Effect of Mineral Fertilizers on the Incidence of Blossom-end Rot of Watermelon

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ABSTRACT

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Potassium and phosphorus fertilizers had no effect on the percentage of blossom-end rot of watermelon in either medium-textured sandy loam soil or in fine-textured loam soil. In sandy loam soil, in 1974, the percentage of blossom-end rot in the Charleston Gray watermelon was significantly reduced by 8.06 and 8.24% in calcium (20 kg/100 m^2 gypsum)- and nitrogen (5 kg/100 m^2 urea [44–45% N])-treated plots, respectively. In loam soil, in 1975, treatment with calcium reduced the percentage of blossom-end rot in cultivars Crimson Sweet and Charleston Gray. In 1976, in loam soil the incidence of blossom-end rot in Crimson Sweet also was significantly reduced and marketable yield was increased with increasing levels of gypsum. In this experiment the increasing levels of nitrogen had no effect on disease incidence, but significantly increased the yield of marketable melons.

Additional key words: *Citrullus lanatus*, calcium, fruit disorder.

"Blossom-end rot" is a nonparasitic disease of watermelon (*Citrullus lanatus* [Thunb.] Matsum & Nakai) recently described in southern Italy (5). In commercial watermelon plantings in the climatic and soil conditions of Puglia and Lucania regions, the disease (Fig. 1) first appears around the middle of July, and the incidence increases until harvest time. Commonly 60–80% of fruits are affected by blossom-end rot in the period from the end of July through August, a period characterized by high temperatures, low humidity, and warm, dry winds. In field trials, cultivars with cylindrical or sub-cylinderical fruit generally are susceptible, and spherical-fruited cultivars usually possess a complete or high resistance to the disease (6).

In physiological disorders of fruits of vegetable crops, such as blossom-end rot of the tomato (*Lycopersicon esculentum* Mill.) water stress and the availability of mineral elements play an important role in influencing disease incidence. In field experiments conducted in southern Italy the frequency of furrow irrigation did not significantly affect the percentage of blossom-end rotted watermelon fruits (6).

In this paper we report on the influence of mineral fertilizer elements on the incidence of blossom-end rot of watermelon.

MATERIALS AND METHODS

Field trials were carried out on medium-textured sandy loam soil near Lecce and on fine-textured loam soil near Policoro. The chemical and textural characteristic of these two soils prior to fertilization are listed in Table I.

Lecce, 1974. The trial included 16 treatments obtained by combining factorially two levels of the following fertilizers: nitrogen (0 and 2.5 kg/100 m^2 urea [44–45% N]); phosphorus (0 and 5 kg/100 m^2 triple-superphosphate [45–48% P_2O_5]; potassium (0 and 5 kg/100 m^2 potassium sulfate [48–52% K_2O]) and, gypsum (0 and 20 kg/100 m^2). The design of this experiment was a randomized block in which the treatments were replicated four times. The area of each plot-treatment was 21 m^2 and included 25 plants. Cultivar Charleston Gray, which is highly susceptible to the disease, was used.

Policoro, 1975. Two watermelon cultivars, the highly susceptile Charleston Gray and the moderately resistant Crimson Sweet, were used. Plots of each cultivar were treated with two levels of four fertilizers, a total of 16 treatments. A split-plot design was used arranging phosphorus levels (0 and 7 kg/100 m^2 superphosphate [18–20% P_2O_5]) in whole plots, potassium levels (0 and 5 kg/100 m^2 potassium sulfate [48–52% K_2O]) in split plots, nitrogen levels (0 and 5 kg/100 m^2 of urea [44–45% N]) in split-split plots, and calcium levels (0 and 20 kg/100 m^2 gypsum) in split-split-split-plots. The area of each split-plot unit was 24 m^2 and each had 30 plants.

