A PRELIMINARY STUDY OF RESISTANCE TO WILT CAUSED BY *FUSARIUM LYCOPERSICI* SACC., AND EARLINESS IN THE TOMATO CROSS, BONNY BEST X MARGLOBE

by

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INTRODUCTION

The tomato is a native of South America, and was introduced into cultivation in Europe during the sixteenth century. The wild fruit was wrinkled and was not used for food as it was thought to be poisonous. It was, however, popular as an ornamental, called "love apple".

During the eighteenth century both yellow and red fruited varieties were known. As the fruit was first used for pickling and preserving, little effort was made to improve its form and practically no progress along this line was made until the nineteenth century.

The credit for the improvement of the tomato belongs to the plant breeders who produced a smooth fruited strain desirable for canning and for use in salads. During the past fifty years, the tomato has risen to first rank among garden vegetables. More tomatoes are grown in the United States than in any other country in the world. They are produced as a forcing crop in greenhouses in the North and as a field crop in the South. As a canning crop, tomatoes rank first among vegetables. Few fruits lend themselves to as many uses as tomatoes. According to Carver (1)

there are 115 ways of preparing them for the table.

The growing of tomatoes has been limited to some extent because of the prevalence and destructiveness of the fungous disease called Fusarium wilt in the market gardens of Kansas. As a result the competition from home gardens has injured the sale of the market garden crop. If an early, wilt resistant variety could be produced, the market gardener in the state would be able to have tomatoes in time to compete with the crop produced in southern states from late maturing varieties. This would be of considerable value to the commercial producer. The quality with respect to color, smoothness, size of core, amount of solid flesh, sugar content, and ratio, quantity of seed and yield of the present day varieties of tomatoes is quite satisfactory.

PURPOSE OF THE STUDY

This experiment was planned and conducted to learn something of the inheritance of wilt resistance and earliness in the cross Bonny Best, which is an early though wilt susceptible variety, and Marglobe, which is wilt resistant but late. It is hoped that possibly later a strain

of tomatoes, through hybridization and selection, that will combine the desirable characteristics of the parental varieties might be developed.

REVIEW OF LITERATURE

Tomato wilt is caused by an imperfect fungus, Fusarium lycopersici, which enters the plant through the roots and later invades the entire vascular system. Many theories have been advanced to explain how wilting is produced, the most likely of which are the bundle plugging (21) and (17), and toxin excretion theories (13).

Heavy loses of tomato crops have been caused by Fusarium wilt. According to Pritchard (17) the loss of tomatoes from this disease amounted to more than 115,000 tons in the Middle Atlantic, Gulf and the lower Mississippi Valley States in 1922 and Chamberlain (2) states that in New Zealand, fifty per cent of tomatoes growing in greenhouses are affected with Fusarium wilt. In Arkansas Ellroth and Crawford (9) state that wilt is a limiting factor in the successful production of tomatoes. In California according to Shapovalova and Lesley (19) Fusarium wilt frequently destroys from five to ten per cent and sometimes as much as

85 per cent of the total crop. Huelsen (14) has concluded that wilt is the most important disease affecting tomatoes in Illinois. Edgerton and Moreland (7) have estimated that in Louisiana, on an average, twenty-five per cent of the crop is lost because of the wilt disease.

Fusarium wilt is found in all of the countries of the world, although it is more abundant in those having warm climates. In the United States although the disease occurs to some extent in the northern tier of states, it is especially destructive in the southern states where it is frequently the limiting factor in successful tomato production, Edgerton and Moreland (7). White (23) states that although tomato wilt was first observed in Kansas in 1918, it probably had been present in the southern and eastern parts of the state several years before that time. It is now recognized as the most destructive tomato pest in this state.

In Louisiana, Edgerton and Moreland (7) found that the disease is not prevalent on the heavier alluvial soils, the organism apparently preferring lighter, well drained, fertile soils.

