSICUMS

In order to secure information on the period of anthesis in the Capsicums, 100 blossoms from representative varieties were used.

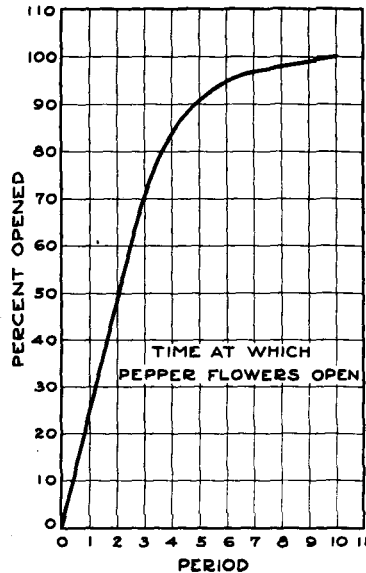


Fig. 1. The major portion of the pepper flowers opened within three hours after sunrise.

5:25, sun appearing above the clouds; small insects beginning to visit the blossoms; 5:45, bright and clear, a hot day in store.

A record of the blossoms which had opened by each succeeding period is shown in fig. 1.

The temperature record for the period under observation is indicated in fig. 2. It is recognized, however, that the intensity of the sunlight is probably the more important factor of the two.

It is interesting to note that the curve in fig. 2 rises up to the sixth period (8:15 a. m.), from which point the curve flattens out and by the tenth period (10:15 a. m.) activity has ceased. In the

The blossoms, which were still in the bud stage and ready to burst open the next morning, were individually tagged the preceding afternoon. The following morning beginning at 5:15 a. m. a count was made of the number of blossoms which had opened in the intervening 30-minute period. On the morning in which the first count was made, Aug. 18, 1931, which is typical of the records, the sun was due to rise at 5:13 a. m., and this was the reason for selecting 5:15 as the starting point. The count was made by Claude Lounsberry, who made the following notes regarding weather conditions: 5:15, cloudy in east;

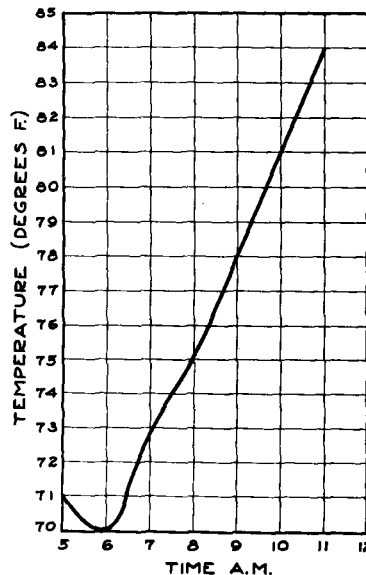


Fig. 2. Dehiscence followed the opening of the pepper flowers and seemed to be governed largely by the temperature factor.

preceding year, 1930, similar records were made on the station plots at Muscatine. In this instance also the peak was reached around 8:00 a. m., and the general trend was similar to that secured at Ames the year following.

The blossoms closed only slightly the first night and by the second morning were in a badly wilted condition or had dropped off. The period of anthesis is therefore comparatively short, in most instances less than a full day. It was also observed that even when the blossoms opened on a cool cloudy day, they became wilted and half closed by the following morning.

Dehiscence was found to follow rather than be simultaneous with the opening of the blossom. As a rule dehiscence did not begin until the petals were fully expanded, which was approximately 3 hours after sunrise, by which time there was a perceptible rise in temperature. The diurnal temperature therefore appears to be the dominant factor in dehiscence in the peppers.

PEPPERS BOTH SELF AND CROSS-FERTILIZED

Are peppers self-fertile or is cross-fertilization necessary? For the purpose of securing information on this question, the following experiment was conducted. One hundred flower buds, labeled class one, were tagged for open pollination. Class two was labeled and tagged and hand pollinated by applying the ruptured pollen sack upon the pistil. Class three was handled similarly to class two, except that the plants were jarred in the afternoon. Ten days later a count was made on the percentage of the flowers that had set. The results were as follows: Class one, 80 percent; class two, 52 percent; class three, 70 percent. Seventeen varieties, representing all of the groups of cultivated peppers, were included in the experiment. The percentage set is less under the artificial conditions of classes two and three, as might be expected; yet it seems clear that the peppers are self-fertile.

In a similar experiment conducted at Muscatine the preceding summer, involving 8 varieties and including counts on 400 blossoms, the set on open pollination was 71 percent and on the self-pollinated 46 percent. The pedicel of the pepper flower is extremely delicate and the flower is rather sensitive to an unfavorable environment. As might be expected, the percentage set was higher in both instances under natural conditions.

The results in both years indicate that the peppers are both self and cross-fertilized. It is the experience of pepper seed growers that the varieties readily "mix," and the maintenance of varietal purity is one of the growers' problems. George Q. Hammell, veteran seed grower, wrote to the author, "It is a real battle to keep the many strains of pepper now on the market, on their own side of the fence. The sweet and the hot peppers should be kept on different farms. It is a good plan to plant 8

or 10 rows of corn between the different varieties. The bees will stop on the corn blossoms and clean their feet and the corn will also prevent mixture of pollen by acting as a windbreak."

Shaw (31) reports that in "23 cultures (selfed flowers) 21 ran true, while in the instance of 96 open pollinations, 21 bred true and 75 split."

Shaw and Khan (31) note that the style is commonly longer than the stamens in the varieties they studied, which renders self-fertilization unlikely. In a study of 13 varieties representing the different groups at Ames, it was found that in 5 groups the stigma was even with the anthers at full bloom, below the anthers in 5, and 3 varieties bore a style longer than the stamens. Thus there is a considerable variation in this regard.

The conclusion that the peppers are both self and cross fertile seems warranted. The fact that it is a nectar bearing plant and visited by pollen bearing insects, suggests that cross pollination is likely to occur.

INHERITANCE OF CHARACTERS

Although the commercial varieties of peppers have been secured by selection, interesting genetic studies have been made bearing upon inheritance of characters in this genus. Halsted (12) made a number of crosses between the Birds Eye, a primitive type, and the large-fruited sweet peppers. He concluded that the long-fruited is partially dominant over the oblate forms. Webber (39) made a study of inheritance. He found that violet flowers are associated with a corresponding pigmentation of the stems, leaves and immature fruit and that white flowers are associated with the green shades. Ikeno (14) found that the recurved type of peduncle was dominant over the erect type. Shaw (31) concluded that yellow color and erect habit of growth are recessive to red color and pendent habit.

Dale (7) made a study of fruit length in a cross between two varieties of peppers—Coral Gem and Anaheim. The fruit of the F_2 and backcross generations in logarithmic classes gave normal curves and in arithmetic classes gave skewed curves, indicating that the factors for length have proportionate rather than additive effects.

