HYDROGEN ION CONCENTRATION AND TITRATABLE ACIDITY OF TOMATOES AND THEIR RESISTANCE TO FUSARIUM WILT.*

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INTRODUCTION.

The question of the nature of the resistance or susceptibility of plants to various diseases is one of the fundamental problems with which workers in the field of plant pathology have to deal. The literature on the subject is extensive and varied. Many theories have been advanced to account for the striking differences of response among varieties of certain species of plants to the attacks of parasitic organisms. One of the numerous theories suggested is that the acidity of the sap may be a determining factor in the resistance or susceptibility of plants to certain diseases.

The present paper is a report of work on the relation between hydrogen ion concentration and titratable acidity and the resistance of tomatoes to Fusarium wilt.

1. HYDROGEN ION CONCENTRATION AND RESISTANCE.

Review of Literature.

Hawkins and Harvey (4) found that the H-ion concentration of potato varieties was not related to their property of resisting the attack of *Pythium deBaryanum.* Hurd (5) made extensive investigations of the H-ion concentration of several varieties of wheat and concluded that there was no correlation between this factor and their resistance or susceptibility to certain diseases. Tims (11) investigated the pH of cabbage varieties resistant and susceptible to Fusarium wilt and found that, although there were some variations between the varieties, the differences were not large enough to be significant. Smith and Quirk (10) found that certain begonias which possessed high

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acidity were very resistant to crown gall infection. Furthermore, if the begonia juice was pressed out and neutralized, the crown gall organism grew very well in it. They also state that all plants known or suspected of being immune to crown gall have been found, as far as tested, to have juice more acid than pH 5.7, which is the limit of growth of *Bact. tumefaciens* in bouillon media and in acid juice.

Methods.

Two precautions were exercised in order that the H-ion concentration of all plants might be as equally influenced by environmental conditions as possible. Since there is a possibility that wilt infection might alter the normal acidity of the plants, they were grown on "wilt-free" soil, and were, in addition, clinically examined for incipient wilt infection before being used as a source of juice for the determinations.

Haas (3), Truog (12) and others have reported that the reaction of the soil in which certain plants are growing influences their hydrogen ion concentration. Care was taken, therefore, to test the soil of all the plots in which the plants were grown and it was found to be fairly uniform, about pH 7.20.

For the determinations of pH and total acidity the plants were brought into the laboratory and portions of the stems cut into short pieces. The pieces were washed and wiped dry, wrapped in cheese cloth, and placed in a 3-inch pipe cap. Another pipe cap, slightly smaller than the first, was set over them. The cylinder and piston thus formed by the two caps were placed under the screw of a letter press mounted on a vertical frame and pressure was applied. About 25 to 30 cc. of juice were squeezed from the younger parts of tomato stems at one pressing. The whole operation required about three minutes.

Actual and titratable acidity were determined electrometrically. The apparatus consisted of a quinhydrone electrode, a Leeds and Northrup type K potentiometer and type R galvanometer, a saturated calomel cell, and a two percent agar bridge saturated with KCl. The system was frequently checked with M/20 potassium acid phthalate solution (ph 3.97) as recommended by Clark (1) to determine its accuracy.

Ten cubic centimeters of the juice were transferred to a beaker and .2–.3g. of quinhydrone added and stirred. In two or three minutes equilibrium was reached and a reading made.

The adaptability of the quinhydrone electrode for determining the pH and titratable acidity of the tomato juice was ascertained by comparing it with the standard hydrogen electrode. Determinations of the pH values and of the titratable acidity of comparable samples of expressed tomato juice

TABLE I.

HYDROGEN ION CONCENTRATION IN pH UNITS OF DIFFERENT PARTS OF WILT RESISTANT (R) AND SUSCEPTIBLE (S) TOMATO PLANTS.

	Bonny Best S	Marglobe R	Norton R
Soil	7.20	7.20	7.20
Fiber roots	5.71	5.85	5.80
Large roots:			
Central cylinder	6.15	5.95	6.20
Cortex	5.44	5.58	5.45
Root stock			
Central cylinder	6.20	5.90	5.95
Cortex	5.61	5.60	5.55
Stem (at ground level)			
Pith	5.97	5.91	5.94
Rest of stem	5.73	5.77	5.80
Stem (one foot above ground)			
Pith	5.97	5.93	5.96
Rest of stem	5.97	5.88	5.90
Stem (two feet above ground)			
Pith	5.65	5.70	5.68
Rest of stem	5.65	5.70	5.69
Stem tip	5.58	5.61	5.64
Petioles	5.58	5.56	5.60
Leaf blades	6.06	6.01	5.98

made with both the hydrogen electrode and the quinhydrone electrode gave results agreeing very well. The differences between the pH values of the expressed juice obtained by the two methods were in the second decimal place as a rule. The titrations were carried to pH 7.00, as it was found that the quinhydrone electrode was not accurate in solutions less acid than this.

Results.

Table 1 summarizes the results of five determinations of the hydrogen ion concentration of various parts of mature tomato plants.

Fusarium lycopersici Sacc. usually enters the plant through the roots. It was thought that an investigation of the pH of the root systems of resistant and susceptible varieties might show some interesting differences but, as the results recorded in Table 1 show, this was not the case.

The data show that the different tissues of the tomato plants examined did not have the same H ion concentration.

TABLE II.

HYDROGEN ION CONCENTRATION IN pH UNITS OF THE EXPRESSED JUICE OF WILT RESISTANT AND SUSCEPTIBLE VARIETIES OF TOMATOES OF DIFFERENT AGES.