As the causal organism is a faculative parasite it is able to exist in the soil by utilizing the dead organic

matter. Primary infections are caused by the mycelium overwintering in the soil or by the germinating chlamydospores and conidia produced by the existing hypha. Secondary cycles, if they occur at all, are rare.

After infection has taken place through the roots, all parts of the plant are invaded systematically. The wilt organism is an intra-vascular parasite. It possibly causes death to the plant by plugging up conducting vessels of the xylem as found by Edgerton and Moreland (8), and Chamberlain (2) and other early workers or by excreting materials that are toxic to the tissues of the leaves (13).

Edgerton and Moreland (8) found that wilt may affect the tomato plant in any stage of its development. It may appear while the plants are in the seedling stage if the conditions for infection and invasion are favorable. However, the disease is most noticeable at about the time the plants are developing their first fruit. The first noticeable symptoms of the disease are the yellowing and wilting of the lower leaves. This is followed by a progressive discoloration of the upper leaves and the death of the entire plant. A susceptible plant generally dies rather rapidly, but one of a resistant variety sometimes may live through the season even though it has been infected and

there is some mycelium of the causal fungus in its tissues (17). Pritchard (17) found that no variety of tomato was absolutely immune to Fusarium lycopersici. Haymaker (12) reported that only two per cent of the seedlings of the variety Marvel actually wilted although 52 per cent showed the presence of the wilt fungus.

There is no external development of the wilt fungus until the very last stages of the disease. When the plant is dead, according to Pritchard (17), the fungus may produce a pinkish cobwebby growth of mycelium on the dead stems.

The internal symptoms of diseased plants can be observed by making a cross-section of a root or stem and examining the vascular bundles. Those of affected plants are brownish to blackish in color.

Various methods have been used in an attempt to control the disease. Heavy applications of lime have been used by Durst (5) and Edgerton (6) but this treatment was of questionable value. Such applications retarded the growth of the Fusarium wilt but had a deleterious effect on the tomato plant also. Other chemicals have been used by earlier workers but with no satisfactory results.

Edgerton (6) was perhaps the first investigator to sterilize the soil and inoculate with a pure culture of

the organism causing the wilt disease. He maintained that in garden soil the presence of bacteria and other fungi seem to have an inhibitory effect on the wilt fungus. By sterilizing the soil and adding a pure culture of the pathogen Edgerton (6) obtained the following results in two tests: In unsterilized soil the percentage of infected plants was 22.7 and 60.6, while in sterilized soil the percentage was 86.8 and 85.6. This method of inoculation has also been used by Shapovalova and Lesley (19) with good results.

Although many critical observations had been made in the field concerning the relation of tomato wilt to ecological conditions, Clayton (4) was the first to study the relation of temperature to the development of the disease under controlled conditions in the greenhouse. He found that 28° C. favored the lateral expansion of the organism growing on an artificial medium and that a temperature ranging from 24° - 28° C. favored the development of the disease. He also found that the moisture requirement for the maximum growth of the host plant correlated with that which favored the production of the disease. Plants in a soil with a low moisture content, 13 to 19 per cent, were very resistant, and plants grown in saturated soil were immune

(3). Haymaker (13) obtained results similar to these of Clayton (3). Haymaker (13) found that the disease as caused by two strains of the fungus would develop most vigorously at temperatures 24° - 28° C. (12).

Various methods have been tried to control tomato wilt, not one of which is completely successful. Rotation has been helpful. Lesley (16) found that disinfecting the seed bed; changing the seed bed soil every three years; and locating the seed bed on higher ground some distance from the packing shed and tomato field aided in keeping Fusarium wilt under control. The most practicable method of controlling the disease, however, would seem to lie in developing varieties resistant to the wilt, as the characters favoring wilt are apparently as permanent as other characters in tomatoes, (6), (17), (10).

Resistance fluctuates somewhat with changes in soil temperature, soil moisture, and other ecological factors, but on the average is less variable than the tomato fruit characters (11), (17).

