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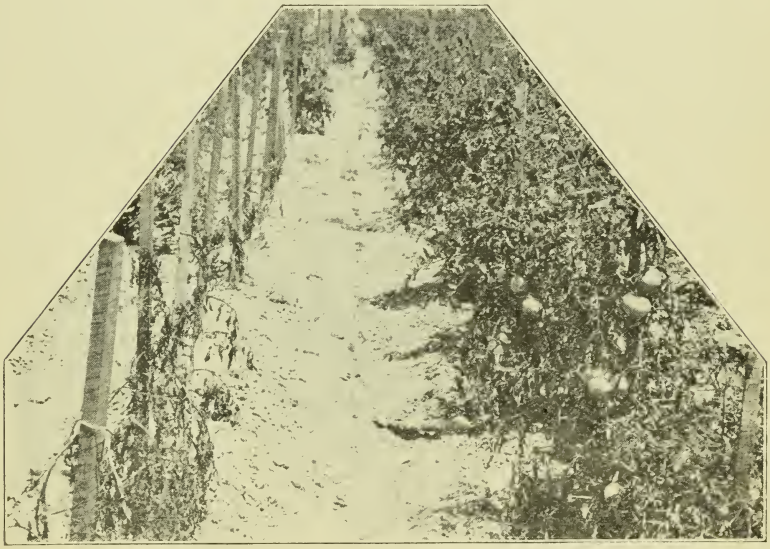

Non-resistant Stone Wilt-resistant Norton

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WILT AND BLOSSOM-END ROT OF THE TOMATO
VARIETAL SUSCEPTIBILITY

By

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The tomato is one of the most important truck and garden crops in Mississippi, ranking second only to the sweet potato in value of vegetable crops. The value of the commercial tomato crop was less than $2,000,000 in 1919 and nearly $5,000,000 in 1926. With this increase in the tomato crop, as with the intensive production of all crops, plant diseases have become an important limiting factor in economical production. The two most important of these diseases are Fusarium wilt and blossom-end rot.

WILT

Tomato wilt was reported as being common in the State in 1912 and has probably been prevalent for several years. It has now spread to practically every county in the State and is probably the most serious parasitic disease of the tomato in Mississippi. Before the introduction of wilt-resistant varieties, it was estimated to take an annual toll of about 25 per cent of all garden or midseason tomatoes. In 1920, wilt-resistant varieties were introduced into the State by one of the authors (Neal) and from 1922 to 1927 about 40,000 samples of wilt-resistant tomato seed were grown and distributed throughout the State by the Mississippi State Plant Board and the Mississippi Agricultural Experiment Stations. The use of these wilt-resistant varieties has probably reduced the loss from tomato wilt to about 15 or 20 per cent of the annual garden crop. Probably 4 or 5 per cent of the early truck crop of tomatoes is destroyed annually by this disease.

Symptoms. When the environment is especially fav-

orable for the development of the wilt fungus, it will attack plants in the seedling stage causing them to wilt, turn yellow, and die. Under more normal conditions, that is, a moderately cool soil temperature during the growth of the plants in the seed and plant beds, infection is not noticeable until the first fruits begin to form. At this stage, the dis-

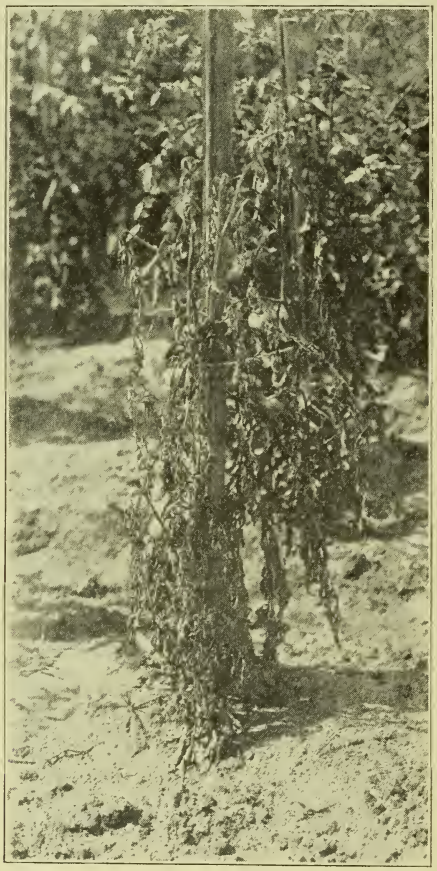

Fig. 1. Tomato plant of the Stone variety infected with wilt.