Policoro, 1976. In this trial the Crimson Sweet watermelon was used with nine treatments obtained by combining three levels of two fertilizers. A split-plot design was used in which three nitrogen levels (0 kg/100 m^2, 5 kg/100 m^2 and 10 kg/100 m^2 of urea [44–45% N]) in whole plots and three calcium levels (0 kg/100 m^2, 20 kg/100 m^2, and 40 kg/100 m^2 gypsum) in split plots. The area of each of the split-plot units was 56 m^2 and included 60 plants. In all the experiments, plots were separated by a strip of fallow soil at least 5 m wide. Treatments of phosphorus, potassium, and calcium were incorporated into the soil about 1 wk before sowing. Nitrogenous fertilizer was applied twice, half before sowing and half 2 mo after the plants had emerged. Furrow irrigation was applied at 6-day intervals. At harvest the total yield was counted and weighed. The number of fruits with blossom-end rot was expressed as a percentage of the total fruits harvested.

RESULTS

Potassium and phosphorus fertilizers had no effect on the incidence of blossom-end rot in both types of soils. Nitrogen affected the incidence of blossom-end rot only in sandy loam soil that was low in total N. Calcium applications reduced the number of fruits with blossom-end rot in all experiments.

Medium-textured sandy loam (Lecce, 1974). The percentage of Charleston Gray watermelon fruits with blossom-end rot was reduced ($P = 0.05$) by 8.06 and 8.24% (total means) in gypsum- and urea-treated plots, respectively (Fig. 2).

Fine-textured, loam soil (Policoro 1975). With Crimson Sweet, but not with the Charleston Gray watermelons, there was a significant ($P = 0.05$) interaction between superphosphate and gypsum applications that resulted in lower blossom-end rot percentages with increasing levels of P. In the 20 kg/100 m^2 gypsum plots, blossom-end rot was 15.92 and 10.33% for P_0 (0 kg/100 m^2 and P_1 (7 kg/100 m^2 superphosphate) levels of phosphorus, respectively. Applications of gypsum resulted in a statistically significant ($P = 0.01$) reduction of the disease (Table 2) in Crimson Sweet and

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TABLE 1. Chemical and textural characteristics of the soils used in studies of blossom-end rot of watermelon at Lecce and Policoro, Italy

Location and soil type	Sand (%)	Silt (%)	Clay (%)	Soluble carbonates[a] (%)	Organic matter[b] (%)	Total N[c] (%)	Available K[d] (ppm)	Available P[e] (ppm)	pH
Lecce									
Sandy loam	81.4	5.1	13.5	0.75	1.1	0.67	108	16.00	7.5
Policoro									
loam	42.5	33.6	23.9	6.10	2.20	1.38	363	1.25	7.6

Extraction procedures:
[a]= ammonium oxalate
[b]= Walkley-Black
[c]= Kjeldahl
[d]= ammonium acetate
[e]= Bray

Charleston Gray watermelons. Applications of urea had no effect on disease incidence.

Policoro, 1976. In view of the 1974 and 1975 results, an experiment was carried out in 1976 on the loam soil at Policoro to test more throughly the influence of increasing levels of calcium and nitrogen on incidence of the disease in the Crimson Sweet watermelon. The incidence of blossom-end rot was again reduced statistically with increasing levels of gypsum; the percentages of diseased fruits were 34.02, 22.23,and 19.53% for 0 kg/100 m^2, 20 kg/100 m^2, and 40 kg/100 m^2 gypsum, respectively. The average marketable yield was 419.2 kg/100 m^2, 491.7 kg/100 m^2 and 514 kg/100 m^2 for plots that had received 0 kg/100 m^2, 20 kg/100 m^2, and 40 kg/100 m^2 gypsum, respectively. In this experiment the different levels of nitrogen had no significant effect upon disease incidence although there was a statistically significant increase in marketable yield in plots receiving higher rate of nitrogen fertilization (Fig. 3).

DISCUSSION

The results of these experiments indicate that some mineral fertilizer elements affect the incidence of blossom-end rot of watermelon both in the highly susceptible cultivar Charleston Gray and the moderately resistant cultivar Crimson Sweet.