Hybrid vigor is often exhibited in tomatoes as well as in other plants. Willington (25) found that in a cross Stone X Dwarf Champion, the average increase of fruit was 8 per cent over the parental average. Hays and Jones (11)

think that such increases are sufficient to make the practice of growing first generation hybrid tomatoes commercially profitable. All experiments in tomato crosses conducted by Willington (25) at the Geneva, New York station during the years 1907 to 1910 gave gains in yield for the first generation.

Experiments by Hays and Jones (11) have shown that crossing inbred lines of tomatoes also results in hastening the time of ripening of the fruit. Sayre (18) states that yields and earliness of tomatoes vary due to differences in temperature, rainfall, frost period and time of transplanting. Proper cultural practices are important factors in maintaining high average yields and producing the crop in time for the early market.

The development of a resistant variety of tomatoes may possibly be complicated by the existence of physiological strains of the organism. White (29) and Haymaker (12) have demonstrated that strains from different localities vary markedly in pathogenicity, and that various varieties of tomatoes react differently in their susceptibility to the various strains. Tomatoes also vary in productivity in different localities. Jones (15) found that Break O'Day was worthless as a commercial tomato in California while

it is considered one of the better varieties in the East.

A great deal of work has already been accomplished in breeding tomatoes for resistance to wilt, by such pioneer investigators as, Edgerton, Norton, Moreland, Pritchard, White, Vilmorin, and Andrien.

Marvel is a selection from Merville des Marches (Marvel of the market) a French variety bred by Vilmorin, Andrien and Company, Paris, France.

Pritchard crossed Marvel with Globe and produced a variety of tomatoes which he called Marglobe, one of the parents used in this study. By crossing Marvel with Earliana, Marvana was produced. Both of these varieties are resistant and are earlier maturing than Marvel.

Edgerton and Moreland (7) developed Louisiana Red and Louisiana Pink, Louisiana Red being one of the better commercial wilt resistant tomatoes grown in Kansas.

White crossed Norton and John Baer and produced a variety which he called Kanora. Although Kanora showed resistance to some strains of the wilt fungus, it was more susceptible than some of the varieties developed by Pritchard (17).

MATERIALS AND METHODS

Bonny Best and Marglobe were chosen as the two parents. Thompson (22) describes Bonny Best and Marglobe as follows: Bonny Best is of medium heavy growth, medium in size of foliage. The fruit is borne in clusters of four to six, small to medium in size, red color, nearly globular to slightly flattened, very smooth, shallow stem cavity, and a small core. It is one of the earliest varieties on the market and ranks among the better tomatoes for its fine qualities. Marglobe is a wilt resistant variety, medium early and popular as a shipping tomato because it carries well due to the thick skin and solid fruit. The fruit is red, round, to flattened shape, very regular, smooth, medium in size. In choosing these two varieties to work with, market qualifications were given less emphasis than earliness and wilt resistance.

The seeds of the parent varieties were obtained from a commercial seed house. They were sown in pans in the greenhouse on March 4, 1932 and the seedlings were pricked off into flats April 4. They were transplanted to the field on April 20.

Before the blossoms opened, they were covered with glassine bags to prevent accidental crossing. As soon as the plants came into bloom reciprocal crosses were made. The female parent was emasculated two or three days before the stigma became receptive to prevent selfing. According to Lendstrom (*) this may not be necessary but it seemed desirable in order to prevent any possibility of cross fertilization. When the pistil was receptive the stigma was dusted with pollen from the male parent. It was found that better results could be obtained when the pollen sheds freely, which is on warm sunny days. In order to insure pollination, the stigma was pollinated on three consecutive days.

Five crosses were made in the field. All five crosses set fruit, but only one fruit from each cross matured normally, the others were injured by "sun scald", which caused a heavy loss of tomatoes in Kansas in 1932.