ease causes a yellowing of the lower leaves of the plant which progresses upward. This is usually preceded by a cessation of growth and accompanied by a wilting of the plants (fig. 1). Wilting is usually very rapid in susceptible plants but develops slowly in more resistant ones. Slightly infected plants may wilt during hot, dry

days and revive during the night. If hot weather prevails, however, this reviving at night will last for only a very short time. Many of the roots of infected plants soon rot making the plant easily pulled from the soil. When the stems of infected plants are cut lengthwise, the vascular or water conducting tissues appear as dark brown streaks extending up the stem and often extending into the leaf petioles.

Cause and Contributing Factors. Tomato wilt is caused by the fungus *Fusarium lycospersici Sacc.* The fungus hyphae grow from the infested soil into the small roots and after penetrating to the vascular bundles extend upward through the stem until nearly or all of the plant is invaded. Recent experiments have shown that the fungus secrets a toxic substance which causes the plant to wilt and die. It was formerly thought that the water conducting tissues were actually plugged to such an extent by the growth of the wilt fungus within these tissues that it caused the plant to wilt. After the plant dies the fungus pushes outward and produces spores or seeds on the surface of the stem. These spores may be readily carried from one plant to another or from one field to an adjoining one, by washing water or in any way that infested soil particles may be conveyed from one place to another. Seed from infected plants may be infested with the spores of the fungus and may serve to disseminate the disease. The fungus may live saprophytically in the soil for several years when it is once introduced.

The fungus develops most abundantly at a temperature of about 80 to 85 degrees F. which is reached about the last of May or the first of June in the trucking sections of the State. This explains why the disease is less severe in the early truck crop tomatoes than in those grown during the warmer seasons. It, also, explains the scarcity of the disease in the northern states. The fungus is favored by an acid soil although it will develop to some extent in an alkaline soil. The fungus develops very slowly if at all in very dry or very wet soils. It seems to develop most abundantly at a soil moisture content best suited for the development of the tomato plant.

Control. Since the wilt fungus can live for several years in the soil after it becomes infested, the following control measures are to be considered: (1) The prevention of the introduction of the organism on new soil by the use of disease-free seed or plants. Seed should be selected from healthy vines and the plants should be grown in soil that has never been planted to tomatoes before. (2) The practice of a long system of crop rotation. Although the fungus can exist for several years without its host plant and hopes of eradication by this method seem discouraging, experiments have shown that the amount of inoculum or fungus in the soil is reduced materially each year that the soil is planted to some other crop than tomatoes. Therefore, a four year or longer system of crop rotation is recommended for this disease as well as several other important diseases of the tomato. (3) The use of wilt-resistant varieties or strains of tomatoes. This is by far the most satisfactory and encouraging method in the control of this disease. Several wilt-resistant varieties have been developed by the various agricultural experiment stations and by the United States Department of Agriculture. These varieties have been developed by selecting healthy plants from heavily infested soils and also by hybridization. Many of these varieties, including the most promising ones, have been tested by the Mississippi Agricultural Experiment Stations for the past several years.

During 1920 to 1923 several selections of tomatoes were studied as to their resistance to wilt, yielding ability, fruit characters, etc. The main tests, however, were conducted during the seasons of 1924, 1925, and 1927.

