Effects of Chloride and Nitrogen Form on Growth of Asparagus Infected by *Fusarium* spp.

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ABSTRACT

Elmer, W. H. 1989. Effects of chloride and nitrogen form on growth of asparagus infected by *Fusarium* spp. Plant Disease 73: 736-740.

Amendments of potassium chloride or sodium chloride and the nitrogen forms $Ca(NO_3)_2$, KNO_3, NH_4NO_3, NH_4Cl, $NH_4H_2PO_4$, $(NH_4)_2SO_4$, or urea were examined in factorial combinations on asparagus (cv. Mary Washington) seedlings cultured in test tubes containing agar media. Greenhouse soil treatments combined each chloride salt with the following N forms: $Ca(NO_3)_2$, KNO_3, NH_4NO_3, or $(NH_4)_2SO_4$. Seedlings and 12-wk-old transplants grown with each N form, but without Cl, served as controls. Weights of seedlings were greater with NO_3-N than with NH_4-N, but growth was greatest when KCl was combined with NO_3-N. Seedlings inoculated with *Fusarium oxysporum* or *F. moniliforme* were largest when grown in combinations of $Ca(NO_3)_2$ and KCl or NaCl. The weights and root lengths of transplants after 10 wk increased when NaCl was added to both infested and noninfested soils, but variation was high. Similarly, disease and root colonization were reduced when NaCl was applied. Potassium nitrate produced the largest plants in noninfested soil but was more conducive to disease and fungal root colonization than the other N forms. Conversely, $Ca(NO_3)_2$ suppressed disease, but plants were not as large as those grown with KNO_3. Suppression of Fusarium crown and root rot of asparagus with Cl may depend on the presence of NO_3-N with adequate potassium and calcium.

Asparagus officinalis L. is the most chloride-tolerant crop grown commercially (10). Applications of rock salt were once recommended (1,29) because they increased yields (20,21,27).

Coincident with the discontinuation of salt applications were reports of Fusarium crown and root rot of asparagus (3,12,13). The severity of the disease has increased worldwide and is now in every asparagus-producing area. The disease is caused by two soilborne Fusaria. *Fusarium oxysporum* (Schlecht.) emend. Snyd. & Hans. (syn. *F. o.* f. sp. *asparagi* Cohen) usually infects roots (3,12), whereas *F. moniliforme* (Sheld.) emend. Snyd. & Hans. commonly invades crowns and stems (6,12).

Recently, Cl salts have been shown to suppress certain soilborne diseases (2,11,22,23,25,30). For example, NH_4Cl suppressed take-all root rot of wheat incited by *Gaeumannomyces graminis* (Sacc.) v. Arx & Oliv. var. *tritici* Walker (2,25). Potassium chloride suppressed Fusarium stalk rot of corn (30); common root rot of barley caused by *Cochliobolus sativus* (Ito & Kurib.) Drechs. ex Dastur, *F. graminearum* Schwabe, and/or *F. culmorum* (W. G. Sm.) Sacc. (11,23); and Fusarium yellows of celery caused by *F. o.* f. sp. *apii* (Nels. & Sherb.) Snyd. & Hans. race 2 (22). Schneider (22) reported that the effectiveness of KCl in suppressing Fusarium yellows of celery was strongly influenced by the N form. This paper reports the interactive effects of Cl and N form on asparagus seedlings and transplants infected by *F. oxysporum* and *F. moniliforme*.

Accepted for publication 10 April 1989 (submitted for electronic processing).

MATERIALS AND METHODS

Seedling experiments. Because it is extremely difficult to grow Fusarium-free asparagus in the greenhouse or growth chamber (6,24), an axenic culture (7) of asparagus seedlings in agar media was employed. This type of seedling assay was comparable in disease reactions to greenhouse trials for different asparagus cultivars (24). The agar media contained N (14.3 mM) in one of the following forms: $Ca(NO_3)_2$, KNO_3, NH_4NO_3, NH_4Cl, $NH_4H_2PO_4$, $(NH_4)_2SO_4$, or urea. These seven N forms were each factorially combined with three Cl treatments: no Cl, KCl, or NaCl (17.1 mM), for a total of 21 combinations. All media contained KH_2PO_4 (1.0 mM), $MgSO_4$ (2.0 mM), $CaCO_3$ (0.1 mM), 1 ml of Hoagland's (15) microelement solution per liter of media, and 1.0 mg of EDTA-Fe per liter. Solutions were adjusted to pH 6.7 with NaOH or H_2SO_4 before 6.0 g of Noble agar was added per liter and dissolved. Glass test tubes (18 × 150 mm) containing 7 ml of the media were capped and autoclaved for 25 min.