The fruit was picked when thoroughly ripe, thus allowing the seeds to obtain nutrients from the pulp of the fruit during the later stages of development. After the fruit had been picked, it was allowed to dry until the skin shriveled. The seeds were then extracted and dried in the

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* Letter - May 3, 1933

sun.

After drying the seeds were placed in a cool, dry dark room for about five days. The seeds to produce the F_1 plants were sown in the greenhouse in twelve inch pans in August. The pans contained wilt infested soil. This soil was obtained from the tomato plots of the Department of Botany and Plant Pathology. Tomato wilt has been present in these plots for twelve years, thus assuring that a viable strain of the organism was present.

The plants, in pans, were then put on the forcing bench. The soil in the pans was kept at a temperature of 28° C. When the plants were five inches tall they were transplanted into three inch pots. Nine of the potted plants were selected from a hundred seedlings to be transplanted to the greenhouse beds in late September. These were given the usual greenhouse tomato culture. Accidental cross pollination was prevented in the greenhouse, as it had been in the garden the previous summer, by covering the blossoms with glassine bags.

When two fruits had set on each "hand", the remainder of the blossoms were removed to allow the plant to give all its nutrients to these two fruits. It was thought that this method might result in larger fruits maturing a little earli-

er. When the fruit had set the glassine bags were removed.

The F_1 plants apparently exhibited hybrid vigor, but as there were no plants of either parent as controls, it is impossible to make a positive statement. Plantings of parental, F_1 and F_2 plants have been made in the garden for further observations and study of hybrid vigor. The F_1 plants growing in the greenhouse had made a vegetative growth of eight feet when the first fruit matured. Plants of another variety grown in the greenhouse at the same time were five feet tall when the first fruit matured. The foliage, main stalk and branches of the F_1 hybrids, were larger and heavier.

As soon as each fruit became ripe it was picked and the seeds extracted. Each fruit of the F_1 generation was kept separate and labeled. All the fruit matured within a period of 19 days. Thus the seed of the earliest maturing fruit could be planted at the same time as that of the later maturing fruit.

The seeds from the F_1 plants were planted in six inch pans containing one part of sand to four parts of disease free greenhouse soil. When the F_2 hybrids were large enough they were transplanted into $2\frac{1}{2}$ inch pots. Four hundred thirty-five F_2 plants were potted but only 117 were grown to

maturity. A larger number of F_2 plants would have been desirable, but the F_1 plants failed to produce as many seeds as expected and greenhouse space for growing the F_2 plants was limited.

After the plants had grown three weeks in two and one-half inch pots, they were transplanted to three inch pots. The mixture one part of sand to four parts of wilt infested soil was used in the three inch pots. Fifty cubic centimeters of spore suspensions of Fusarium lycopersici were added to each pot. The cultures of this fungus were grown in 45, 125 cubic centimeter flasks. Cornmeal was used as the culture medium.

The plants in the three inch pots were next placed in a large Wardian glass case for 10 days. Due to the limited space in the humid chamber, two incubation periods had to be used to include all the F_2 plants. A week after the last set of pots had been taken out of the Wardian case, the F_2 hybrids were transferred to the ground beds in the greenhouse. Only vigorous healthy looking plants were chosen. Placing the young plants in the Wardian case for 10 days caused them to make slender and spindly growth. Such plants cannot be expected to produce as good a tomato crop as plants growing under normal greenhouse conditions.

One hundred and seventeen F_2 plants were set out in the greenhouse bed spaced two feet on the square. There were 13 F_2 plants from each of 9 F_1 plants. Parental controls included four Bonny Best and five Marglobe. All the plants were given the usual greenhouse culture. The remainder of the 426 F_2 plants were used for the blackened bundle test for the tomato wilt organism, as later described.

The seeds to produce the F_1 and F_2 plants for testing in the field were sown in 8-inch pans containing wilt infested soil. Usual greenhouse culture was given the crop until the plants were set in the field on May 13, 1933.

