Manganese Stresses and Mineral Nutrition of Cucumber Plants

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SUMMARY

Cucumber plants in the vegetative phase of growth received deficient, sufficient, or toxic treatment of manganese (Mn) during a 15 - day period beginning 43 days after germination. Deficiency and toxicity of manganese both supressed accumulation of fresh and dry weight. Stem length, number of leaves, and number of seconday meristems per plant were not significantly different among Mn treatments. Manganese-deficient plants accumulated less manganese and nitrogen but more copper and iron, and about the same amount of zinc, phosphorus, and potassium as the Mn-sufficient plants. Manganese toxicity caused cucumber plants to accumulate less copper, nitrogen, phosphorus, and potassium, but more manganese, and about the same amounts of iron and zinc as the Mn-sufficient plants.

INTRODUCTION

Manganese deficiency in citrus and manganese toxicity in corn have been reported in Arizona. To better understand effects of deficiency and acute toxicity of manganese on growth and mineral accumulation of a fast - growing vegetable crop, a commercial variety of cucumber was chosen. Nutrient solutions were used to begin the manganese treatments when the plants began their rapid phase of growth and to allow recovery of the roots. The plants were kept from developing fruit to confine the study to the vegetative phase of growth.

METHODS

Seeds of cucumber (cv. Sumter) were germinated in water. When the radicles appeared, seedlings were transferred onto cheesecloth stretched over dilute nutrient solution and were allowed to grow to sufficient size to begin the experiment. Plants were selected for uniformity and were grown in individual pots containing nutrient solution with sufficient concentrations of all essential mineral nutrients.

After a 15 - day pretreatment period of growing in nutritionally sufficient solution, replicate plants were harvested, and the remaining plants were divided into three groups: One group continued to receive nutritionally sufficient solution with 0.1 ppm Mn, one group received nutrient solution without Mn, and the third group received nutrient solution with Mn at 100 times the concentration of the Mn-sufficient solution.

Fifteen days later, plants of the three treatments were harvested. Fresh weight, dry weight, total stem length, number of leaves, number of secondary meristems, and amounts of copper, iron, manganese, zinc, nitrogen, phosphorus, and potassium were determined for each plant, including the roots. If the F - test of analysis of variance (ANOVA) indicated significant ($P = 0.05$) differences among treatment means, then the least significant difference (LSD) was used to test differences ($P=0.05$) among treatment means.

RESULTS

During the 15 - day treatment period, both deficiency and toxicity of manganese supressed accumulation of fresh weight and dry weight per plant, compared to manganese sufficiency (Table 1). The stem length, number of leaves and number of secondary meristems per plant were not significantly affected by any of the Mn treatments. At the end of the experiment, Mn - sufficient plants were dark green, and the Mn - deficient plants were slightly lighter green in the newer leaves, but otherwise resembled the Mn - sufficient plants. The cucumber plants suffering

acute Mn toxicity were stunted, and their leaves were small, curved downward and inward, with bronze - colored spots visible on both the top and bottom of each leaf.

Manganese deficiency increased accumulation of two other essential micronutrients, copper and iron, while Mn toxicity decreased accumulation of copper, compared to Mn sufficiency (Table 2). Nitrogen accumulation in the cucumber plants was supressed by both Mn deficiency and toxicity, compared to Mn sufficiency (Table 3). Manganese deficiency had no significant effect on accumulation of phosphorus and potassium, but Mn toxicity supressed accumulation of both elements, compared to Mn sufficiency.

The manganese toxicity treatment of this experiment was acute (of relatively short duration) and extreme (100 times more concentrated than a sufficient concentration of Mn in solution). It is probable that a less extreme acute Mn toxicity (for example, 50 - fold higher concentration than sufficient) would have similar, but less evident effects. Further research is needed to understand effects of both lower - level, acute Mn toxicity and chronic, low - level Mn toxicity on growth and mineral nutrition of cucumber and other vegetable crops.

These results show growers that manganese can affect crop growth and uptake of many essential plant nutrients. For crops grown in soils where manganese deficiency or toxicity is suspected, the manganese status of the soil and plant should be considered when evaluating soil or plant analyses for fertilizer recommendations.

Table 1. Fresh weight, dry weight, stem length, number of leaves, and number of secondary meristems per cucumber plant for each manganese treatment.

Mn Treatment	Fresh Weight	Dry Weight	Stem Length	Leaves	Secondary Meristems
	------- g ------		- cm -		
Suff. pretr.	108d#	7.0d	58##	14	2
Deficiency	536b	32.4b	221	40	3
Sufficiency	619a	46.5a	592	59	4
Toxicity	360c	26.0c	302	43	3
LSD (0.05)	57	6.3			

Table 2. Amounts of copper, iron, manganese, and zinc per cucumber plant for each manganese treatment.

Mn Treatment	Cu	Fe	Mn	Zn
	----------	mg	----------	
Suff. pretr.	0.20d#	12.34c	0.19c	0.73c
Deficiency	1.23a	59.48a	0.43c	3.58a
Sufficiency	1.02b	41.32b	1.49b	3.00ab
Toxicity	0.70c	41.54b	32.27a	2.55b
LSD (0.05)	0.09	14.53	0.59	0.62

 # Means followed by the same letter in a column are not significantly different by LSD (0.05) test.
Means not followed by a letter in a column are not significantly different by F - test (0.05) of ANOVA.

Table 3. Amounts of nitrogen, phosphorus, and potassium per cucumber plant for each manganese treatment.

Mn Treatment	N	P	K
		----------mg----------	
Suff. pretr.	346c#	65c	410c
Deficiency	1152b	374a	1993a
Sufficiency	1416a	403a	2367a
Toxicity	1009b	283b	1466b
LSD (0.05)	191	60	442

 # Means followed by the same letter in a column are not significantly different by LSD (0.05) test.
Means not followed by a letter in a column are not significantly different by F - test (0.05) of ANOVA.