Seeds of asparagus (cv. Mary Washington) were obtained from Comstock and Ferre Seed Co. (Wethersfield, CT). Seeds were surface-sterilized in 1.1% sodium hypochlorite (20% household bleach) for 30 min, agitated on a wrist-action shaker for 24 hr in 100 ml of acetone that contained 2.5 g of benomyl (Benlate 50WP, Dupont Co., Wilmington, DE) (5,9), and washed in acetone followed by sterile distilled water. They were germinated on water agar (0.6%, w/v), and uniform seedlings with healthy radicles (3–7 mm) were transplanted into 40 test tubes per treatment, one seedling per tube. The tubes were capped and incubated for 1 wk at 23–25 C under cool-white fluorescent lights for 16-hr photoperiods. Then 30 uniform seedlings were inoculated and 10 were discarded.

Fungal isolates were obtained from infected asparagus crowns. They were single-spored and stored in sterile soil (19). Conidia of *F. oxysporum* (isolate CT661) and *F. moniliforme* (isolate P214) were grown on potato-carrot agar (8) at 25 C for 10–14 days. Conidia were washed from the agar with sterile water, passed through four layers of sterile cheesecloth, and diluted with sterile

water to 1 million conidia (total) per milliliter, based on hemacytometer counts. The ratio of macroconidia to microconidia for *F. oxysporum* and *F. moniliforme* was about 1:25 and 1:210, respectively. Ten replicate tubes each received 1 ml of the conidial suspension of *F. oxysporum* or *F. moniliforme*, or received 1 ml of sterile distilled water. Excess water that did not evaporate was absorbed into the agar media within 4 days. The tubes were left uncapped and were placed into racks enclosed in clear plastic bags. Bags were tied loosely, supported above the tubes to allow for seedling growth, and incubated as before inoculation. Ferns were weighed after 4 wk. A single experiment with 10 replicates each is reported here, but the experiment was repeated twice with similar results.

Greenhouse experiments. Asparagus (Mary Washington) transplants were grown from germinated seedlings for 12 wk in 36-cell plastic trays containing commercial potting mix (ProMix BX, Premier Brand, Inc., New Rochelle, NY). Seeds were surface-sterilized and germinated on water agar as described above. Plants received 50 ml of Hoagland's solution (15) every week beginning 7 wk after germinated seeds were placed in soil. Transplants were washed to remove soil, inspected to assure that roots were white and healthy, and weighed to choose uniform transplants.

Inoculum of *F. oxysporum* (isolate CT661) or *F. moniliforme* (isolate P214) was cultured on asparagus residues. Fifty grams of dried, ground (1.41-mm mesh size) asparagus crowns and stems were combined with 25 ml of distilled water and were autoclaved for 1 hr on 2 consecutive days. Asparagus residues were seeded with colonized or sterile potato-carrot agar (8) plugs (6-mm diameter) and incubated at 25 C for 4 wk. They were then air-dried. Residues were mixed with separate lots of soil at 1.5 g of residue per kilogram of soil.

Soil consisted of one part sand to two parts (v/v) commercial potting mix (ProMix C, Premier Brand, Inc., New Rochelle, NY), resulting in a bulk density of 0.68 g/cm^3. The soil characteristics were as follows: NO_3-N, 5.0 μg/g; NH_4-N, 25.0 μg/g; PO_4-P, 100.0 μg/g; exchangeable K, 12.0 meq/100 g; exchangeable Ca, 8.0 meq/100 g; exchangeable Mg, 2.5 meq/100 g; and exchangeable Cl, 1.7 meq/100 g (18). Each soil was treated with K_2SO_4 (0.1 g/kg of soil) to supply adequate K and SO_4, with hydrated lime (1.0 g/kg of soil) to yield a pH of 6.7–6.9, and with nitrapyrin (N-Serve 24, Dupont Co, Wilmington, DE) (2 mg a.i./kg of soil) to inhibit nitrification. Granular applications of $(NH_4)_2SO_4$, NH_4NO_3, $Ca(NO_3)_2$, or KNO_3 were incorporated at equal rates of N (0.27 g/kg of soil). Three Cl treatments, KCl, NaCl (2.65 g/kg of soil, simulating field rates of 560–1,120 kg/ha [20,21]), or no Cl, were added factorially to each infested soil containing each N form. Each of the 36 soil mixtures (three soils × four N forms × three Cl treatments) was homogenized in a cement mixer.

