Use of NaCl to Suppress Root Diseases of Asparagus, Beets, and Cyclamens.

W. H. Elmer

The Connecticut Agricultural Experiment Station
123 Huntington St.
P. O. Box 1106
New Haven, CT 06504 USA

Asparagus (*Asparagus officinalis)*, beets (*Beta vulgaris*), and cyclamens (*Cyclamen persicum*) are salt tolerant crops. These plants suffer from soilborne fungal diseases which are difficult to manage. Greenhouse and field trials were conducted to determine how NaCl affected the growth of each plant when grown in soils infested with these pathogens. Plants were treated with 100 mL of fertilizer solution containing 0, 2.5, 5.0 or 10.0 g NaCl/L. Compared to the controls, asparagus and beets had a 50% reduction in disease severity and 15-25 % increase in plant growth at the higher rates of 5.0 and 10.0 g/L. Cyclamens responded with less disease and more growth at 2.5 to 5.0 g/L when compared to no NaCl. Tissue levels of Na, Cl, and Mn increased each plant with NaCl rate. Field trials in soil infested with the fungal pathogens showed that yields of asparagus and beets were increased when NaCl (280-560 kg/ha) was applied to field plots. Sodium chloride may be useful as a component in disease management of these crops.

1. INTRODUCTION

Asparagus (*Asparagus officinalis)*, table beets (*Beta vulgaris*), and cyclamens (*Cyclamen persicum*) are agronomic crops that possess salt (NaCl) tolerance. Although they are not classified as halophytes, there can tolerate exposure to NaCl without any visible damage. Moreover, salt was once used in the United States in production of asparagus and beets to suppress weeds. (8,16). Evidence on the salt tolerance of cyclamen was just recently reported (5).

These plants are also susceptible to destructive root diseases caused by soilborne fungal pathogens. Asparagus is susceptible to fungi known as *Fusarium oxysporum* f. sp. *asparagi* and *F. proliferatum* (3). Beets are routinely infected by *Rhizoctonia solani* (1), and cyclamens are susceptible to a disease caused by *F. oxysporum* f. sp. *cyclaminis* (15). These fungi are difficult to control and cause major losses each year.

Since resistant varieties and effective chemicals are not available for use, alternative control strategies need to be developed. The aim of these studies was to determine how different rates of NaCl affected the disease on each plant and how the NaCl affected the tissue levels of nutrients.

2. METHODS

2.1. Greenhouse studies.

Three-mo.-old transplants of asparagus (cv. Mary Washington) were produced from seeds in the greenhouse. Beets (cv. Early Wonder) seedlings were 3-wk-old and grown from seeds. Cyclamen (cv. Halios) were provided as seedling plugs from the Hortus Group, Inc. (Castroville, CA USA).

Inoculum of each pathogen was produced on sterile millet seeds. Millet seed was moistened with an equal volume of water, autoclaved for 1 hr. on consecutive days, and seeded with agar plugs (0.5 cm) that were colonized by the pathogens. Inocula was incubated for 2 wk at room temperature, dried in sterile bags, ground in mill and passed through a 1 mm sieve. Inocula were added to the potting soil using a rotary mixer. Both *Fusarium* pathogens on asparagus were added to the soil at 1.0 g colonized millet/L soil. The cyclamen pathogen was added at 0.5 g millet/L soil, and the pathogen of beets, *R. solani*, was added 0.2 g/L soil. Each inoculum load had been determined in previous studies (3-5). There was one plant per pot, and there were 12 replicates/treatment.

Pots were treated with NaCl dissolved in Hoagland's fertilizers solution (9). Each pot

received 100 ml of fertilizer solution containing 0, 2.5, 5.0 or 10.0 g NaCl/L (0, 43, 85, or 171 mM NaCl). Leachates from these pots had a salinity of 1.1, 1.5, 3.0 or 3.3 mhos/cm, respectively. Asparagus and cyclamen plants were held in the greenhouse for 15 wk. These plants received a second fertilization with Hoagland's solution without NaCl after 6 wk. Beets were held for 2 mo. All plants were irrigated with deionized water as needed.