WILT-RESISTANT VARIETY TEST FOR 1924

The seed of the various varieties which were used in this test were sown in flats in the greenhouse on February 11. The plants were transplanted to cold frames about the first of March and then to the field on April 21. The soil to which the plants were transplanted was a medium-heavy sandy loam soil to which about ten tons of stable manure had been applied per acre about four weeks before the plants were set. The plants were staked and pruned to one main stem until about the middle of July. The plants

Fig. 2. Experimental plats of tomato varieties during 1924. At left, wilt-resistant Norton. At rights, non-resistant Stone.

were not topped and the fruit clusters developed, of course, late in the season well toward the top of the plants. The fruits were picked on June 16, 22, 28, July 7, 17, 25, and August 3 and weights were taken on the sound fruits. Apparent wilt readings were made on June 23 and the actual infection determined by cutting the stems lengthwise on August 2. The results of this test are given in table 1.

TABLE 1

TEST FOR WILT RESISTANCE OF 12 VARIETIES OF TOMATOES IN 1924*

Variety	Apparent wilt June 23 per cent	Actual wilt by cutting stems August 2 per cent	Rank in resistance	Yield in pounds per acre
Louisiana Pink	1.9	41.7	5	17,180
Marglobe	1.5	29.5	2	15,680
Marvana	10.0	42.5	6	13,880
Louisiana Red	0.0	19.5	1	12,980
Marvelosa	6.8	38.0	3	8,880
Perfection	23.5	70.6	8	8,340
Norton	12.2	56.0	7	7,720
Marvel	5.8	40.0	4	7,500
Livingston's Globe	28.0	77.5	10	7,180
Gulf States	18.0	73.2	9	5,500
Red Field Beauty	54.3	93.4	11	4,780
Stone	55.6	98.5	12	4,480

*Average 3 plats.

WILT-RESISTANT VARIETY TEST FOR 1925

The same procedure used in 1924 was followed during 1925 except for dates of planting, harvesting, etc. which were approximately the same as those of 1924. The same soil used in 1924 was used for the 1925 test. The results of the 1925 tests are given in table 2.

TABLE 2

TEST FOR WILT RESISTANCE OF 12 VARIETIES OF TOMATOES IN 1925*

Variety	Apparent wilt June 18 per cent	Actual wilt by cutting stems July 28 per cent	Rank in resistance	Yield in in pounds per acre
Marglobe	3.5	32.4	2	16,280
Louisiana Red	1.6	39.2	3	15,460
Louisiana Pink	6.5	52.3	7	15,300
Price's A. & M.	4.2	48.5	6	12,540
Marvana	16.0	61.5	8	12,300
Marvelosa	8.6	42.5	5	11,760
Perfection	27.0	89.7	10	10,060
Livingston's Globe	31.2	88.8	9	10,040
Marvel	3.5	40.2	4	9,800
Norduke	1.5	29.2	1	7,680
Early Detroit	48.4	100.0	11	4,420
Stone	62.7	100.0	12	3,720

*Average 3 plats

WILT-RESISTANT VARIETY TEST FOR 1927

The same general plan outlined for the tests during 1924 and 1925 was followed during the season of 1927. In addition to wilt-infested soil as used in 1924 and 1925, the varieties were also grown on soil which was free of the wilt fungus during 1927. The results from the tomato tests on wilt-free soil are given in table 4 and are discussed briefly under the control of blossom-end rot. The yields, however, given in table 4 which indicate the relative productiveness of the various varieties under conditions similar to those of this experiment, should be compared with the rank in production given in table 3.

The seed for the 1927 test were sown in greenhouse

flats on February 7. The plants were transplanted to cold frames on March 8 and to the field on April 13. The soil in the field was of a light sandy loam type and had received an application of about 1000 pounds of an 8-4-4 (P-N-K) fertilizer per acre in the drill about ten days before transplanting. The soil was inoculated by placing about 25 grams of a mixture of sand and a strain of the wilt fungus, which had been isolated during the summer of 1926 and

Fig. 3. Experimental plats of tomato varieties during 1927. (A) Non-resistant Stone. (B) Wilt-resistant Norton.

which had been grown for about four weeks on steamed rice, in each hill as the plants were being transplanted. The plants were set 28 inches apart in row 3½ feet wide and 100 feet long. They were staked and pruned to two main stems until about the first of July. They were not topped, however, and the plants continued to form new clusters of fruit until late in the season. The fruits were harvested as soon as ripe, sorted into marketable and culls, and weighed in the field. The picking dates were as follows: June 16, 21, 25, 28, July 1, 5, 8, 11, 14, 19, 25, August

1, and 9. Wilt readings were made at intervals of about three weeks during the growing season. The data obtained from this test are given in table 3 which is self-explanatory.