Single plants weighing 5–7 g were transplanted into 950-cm^3 plastic pots containing 0.6 kg of treated soil. There were five replicate pots per treatment. Pots were placed in 500-cm^3 paper Dixie squat containers (Eastern Bag Co., Bridgeport, CT) to retain leachates and were arranged in a randomized block design in the greenhouse (22–30 C). Soil was kept moist, but care was taken to avoid excessive leaching. After 10 wk, entire plants were washed and weighed; roots and ferns were weighed separately. Ferns were dried to constant weights at 75 C and were then reweighed.

Feeder root lengths were estimated by photographing roots overlaying a 20 × 20 cm plastic board with 2 × 2 cm grid markings. Root length per plant was estimated from these photographs using the modified line intersect method (26). Root colonization and the percentage of roots exhibiting lesions were determined from entire root systems that were washed for 3–5 min in tap water, placed into 0.02% sodium hypochlorite (4.0% household bleach) for 4 min, and rinsed with tap water. Excess water was removed by pressing roots between absorbent paper towels. Young feeder roots (1.0–3.0 cm) were removed and placed onto Falcon (10 × 10 cm) Integrid petri dishes that contained 1.3 × 1.3 cm grids (Macalaster Bicknell, New Haven, CT). Dishes contained 15 ml of Komada's medium (17), which is selective for *Fusarium* spp. The total length of these roots and that portion with lesions were estimated by the modified line intersect method (26). Roots from each plant were placed on three petri dishes and incubated at 20–25 C for 5–7 days. Colonies of *F. oxysporum* or *F. moniliforme* were enumerated. Isolates recovered from representative colonies were confirmed to be the original inoculum by vegetative compatibility, using complementation tests as described by Correll et al (4). Root colonization was expressed as colony-forming units per centimeter of root, and disease was expressed as percentage of root length exhibiting lesions.

Statistical procedures. Data in each of the three inoculation groups were analyzed separately. Linear contrasts were computed in each analysis for certain main effects, whereas mean values were compared by the LSD test at $P = 0.05$.

Table 1. Effects of chloride and nitrogen form on fresh weights of asparagus seedlings cultured on agar media and infected with *Fusarium oxysporum* or *F. moniliforme*

	Fresh wt (mg)		
Treatment	**Noninoculated**	***F. oxysporum***	***F. moniliforme***
Urea	66[w]	...[x]	17
Urea + KCl	33	...	10
Urea + NaCl	64	...	8
$NH_4H_2PO_4$	73	...	4
$NH_4H_2PO_4$ + KCl	41	...	...
$NH_4H_2PO_4$ + NaCl	53	...	...
NH_4Cl	48	14	...
NH_4Cl + KCl	82	19	17
NH_4Cl + NaCl	61	9	7
$(NH_4)_2SO_4$	42	7	...
$(NH_4)_2SO_4$ + KCl	50	6	...
$(NH_4)_2SO_4$ + NaCl	53	...	...
NH_4NO_3	122	13	33
NH_4NO_3 + KCl	108	6	34
NH_4NO_3 + NaCl	120	8	7
$Ca(NO_3)_2$	83	43	54
$Ca(NO_3)_2$ + KCl	136	104	64
$Ca(NO_3)_2$ + NaCl	109	19	82
KNO_3	116	15	53
KNO_3 + KCl	161	9	51
KNO_3 + NaCl	119	38	52
LSD ($P = 0.05$)	26	18	18
Linear contrasts (*P*)			
NH_4 vs. NO_3[y]	0.001	0.001	0.001
$Ca(NO_3)_2$ vs. KNO_3	0.08	0.006	0.001
No Cl vs. Cl	0.09	NS[z]	NS
KCl vs. NaCl	NS	NS	NS
KCl vs. NaCl with NO_3-N	0.001	0.08	NS

[w] Values represent the means of 10 seedlings.
[x] Seedlings in these treatments died.
[y] NH_4NO_3 was treated as an NH_4-N form.
[z] Not significant at $P = 0.10$.