After the appointed amount of time had passed, plants were assayed for disease. Asparagus roots were washed in water and arbitrarily placed on a plexiglass board with 1 cm grids. Total root length and that fraction of roots diseased and discolored was determined using the line-intersect method as described by Tennant (14). Beets and cyclamen were rated on a scale of 1 to 5 where 1 = no disease, 2 = slight stunting, 3 = stunted plants with wilted basal leaves, 4 = badly stunted and/or wilted plants, and 5 = dead or near death. Plants were harvested, dried in an oven, and weighed.

Dried plant tissue (0.5 g) was acid digested and assayed for elemental analyses. Tissue was analyzed for K, P, Ca, Mg, Na, S, Fe, Mn, Zn, Cu, and B by ICP spectrophometry. Nitrogen was determined using the Kjeldahl procedure, and Cl was determined by titration using a chloridometer.

All data were subjected to analysis of variance at $P = 0.05$. Tests for linear and quadratic fits were computed and designated as significant at $P = 0.05$ as *, $P = 0.01$ as **, and $P = 0.001$ as ***.

2.2. Field studies

Asparagus (cv. Syn 4-56) and beets (cv. Early Wonder) also were planted in naturally infested field plots that were 1.8 m long. Beets were treated with 0, 280 or 560 kg NaCl/ha after plant emergence. Asparagus crowns were planted in 1989 and treated with 560 kg/ha every year beginning in 1991. Nontreated plots served as controls. There were four replicated plots. Marketable spear yields (22.5 cm long) were harvested for asparagus in 1991 and every year after for eight yr. Beets were harvested for root weight after 10 wk.

3. RESULTS

The disease severity ratings of asparagus and beets were linearly and quadratically related to NaCl rate (Table 1). Cyclamen had the lowest disease rating at the NaCl rate of 5.0 g/L while the highest rate was associated with disease similar to the control.

Table 1
The influence of NaCl rate on disease severity of asparagus, beets, and cyclamen grown in soil infested with root pathogens.

NaCl g/L	Asparagus (% disease)	Beet (scale)	Cyclamen (scale)
0	42.4	3.8	4.0.
2.5	28.1	3.6	3.7
5.0	23.3	2.4	3.1
10.0	27.8	1.8	3.8
Linear	*	***	ns
Quadratic	**	*	**

Sodium chloride improved the growth of each plant (Table 2). Asparagus and beets were larger when treated with higher rates of NaCl where cyclamen responded favorably to rates between 2.5 and 5.0 g/L.

Table 2
The influence of NaCl rate on the dry weight (g) of asparagus, beets, and cyclamen grown in soil infested with root pathogens.

NaCl g/L	Asparagus	Beet	Cyclamen
0	1.3	1.0	0.7
2.5	1.2	1.5	1.3
5.0	1.6	1.7	2.4
10.0	2.2	1.6	1.4
Linear	*	**	*
Quadratic	ns	*	**

The NaCl treatments increased plant levels of Na, Cl, and Mn for all three plants (Tables 3-5). Uptake of Na was greatest for cyclamen and reached very high levels (Table 5). Chloride was

absorbed in the greatest amounts by asparagus (Table 3). Manganese increased in asparagus and cyclamen at similar rates, but increased at lower rates in beet tissue as the NaCl rate increased.

Table 3
The influence of NaCl rate on Na, Cl and Mn levels (ppm) in asparagus grown in soil with root pathogens.

NaCl g/L	Na	Cl	Mn
0	664.6	1124.1	18.3
2.5	1286.0	3387.7	16.2
5.0	2419.7	5442.1	21.0
10.0	3596.7	8170.9	21.9
Linear	***	***	*
Quadratic	***	***	ns

Table 4
The influence of NaCl on the Na, Cl and Mn level (ppm) of beets grown in soil with root pathogens.