TABLE 3

SUSCEPTIBILITY OF 14 TOMATO VARIETIES TO FUSARIUM WILT DURING 1927*

Variety	Apparent wilt in percentage				Rank in resistance	Pounds of marketable fruit per A.	Rank in production
	June 4	June 25	July 16	August 6			
Norton	.86	1.72	6.03	32.76	3	8856	4
Stone	49.57	74.36	93.16	98.29	13	1685	13
Louisiana Red	2.56	3.42	7.63	37.61	6	9405	3
Louisiana Pink	.85	.85	5.98	34.19	4	10000	1
Gulf States	23.08	45.30	65.81	92.31	12	5449	10
Marglobe	.86	6.03	9.57	37.07	5	9855	2
Kanora	7.83	9.57	12.17	46.09	7	6451	8
Globe	11.21	13.79	17.24	81.03	11	6179	9
Marvel	.85	1.71	4.27	19.65	1	8016	5
Marvelosa	2.59	2.59	25.86	70.69	9	6592	7
Perfection	16.67	28.07	38.60	73.68	10	4403	12
Marvana	7.69	10.26	11.97	29.06	2	7361	6
Columbia	8.63	12.07	18.96	62.93	8	5269	11
Detroit	51.30	72.17	91.30	99.13	14	1442	14

*Average 3 plats.

The data presented in tables 1 to 3 show conclusively that wilt-resistant varieties of tomatoes are the most effective means of preventing the enormous losses caused annually by this disease. There is a marked difference between the so-called wilt-resistant varieties. It is no longer sufficient to plant a variety of tomatoes because it is resistant to wilt without considering its other varietal characteristics even though resistance to wilt is fast becoming the most important prerequisite for a tomato variety for Mississippi conditions. Table 4, however, shows that the best wilt-resistant varieties of tomatoes compare very favorably with the best commercial non-resistant varieties even on non-infested soil.

BLOSSOM-END ROT

Blossom-end rot is often called black-rot, point-rot, or dry-rot. It has probably been present since the modern varieties of tomatoes first came into existence and occurs everywhere that the tomato is grown. Under certain environmental conditions the disease may cause a loss of the greater part of the crop. Under the same conditions, however, some varieties suffer a greater loss than others from this disease. Blossom-end rot is probably the most important disease of the early crop of tomatoes in the trucking section of Mississippi and is equally severe on the garden tomatoes. It takes an annual toll of about 10 per cent of the entire tomato crop of the State.

