Effect of Foliar and Soil Magnesium Application on Bacterial Leaf Spot of Peppers

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ABSTRACT

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Early Calwonder pepper plants were grown in Myakka fine sand amended with calcium carbonate or dolomite. Plants were sprayed weekly with magnesium chloride (2.4 g/L) or were left unsprayed. Inoculation consisted of infiltration of *Xanthomonas campestris* pv. *vesicatoria* at 8×10^3 colony-forming units per milliliter in leaves (one per plant) in each treatment in early October; later in November, the same plants were spray-inoculated with *X. c.* pv. *vesicatoria* at 10^8 colony-forming units per milliliter. Disease development was most severe on plants grown in the dolomite-amended soil that were sprayed with magnesium. Unsprayed plants grown in dolomite-amended soil or magnesium-sprayed plants grown in calcium carbonate-amended soil were intermediate in disease, whereas unsprayed plants grown in soil amended with calcium carbonate had the lowest disease severity. Tissue analysis revealed that magnesium levels were positively correlated with disease development. Because disease development followed similar trends when both inoculation procedures were used with the four treatments, it appears that the mechanism of reduced susceptibility in plants with low magnesium levels was, to a large extent, internal rather than completely external (the physical and chemical nature of the leaf surface).

Bacterial spot of pepper and tomato caused by *Xanthomonas campestris* pv. *vesicatoria* (Doidge) Dye can be affected by altered magnesium (Mg) nutrition of the host plant (4). Pepper plants with magnesium levels in the tissue at the upper end of the normal range had considerably more disease than plants with levels at the lower end of the normal range. Mg has been shown to be essential for growth of bacteria (3).

In our study, foliar applications of Mg were superimposed on plants grown in soil amended with dolomite ($CaCO_3 \cdot MgCO_3$) or high Cal limestone ($CaCO_3$) to determine whether foliar-applied magnesium affects disease development. The mechanism by which bacterial spot severity is reduced in plants with low magnesium levels is not known. The physical characteristics of the leaf surface could make entry into the leaf more difficult for the bacterium, or perhaps the internal environment may be responsible for affecting disease severity.

The leaf infiltration method (2) was used in combination with spray inoculation in an effort to introduce inoculum inside the leaf and thus eliminate the effect of the leaf surface on disease development. The infiltration method was also used to determine its value for detecting differences in susceptibility to bacterial spot of plants grown under different nutritional regimes. Additionally, two inoculation methods were compared to determine their relative value in the detection of differences in susceptibility as a result of variations in plant mineral nutrition.

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MATERIALS AND METHODS

Early Calwonder pepper plants were planted in Myakka fine sand in wooden boxes (six/42.5 × 34.5 × 18.5 cm/box) on 2 September 1981. The soil was amended with superphosphate and fritted trace elements (FTE 503) at 15 g and 0.6 g/box, respectively. The soil was limed with $CaCO_3$ or dolomite at the rate of 1,469 kg/ha or 1,104.5 kg/ha (area basis). The experiment consisted of four treatments. Two treatments consisted of a foliar spray of $MgCl_2$ (2.4 g/L) being applied to plants grown in each of the soils amended with either $CaCO_3$ or $CaCO_3 \cdot MgCO_3$ on 2 October 1981 and again 3 days later. Applications were then applied at weekly intervals. In the other two treatments, plants grown in each soil containing either liming material were not sprayed and served as controls. The experimental design was a randomized split plot with five replicates per treatment.

A 48-hr culture of *X. c.* pv. *vesicatoria* strain 81-18 obtained from R. E. Stall was grown at 25 C on nutrient yeast dextrose agar. The bacterial suspension prepared by washing the bacteria from the agar surface with sterile distilled water was adjusted to 10^8 colony-forming units (CFU) per milliliter with a Spectronic 20 and then serially diluted to 8×10^3 CFU/ml. For leaf infiltration inoculations, plants were inoculated 13 October 1981 by injecting (2) the bacterial suspension into one-half of a fully expanded leaf on each pepper plant within a box. Disease severity ratings of the individually inoculated leaves were determined 8, 13, and 16 days after inoculation using the Barrett-Horsfall system (1). On 2 November 1981, the plants within each box were spray-inoculated with 10^8 CFU/ml, and a polyethylene tent was then placed over the boxes to maintain approximately 100% relative humidity for 24 hr. Disease severity ratings were taken 10, 15, and 22 days after inoculation on three leaves toward the top of each plant.