RESULTS

Seedling experiments. Noninoculated seedlings produced the greatest fern fresh weight when grown with $Ca(NO_3)_2$ or KNO_3 fortified with KCl (Table 1). Seedling growth was significantly less with NH_4-N, and weights were not greatly affected by the NaCl supplements. The average weight of seedlings infected with *F. oxysporum* was 17% of the mean fresh weight of healthy seedlings. Seedlings infected by *F. oxysporum* were largest when nourished by $Ca(NO_3)_2$ and KCl. Disease was severe when KNO_3 was fortified with KCl; most seedlings died. Potassium nitrate improved growth only when accompanying NaCl. Ammonium-N greatly enhanced disease and seedling fatality. Inoculation with *F. moniliforme* caused an average 75% reduction in fresh weight as compared with noninoculated controls. When Cl was absent, the effects of $Ca(NO_3)_2$ and KNO_3 were similar, but only $Ca(NO_3)_2$ interacted with NaCl resulting in larger seedlings.

Greenhouse experiments. No significant interaction was detected between Cl and N form in greenhouse studies, but N form and Cl alone had significant effects (Table 2). Mean plant weight, root weight, and, to a lesser extent, root length increased when NaCl was applied. Plant growth did not always increase with KCl. Overall plant growth was similar with NO_3-N as opposed to NH_4-N. Plants were slightly larger when grown with KNO_3 or $(NH_4)_2SO_4$ as compared with plants grown with NH_4NO_3 or $Ca(NO_3)_2$. Although fern dry weight was not significantly affected by Cl, adding Cl to KNO_3 and to $(NH_4)_2SO_4$ caused slight increases in dry weights.

Cl supplements significantly increased root weights of transplants grown in soil infested with *F. oxysporum*, but fern dry weights were not affected. Although fresh weights and root lengths were not significantly altered by Cl, the mean growth measurements of each parameter consistently increased when NaCl was added; KCl increased growth only with NO_3-N. The form of N alone was not significant in affecting the growth of these plants.

Cl did not significantly influence fresh or dry weights of asparagus plants growing in soil infested with *F. moniliforme*. However, feeder root length was significantly increased when NaCl was combined with NH_4NO_3.

Although transplants that grew in noninfested soil had weights significantly greater than plants growing in infested soils (*t* test, $P = 0.05$), up to 12% of their roots were diseased (Table 3). These roots supported an average of 0.3–0.8 colony-forming units of *F. moniliforme* per centimeter of root. Isolates from these colonies were not vegetatively compatible with *F. moniliforme* isolate P214 and probably represent contaminants. Plants grown in soil infested with *F. oxysporum* had roots with less disease and less colonization by *F. oxysporum* when NaCl was combined with each N form. Disease was lowest (9%) when $Ca(NO_3)_2$ was the N form, but combining NaCl with $Ca(NO_3)_2$ further decreased disease to 4.3%. Conversely, 32.5% of the roots were diseased when plants were grown in KNO_3, and addition of NaCl reduced this disease by 68%. Concurrent with the decline in root lesions was a 46% reduction in recovery of *F. oxysporum*. Plants infected with *F. moniliforme* also had 60, 38, and 39% less disease when NaCl was combined with NH_4NO_3, $Ca(NO_3)_2$, and KNO_3, respectively. Similarly, the mean recovery of *F. moniliforme* from these roots grown in NH_4NO_3, $Ca(NO_3)_2$, and KNO_3 declined by 34, 23, and 27%, respectively, when NaCl was included.

DISCUSSION

Cl supplements increased growth of asparagus and suppressed Fusarium crown and root rot in assays with seedlings and in greenhouse transplants grown in soil in all repeated trials. No interaction between Cl and N form was detected in the growth of transplants grown in a soil mix, but seedling growth in agar-culture did react to certain Cl and N form combinations. Basically, seedlings grew best with NO_3-N and KCl. Although transplants were not significantly larger with any N form or Cl salt, repetitions of the experiment suggested that plants grew larger with NaCl than with KCl. In both experiments, disease incited by *F. oxysporum* was enhanced with KNO_3, suppressed with $Ca(NO_3)_2$, and further decreased when a Cl salt was added. In both studies, plants infected with *F.*

Table 2. Effects of chloride and nitrogen form on plant weight and root length of asparagus transplants grown in noninfested soil or in soil infested with *Fusarium oxysporum* or *F. moniliforme*