VARIETAL NAMES HAVE MULTIPLIED

The lists of varieties have changed from time to time, but most of the present day types seem to have existed from the earliest references in horticultural literature. McMahon (25), 1806, lists four varieties: Long Podded, Heart Shaped, Bell and Cherry. Thorburn (1826) offers five sorts: Cayenne, Tomato, Bell, Cherry and Bird. Tracy (36), 1922, lists 135 varieties and synonyms. The collection grown by the author, secured from the American and European seed trade, embraces over 200 va-

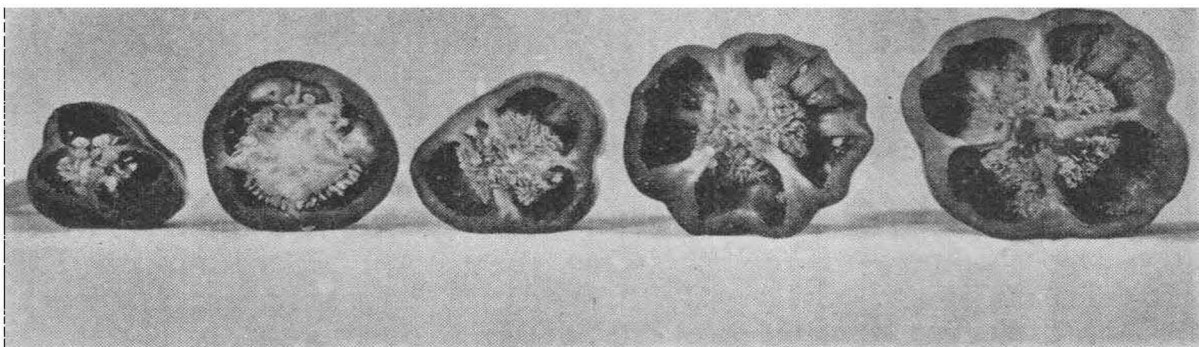


Fig. 8. A marked improvement in size and thickness of flesh is shown between the present day varieties and the primitive types.

rieties and synonyms. It may be added that in this list synonyms predominate.

The varieties included in this study were from seed secured from the seed trade and wholesale growers in the United States. Duplicate lots of each variety were grown at Muscatine, Iowa, as a basis of comparison of plants growing on a warm sandy soil with the ones grown on the heavy black soil at Ames.

In the pursuit of this study a number of evident cases of synonyms were encountered. In many instances the original variety has been renamed and displaced to a large degree by improved sorts or strains showing minor variations from the parent variety. In such instances the only value of information about synonyms is historical. Both the gardener and seedsmen are today cumbered with a long list of varieties, only a few of which are of outstanding merit.

"We² note with hearty approval the tendency . . . to shorten lists of varieties. As an aid in this direction we would encourage the preparation and publication of tentative lists of standard varieties . . . such lists being designed to meet the important commercial needs of the country."

One of the simplest methods of reducing this list is by making the type or group the point of emphasis rather than the variety. Furthermore, in the introduction of new sorts, information regarding the group relationship enables the grower to associate the newcomer with a type with whose general characteristics he is already familiar. In this publication, the synonyms, as such, have not been separated and the study of varieties has been made primarily from the standpoint of their group relationship as shown under Iowa conditions.

PIMENTOS

The term pimento as used in the seed trade and in commerce embraces two distinct types of peppers. The one is an oblate

²Vegetable Growers Association of America.

fruit of the tomato type, examples of which are Sunnybrook and Early Sweet Pimento. The second type includes varieties with a conical-shaped fruit, as Perfection and Sweet Meat Glory. In the retail trade of the upper Mississippi Valley, all of the varieties of the tomato type are commonly sold as pimentos.

E. I. Knight³ has made a search through the leading seedsmen's catalogs of the United States with reference to the use of the word pimiento and concludes that this term was acquired in connection with the canned product imported from Spain and applied particularly to a thick-meated pepper of conical shape.

The spelling is likewise confused; in the American literature the terms pimento and pimienta are both used. It should be noted that the term pimienta is the Spanish for pepper and pimento is the anglicized form of the same word.

Bailey⁴ makes the following comment regarding the application of the term pimento to the Capsicums. "The Spanish word pimienta is feminine and pimienta masculine. It seems that the latter is commonly applied to Capsicums by Spanish speaking people and that pimienta is applied to other kinds of plants yielding pungent qualities. The termination 'o' is apparently correctly applied by North American horticulturists in Capsicum. The elimination of the second 'i' is undoubtedly inevitable inasmuch as it means nothing to us. I doubt whether you could force this extra letter into the horticultural trade if you tried."

Stuckey and McClintock (33) used the spelling pimento, while Woodruff and Bailey (42) in a subsequent bulletin from the same institution used the Spanish form pimienta. The same situation prevails in the seed trade and other literature.

The point has been raised that the term pimento refers to the allspice. It should be noted, however, that this is a later application of the term and that pimento was applied to the red pepper at an earlier date and therefore has priority. "We (2) eat our Breakfast all together, and they persuade me to eat some of a Fruit they call Pimento, which is as long as one's finger, but as hot as Pepper, the least bit of which puts one's mouth in a Flame . . . This Fruit is brought into Spain." The transfer of the term pimento from the pepper to the allspice plant seems to have arisen from the fact that the botanical name of the latter is *Pimenta officinalis*. The public confused the botanical name of one genus with the common name of another. In England, notes Murray's New English Dictionary, the name (pimento) has passed to allspice.

³Office of Horticultural Crops and Diseases, U. S. Dept. Agr. Letter to author, Feb. 4, 1931.

⁴Letter to author, Dec. 14, 1931.

It certainly does not straighten out the tangle to use the Spanish term pimiento to designate one genera of plants and the anglicized form of the same word to designate an entirely distinct group of plants. On the basis of priority, as well as in the preference for simplified spelling, there is ample authority for the use of the anglicized form pimento, and the author has adhered to this spelling in this publication. The term all-spice is still available as the common name for *Pimenta officinalis*.

CLASSIFICATION OF PEPPERS

The classification of any multifarious groups of cultigens is always baffling. Various schemes for the classification of peppers have been proposed. In the notable monograph of Irish (15) two major groups are formed, based upon the fruit being erect or pendent. Sturtevant (34) proposed a key based upon the type of calyx.

Both of the above schemes have merit, but the program of hybridizing and selection has produced so many intermediate forms that it is becoming increasingly difficult to apply characterizations to which there are not many important exceptions.

In a preliminary report (8) on the Capsicums the writer proposed a classification of varieties as pungent and non-pungent. Broadly speaking, the large-fruited varieties with thick walls and a saucer-shaped calyx are non-pungent peppers, and the pungent varieties have a long, slender, thin-walled pod and a cup-shaped calyx. Generally speaking, the degree of pungency is inversely proportional to the size of the fruit. A number of recent introductions due to hybridizing show many exceptions to the above scheme. The Hot Bull Nose, for example, shows all of the characteristics of a sweet pepper except that it is "hot." The variety, Corne de Orient, has the typical shape of a Cayenne, including thin walls and a cup-shaped calyx, and yet it is distinctly a mild pepper. Furthermore, flavor, though an important horticultural quality, is not a taxonomic character. We are therefore convinced that a classification based upon the degree of pungency holds only within broad limits and that there are many exceptions to it.

An effort was also made to classify the varieties as pungent or non-pungent by the Scoville (41) organoleptic test for capsaicin. A number of thick-fleshed varieties gave a mild reaction for capsaicin, which merely emphasizes the statement made above, that the degree of pungency is relative rather than absolute.

The thin-fleshed, long-podded varieties bearing a cup-shaped calyx usually are "hot" and the majority of thick-fleshed varieties with a flattened calyx are "sweet."