Before starting the experiment, soil was assayed for calcium (Ca) and potassium (K) levels using a flame spectrophotometer (Beckman Model B) and for magnesium using the thiazol yellow method (5). The nutrient elements were extracted from 10-g soil samples after 15 min of shaking in 40 ml of a double-acid extractant (5.08 g of conc. HCl and 1.27 g of conc. H_2SO_4 diluted to 1 L with deionized water). Analytical results were expressed in terms of dry weight of soil. Tissue was sampled from each of the plants immediately prior to each inoculation for Mg, Ca, and K tissue determinations. Mg was determined colorimetrically (5), whereas Ca and K were determined on the flame spectrophotometer.

RESULTS

The soil and spray treatments of different Ca and Mg levels were reflected in soil and tissue analyses. The soil Mg and Ca levels were 56 and 149 ppm, respectively, in the dolomite-amended soil and 23 and 272 ppm, respectively, in the $CaCO_3$-amended soil. Higher Mg and lower Ca concentrations were found in the tissue in plants under the treatment of dolomitic lime and foliar spray with Mg, whereas plants that were grown in soil amended with $CaCO_3$ that did not have a foliar application of $MgSO_4$ had higher Ca and lower Mg in the tissue. As expected from the foliar analyses, the plants showed no nutrient deficiency symptoms of Ca, Mg, or K. With leaves inoculated by infiltration, bacterial spot severity was greatest on plants grown in soil amended with dolomitic lime and that had foliar applications of Mg (Table

Table 1. Leaf spot development (percentage of leaf affected) in response to inoculum injection of *Xanthomonas campestris* pv. *vesicatoria* into leaf lamina and associated foliar nutritional status

Treatment	Disease rating[y] (%)	Tissue analysis, percent dry weight		
		Ca	K	Mg
Dolomite + Mg spray	54.9 a[z]	2.8	3.4	1.05 a
Dolomite	43.6 ab	2.7	3.4	0.74 b
$CaCO_3$ + Mg spray	38.9 ab	3.4	3.5	0.64 bc
$CaCO_3$	19.7 b	3.4	3.7	0.52 c
Mg spray effects				
Mg spray	46.9	3.1	3.5	0.85 q
No spray	31.7	3.1	3.6	0.63 r
Liming effects				
Dolomite	49.3	2.8	3.4	0.89 u
$CaCO_3$	29.3	3.4	3.6	0.58 v

[y] Estimated percentage of leaf area visibly diseased (means of three upper leaves per plant); reading made on 27 October 1982.
[z] Means followed by different letters differ at the 5% level of significance according to Duncan's multiple range test.

Table 2. Leaf spot development (percentage of leaf area affected) in response to spray inoculation of *Xanthomonas campestris* pv. *vesicatoria* and associated foliar nutritional status at time of spraying

Treatment	Disease rating[y] (%)	Tissue analysis, percent dry weight		
		Ca	K	Mg
Dolomite + Mg spray	54.0 a[z]	2.3	3.3	0.86 a
Dolomite	37.1 b	2.5	3.2	0.74 ab
$CaCO_3$ + Mg spray	32.8 b	3.1	3.4	0.56 c
$CaCO_3$	22.2 b	3.2	3.5	0.44 c
Mg spray effects				
Mg spray	43.4 a	2.8	3.4	0.71 q
No spray	30.6 b	2.9	3.4	0.59 r
Liming effects				
Dolomite	45.6 u	2.4 u	3.3	0.8 u
$CaCO_3$	27.5 v	3.2 v	3.4	0.5 v

[y] Estimated percentage of leaf area visibly diseased (means of three upper leaves per plant); readings made on 17 November 1982.
[z] Means followed by different letters differ at the 5% level of significance according to Duncan's multiple range test.

