Effect of Plant Nutrition on Susceptibility of *Chrysanthemum morifolium* to *Erwinia chrysanthemi*

R. J. McGOVERN, R. K. HORST, and R. S. DICKEY, Department of Plant Pathology, Cornell University, Ithaca, NY 14853

ABSTRACT

McGovern, R. J., Horst, R. K., and Dickey, R. W. 1985. Effect of plant nutrition on susceptibility of *Chrysanthemum morifolium* to *Erwinia chrysanthemi*. Plant Disease 69:1086-1088.

Susceptibility of *Chrysanthemum morifolium* cv. Bonnie Jean to *Erwinia chrysanthemi* was affected by rate of complete fertilizer (NPK, 20-10-20) and by form of nitrogen. The rate of complete fertilizer was varied from 0 to a concentration containing about 473, 105, and 413 ppm of nitrogen, phosphorus, and potassium, respectively. In separate experiments, three forms of nitrogen were varied from 0 to 400 ppm. Susceptibility was based on the amount of pith maceration in cuttings 4 days after dip inoculation in a bacterial suspension containing about 10^8 colony-forming units per milliliter. Susceptibility increased with increasing rates of complete fertilizer and nitrogen in the form of $(NH_4)_2SO_4$. However, susceptibility was maximal at moderate levels of $Ca(NO_3)_2$ and NH_4NO_3 (100–200 ppm of nitrogen) and decreased when nitrogen was increased to 400 ppm in both forms.

Host nutrition has been widely implicated in the predisposition of plants to disease (7). Extremely high levels of nitrogen significantly reduced the severity of bacterial leaf blight in *Philodendron selloum* by *Erwinia chrysanthemi* Burkholder, McFadden, & Dimock (6). Conversely, high levels of nitrogen increased susceptibility of apples to *E. amylovora* (12,17,18), corn to *E. stewartii* (14) and *E. chrysanthemi* (19), and cabbage, tomato, and sugar beets to *E. carotovora* (4,20,22). Low levels of nitrogen predisposed cucumbers to *E. tracheiphila* (23). High rates of fertilizer were also found to increase the susceptibility of *Chrysanthemum morifolium* Ramat. to bacterial leaf spot incited by *Pseudomonas cichorii* (9).

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The form in which a nutrient is administered is often the key factor in its influence on disease. This concept, as applied to nitrogen, has been well documented by Huber and Watson (8). High levels of NH_4NO_3, for example, applied in a complete fertilizer increased Fusarium wilt in chrysanthemum (11). When applied independently, however, nitrate nitrogen (NO_3-N) decreased and ammonium nitrogen (NH_4-N) increased the severity of disease (24).

The purpose of this research was to examine the effects of different rates of a complete fertilizer on the susceptibility of *C. morifolium* cuttings to *E. chrysanthemi*. We were also interested in determining the effects of different forms of nitrogen on susceptibility. The selection of rates for experimentation was based on the general recommendation that 200 ppm of both nitrogen and potassium be applied daily to chrysanthemums (5,16).

MATERIALS AND METHODS

In a preliminary experiment during fall 1981, cuttings of *C. morifolium* cv. Bonnie Jean that received daily applications of 1.2 kg/L of a complete fertilizer (Peters 20-10-20, Peter's Fertilizer Products, W. R. Grace Co., Fogelsville, PA) were more susceptible to *E. chrysanthemi* than cuttings from unfertilized plants. In a subsequent experiment during winter 1981, complete fertilizer at 0.6, 1.2, or 2.4 kg/L was applied daily for 5 wk. Control plants received daily applications of tap water alone. In separate experiments during summer 1982, five rates of nitrogen (25, 50, 100, 200, and 400 ppm) in the form of $Ca(NO_3)_2$, NH_4NO_3, or $(NH_4)_2SO_4$ were applied in conjunction with 200 ppm of potassium in the form of $K_2(SO_4)$ for 5 wk. Control plants received only 200 ppm of potassium.

Plants were grown in 17-cm-diameter pots using Cornell Peat-lite medium A (16) and were maintained in a greenhouse at about 29 C with a photoperiod of at least 16 hr. The Peat-lite medium was amended with dolomitic limestone at a rate of 3.4 kg/m^3 in the $Ca(NO_3)_2$ treatment and 5.2 kg/m^3 in the NH_4NO_3 and $(NH_4)_2SO_4$ treatments. Five plants were used per treatment, and their shoot tips were removed 6 days after potting to encourage the growth of side shoots.