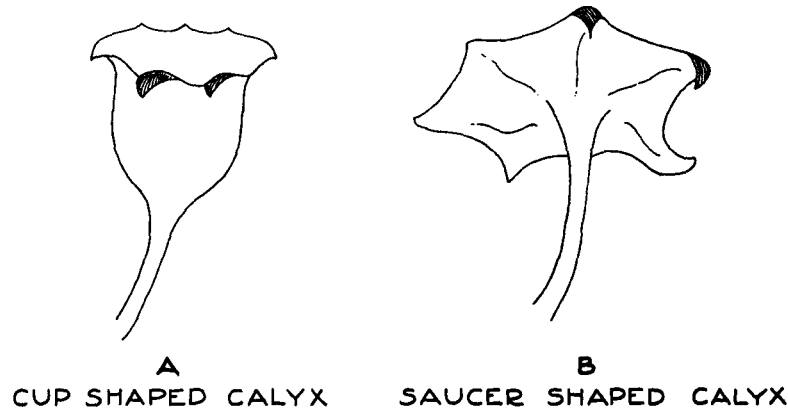


Fig. 4. Two types of calyx are found in the peppers. In the illustrations, A and B, the pod and placenta have been removed.

In the studies of current varieties made by the author, the type of calyx proved to be one of the most constant characters for delineation and is so used in the following key.

Key to Cultivated Groups of Capsicums

- A. Calyx embracing base of fruit or cup-shaped
 - 1. Fruits linear and erect
Tabasco Group
 - 2. Fruits elongate, conical and pendent
Cayenne Group
- B. Calyx pateriform or saucer-shaped
 - 1. Fruits globose
Cherry Group
 - 2. Fruits conical
 - a. Fruits erect
Celestial Group
 - b. Fruits pendent
Perfection Group
 - 3. Fruits oblate
Tomato Group
 - 4. Fruits squarish, sub-truncate
Bell Group

GROUP CLASSIFICATION OF VARIETIES

The outstanding monograph on the cultivated Capsicums is by Irish (15) and was published 38 years ago. Many of the varieties listed therein have disappeared from the trade, and improved sorts have gained recognition. The time therefore seems ripe for a further study of the Capsicums, embracing present day cultigens.

In making such a study, the question arises as to whether the related forms should be designated as botanical varieties or as

horticultural groups. The question of varietal versus specie rank is also involved. A species should be confined to narrow limits, according to some authorities, while other students conceive it to represent broad characterizations. Those interested in the field of economic botany find advantages in the latter point of view. As Wiegand (40) remarked, "Fewer units are easier to group than many; also, fewer names are easier to hold in mind than many. Indicated relation of units is an aid in acquiring a mental grasp of a large number of objects. Comprehensive grouping gives us a mental grasp of a large number of objects. Comprehensive grouping gives us all these advantages. The broadly applied generic or specific name indicates relationship, while segregated groups give us a greatly increased number of units with a corresponding loss of relationship."

There is also a difference in point of view of the taxonomist and horticulturist. It is true as stated by Rehder (27), "I can find no fundamental difference between a form which originated in the wild and one which originated in the garden, but there is a difference in the standing and in the use of fancy garden names and in that of botanical names." On the other hand, there are characters of little significance to the taxonomist and yet of economic importance, and other qualities, such as flavor, which are not taxonomic characters at all. Bailey has said, "Botanical identity and horticultural differences must not be confused." The plan "to stop the technical botanical names at the species or subspecies and leave the rest of the grouping to the horticulturist" would seem to be a happy solution of the problem. Certainly there are objections to the use of botanical names to designated horticultural forms. The group relationships are better understood by the gardener if designated in terms of a familiar variety which is characterized as the group name to represent a number of related varieties, and this plan has been followed in this publication.

TABASCO* GROUP

This group is characterized by small, erect, elongated fruits which are very pungent. The pods are borne singly, in pairs or in clusters and average from 1 to 3 inches long. The fruits are compressed at the base and appear above the foliage; peduncles slender, straight and erect; calyx cup-shaped. Flowers small, usually five petals; corolla greenish yellow; filament purplish. Style long and slender, protruding above the anthers; leaves ovate-lanceolate to lanceolate; plants medium to tall; fruits midseason to late.

The Tabasco is perhaps the best known variety of this group, and from it is made the famous Tabasco sauce. It is one of the

*Erroneously spelled, "tobasco," in many seed catalogs.



Fig. 5. Small erect pungent fruits characterize the Tabasco group.

smallest-podded varieties of long peppers, but what it lacks in size is made up in pungency. The Tabasco is a long-season variety and does not mature well at Ames. It is named after the Tabasco River in Mexico, the region to which it is native.

The Japanese Cluster and Coral Gem Bouquet are of a more dwarf and compact growth than Tabasco. They mature well in this section. These varieties make an attractive ornament and are also used in pickling.

The Tabasco group includes the two botanical varieties *conoides* and *fasciculatum* of Irish. Aside from the point of the fruits being solitary or numerous, they share important taxonomic characters in common, the most important of which are

the small erect fruit and the cup-shaped calyx.

The varieties belonging to the Tabasco group are:

Cardinal	Orange Red Cluster
Chili Dwarf	Red Chili
Chili Piquin	Red Cluster
Coral Gem	Small Cayenne
De Bouquet Rouge	Small Chili
Japanese Cluster	Small Red Chili
Japanese Fuschin Pungent	Tabasco
Japanese Tassel	True Red Chili
	Very Small Cayenne

CAYENNE GROUP

The Cayenne group, often called chili or finger peppers, is characterized by long curved pods ranging from 4 to 12 inches in length. In some varieties, as the Cayenne, the pods are slender; in others the base is enlarged, forming an elongated conical shape. Flesh ranges from thin to moderately thick; color red. Most varieties are distinctly pungent, but some are only mildly so. Fruits commonly pendent, but semi-erect in some varieties. Calyx cup-shaped in the slender-fruited varieties,

and semi-flattened in the larger-fruited forms; peduncles short, often stout, and curved.

Flowers small, white, apex of petals acute; filaments white, anthers pale lilac before dehiscing; leaves of the more primitive types are rather small, ovate to ovate-lanceolate acuminate. In the larger-fruited sorts the leaves are also much larger. Plants 2 to 2½ feet in height.

The Cayenne is one of the oldest varieties of peppers recorded in literature. The name appears to have been derived from the river Cayenne in French Guiana, to which country the plant is native. The dried chilies of this variety are known in commerce as "ginnie peppers." The term is widely used in the drug trade as synonymous with chilis and as a generic term for dried peppers of the long hot type of any variety. The word Chili is spelled with both one and two "l's" in the seed trade. The two "l's" is the Mexican spelling and one the English. The term Chili is of Mexican origin and unknown in English literature until modern times.

Cayenne is probably the most extensively grown variety of this group. It succeeds over a wide range and is commonly grown as a condiment in the home gardens throughout the country. An extremely pungent type, called Mexican Chilles, is grown in the Southwest for drying. The ground pods constitute an important article of commerce in the pharmaceutical trade. The Cayenne pepper of commerce is derived from the seed of varieties belonging to this group.

The former varieties of Cayenne bore a long, slender pod. In recent years a shorter and more blocky type has been introduced under various names, as Giant Cayenne and Thick Long Red.