NaCl g/L	Na (ppm)	Cl (ppm)	Mn (ppm)
0	321	100	6.9
10.0	2169 ***	2888***	9.2*

Table 5
The influence of NaCl rate on the Na, Cl and Mn composition of cyclamen grown in soil with root pathogens.

NaCl g/L	Na (ppm)	Cl (ppm)	Mn (ppm)
0	7285	757	20.8
2.5	17075	3337	23.9
5.0	21420	3928	26.0
10.0	24537	5307	29.0
Linear	***	***	*
Quadratic	***	***	**

Compared to controls, NaCl application caused a reduction in K levels in beet leaves, possibly due to replacement, but K was increased in asparagus (data not shown). Cyclamens were the most sensitive to NaCl rate and had decreasing levels of Ca, Mg S and B when compared to controls (data not shown).

Marketable yields of asparagus and beets were greater than controls when plots were dressed with NaCl. Beet yields increased by 32 and 43% when NaCl was applied at 280 kg/ha and 560 kg/ha, respectively (Figure 1). Applications of NaCl to asparagus plots resulted in 10-21% increase in marketable spear yield in six out of eight seasons (Figure 2).

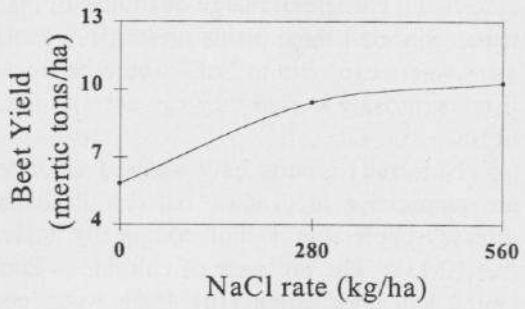

Figure 1. The effect of NaCl on the yield of table grown in soil infested with *Rhizoctonia solani.*

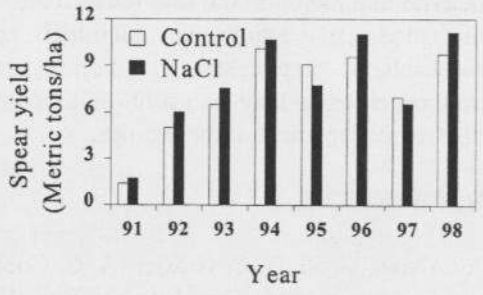

Figure 2. The effect of NaCl on the marketable yield of asparagus from 1991-1998.

4. CONCLUSIONS.

At these rates, NaCl had beneficial effects on the growth of asparagus, beets and cyclamen when grown in soil infested with pathogenic fungi. The

higher rates were more beneficial for asparagus and beets, but the lower rates had growth enhancing properties on cyclamen. Since only single application of NaCl were applied, this practice may not cause deleterious effects on soil structure. The findings suggest that NaCl may be useful in a integrated disease management program on these crops.

Asparagus absorbed Cl in greater amounts than Na, whereas uptake of both ions was roughly equal in beets tissue. Cyclamen was unique in its ability to absorb and concentrate large quantities of Na in the tissue. Since all three plants presumably evolved in areas where exposure to NaCl would be frequent, it is not surprising to find they can absorb high levels of Na.

Numerous reports have showed chloride salts are suppressive to disease, but the mechanism of disease suppression is not completely understood (2,6,10-13). The presence of chloride is known to inhibit soil nitrification (10). Plant water potential and root exudation also are affected (2,12). It has been proposed that chloride may alter host resistance by increasing Mn. The increased Mn availability may also function to enhance enzymatic production of phenols and other defense products in roots (7,11). Areas for future research include determining the optimum rate for different soils and the mode of action on microbial and plant mechanisms implicated in disease resistance. Sodium chloride may be useful as a component in disease management of these crops.

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