Stage of Growth of Plants	Bonny Best (S)	Earliana (S)	Norton (R)	Norduke (R)	Marglobe (R)	La. Pink (R)
Seedlings (4″)	6.10	6.08	6.11	6.12	6.23	6.09
Transplants (9″)	6.07	6.05	6.02	6.05	6.09	6.04
Transplants (15″)	5.92	5.87	5.83	5.79	5.81	5.80
Vining begun	5.83	5.79	5.75	5.81	5.70	5.73
First fruit setting	5.70	5.72	5.69	5.77	5.72	5.70
Mature fruit on vines.	5.38	5.40	5.46	5.40	5.42	5.43

However, similar tissues in the three varieties had about the same H ion concentration and therefore need not be considered further so far as wilt resistance is concerned.

Table 2 shows the pH values of the juice of wilt resistant and susceptible varieties of tomatoes at various stages of development. Each pH value given is an average of several determinations. All the plants except the youngest seedlings, which were started in flats in the greenhouse, were grown under field conditions.

The results recorded in Table 2 indicate that there were no significant differences in hydrogen ion concentration between the varieties used in the experiments at any given stage in the growth of the plants. It is evident, however, that the acidity of the plants increased as the season advanced and as the plants became older. Several factors may be involved in this increase of acidity. Hurd (5) has shown that wheat seedlings may vary considerably in pH if their environment is changed. The data in Table 2 were taken at various times during the summer from May until September. Environmental conditions changed during that time and these changes may have been partly responsible for the increase. Hurd (6) has also found that there is an increase in the hydrogen ion concentration of wheat plants as they pass through the flowering and later stages. In the present case, since there was a regular progression from lesser to greater acidity as the plants increased in age, it is felt that the age of the plants was an important factor in the change. But, whatever may have been the cause of the increase in the acidity of the plants, all varieties changed to about the same pH values at the same time.

The data in Table 1 and 2 permit the conclusion that in tomatoes there is no correlation between the hydrogen ion concentration of the juice and the susceptibility of the plant to Fusarium wilt.

2. Titratable Acidity and Resistance.

Review of Literature.

Although it is evident that the hydrogen ion concentration of the juice is not the factor determining resistance or susceptibility to the wilt disease, it was thought possible that there might be significant differences in titratable acidity between the resistant and susceptible varieties.

Hurd (6, 7) found that the titratable acidity of wheat varieties was not correlated with their degree of resistance or susceptibility to *Puccinia graminis tritici* or to *Tilletia tritici*. Laurent (9) titrated the expressed juice of potato tubers resistant and susceptible to bacterial rot and found no relation between acidity and resistance. On the other hand Kirchner (8) found more titratable acid in two rust resistant and one smut resistant varieties of wheat than in an equal number of susceptible varieties. A more extensive review of the pertinent literature may be found elsewhere (7).

Methods.

The juice from growing stems was ordinarily taken for the determination of titratable acidity. Gustafson (2) found that the younger parts of some plants, although of less actual acidity, may have a higher total titratable acidity than older portions of the same plants. A few determinations were made with this point in mind and it was found that in some cases the younger parts of the stems had more total titratable acid than the older parts, but in other cases there were no differences. However, in order to standardize the method, only the upper 8–10 inches of the stems were used. The juice was squeezed out by the method already described. Ten cc. constituted a sample which was titrated with .2 cc. increments of N/125 NaOH until the pH of the sample became greater than 7.00. Duplicate determinations were made on all samples.

TABLE III.

TITRATABLE ACIDITY OF TOMATOES TAKEN AT INTERVALS FROM SEEDLING TO FRUITING STAGE IN CUBIC CENTIMETERS OF N/125 NaOH REQUIRED TO NEUTRALIZE 10 CC. OF EXPRESSED JUICE.

Stage of Growth of Plant	SUSCEPTIBLE	RESISTANT			
	Bonny Best	Norton	La. Pink	Marglobe	Norduke
Seedling (5″)	1.15	1.20	1.17	1.23	1.21
Young plant (15″)	.50	.54	.58	.61	.60
First flowers open	.46	.49	.48	.48	.52
First fruit setting	.48	.53	.60	.55	.52
Mature fruit on vine	.40	.43	.38	.42	.46
Average, excluding 5″ seedlings	.46	.49	.51	.51	.52

Results.

Table 3 shows the average quantities of N/125 NaOH required to bring 10 cc. samples of the expressed juice to neutrality. The figures were obtained by plotting the titration values against the volumes of NaOH necessary to produce them. From the resulting curve the volume of NaOH required to bring the juice to neutrality (pH 7.0) was determined.

The figures given above are the average of a large number of titrations made at intervals throughout the season. The data show that seedlings have greater titratable acidity than older plants and that this factor is not constant during the growth period of the plants, either as the result of ageing or of changing environmental conditions. In so far as differences between the varieties are concerned there are none that can be considered significant from the standpoint of resistance or susceptibility to disease. It is true that Louisiana Pink, Marglobe, and Norduke had a slightly greater titratable acidity than Bonny Best, but the total acidity of Norton, another resistant variety, was about the same as that of Bonny Best. Furthermore, if the toleration of high H-ion concentration in culture media by *F. lycopersici* and the tendency of this fungus to shift the pH of rather highly buffered acid media toward greater alkalinity can be taken as an idex of its ability to tolerate acidity in tomato, the varietal differences found are of little consequence as far as resistance is concerned.

SUMMARY.

1. The hydrogen ion concentration and titratable acidity of five varieties of tomatoes were determined at various stages in the growth of the plants.

2. Neither resistance nor susceptibility of these varieties of tomato to Fusarium wilt was correlated with actual or titratable acidity at any stage of growth of the plants.

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