Through selection various strains of the Cayenne type have been developed. The Anaheim Chili was introduced in 1903 by H. L. Musser, who made selections for a long, thick-fleshed pod



Fig. 6. Fruits of the Cayenne group are long and pendent.

of the Cayenne type. The side walls range from 1/16 to 3/16 of an inch in thickness. Pods curved, base 1½ inches, length 8 to 10 inches. Flavor mildly pungent as compared with most varieties of this type; season late for this region. Extensively grown in California, particularly around the town of Anaheim, after which it is named. A considerable portion of the crop is used for dried chilies.

Professor Fabian Garcia (10) of the New Mexico Agricultural Experiment Station has given special attention to the improvement of the chilies for canning, one of the most important of which is known as seedling No. 9. Garcia⁵ writes: "In regard to the work that we have done on the improvement of one of our chile varieties of Capsicums, I will state that considerable chile is being canned in this State (New Mexico). When chile is canned, it has to be roasted in order that the skin can be separated from the pulp. The peeling of this skin is quite tedious and more or less expensive. The old varieties that were being used for this purpose were very irregular in shape and smoothness. The more irregular the pod is the rougher the surface, and the deeper the shoulder at the stem end, the more work it takes and, consequently, the more expensive it is to peel. At the same time, there is considerable loss in pulp, as frequently part of the pulp is pulled off with the skin. Our idea at that time in improving this chile was to produce a pod that would be as smooth as possible, straight in shape, shoulderless at the stem end and as fleshy as possible. This work we did by selection. We have been able through roguing our seed plots to keep up the characteristics that we improved on over the old variety. Chile, we find, tends to revert back and to cross readily with other varieties. Therefore, we have to be careful to keep up the shoulderless, fleshy, and smooth pod true to name by preventing cross pollination. This variety is now widely grown in this State."

Japanese Ornamental is an attractive variety with variegated leaves and small pods which are first a deep purple then red. The flowers also are a deep purple shade.

The varieties comprising the Cayenne group are:

Anaheim	Large Red Chili
Anaheim Giant Chili	Large Thick Cayenne
Bulgarian Hot	Long Cayenne
Bulgarian Long Hot	Long Narrow
Cayenne	Long Narrow Cayenne
Cayenne Langer—dunner roter	Long Red
Cayenne Pickling	Long Red Cayenne
Chili Ancho	Mammoth Cayenne
Come d'Orient	Mexican Chili
Du Chili—smallest of the Cayennes	New Giant Cayenne
Dwarf Chili	New Quality

⁵Letter to author, June 30, 1929.

Garcia's No. 9
 Giant Cayenne
 Half Long Hot
 Half Long Narrow Cayenne
 Hungarian
 Hungarian Long Wax
 Hungarian Wax
 Improved Thick Long Red
 Japanese Fuschin—sweet, green
 Japanese Fuschin Pungent
 Japanese Nikko Long Scarlet
 Japanese Ornamental—variegated
 Jaune demi long antibes
 Jaune Long
 Large Anaheim Chili

Pot Herb
 Prolific
 Prolific Red
 Red Cayenne
 Red Chili
 Rainbow
 Red Dawn
 Red Hot
 Rouge Long Ordinaire
 Rouge Long Ordinaire Paivre
 Santa Fe
 Short Thick Cayenne
 Thick Long Red
 Trompe d'Elephant
 True Red Chili

CHERRY GROUP

The pods of this group are cherry-shaped or globose. The fruits are borne on long, slender, upright pedicels which carry the fruit more or less above the foliage. The berries are orange to a deep red in color, solitary, three celled, pungent; blossoms small, white; filaments white except in Japanese miniature, which are purple; leaves small, ovate-lanceolate; plants dwarf, 1 to 2 feet high, quite compact and very fruitful.

The varieties of this group are used to only a minor degree as a condiment. They are an attractive ornamental and are widely grown under glass for the holiday trade. The plants are often confused with Jerusalem Cherry, a Pseudo Capsicum. The Bird Cherry is a small fruited, primitive type belonging to the Cherry group.

The varieties included in this group are:

Bird Cherry
 Bird's Eye
 Cerise
 Cherry
 Creole
 Japanese Miniature
 Large Cherry
 Red Cherry
 Small Cherry
 Tom Thumb
 Yellow Cherry



Fig. 7. Cherry-shaped fruits are typical of the Cherry group.

CELESTIAL GROUP

In the Celestial group the pods are cone shaped, $\frac{3}{4}$ to $1\frac{1}{4}$ inches long, three-celled; color changing from a yellowish green to purplish, then orange-red—the different shades often appearing on the same plant at one time, making it an attractive ornamental plant; season, medium to late.

The fruits are three-celled, erect and very abundant, appearing above the foliage, and acrid; peduncles short, stout and straight; flowers very small, white, six segments; filaments white; anthers indigo shade; calyx distinctly flattened; plants dwarf, commonly $1\frac{1}{2}$ to 2 feet, well branched and symmetrical; leaves small, ovate-lanceolate blade.

Floral Gem is one of the older varieties of this group which is still popular. The pods are a greenish-yellow, later turning red.

Celestial is more dwarf than the Floral Gem, pods smaller and blushed with purple. This variety is grown in the garden and is also used as a greenhouse ornamental plant.

The varieties included in this group are:

Celestial
Chameleon
Chinios
Coral Gem

Floral Gem
Little Gem
Prince of Wales
Spanish Gem

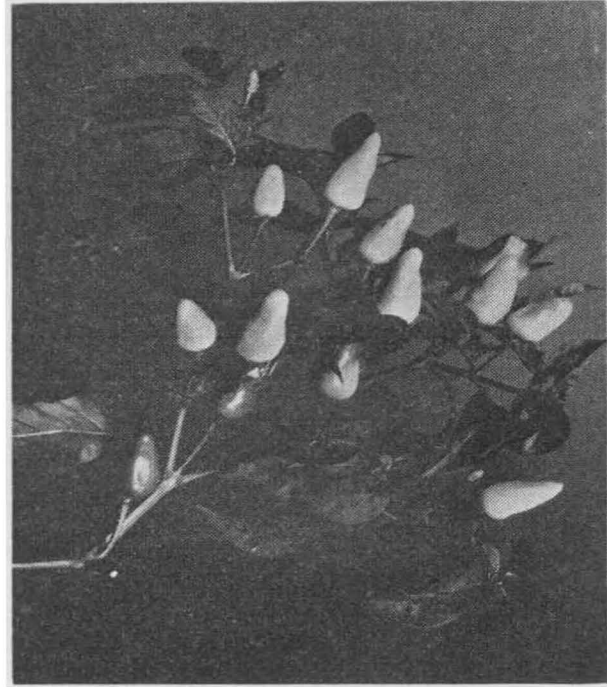


Fig. 8. Erect, purplish white fruits are found in the Celestial group.

PERFECTION GROUP

Pods distinctly conical to sub-conical, apex bluntly pointed, 3 to 4 inches long, smooth; calyx flattened, stems stout, curved; flesh thick, non-pungent; flowers large, white, bell-shaped when fully expanded; filaments white; anthers lilac-tinted.

Leaves large, short and broad, dark green shade; plants 3 feet in height. Most varieties of this group are only moderately productive in this region and are rather late in maturing.