	Noninfested				*F. oxysporum*				*F. moniliforme*			
	Fresh wt (g)				Fresh wt (g)				Fresh wt (g)			
Treatment	Plant[v]	Root	Fern dry wt (g)	Root length[w] (m)	Plant[v]	Root	Fern dry wt (g)	Root length[w] (m)	Plant[v]	Root	Fern dry wt (g)	Root length[w] (m)
$(NH_4)_2SO_4$	42.4[x]	26.5	4.4	23.3	33.5	18.8	3.8	16.0	30.6	18.8	3.4	11.2
$(NH_4)_2SO_4$ + KCl	49.1	31.0	4.8	28.1	26.9	14.1	4.0	14.9	30.2	17.2	4.6	16.2
$(NH_4)_2SO_4$ + NaCl	51.4	33.9	5.0	30.5	39.4	24.1	4.3	18.0	30.7	17.3	3.3	13.1
NH_4NO_3	38.3	22.3	4.3	19.9	46.1	25.9	4.9	19.2	35.6	22.0	3.9	14.9
NH_4NO_3 + KCl	46.4	29.3	4.6	30.7	33.2	20.7	3.3	18.2	30.0	22.2	4.4	22.5
NH_4NO_3 + NaCl	46.0	32.4	3.3	29.6	46.3	29.3	4.2	20.0	31.2	22.7	3.4	32.5
$Ca(NO_3)_2$	38.4	21.8	4.9	16.1	27.4	16.9	3.1	14.3	28.7	16.2	3.2	11.3
$Ca(NO_3)_2$ + KCl	37.1	24.7	3.4	19.3	39.7	23.9	3.8	15.8	25.9	15.7	2.4	13.6
$Ca(NO_3)_2$ + NaCl	38.4	23.2	3.7	23.9	38.0	24.0	3.3	19.6	28.8	18.2	2.9	12.2
KNO_3	46.3	28.2	4.9	25.5	30.0	14.5	3.9	12.1	34.4	18.6	3.4	12.4
KNO_3 + KCl	56.0	36.0	5.3	28.2	34.5	21.1	3.5	13.5	22.0	14.3	1.9	10.3
KNO_3 + NaCl	57.6	36.8	5.6	30.3	37.8	25.6	3.1	16.7	37.8	20.7	4.3	15.4
LSD ($P = 0.05$)	12.5	10.7	1.4	9.0	16.9	6.9	1.8	9.2	15.7	11.1	1.6	13.6
Linear contrasts (*P*)												
NH_4 vs. NO_3[y]	NS[z]	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
$Ca(NO_3)_2$ vs. KNO_3	0.001	0.001	0.001	0.001	NS	NS	NS	NS	NS	NS	NS	NS
No Cl vs. Cl	0.03	0.01	NS	0.10	NS	0.05	NS	NS	NS	NS	NS	NS
KCl vs. NaCl	NS	NS	NS	NS	NS	0.10	NS	NS	NS	NS	NS	NS
KCl vs. NaCl with NO_3-N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[v] Plant fresh weight represents the ferns, crown, and roots.
[w] Root length represents feeder roots only and was estimated by the modified line intersect method (26).
[x] Values represent the means of five replicate plants.
[y] NH_4NO_3 was treated as an NH_4-N form.
[z] Not significant at $P > 0.10$.

moniliforme did not respond to Cl amendments to the extent that plants infected with *F. oxysporum* did. These recurring trends suggest Cl affects resistance of seedlings and transplants by similar mechanisms.

It is evident that Cl was not simply alleviating a nutrient deficiency because not all Cl supplements improved growth. Factors affecting the response of seedling growth to Cl were N form, Cl source, and possibly K and Ca. The reaction of transplants to Cl was less dependent on N form or Cl source, but disease suppression was consistently greatest with $Ca(NO_3)_2$ and NaCl.

The combination of $Ca(NO_3)_2$ and Cl in suppressing disease has been observed repeatedly. Schneider (22) reported that $Ca(NO_3)_2$ and KCl provided optimal suppression against Fusarium yellows of celery, and plants that had equal petiole concentrations of K and Cl had the least disease. If a similar relationship between disease and the ratio of K to Cl in asparagus exists, it may help to explain why KCl was the optimal Cl source in seedling experiments, whereas NaCl was favored in greenhouse studies. Asparagus is known to restrict Na uptake, but it will accumulate Cl (10). Seedlings cultured on agar media were supplied a low level of K (1.0 mM). Consequently, the NaCl supplements (17.1 mM) would have produced seedlings that were high in Cl but low in K; these treatments had no disease suppression. However, when KNO_3 was the N form, adding NaCl may have produced seedlings with balance between K and Cl; disease in these treatments was less than in other NaCl-treated seedlings. Amendments of KCl provided sufficient K and Cl, and disease was most suppressed when combined with $Ca(NO_3)_2$. Transplants, on the other hand, were supplied sufficient K. Adding NaCl provided the Cl component for an optimal K-to-Cl ratio and may explain why plants grew larger with NaCl than with KCl. Supplying KCl could have produced K concentrations too high in relation to the amount of Cl. Elemental tissue analysis will be required to validate these assumptions.