Additions of potassium produced no reduction in the amounts of blossom-end rot, either in medium textured sandy loam at Leece or in the fine textured loam at Policoro. The interaction between superphosphate and gypsum applications in the 1975 Policoro trials seems to be due to the additive effect of the 30% $CaSO_4$ content of the superphosphate rather than to the phosphorus supplied by this fertilizer. It would seem, therefore, that applications of these elements in soils with potassium and phosphorus content near that of our soils (Table 1) will not reduce the incidence of blossom-end rot.

In our tests, nitrogen, suppplied as urea, produced no increase in blossom-end rot even when applied at the high level of 10 kg/100 m^2. On the contrary, urea, with the sandy loam soil low in total N content, applied at the rate of 2.5 kg/100 m^2, resulted in a statistically significant reduction of blossom-end rot. The reduced incidence of the disease following the applications of calcium to the soil in these experiments with watermelon agrees with numerous observations of its effect on blossom-end rot of tomato and indicates that this disorder is related to the availability of calcium in

TABLE 2. Influence of field applications of calcium (as gypsum) on the blossom-end rot (B.E.R.) and marketable yield of cultivars Crimson Sweet and Charleston Gray watermelon grown in loam soil, Policoro, Italy, in 1975

	Crimson Sweet		Charleston Gray	
Gypsum (kg/100 m^2)	Yield (kg/100 m^2)	Fruits with B.E.R. (%)	Yield (kg/100 m^2)	Fruits with B.E.R. (%)
0	457.1	19.6	305.3	57.7
20	521.1	13.1	328.5	54.0
LSD ($P=0.05$)	49.9	2.6	30.1	3.6
($P=0.01$)	67.5	3.6	40.7	4.9

Fig. 1. Blossom-end rot of watermelon.

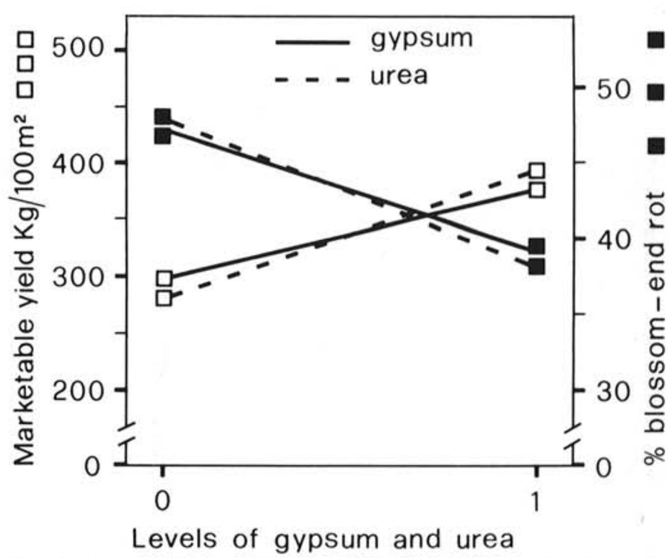

Fig. 2. Influence of field applications of calcium (as gypsum) and nitrogen (as urea) on the blossom-end rot and the marketable yield of watermelon cultivar Charleston Gray grown in sandy loam soil, Lecce, Italy, in 1974. Legend: gypsum 0 = 0 kg/100 m^2, 1 = 20 kg/100 m^2); and urea (0 = 0 kg/100 m^2, 1 = 5 kg/100 m^2).

the soil (10,12) and the calcium content of the fruit (22,26), and that calcium has a fundamental role in the etiology of blossom-end rot in both tomato and watermelon.

Calcium, as calcium pectate, is a constituent of the middle lamella (7) and thus contributes to cell-wall stability. More recently, however, there is evidence that calcium in plants is more directly related to interactions with the cell membranes than with cell walls. Marinos (20) reports that calcium deficiency in the shoot apex of barley initially causes a break up of the nuclear envelope and the plasma and vacuolar membranes, the disorganization of mitochondria and Golgi apparatus and, later, the weakening of cell walls eventually followed by cell necrosis. The involvement of Ca in membrane maintenance and function has a great influence on a number of enzymatic activities (eg, ATPase [9] and phospholipase [8]) and on the selective ion-absorption mechanism (27). The effects of calcium on mitochondria (20) also explains its influence on the active uptake of other ions (eg, phosphate, nitrate, chloride, and bromide [15,16] and potassium [17,18]) since uptake is a respiration-dependent phenomenon.