The varieties belonging to this group constitute the leading canning varieties. The nomenclature of the group has become seriously confused, particularly so in the case of the variety

Perfection. Vilmorin - Anderson introduced in 1909 the Piment doux de Genes or Sweet Genna (37) pepper which they describe as "distinct conical or heart-shaped, thick fleshed, bright red pendant fruit of a mild flavor." Illustration No. 65158 accompanying the description in their catalog of that year shows a conical fruit which is clearly the prototype of the Perfection and other varieties of this group.

In 1911 the "Texas Shipper" was offered by the Moore Seed Company. The illustration is that of a conical pepper, and it is described as having thick sweet flesh.

In 1912 a similar if not identical variety, Glory, was introduced by the California Seed Company. It is described as "thick fleshed, large, scarlet . . . elongated conical form of 4 to 4½ inches long by 3 inches wide at the top and of a brilliant deep scarlet color."

Aggeler and Musser list a conical pepper in their 1913 catalog.

Riegel's catalog of 1914 announced a new variety, Perfection Pimento, which it states is a sport of a variety received from Valencia, Spain. In a letter to William Tracy of the United States Department of Agriculture, dated Dec. 2, 1914, Riegel stated that he had been experimenting with this variety for the past three years. A number of seedsmen have dropped the introducer's name Perfection and list this variety as Pimento or Pimiento. The term pimiento is the Spanish for pepper; in other words it is a generic term without respect to kind. In the interests of historical accuracy and identification the term Perfection should be used for Riegel's variety. "The name Perfection should be used for our strain of pimento. There are all sorts of types called pimento and the grower should know which one is meant," states Riegel.⁶

Numerous variations from the original type have appeared in the trade. The author observed strains on the Pacific Coast

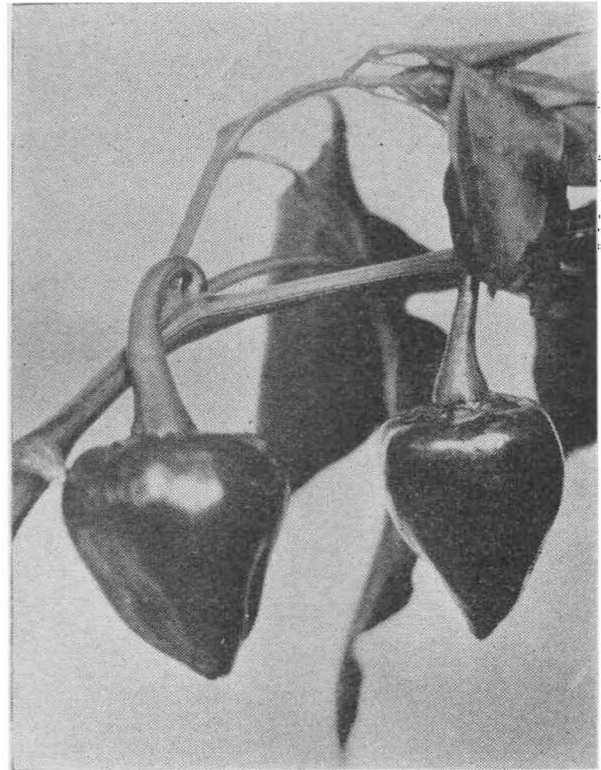


Fig. 9. The Perfection group presents smooth, conical, thick fleshed pods.

⁶Letter to author, Jan. 13, 1930.

which were longer and more pointed and others of a more blocky type with a recessed apex, suggesting the tomato type.

The introduction of the Perfection pepper and the invention, by Mark Riegel, of canning machinery for roasting to remove the skin mark the beginning of the pimento canning industry in America. It is extensively grown for this purpose in Georgia and on the southern Pacific Coast.

It should be further noted that in the Perfection group of pimentos, Aggeler and Musser in 1923 offered under the name of "Salad Pimiento" a distinctly oblate form of fruit. The same firm in 1926 offered a Pimiento which is more circular longitudinally and bluntly pointed. Both of these forms are sufficiently distinct from the Perfection to merit varietal rank. In brief, the term pimento is a general term meaning pepper. Specifically it is applied to varieties of either the Perfection or Tomato type in the seed trade. Among the canners it is restricted to varieties of the Perfection group.

Varieties included in the Perfection group are:

Doux de Genes	Salad Pimiento
Giant Pimiento	Spanish Pimiento
Panama	Sweet Genna
Perfection	Sweet Meat Glory
Pimiento	Sweet Salad
Salad	Rouge de Cavailon

TOMATO GROUP

The tomato group is characterized by a distinctly flattened or oblate form of four cells which bears a striking resemblance to a tomato. The fruit usually is flattened at both the base and apex; size 2-4 inches in diameter and half as thick; furrowed, walls thick, in some varieties as much as $\frac{3}{8}$ inch; four celled; flavor mild, said to be "as sweet as an apple." Flowers intermediate in size and bell-shaped when expanded; filaments white; anthers indigo. Peduncles upwards of 2 inches long, stout, curved and much enlarged next to the calyx; leaves large, ovate, $2\frac{1}{2}$ to 3 inches wide and 4 to 5 inches long; plants $2\frac{1}{2}$ to 3 feet high, branches quite erect.

The varieties of this group are all closely related and represent a well fixed type. They are widely grown in the home garden and are a general favorite for pickling and home canning. They are only moderately productive and the fruit matures midseason to late. The varieties of this group are also known as the squash or cheese pepper.

Sunnybrook probably is the most widely grown variety of the group and in the Middlewest is often sold as pimento.

Topepo is one of the newer varieties of this group. The fruit is unusually large, 3 to 4 inches in diameter, fairly smooth, flesh thick, flavor mild. As grown at Ames the color is yellow,