Another intriguing aspect noted in this study was that transplant fresh weights increased in response to Cl, whereas dry weights did not always respond (Table 2). It is likely that Cl affected osmotic regulation in asparagus. Christensen et al (2) found that wheat plants fertilized with Cl salts had lower osmotic potentials and less take-all root rot disease. They suggested fungal colonization may have been influenced.

The disease suppressiveness of $Ca(NO_3)_2$ is well documented for many diseases (16). As with Cl, the mechanism of suppression is not clear, but host resistance is probably altered because the inoculum densities per gram of soil of both *Fusarium* spp. did not decrease in $Ca(NO_3)_2$-treated soil when NaCl was added (*unpublished*). Ammonium-N was much more deleterious to seedlings than to transplants, probably because of NH_4 toxicity (14) and because the root-mediated acidification of the agar restricted growth (28).

Caution must be exercised before extrapolating these results to the field situation. Many normal soil-root interactions were absent or altered by these experimental conditions. Also, multiple root infections were not detected by the technique used. Therefore, data on root infection represent underestimates. However, results from one season's field experiments have showed that plots receiving NaCl had greater spear numbers and spear weights than untreated plots (*unpublished*). The tradition of applying rock salt to asparagus plantings may have unknowingly benefited plant health and suppressed Fusarium crown and root rot. These results should encourage additional studies for practical field management of asparagus and for the elucidation of the mechanism of Cl on disease.

Table 3. Effects of chloride and nitrogen form on disease and colonization of asparagus roots by *Fusarium oxysporum* or *F. moniliforme*

Treatment	Noninfested		*F. oxysporum*		*F. moniliforme*	
	Percent disease[v]	Colony-forming units[w]	Percent disease[v]	Colony-forming units[w]	Percent disease[v]	Colony-forming units[w]
$(NH_4)_2SO_4$	4.6[x]	0.7	21.3	1.0	18.8	0.9
$(NH_4)_2SO_4$ + KCl	5.1	0.6	12.3	0.6	21.0	0.7
$(NH_4)_2SO_4$ + NaCl	9.4	0.7	14.8	0.9	41.0	0.7
NH_4NO_3	11.4	0.7	10.0	1.1	35.8	1.2
NH_4NO_3 + KCl	6.0	0.8	15.2	0.7	18.7	0.9
NH_4NO_3 + NaCl	2.6	0.3	7.4	0.9	14.4	0.8
$Ca(NO_3)_2$	3.3	0.5	9.0	0.7	20.2	0.9
$Ca(NO_3)_2$ + KCl	3.9	0.3	16.9	0.9	15.0	0.7
$Ca(NO_3)_2$ + NaCl	4.3	0.5	4.3	0.6	12.6	0.7
KNO_3	5.5	0.4	32.5	1.3	34.8	1.1
KNO_3 + KCl	7.9	0.8	13.7	1.1	17.2	0.9
KNO_3 + NaCl	6.0	0.7	10.5	0.7	21.2	0.8
LSD ($P = 0.05$)	6.7	0.3	15.8	0.3	16.3	0.3
Linear contrasts (*P*)						
NH_4 vs. NO_3[y]	NS[z]	NS	NS	NS	NS	NS
$Ca(NO_3)_2$ vs. KNO_3	NS	NS	NS	0.08	NS	0.04
No Cl vs. Cl	NS	NS	0.10	0.05	NS	0.006
KCl vs. NaCl	NS	NS	NS	NS	NS	NS
KCl vs. NaCl with NO_3-N	NS	NS	0.08	NS	NS	NS

[v] Percent disease was determined by diseased feeder root length per total feeder root length × 100. Feeder root length was estimated by the modified line intersect method (26).
[w] Colony-forming units per centimeter of root length, estimated from colonies recovered from roots placed on Komada's medium (17).
[x] Values represent the means of five replicate plants; one replicate consisted of the total root length counts from three petri dishes.
[y] NH_4NO_3 was treated as an NH_4-N form.
[z] Not significant at $P > 0.10$.

ACKNOWLEDGMENT

I thank Mary Inman for technical assistance.

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