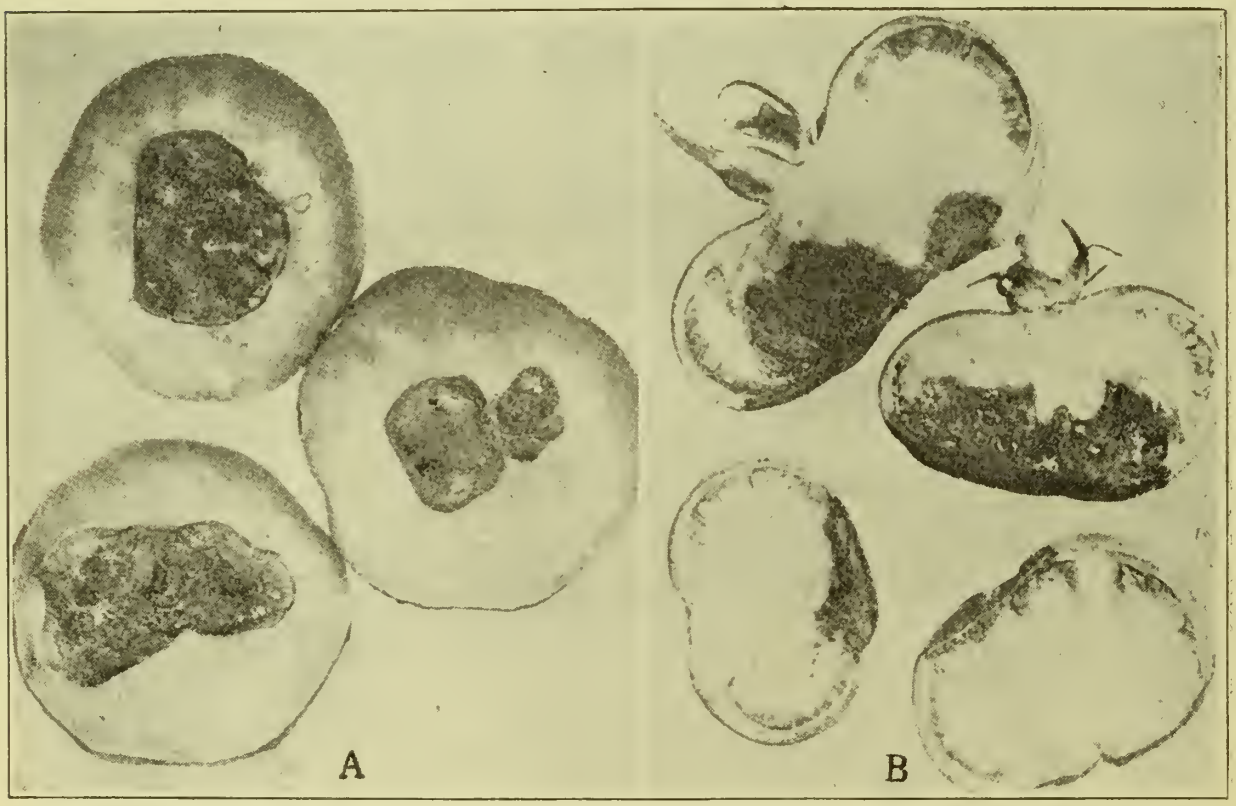

Fig. 4. (A) Blossom-end rot in advanced stage.
(B) Cross section of tomatoes with blossom-end rot. (After Stuckey).

Symptoms. As the name implies the disease affects the blossom ends of the fruit. The fruits seem to be most susceptible when they are one-half to two thirds mature but may be infected at all ages to maturity. The first indication of the disease is a small, water-soaked spot around or near the style. This spot becomes dark in color and may enlarge

to form a large spot which will involve more than half of the fruit (fig. 4). As the spot enlarges, the inner tissues shrink and the end of the fruit becomes flattened or sunken. The black discoloration may extend deeply into the tissues of the fruit (fig. 4). Unless saprophytic organisms gain entrance into the diseased tissues it becomes a firm, dry rot.

Cause. The cause of blossom-end rot is not very well understood. It has been quite clearly established, however, that the disease is not caused by a parasitic organism. The cause seems to be related in some way to transpiration or the giving off of water. It is known that the leaves have a greater osmotic pressure than does the fruit. Therefore, the leaves are able to take up more water than the fruit. Under cases of emergency the leaves take up the water that should rightfully go to the fruit or during a severe drought the leaves may actually draw water from the fruit. This, of course, would cause the fruit cells farthest from the roots to suffer first. Any condition, therefore, that would greatly increase transpiration or cut off the water supply would induce the disease. The most important factors affecting transpiration are soil moisture, humidity, sunlight, and fertilizers.

The lack of sufficient moisture is probably the principal contributing factor. An over supply of moisture will also induce the development of the disease if later the amount of water is cut off suddenly. The more succulent plants are the most susceptible to blossom-end rot during sudden changes of the water supply.

It has been found that strong sunlight tends to induce the disease. A comparison of strong, direct sunlight and diffused, weaker sunlight may be had from tomatoes that mature and ripen in midsummer when losses are usually heavy from blossom-end rot, and those which mature in the late fall when, as a rule, very little of the disease is present.