Differences in susceptibility to the bacterium were assessed by bacterial maceration assays. Three shoots were selected randomly from each test plant, trimmed to 40 mm, and inoculated with a standardized suspension of *E. chrysanthemi* strain 159, corresponding to about 10^8 colony-forming units per milliliter. The inoculum level was determined to be optimal for our experimental conditions. To produce bacterial inoculum, 24-hr nutrient agar (Difco) cultures of strain 159 of *E. chrysanthemi* were streaked on slants of modified yeast-dextrose-calcium carbonate agar (2) containing 5 g/L of dextrose rather than 20 g/L. All cultures were grown at 27 C and used within 24 hr. Shoot bases were placed in tubes containing sterile water, enclosed in plastic bags, and incubated for 4 days at 29 C. After incubation, each cutting was dissected longitudinally and the extent of pith maceration was measured (mm). In addition, three recently enlarged, mature leaves were removed from each plant, pooled by treatment, and used for nitrogen analysis by the micro-Kjeldahl method (1). Phosphorus and potassium were measured by inductively coupled argon plasma atomic emission spectroscopy (ICP) developed by the Department of Pomology, Cornell University, Ithaca, NY. In this procedure, 0.2 or 0.4 g of dry, ground sample is weighed into either quartz crucibles or test tubes. The sample is placed in a muffle furnace and dry-ashed overnight at 450 C. The ashed sample is cooled and 0.25 ml of concentrated nitric acid is added before additional digestion on a hot plate until dry. The acid is dissolved in a 2-ml solution of 10% hydrochloric acid and nitric acid, then 8 ml of distilled water is added. The sample is mixed, and when the sediment has settled to the bottom, it is assayed twice by ICP.

RESULTS AND DISCUSSION

Susceptibility as measured by pith maceration increased with increasing rates of all forms of fertilizer studied (Fig. 1). This increase in susceptibility was correlated with content of NPK (complete fertilizer) (Table 1) and with increased uptake of nitrogen in three forms (Table 2). Susceptibility was maximal at the highest rate of complete fertilizer and $(NH_4)_2SO_4$. Daily application of complete fertilizer in 2 yr of experimentation proved effective in maintaining high susceptibility to *E. chrysanthemi* with which to investigate viroid-*E. chrysanthemi* interactions (McGovern et al, *unpublished*).

Susceptibility was maximal at moderate levels of $Ca(NO_3)_2$ and NH_4NO_3 (100–200 ppm of nitrogen) and decreased sharply when nitrogen was increased to 400 ppm in both forms. Pith maceration increased linearly with increasing rates of complete fertilizer and $(NH_4)_2SO_4$ (Fig. 1A,B). For increasing concentration of $Ca(NO_3)_2$ and NH_4NO_3, pith maceration increased curvilinearly (Fig. 1C,D).

Plants can accumulate NO_3-N in excess of their needs, and some cases, this accumulation can reach phytotoxic levels (13). Transport of NO_3-N in a predominantly unreduced form occurs in the xylem of chrysanthemum, whereas reduction occurs in leaves (25). Perhaps at 400 ppm of nitrogen, unreduced $Ca(NO_3)_2$ accumulated in stem tissue at a level that directly inhibited the bacterium or adversely altered its environment by changing pH, osmotic pressure, or amino acid content or by induction of inhibitory plant-produced stress metabolites. Naidu et al (15) observed that increased susceptibility of rice to *Xanthomonas oryzae* resulted from treatment with ammonium sulfate and urea, whereas plants to which calcium *or* ammonium nitrate were applied were more resistant. This increased susceptibility was correlated with decreased phenolics and sugars and increased nitrogen content. Tejerina et al (21) reported that *E. carotovora*