1). The rate of disease development was greatest on plants grown in soil amended with dolomitic lime regardless of foliar-applied Mg (Table 1, Fig. 1).

In the spray inoculation test, the same trends in disease development progression for the four treatments were observed as with leaf infiltration (Table 2, Fig. 2). Throughout the experiment, the plants with highest Mg levels (dolomite plus foliar) had significantly more disease than the lowest Mg treatment ($CaCO_3$ only). Also, plants grown in dolomite-amended soil had more disease than plants grown in $CaCO_3$-amended soil. Tissue analyses prior to spray inoculation demonstrated that leaves from the high Mg treatment had a high concentration of Mg and low concentration of Ca, whereas leaves from the low Mg treatment had high Ca and low Mg in the tissue.

DISCUSSION

In agreement with an earlier study, bacterial spot in the inoculated plants was more severe in leaves with high levels of Mg (4). This susceptibility was found to be to some extent an internal effect. This conclusion was reached because leaves injected with the bacterium responded similarly to disease susceptibility as those that were inoculated by spraying the bacterium on the leaf surface.

The usefulness of leaf infiltration as a tool for studying the effects of mineral nutrition is questionable. It is a lengthy procedure and, as a result, fewer leaves can be inoculated. With the variability that exists from leaf to leaf, use of the infiltration procedure makes it more difficult to assess the effect of mineral nutrition on disease susceptibility because of the limited number of leaves that can be inoculated. With spray inoculation, a large number of leaves can be inoculated, and the effects of mineral nutrition on bacterial spot susceptibility can be determined more readily.

Apparently, the manner in which Mg is applied to green peppers is important in its effect on bacterial spot development. Foliar application of Mg had a pronounced effect on disease development, possibly through the increase in available Mg. These results would suggest that caution should be exercised in foliar feeding of green peppers with Mg so as not to enhance disease severity.

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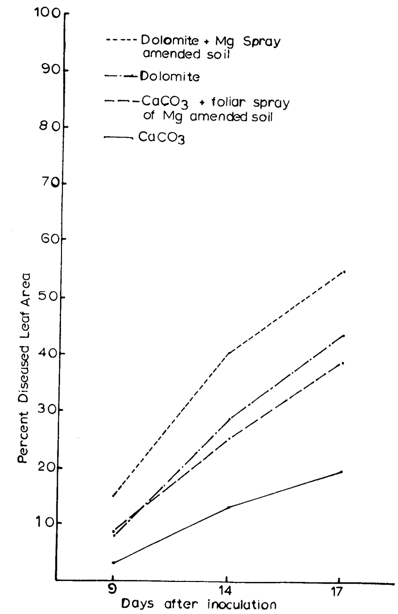

Fig. 1. Effect of foliar-applied magnesium and soil amended with limestone or dolomite on susceptibility of Early Calwonder pepper plants when infiltrated with 8×10^3 colony-forming units per milliliter of *Xanthomonas campestris* pv. *vesicatoria.*

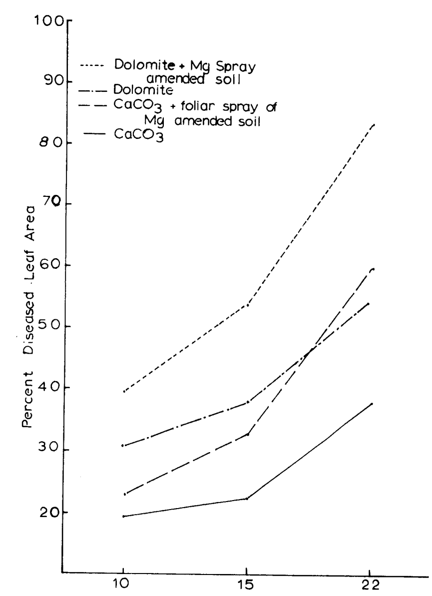

Fig. 2. Effect of foliar-applied magnesium and soil amended with limestone or dolomite on susceptibility of Early Calwonder pepper plants when spray-inoculated with 10^8 colony-forming units per milliliter of *Xanthomonas campestris* pv. *vesicatoria.*