The question of fertilizers in relation to blossom-end rot is a much debated one. Heavy applications of unrotted stable manure which provide an excess of aeration and cause the soil to dry out rather quickly favor the develop-

ment of the disease. Some investigators state that increased amounts of potash may increase the amount of blossom-end rot materially while increased amounts of phosphate have little or no effect. The influence that nitrogen has on the disease has not been clearly demonstrated. Ammonia-carrying fertilizers are said to increase the disease. Nitrogen in the form of nitrates may not be detrimental.

Control. To prevent or lessen the losses from blossom-end rot the following points must be considered: (1) The soil moisture content should be kept as uniform as possible by giving good drainage, plowing deeply in fall or winter, providing sufficient humus, and irrigating where facilities are to be had. (2) Shading, to a limited extent, tends to reduce the disease. Spacing the plants as thickly as practical may aid in shading the fruits. However, under Mississippi conditions it is not usually practical to have the plants very thick or to have them unstaked to aid in shading the fruits because with the heavy rain-fall in this section soft-rot or ground-rot would cause serious losses. Excessive pruning should be avoided as it allows the fruits to become exposed to direct sunlight. (3) The use of unbalanced fertilizers seems to increase the disease, therefore, the fertilizer should be balanced for the needs of the soil. At any rate, heavy applications of ammonia-carrying fertilizers, and unrotted stable manure should be avoided. (4) Some varieties are more susceptible than others, although none of the commercial varieties are immune. Careful notes were made during the season of 1927 on the susceptibility of fourteen varieties of tomatoes in connection with studies on wilt-resistant varieties.

SUSCEPTIBILITY OF 14 VARIETIES OF TOMATOES TO BLOSSOM-END ROT

The fourteen varieties of tomatoes used in the wilt-resistant variety test in 1927 were also planted on wilt-free soil for a study of susceptibility to blossom-end rot, fruit characters, and yielding ability on non-infested soil. The dates of planting and harvesting, methods of culture, etc. were identical with those for the wilt test except that the

soil was not inoculated with the wilt fungus and was somewhat more fertile than the soil used for the wilt test.

The fruits were sorted into marketable and culls and weighed in the field. The culls were divided into various classes depending upon the cause; namely, blossom-end rot, cat-faces, mechanical injury, etc. The summarized results from these tests are presented in table 4.

TABLE 4

SUSCEPTIBILITY OF TOMATO VARIETIES TO BLOSSOM-END ROT AND NOTES ON OTHER VARIETAL CHARACTERISTICS DURING 1927

Variety	Character of fruit			Per cent blossom-end rot	Per cent cat-faces	Total per cent culls	Lbs. marketable fruit per acre	Rank in production
	Color	Av. wt. in lbs.	Order of ripening					
Norton	Red	.288	10	9.5	5.8	39.2	13,632	6
Stone	Red	.307	13	24.2	5.3	45.1	12,954	7
Louisiana Red	Red	.250	2	12.6	4.6	45.5	13,642	5
Louisiana Pink	Pink	.256	4	17.0	3.8	45.6	15,193	1
Gulf States	Pink	.271	6	6.7	3.2	41.9	14,267	3
Marglobe	Red	.291	3	5.5	2.8	33.5	14,566	2
Kanora	Red	.226	9	5.5	4.4	38.4	14,155	4
Globe	Pink	.265	8	12.9	4.8	48.1	12,124	9
Marvel	Red	.246	5	9.9	8.3	42.9	10,074	13
Marvelosa	Pink	.314	12	30.5	4.7	57.6	11,555	10
Perfection	Red	.267	7	9.7	13.4	54.4	12,155	8
Marvana	Red	.211	1	8.0	5.3	51.0	10,122	12
Columbia	Red	.266	11	6.6	16.0	49.6	8,734	14
Detroit	Pink	.295	14	17.1	8.3	45.9	10,860	11

*Average 2 plats

The data presented in table 4 show that there is a marked difference in the susceptibility of the various varieties of tomatoes to blossom-end rot. Although the results are for only one season, the writers believe the figures represent the relative resistance of the varieties to blossom-end rot, at least, for conditions similar to those under which the experiment was conducted.