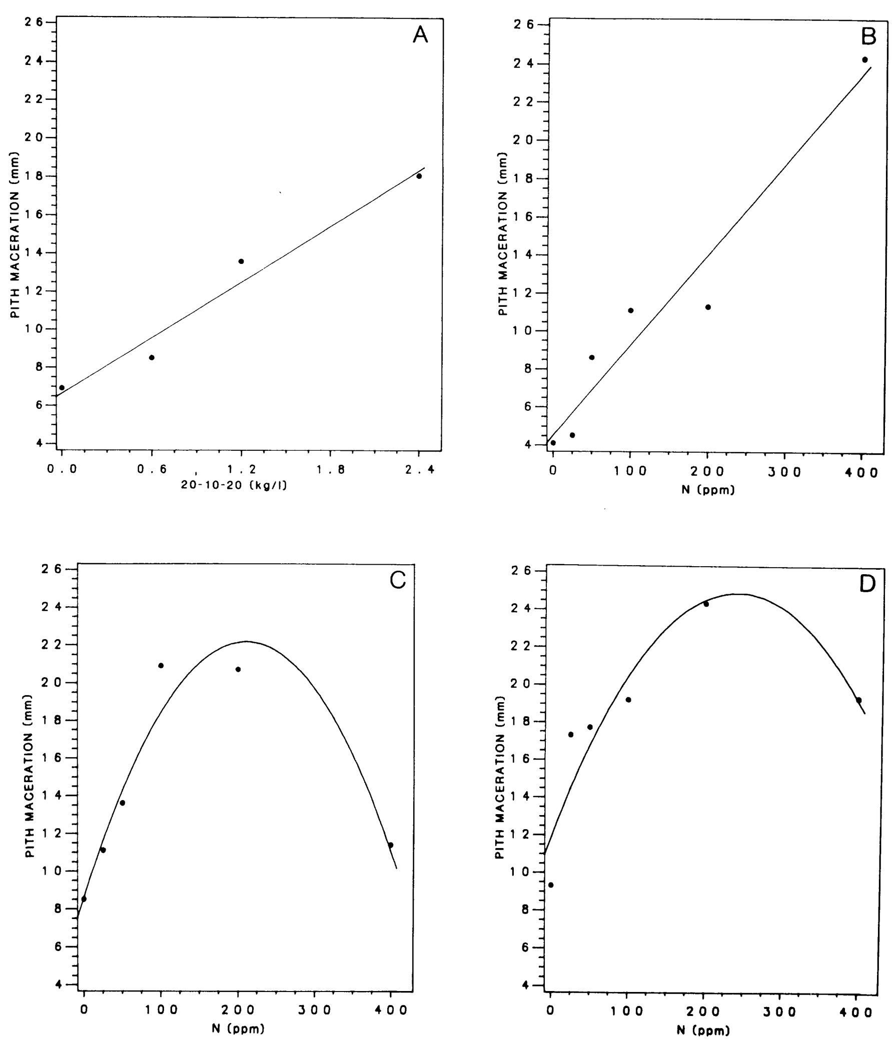

Fig. 1. Regression of pith maceration on nutrients for cuttings of the chrysanthemum cultivar Bonnie Jean with daily applications of **(A)** 20-10-20 complete fertilizer ($y = 6.64 + 4.89x$, $P = 0.02$, $r^2 = 0.97$, SD = 1.2), **(B)** $(NH_4)_2SO_4$ ($y = 4.50 + 0.048$, $P = 0.001$, $r^2 = 0.94$, SD = 4.0), **(C)** $Ca(NO_3)_2$ ($y = 8.57 + 0.129x - 0.0003\,x^2$, $P = 0.008$, $r^2 = 0.93$, SD = 3.0), and **(D)** NH_4NO_3 ($y = 11.86 + 0.108x - 0.0002\,x^2$, $P = 0.04$, $r^2 = 0.85$, SD = 5.8). Statistical analysis according to methods of SAS Institute, Cary, NC.

Table 1. Effect of daily application of a 20-10-20 complete fertilizer on the uptake of NPK in *Chrysanthemum morifolium* cv. Bonnie Jean

Treatment	Mean % dry weight leaf tissue N	P	K
Control[a]	1.36	0.238	3.82
Complete fertilizer (g/L)			
0.6[b]	2.86	0.351	3.95
1.2[c]	4.12	0.577	4.61
2.4[d]	5.10	0.830	5.77

[a] Plants were irrigated with tap water.
[b] About 118, 26, and 103 ppm of N, P, and K, respectively.
[c] About 236, 52, and 206 ppm of N, P, and K, respectively.
[d] About 473, 105, and 413 ppm of N, P, and K, respectively.

Table 2. Effect of daily application of $Ca(NO_3)_2$, NH_4NO_3 and $(NH_4)_2SO_4$ on the uptake of N in *Chrysanthemum morifolium* cv. Bonnie Jean

N (ppm)	Mean % N of dry weight leaf tissue $Ca(NO_3)_2$	NH_4NO_3	$(NH_4)_2SO_4$
0	1.30	1.98	1.26
25	2.24	2.32	2.20
50	2.62	3.02	2.80
100	3.36	3.42	3.72
200	4.04	4.08	4.70
400	3.92	4.46	6.82

underwent morphological changes, which they related to losses in pathogenicity, in a growth medium containing high concentrations of KNO_3. Excessive levels of nitrogen in the form of $Ca(NO_3)_2$ were also observed to significantly depress bacterial wilt of tomato incited by *Pseudomonas solanacearum* (10).

Although pith maceration was lower at 400 than at 200 ppm of nitrogen with NH_4NO_3, it was higher than at a comparable level of $Ca(NO_3)_2$. Perhaps this phenomenon may be attributed to a lower ratio of NO_3-N to NH_4-N in the tissue, which created a more favorable environment for the bacterium. Kelman (10) observed an increase in susceptibility of tomato to *P. solanacearum* when the ratio of NO_3-N to NH_4-N was increased. Although cuttings of Bonnie Jean from the $(NH_4)_2SO_4$ treatment were actually more susceptible to *E. chrysanthemi* at 400 ppm of nitrogen than their counterparts from the $Ca(NO_3)_2$ and NH_4NO_3 treatments, low and moderate rates of $(NH_4)_2SO_4$ resulted in less maceration than in the other two treatments.

At low and moderate rates of $(NH_4)_2SO_4$, the plant may be able to compete more successfully with the bacterium for the utilization of nitrogen. Although NH_4-N can more readily induce phytotoxicity than NO_3-N (2), it should theoretically provide a more easily assimilated form of nitrogen when provided at nonexcessive levels (3). In fact, chrysanthemums convert NH_4-N directly into amino acids in their roots (25). At the highest rate of $(NH_4)_2SO_4$, plants were stunted and their foliage was darkened. These symptoms are typically observed with ammonium toxicity (3). NH_4-N and amino acids accumulating in excess of plant needs could have thereby provided an enhanced nutrient environment for the bacterium.

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