A Test to Determine the Pathogenicity of the Organisms Causing Fusarium Wilt

Since it was impossible to obtain a temperature of 28° C. under available greenhouse conditions, a special enclosed glass frame was constructed of standard cold frame sashes. This Wardian case was built over a forcing bed where it was possible to have bottom heat to control the temperature accurately. Soil and air temperatures were taken hourly to insure a constant optimum temperature. A pan of water was kept in the case to assure saturation of the air with

water vapor. The Wardian case proved very effective in controlling temperature and humidity.

The damping-off organisms grow rapidly under such conditions. These fungi damage the plants by girdling them at the surface of the ground. The damage from damping-off organisms were reduced as much as possible by giving the plants less than the optimum of water.

A strain of Fusarium lycopersici was obtained from Dr. O. H. Elmer of the department of Botany and Plant Pathology. Cultures of this fungus were grown by Dr. H. H. Haymaker of the same department in a sterilized cornmeal medium. The cultures were grown in two different types of containers to determine, if possible, the effect on the pathogenicity of the Kansas strain of Fusarium lycopersici. One culture was grown in 300 cubic centimeter flasks; a second culture in Petri-dishes. From these cultures spore suspensions were obtained by adding distilled water to the media. A microscopic examination to determine the presence of spores before inoculating the soil in which the tomatoes were growing gave positive results.

Three varieties of tomatoes, Louisiana Red, Break O'-Day were used to test the pathogenicity of the cultures. Louisiana Red and Break O' Day are resistant while Bonny

Best is susceptible to Fusarium wilt.

Three methods of inoculation were used in order to determine the most effective method. Six Louisiana Red plants were inoculated with the Fusarium wilt spore suspension by pouring the suspension on the soil in which four week old plants were growing in four inch pots. The spore suspension was obtained from the 300 cubic centimeter flasks. Three more plants were inoculated with spore suspensions obtained from Petri-dishes. Three Louisiana Red plants were grown in uninfected greenhouse soil as controls.

A second series of these trials were made by growing Bonny Best, susceptible, and Break O' Day, resistant, from the seed stage to maturity in inoculated soil obtained from the Department of Botany and Plant Pathology. The seedlings were pricked-off from the twelve inch pans in which they were growing and transplanted into six inch pots, three plants to a pot. Fifty-seven Bonny Best and seventeen Break O' Day seedlings were grown.

The last series consisted of six five week old Louisiana Red seedlings grown in greenhouse soil with a top dressing of the soil obtained from the Department of Botany and Plant Pathology.

Possibly some of the inoculated plants failed to be-

come infected because the strain Fusarium lycopersici obtained from Dr. Elmer may have lost some of its pathogenicity, or because the plants were kept rather dry to retard the damping-off organisms. It would have been desirable to test the virulence of this strain of Fusarium wilt before this investigation was under taken.

Cross sections of the stems were cut to determine the presence or absence of blackened fibers caused by the presence of the wilt fungus in the vascular bundle region. The results of this investigation are shown in Table II. On the bases of these preliminary studies it was decided to grow the F_2 plants in infested soil to which spore suspensions were added. By using two sources of inoculum it was hoped that infection would be uniform, thus providing the condition needed to determine the wilt resistance of the F_2 plants.

EXPERIMENTAL RESULTS

The nine F_1 plants grown in the greenhouse showed no wilt. The plants made an exceptionally vigorous vegetative growth and were very productive. The luxurious vegetative growth was probably due to hybrid-vigor but as there were

no parental controls, this could not be accurately determined. The leaves of the F_1 plants were much larger than these of either parent as usually grown and observed in the greenhouse. As many as 30 blossoms developed on a single hand, but only 8 to 10 fruit matured on such a hand. The fruits of the F_1 plants were wrinkled, solid, and contained few seeds. This "seedless" character is desirable in a commercial tomato. The fruits of the parental varieties are smooth and usually larger than the fruits of the F_1 plants as grown in the greenhouse. The size of the fruits of the F_2 plants varied considerably. Some of the fruits were larger than either parent, while other fruits were smaller. The fruits of the F_2 plants had few seeds, in this respect resembling fruits of the F_1 plants.