WILT-RESISTANT VARIETIES OF TOMATOES FOR MISSISSIPPI

The reader should refer to table 4 for a comparison of the size, color, yielding ability, and relative earliness of the various varieties of tomatoes.

MARGLOBE

Marglobe is the result of a selection made from crossing the Globe with the Marvel by Dr. F. J. Pritchard of the U. S. Department of Agriculture. It is a very productive, second early variety. The fruits are medium large, smooth, red, and globular. The plant is highly resistant to wilt and is moderately resistant to blossom-end rot. This variety is replacing the Globe and other early trucking varieties in the Carolinas and in Florida for wilt-infested soils. It is suited to fertile soils and good cultural conditions. The Marglobe is one of the best wilt-resistant varieties for the home garden and is very promising as a shipping tomato. It is worthy of extensive trials by the truck growers of this State.

LOUISIANA RED AND LOUISIANA PINK

Louisiana Red and Louisiana Pink are the result of a selection made from crossing a wilt-resistant selection of Acme with Langdon's Earliana by Dr. C. W. Edgerton of the Louisiana Agricultural Experiment Station. These varieties have become widely known in several sections of the United States because of their resistance to wilt and their high yields of good quality fruits. The fruits of both varieties are medium-sized, and more or less globular in shape. They are second early varieties and produce vigorous plants which are highly resistant to wilt. They are among the best varieties for home gardens that have been tested at the Mississippi Agricul ural Experiment Stations.

NORTON

The Norton is one of the oldest wilt-resistant varieties having been selected by Professor J. B. S. Norton of the University of Maryland about 1914. It was later improved by Dr. F. J. Pritchard of the U. S. Department of Agriculture. The variety is very similar to the Stone in that it is

very prolific, matures rather late in the season, and produces large, smooth, solid red fruits. It is highly resistant to wilt and is one of the best late-season wilt-resistant varieties.

MARVEL

The Marvel was selected by Dr. F. J. Pritchard of the U. S. Department of Agriculture from Merveille des Marches (marvel of the market) a French variety sold by Vilmorin-Andrieus and Company, Paris, France. It is a medium early variety and produces medium-sized, smooth, deep red fruits. It is very resistant to wilt and produces vigorous growing plants. It is a good garden and trucking tomato.

MARVANA

The Marvana is the result of a selection made from crossing the Marvel with the Earliana. It is the earliest of the wilt-resistant varieties. It produces a good yield of medium-sized, smooth red fruits, and is highly resistant to wilt. This variety was also selected by Dr. F. J. Pritchard of the U. S. Department of Agriculture.

KANORA

The Kanora is the result of a selection made from crossing the Norton with the John Baer which was developed at the Kansas Agricultural Experiment Stations. In Kansas, it seems to be a heavy producer of medium-sized, smooth, deep red fruits. It has been tested in Mississippi for only one season and other trials are needed to determine its value under the conditions of this State. During the season of 1927 it was very prolific producing small, smooth, deep red fruits. It is very resistant to wilt.

SUMMARY OF EXPERIMENTAL WORK

Extensive tests on the resistance of tomatoes to wilt have been conducted for several years at the Mississippi Agricultural Experiment Stations in which about seventeen standardized varieties or strains and many new selections have been tested for resistance to wilt and blossom-end rot, fruit characters, yielding ability, etc. Several varieties have proved to be highly resistant to wilt and very desirable commercially. In fact, some of the wilt-resistant varieties seem to be superior to the best commercial non-resistant ones even on wilt-free soil. Marglobe has been an outstanding producer of high quality fruits each year that it has been in the tests. It is the most outstanding variety for early market and for long distance shipping. The Louisiana Red and Louisiana Pink are outstanding varieties for midseason, home garden varieties. The Marvana is the earliest of the wilt-resistant varieties and is also a heavy producer. The Norton is the outstanding late-season tomato.

Studies on the susceptibility of the various varieties to blossom-end rot were made during 1927. The Marglobe and the Kanora seem to be most resistant to this disease.