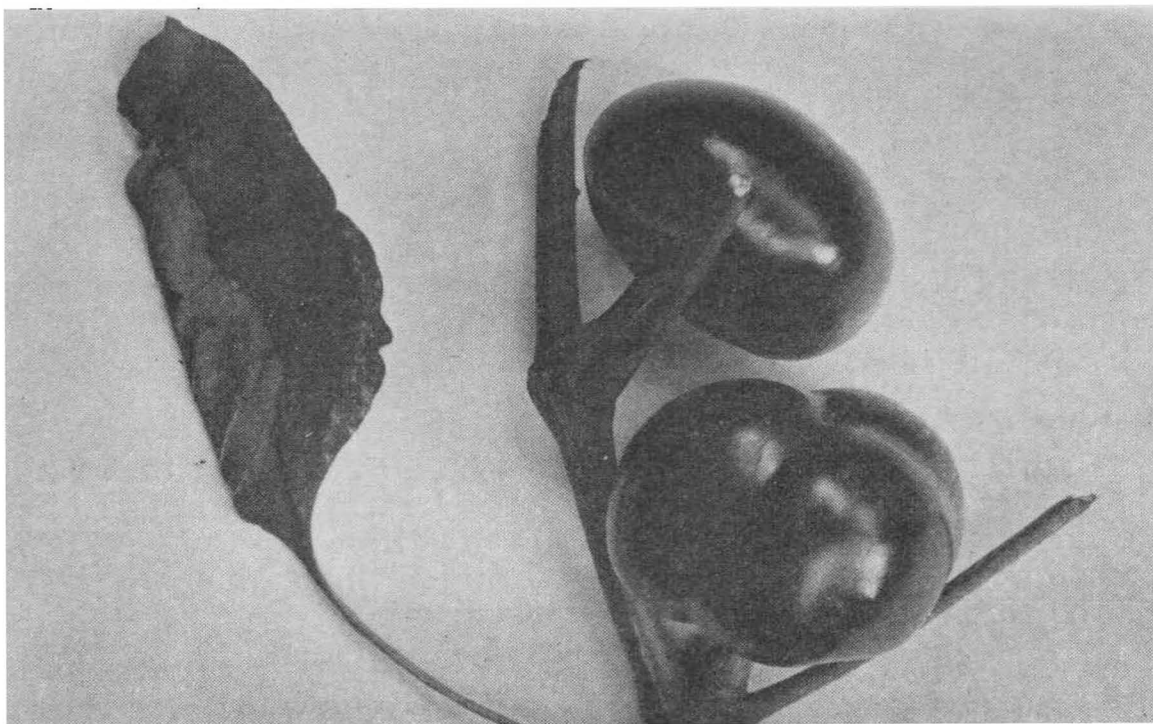


Fig. 10. The Tomato peppers are thick fleshed, mild and bear a striking resemblance to a tomato.

later developing a reddish flush; season late. This variety is claimed to be a cross between a yellow Bell pepper and Stone tomato. In taxonomic characters we see no evidence of its being of hybrid origin. In leaf, flower and fruit it is a typical *Capsicum* of the Tomato group. The one deviation in character is the fact that the fruit is yellow instead of red. A yellow fruited type, however, is not new to this group. A variety known as the Yellow Squash was listed as far back as 1863 by Buist (4). It may also be noted that the peppers and tomatoes belong to two distinct genera and that such crosses rarely if ever occur and that where they do the offspring is practically always a sterile hybrid. In the same class of spurious hybrids belongs the so-called Pepper tomato, recently introduced.

Tomato is probably the oldest variety of the group, but is has been largely supplanted by sorts having a smoother and larger fruit. In some sections this variety is known as the Squash pepper.

The varieties that belong to this group are :

- | | |
|---------------------|------------------------|
| Bickling | Squash |
| Cheese Pepper | Sunnybrook |
| Early Sweet | Tomato Nain Hatif |
| Early Sweet Pimento | Tomato Salad |
| Polombo | Tomato Shaped |
| Red Apple | Tomato Shaped Pimiento |
| Salad | Topepo |

BELL GROUP

The Bell group includes the varieties of greatest economic importance and also the largest number of varieties. Some of the varieties, such as the Bull Nose, are found in every home garden and are also sold in the green state as mangoes throughout the year. They also represent the highest stage of development in the improvement of the fruit.

The term Bell pepper is an ancient one. Wafer (38), a British buccaneer, in his voyage of 1861 to the "Isthmus of America," wrote: "These two sorts of pepper, the one called Bell pepper and the other Bird pepper and great quantities of each, are most used by the Indians. Each sort grows on a weed or shrubby bush about a yard high. The Bird pepper has the smaller leaf and is by the Indians better esteemed than the other, for they eat a great deal of it." Bailey (3) also reports that a Bell podded pepper is still to be found in the tropics of South America. The terms Bell pepper and Bull Nose are used interchangeably in the markets. The former, however, appears to be the historic term and on the basis of priority is used as the group name in this study. The earliest reference we have found in which the term Bull Nose is applied to the Bell pepper is Burr (5), 1863. Henderson (13) likewise used the terms interchangeably (1874).

Fruits blocky, about 4 inches long and equally as wide, squarish, subtruncate to truncate, often deeply furrowed; apex 3-4 nosed; calyx recessed, flattened; flesh thick, as much as $\frac{3}{8}$ of an inch; flavor usually mild, but hot in a few varieties; color red or yellow.

Flowers white, large and bell-shaped, never fully expanded when open; calyx 5-7 segments; style short and stout; stigma below or even with the anthers; peduncle stout and short, about 1 inch, and curved.

Plants large, $3\frac{1}{2}$ to 4 feet, erect, moderately branched; leaves large, 3 to 5 inches long and half as wide, glossy above, more or less wrinkled or puffed, margin often involute; veins prominent; petioles as long as the blade and deeply channeled.

California Wonder probably is the most important acquisition to this group, if not to the entire pepper family. The fruits are large, short, blocky. Many of the fruits measure 4 inches long and the same in breadth; very smooth. The flesh is upwards of $\frac{3}{8}$ of an inch thick and free from pungency. As grown at Ames it is late in maturing and only moderately productive, and it requires too long a season to be of greatest value in the upper Mississippi Valley.

Bull Nose probably is the oldest mango pepper in the trade as well as the most popular variety grown in the United States.

It is the leading sort for home gardens and is also extensively grown in the Southeast and Southwest for the winter trade for mangoes. It is classed as a "sweet pepper," though pungent strains occasionally appear and one of this type is offered in the seed trade under the name of Hot Bull Nose.

The introduction of the Bull Nose is uncertain, as the name is used interchangeably with Bell pepper and the latter term as previously noted comes down from the earliest American horticultural literature. Bernard McMahon (24) in his "Catalogue of Kitchen Garden Esculent Plants" lists the Bell Pepper. Henderson's catalog of 1875 lists a Large Bell or Bull Nose. As to when the term Bull Nose was introduced or by whom, we have not been able to ascertain.

The Chinese Giant proved an outstanding variety among the large-podded varieties which mature late in the season. The fruits are blocky, 4 to 5 inches in diameter, flesh thick, flavor mild. The pods are not so smooth and well shaped as the California Wonder. It is a better producer and earlier than that variety.

In the tests at Ames, Sweet Mountain proved to be one of the most productive midseason sorts. The fruit is of the Ruby King type but more pungent.