Segregation in the F_2 generation was clear cut and was most noticeable in the foliage characters. The shape of the fruits also varied greatly. Some of the fruits were flattened, some round, and some were pear shaped. The F_2 plants varied in date of first ripening of fruit, (Table 1), from June 1, 1933 to June 23. The first fruit of the resistant parent, Marglobe, ripened June 10 while the first fruit of the susceptible early parent, Bonny Best, ripened June 13. The early susceptible parent probably failed to

Table I. Comparison of date of first ripening of F_2 fruits grown in the greenhouse beds June, 1933.

F_1 Plant numbers	F_2 Plant Numbers													
	1	2	3	4	5	6	7	8	9	10	11	12	13	Average
I	20	15	21	(1)	20	16	12	20	23	18	11	17	13	17
II	25	12	21	21	20	11	15	17	4	8	21	18	20	16
III	11	11	8	10	1	9	17	9	21	-	18	9	10	11
IV	11	11	-	10	11	11	14	7	14	10	7	8	1	10
V	-	3	9	8	11	8	12	11	11	11	14	12	7	10
VI	14	17	-	20	17	15	20	18	-	7	-	-	12	16
VII	11	7	20	7	9	20	10	11	10	10	9	9	8	11
VIII	9	13	14	7	11	11	3	11	7	11	8	9	14	10
IX	9	9	10	10	10	13	22	11	8	14	13	14	19	12
										Average				13
Bonny Best P_1	17	13	13	16										15
Marglobe P_1	16	13	10	13	11									13
										Grand Average				14

(1) - Killed by termites

ripen fruit before the late resistant parent because of severe infections of Fusarium wilt. Fruits of F_2 plants matured between June 1 and June 23. Some of the early maturing hybrids showed susceptibility to Fusarium wilt but others showed resistance.

One of the 5 plants of the resistant parent, Marglobe, was susceptible to the tomato wilt and one of the 4 susceptible parents, Bonny Best, apparently showed resistance to wilt. The fruit of most of the F_2 generation had thick meat resembling the Marglobe parent in this character, small core common to both parents and the tough skin of the resistant Marglobe variety. The size of the fruit varies as it does in both parents.

Of the 116 F_2 hybrids grown to maturity in the greenhouse 16 per cent wilted completely and did not produce any fruit, 22 per cent were infected with Fusarium wilt as shown by examining cross sections of the petiole of the lower leaf, and the remainder of the plants apparently were free from the disease (Table 2). Of the 318 seedlings which were examined while in 3 inch pots and which were destroyed by examination, 28 per cent were infected as shown by the blackened bundles observed in cross sections of stems (Table 3). Resistance to Fusarium wilt evidently behaves as a dominant character in this cross.

Table II. Wilt infection of F_2 plants grown in greenhouse beds, 1933.

Pedigree		I	II	III	IV	V	VI	VII	VIII	IX	Average Hybrids	Bonny Best	Marglobe	(2) Average P_1
numbers		1 to 5 7 to 13	1 to 13	1 to 13	1 to 13	1 to 13	1 to 13	1 to 13	1 to 13	1 to 13	13	4	5	5
Total number of plants		(1) 12	13	13	13	13	13	13	13	13	13	4	5	5
Infected	number	5	4	1	2	3	1	5	3	2	26	3	1	2
	per cent	42	31	8	15	23	8	38	23	15	22	75	20	45
Not infected	number	7	9	12	11	10	12	8	10	11	90	1	4	3
	per cent	58	69	92	85	77	92	62	77	85	78	25	80	53
Wilted	number	4	1	1	2	1	1	4	2	2	18	2	1	2
	per cent	33	8	8	15	8	8	31	15	15	16	50	20	35

(1) - One plant killed by termites.