In studies of tomatoes, it has been shown that factors other than mineral element deficiency interact to produce blossom-end rot. An important role is attributed to water stress in the plant. In normal tomato fruits, the tissues of the distal end would be more permeable to water because of poor orientation of cellulose molecules of the cell wall (13). Thus, it would seem that water stress due to high transpiration or low soil moisture availability may increase the sensitivity of this portion of the fruit and induce collapse and necrosis of the cells.

To fully appreciate the importance of the combined effects of Ca deficiency and water stress in the etiology of blossom-end rot, one has to consider that in normal tomato plants only one-half of the Ca^{2+} is water-insoluble whereas in calcium-deficient plants nearly all the Ca^{2+} is water-insoluble (21). Thus, since Ca is poorly translocated (1), it would be expected that the apex of plant organs, including actively growing fruits, would tend to be deficient in Ca and would be more severely affected since the Ca requirement for maintaining integrity of fruit cells is high. Furthermore, the dramatic influence of Ca on rapidly growing fruits is increased because the translocation of this element depends on the water flow into the fruit. Gerard and Hipp (14), report that the incidence of blossom-end rot in tomato is highly correlated with the number of hours above (90F) or high evaporative conditions which determine, together with a poor input of Ca, a deficit in the water balance of the fruit. Consequently, a further lowering of blossom-end rot in watermelon, which is in agreement with the tomato findings, could be obtained by foliar spraying with calcium chloride during periods of high Ca requirement of the plant (10,12) and applying sprinkler irrigations during highly evaporative weather conditions (14).

It appears that in studies of such physiologic disorders, the effect of mineral elements may vary according to environmental conditions (low or high evaporative climate, open field or greenhouse) and to the substrata (field soil or nutrient solution media) in which plants are tested. In our field trials, blossom-end rot of watermelon was not increased by high levels of nitrogen (urea). This differs from what is generally observed with tomato (4,11,12,19,23). However, in some cases, applications of nitrogen either caused a reduction (2), or did not increase (25), the disease. The different responses to nitrogen applications in tomato may be due to differences in environment, substrata for growth of plants, and cultivars used. However, the effect that nitrogen has shown in our experiments also may be attributed to the metabolic differences between tomato and watermelon.

In conclusion, the lack of conclusive information on the numerous nutritional, water supply (6), varietal (6) and, (perhaps) hormonal factors (see Mullison and Mullison [21], Struckmeyer [24], and Burström [3]), and their interactions, makes it impossible to obtain complete control of the blossom-end rot of watermelon in commercial fields. Nonetheless, in order to significantly reduce the incidence of the disease, balanced fertilizations, applications of gypsum, frequent irrigation, and the use of spherical-fruited resistant cultivars are recommended.

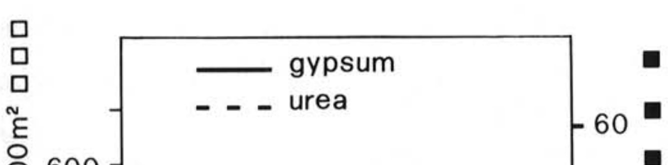

Fig. 3. Influence of field applications of calcium (as gypsum) and nitrogen (as urea) on the blossom-end rot and marketable yield of watermelon cultivar Crimson Sweet grown in loam soil, Policoro, Italy, in 1976. Legend: gypsum (0 = 0 kg/100 m^2, 1 = 20 kg/100 m^2, and 2 = 40 kg/100 m^2); urea (0 = 0 kg/100 m^2, 1 = 5 kg/100 m^2, and 2 = 10 kg/100 m^2).

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