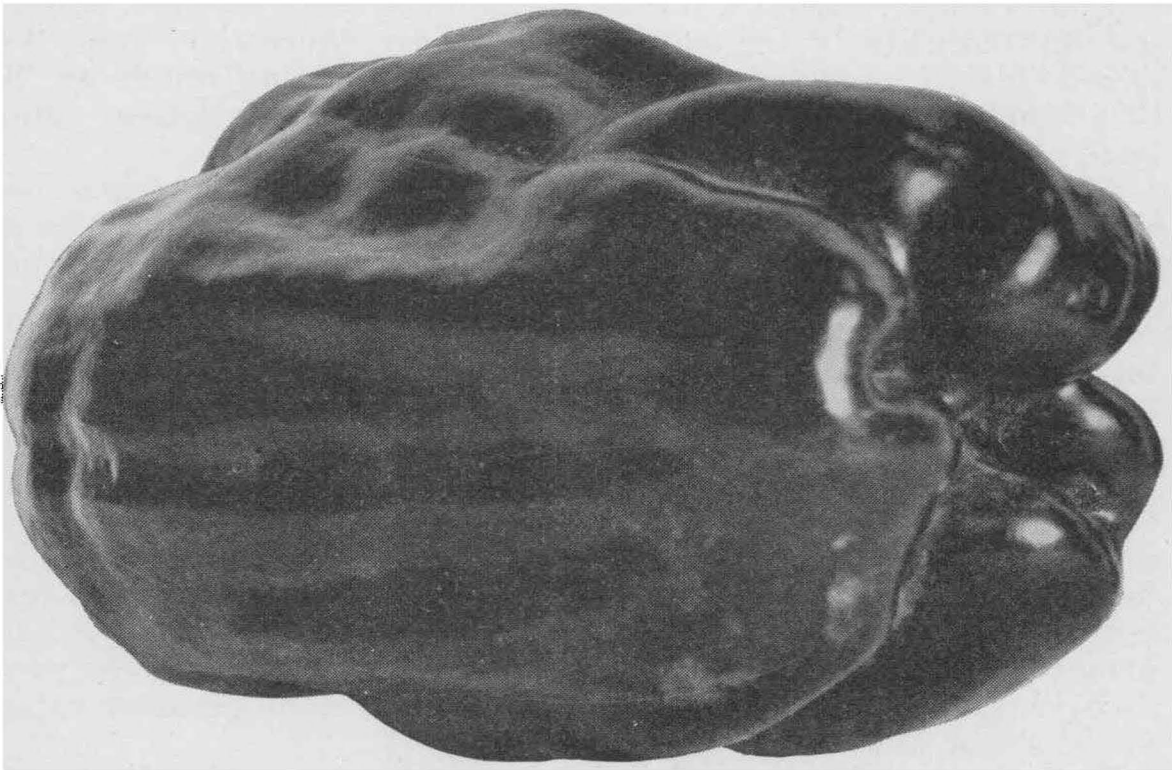


Fig. 11. The Bell peppers constitute the mangoes of commerce and are the most important economic group of capsicums.

Ruby King has long maintained a place as a standard mid-season pepper and has been the progenitor of numerous strains showing minor variations. The plants are upwards of 30 inches in height and productive. The pods average 4 to 5 inches in length, tapering to three lobes. According to Schneck (29), Ruby King is the most important variety grown in New York state.

It is one of the older varieties which still remains a favorite as an early sort with many growers, but will probably be supplanted by superior varieties. The fruits are about 4 inches in length and half as wide, and three lobed. Flavor mild.

Early Giant (Harris) is a favorite second early for this state. It is not so productive as Harris Earliest, but the fruits are longer, ranging 4 inches or more in length and 3 inches in diameter. The pods are three-lobed; flavor mild.

The Harris Earliest is an outstanding early variety. The plants are dwarf—less than 2 feet in height—and very productive. Fruits pendent, three-lobed; flavor mild; length $3\frac{1}{2}$ inches. At Ames this variety has led the list of early maturing peppers.

Lloyd (20) reports that a comparison of six varieties indicated that Neapolitan Salad was the earliest, but that Sweet Mountain was the heaviest yielder. Chinese Giant was the poorest yielder.

The following list of mangoes is by no means complete but does comprise a number of the leading varieties recommended for this state.

Early	Harris Earliest	Harris Early Giant	Neapolitan
Midseason	Ruby King		Bull Nose
Late	Chinese Giant		California Wonder

The varieties belonging to the Bell group are:

Bull Nose	Harris Earliest
California Wonder	Italian Sweet Neapolitan
Chinese Giant	Kolumbus Roter
Crimson Giant	Large Bell
Early Giant	Magnum Dulce
Early Giant Neapolitan	Neapolitan
Early Large Neapolitan	Ohio Crimson
Giant Crimson	Royal King
Great Western H	Schells Quality
Hamilton Market	Sweet Upright
	Sweet Upright Salad

YELLOW BELL PEPPERS

The following named varieties conform to the general type of Bell peppers as to taxonomic characters except that they are yellow in color. They are therefore classed as a subgroup of cultigens under Bell peppers. Economically they occupy only a minor place, as the red sorts have always had the advantage on color.

Chinese Schlacher Riesen	Golden Prize
Golden Bell	Golden Queen
Golden Chinese Giant	Jaune Gros
Golden Dawn	Kolumbus Gold Gelber
Golden Giant	Nucera Gelber
Golden Hercules	Oshkosh
	Prolific Yellow

CULTURE

The peppers are distinctly tropical in their temperature requirements. In the North they are commonly started about 2 months ahead of the transplanting time, as in the case of the tomato. The longevity of pepper seed is generally regarded as about 4 years. The seed is rather slow to germinate and usually requires about two weeks. Peppers do best on a well-drained, warm soil, and particularly one that is not too rich in nitrogen. In the latter instance there is a tendency towards delayed maturity and an excess of vine growth. The spacing varies for different sections. Three-foot rows and a two-foot interval between the plants is perhaps the most common spacing.

The number of days from seeding to maturity varies widely in the different groups. Generally speaking, the range is from 120 to 150 days. Auchter and Harley (1) found that peppers were not sensitive to the intensity nor length of daily illumination. The addition of electric light to the normal daily period delayed the appearance of blossoms. The time required is not wholly a matter of the size of the fruit. Some of the smallest-fruited sorts, such as the Tabasco, require the longest time in which to mature in this section.

YIELDS

The figures in table I on yields were secured from plants grown at Ames and are an average for 10 plants of each variety for the years 1929 and 1930. The total yield will vary from year to year and the figures are regarded as useful chiefly in indicating the relative yields from a few of the leading varieties belonging to the different groups.

Woodruff and Bailey (42) report a yield of approximately 2 tons per acre of Pimento peppers for canning from commercial fields in Georgia.

TABLE I. YIELDS OF PEPPER PLANTS AT AMES

Variety	Average yield per plant in ounces
Japanese Cluster	11
California Wonder	24
Chili Red	20
Red Cherry	21
Celestial	27
Golden Queen	52
Ruby King	23
Hungarian	40
Perfection	12
Tomato	40
Topepo	51
World Beater	45
Anaheim	48
Neapolitan	36
Chinese Giant	67

The yield of dry Chili ranges from 1,250 to 3,000 pounds per acre according to Jones and Rosa (16).

USES

Peppers are used in various ways, principally as a condiment, particularly in warm climates. According to Rose (28) it is "one of the almost universally used plants of Mexico." Peppers were also esteemed by the Indians as a digestive stimulant. "When the axi (chili) is taken moderately it helps and comforts the stomach for digestion; but if they take too much it hath bad effects," notes Father Acosta. It was used by the medicine man to ward off evil spirits by squeezing the juice into the patients' eyes, and in grandmother's day a drop or two of the juice was a sure cure for toothache. Peppers are a powerful rubefacient, and generations ago pepper poultices were a general favorite. "Capsacin (17) and the pepper derived from it is a diffusible stimulant; it also promotes the secretion of gastric and pancreatic juices. As a condiment, a reasonably small quantity is of value in cases of dyspepsia attended with flatulence, etc.; it is of value to alcoholic subjects, but is more especially used by the residents of hot climates, to arouse appetite and relieve dyspeptic symptoms generally."

In general the northern races show a preference for the large non-pungent types, whereas in the more temperate and tropical climes the hot varieties, particularly the cayennes, predominate.

Dried chilies form an important article of commerce. The product used for seasoning was formerly imported mainly from Mexico. Of late years production has increased rapidly in California, and at present approximately two-thirds of the domestic supply comes from that region. The production of chilies for drying is an important item in the Southwest. The long-podded, hot varieties are used for this purpose. The domestic consump-

tion of chilies exceeds the production and considerable quantities are imported annually. The importation of chilies varies widely from year to year, some years amounting to around 3 million pounds, according to the Bureau of Agricultural Economics, United States Department of Agriculture.