(2) - These plants were so badly infected that they died or are dying from the disease.

Table III. Wilt infection of F_2 plants grown in flats in the greenhouse, 1932-'33.

Pedigree numbers	I 1 to 32	II 1 to 28	III 1 to 2	IV 1 to 36	V 1 to 33	VI 1 to 43	VII 1 to 12	VIII 1 to 9	IX 1 to 14	Average of Hybrids	Bonny Best P_1	Marglobe P_1	Average P_1
Total number of plants	32	83	2	36	33	43	12	9	14	29	8	8	8
Number of infected plants	4	30	1	7	7	13	4	3	6	8	2	0	1
Plants free of disease	28	53	1	29	26	30	8	6	8	21	6	8	7
Per cent infected	13	36	50	19	21	30	33	33	43	29	25	0	13

The results of the test to determine the pathogenicity of the organism causing Fusarium wilt are shown in (Table 4) but were not very satisfactory. Damping-off caused the loss of many seedlings in the Wardian case so that a count of wilt infected plants based on the total number of plants could not be made. Of 98 plants used in this preliminary test 64 were living at the time final records were taken. Some of the 34 plants which died may have been infected with Fusarium wilt but only five of the 64 plants examined were infected by Fusarium wilt as determined by the blackened bundle method. The low wilt infection may be due to the small quantity of spore suspension used and to a lack of sufficient moisture supply. About 160 F_2 plants, 30 of each parent and 30 F_1 plants are being grown in the field during the summer of 1933 (Plate I). Little accurate information can be obtained from this field test because of the extremely dry weather of June. Some of the hybrids in the field grew as well as tomato plants of standard varieties under irrigation in the Experiment Station test plots. The F_1 hybrids growing in the field showed some evidence of hybrid vigor as compared with plants of the parents growing in adjacent rows.

Table IV. Comparison of wilt susceptible and wilt resistant tomato plants to the Kansas strains Fusarium lycopersici in the preliminary test.

Variety	Treatment	Plants in test	Infected plants	Wilt free plants	Surviving plants
Louisiana Red:	Flask suspension (Greenhouse soil)	6	1	3	5
	Petri-dishes suspension (Greenhouse soil)	3	1	2	3
	Control	3	0	3	3
Bonny Best :	Infested soil	57	2	29	31
	Control	6	0	6	6
Break O' Day :	Infested soil	17	1	9	10
Louisiana Red:	Top dressed with infested soil (Greenhouse soil)	6	0	6	6
	Total	98	5	58	64

DISCUSSION

This study suggests the presence of dominant factors in the inheritance of resistance to Fusarium wilt in the cross Bonny Best X Marglobe (Plate II). Although Bonny Best is susceptible to Fusarium wilt (Plate III), it may carry one or several factors for resistance which differ from the resistant factors found in Marglobe (Plate IV). Since only the F_1 and F_2 (Plate V) generations were grown, it is impossible to make any positive statements regarding the inheritance of susceptibility and resistance. Not all of the hybrids were resistant (Plate VI).

The number of F_2 hybrids was too small to permit a genetic analysis of resistance to Fusarium wilt in this cross. The cross should be carried through the F_3 generation to study the manner of genetic inheritance to Fusarium lycopersici. A larger number than that used in the F_2 generation would be more desirable in the F_3. The genetics of tomatoes has not been studied enough to determine the association between resistance to Fusarium wilt and other characters found in tomatoes.

There are many physiological forms of Fusarium lycopersici found in the United States. It is thought that it

would be possible, if this experiment were carried through 8 generations, to develop a variety that would be resistant to the physiological strains found in Kansas.

SUMMARY

The purpose of this experiment was to study the inheritance of wilt resistance and earliness in a cross between an early variety of tomato, Bonny Best, and a wilt resistant variety, Marglobe. Only the F_1 and F_2 generations have been grown.

It is hoped to produce a strain by hybridization and selection that will combine the desirable characteristics found in the two varieties used as parents.

Bonny Best tomato was chosen as one parent because of its early maturity, medium size, red color, smooth fruit, and small core. This variety ranks among the better tomatoes because of these fine qualities. Marglobe was selected as the other parent because of its resistance to Fusarium wilt, productivity, good quality and ability to ship well.

The parents were grown in the field during the summer of 1932. Reciprocal crosses were made in the field. Seeds

of this crop were sown in wilt infested soil in the greenhouse in August, 1932. Seedlings were transplanted to greenhouse beds in late September. The F_1 plants showed hybrid vigor. The fruits were rather small but large quantities were produced. The fruits had relatively few seeds and were thick-meated and had a tough skin which is desirable for shipping. The fruit of the F_1 plants compared favorably with the tomatoes grown commercially in the greenhouse at Manhattan.

Seed to produce the F_1 plants sown in wilt infested soil but none of the nine F_1 plants grown to maturity were wilted.

Tomato plants resistant to the wilt can be infected with Fusarium wilt and still produce a normal crop, while a susceptible tomato plant may wilt and produce a small crop of tomatoes or none.

Two methods were used to determine wilt resistance. The first method was by observing wilted plants and the second by cutting cross sections of the stem of tomato plants and determining the presence or absence of blackened fibers in the vascular bundle region.

The seeds to produce the F_2 plants were planted in the greenhouse in February, 1933, in wilt infested soil, to

which was added spore suspensions of pure cultures of Fusarium lycopersici thus insuring a good infestation of the causal organism of Fusarium wilt.

In the F_2 generation of 116 plants, 18 plants were severely wilted. Three of these plants died during June and the others failed to make normal growth and produced less fruit than healthy plants. These results indicate that resistance to Fusarium wilt behaves as a dominant character in the cross.

Studies were made of the wilt resistance and earliness of the F_2 hybrids. Segregation was evident for characters of the leaves, fruit and rate of growth of the plants, as well as for wilt resistance. The large number of resistant plants of desirable type in the F_2 generation of the tomato cross Bonny Best X Marglobe indicates that it probably will be possible to produce a new variety combining the earliness and other desirable characters of Bonny Best with the wilt resistance of Marglobe. The fruits of most of the F_2 plants are of good quality, and have smooth, solid flesh, few seeds and good flavor.

Tests of F_3 lines will be necessary to determine the mode of inheritance of wilt resistance, earliness and other characteristics. Pedigree selections of several succeeding

generations must be carefully tested in the greenhouse and field before one of these is selected as the new commercial variety.

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PLATE I

F_1 and F_2 plants during the summer of 1933.

Field culture.

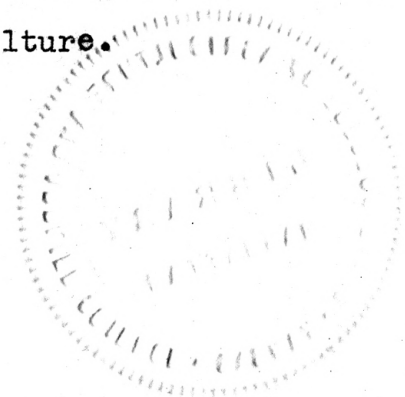

PLATE I

PLATE II

A plant of a wilt resistant F_2 hybrid growing in ground bed in the greenhouse, 1933.

PLATE II

PLATE III

A plant of the wilt susceptible parent, Bonny Best, growing in the ground bed in the greenhouse, 1933.

PLATE III

PLATE IV

A plant of the wilt resistant parent, Marglobe, growing in the ground bed in the greenhouse, 1933.

PLATE IV

PLATE V

Illustrates F_2 plants growing in ground bed in the greenhouse, 1933.

PLATE V

PLATE VI

A wilt susceptible F_2 hybrid plant growing in a ground bed in the greenhouse, 1933.

PLATE VI