The bulk of peppers grown in Iowa is sold as mangoes. The term mango, as applied to peppers, refers to the large-podded "sweet" peppers used in either the green or mature stage for stuffing, salads, etc. The bulk of the trade in mangoes is from varieties of the Bell group.

WHERE COMMERCIAL PEPPERS ARE GROWN

The principal producing area for mangoes is Florida, from which state shipments total over 1,400 cars per year; New Jersey ranks second with about half that number and Louisiana third. The Florida shipping season runs from November to July; New Jersey, June and July. The production of mangoes in Iowa is primarily for the home market and the areas adjoining the towns and cities of the state.

The canning of pimentos is a comparatively new industry in the United States and had its birth following the invention of a machine by Mark Riegel. The machine was designed to roast the pods for the purpose of removing the skin, which is the first step in canning. This was in 1914, in which year Riegel also introduced the Perfection pepper, a variety especially suited for canning purposes.

The two important producing centers for pimentos are California and Georgia. The domestic pack is in the neighborhood of half a million cases annually. The industry gives promise of further expansion as considerable quantities of pimentos are imported. The imports for 1929 amounted to 3,138,746 pounds.

The varieties of peppers grown for pimentos require a long season and are not adapted for growing in this state.

The skin of the pepper is very tenacious and unlike most vegetables is not separated from the flesh by scalding. An oven treatment at a high temperature is required to "blister" the skin. The development of smooth-fruited varieties and the elimination of ridges and furrows, as in the Perfection, has been an important step for the canner. The development of a variety with a skin that will peel would be of great value to the packing industry.

PEPPERS CONTAIN VITAMINS

Quinn, Burtis and Milner (26) in a study of the vitamin content of green peppers found that they contain vitamin A in about the same concentration that lettuce does, more than cabbage, but not as much as spinach. They found that the vitamin

B content compared favorably with that of lettuce and cabbage but was less than that of spinach. Vitamin C content was found to compare favorably with that of any of the vegetables so far studied, including spinach.

The vitamin content of canned pimentos, according to MacLeod and Booher (21), is comparable to canned tomatoes in vitamin C content.

STORAGE

In a storage experiment conducted by Lauritzen and Wright (18), covering a range of temperature at varying degrees of humidity, they conclude that "A temperature of 0° C. (32° F.) and a relative humidity of 90 percent were more favorable for the storage of peppers than any other temperatures and humidities employed. This temperature is sufficiently above the freezing point of peppers (-1.06° C.) to insure against injury from freezing."

DISEASES OF PEPPERS

Dr. C. S. Reddy, of the Botany and Plant Pathology Section, made a disease survey of the station collection at the request of the author. His report is presented herewith.

Black Spot

The black spot of peppers caused by a large-spored *Alternaria* species was prevalent in Iowa in 1931, especially on the large Bull Nose peppers. Usually it was associated with "sunscald" or "blossom-end-rot," which are two non-parasitic diseases of peppers. Diseased ripe fruits were rapidly destroyed. The surface of the lesions was covered by a thick olivaceous layer of *Alternaria* spores. Further examination usually showed the presence also of soft rot bacteria.

General recommendations for the control of pepper diseases are sanitation and rotation of crops. Spraying at weekly intervals with 3-6-50 bordeaux mixture has sometimes proved of value. Care in the selection and treatment of the seed is important because it is known that the following pathogenic organisms can be carried on or in the seed. *Bacterium vesicatorium*, *Cercospora capsici*, *Colletotrichum nigrum*, *Gloeosporium piperatum*, *Alternaria solani*, *Phoma destructiva*, *Phytophthora capsici* and *Vermicularia capsici*. Seed treatment experiments conducted in the greenhouse with seed of five varieties of pepper confirmed the work of other investigators in showing that copper sulfate is an efficacious treatment. Wet treatments using Semesan, mercury chloride and copper sulfate indicated that seed previously soaked in water for 4 hours was benefited most by a 5-minute dip in a solution of 1 part copper sulfate in 80 parts water fol-

lowed by dusting with lime. Experiments with two organic mercury dusts and monohydrate copper sulfate used on the dry seed indicated that the copper dust was the most satisfactory.

Damping-Off

Seedbed diseases are important, not only because many pepper diseases are seed-borne, but because it is the practice to produce plants for transplanting by sowing the seed in hotbeds or greenhouses where damping-off diseases are prevalent. *Rhizoctonia solani* Kuhn (*Corticium vagum* Burk. and Curt.), *Sclerotinia sclerotiorum* (Lib.) Mass., and *Pythium debaryanum* Hesse. are pathogens identified with rapid decay of pepper plants at the soil line, characteristic of damping-off. The latter has also been cited as the cause of a fruit rot. Control measures which have been suggested are: (1) keeping the surface soil dry by careful watering and stirring between the rows, and (2) spreading air-slaked lime between the rows to lessen the progress of the disease.

Sclerotium Blight

The disease caused by *Sclerotium rolfsii* Sacc. is somewhat similar to damping-off in that it usually causes wilting by girdling the stem near the soil line, but it is typically a field disease rather than a seedbed disease. The spherical resting bodies, sclerotia, may be observed by removing the dead bark. *Sclerotium Batabicola* Taub. may also cause a stem and fruit rot.

Fusarium Wilt

A soil inhabiting fungus, *Fusarium annuum* Leonian, is reported from New Mexico as the cause of a wilt of peppers. It attacks the roots and often girdles the stem, resulting in sudden death of the plant.

Mosaic

This virus disease seems to be general in distribution and has been noted several times in Iowa. The leaves are mottled and distorted. Mottling and dwarfing of the green fruit has also been noted. Aphids are mainly responsible for its spread in the field, but its manner of overwintering is not definitely known. It is known, however, that this mosaic can live over on wild perennial solanum hosts.

Bud Rot

A disease occurring under very humid conditions resulting in soft rot of buds, leaves and other tender tissues of peppers was reported from India. The causative agent was reported as *Choanephora cucurbitarum* (B. and Rav.) Thaxter. An organism was isolated from a watery soft rot occurring on pepper pods in Iowa, which was thought at first to be the bud-rot organism

was later identified as a *Mucor* species. Inoculations with the *Mucor* species produced a rapid and watery soft rot.

Cercospora Leaf-Spot

It is caused by *Cercospora capsici* Heald and Wolf and is general in occurrence, becoming serious in very humid weather by causing defoliation.

Bacterial Spot

Bacterium vesicatorium Doidge causes pimple-like spots on leaves, stems, and fruits of peppers. The rough wart-like spots are most prominent on the fruits and offer an easy means of entrance for secondary invaders. The disease has been reported mainly from southern states.

Anthracnose

This is a very common disease of peppers, especially severe as a ripe rot of the pimento types. The disease may be caused by a number of species of *Colletotrichum*, *Gloeosporium* and *Vermicularia*. It appeared on the fruit as circular, depressed, saucer-like lesions, more or less covered with black setae. Microscopic examination usually showed an abundance of vegetative spores, probably identifying it with *Vermicularia capsici* Syd. The value of the fruits was quickly destroyed after they became diseased. The fungus lives over winter on the seed and possibly on the old diseased pods.

Phytophthora Blight

This is a stem and fruit blight of Chile peppers occurring in New Mexico caused by *Phytophthora capsici* Leonian. The fungus overwinters in the seed and in the soil.

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