Effect of Manganese Soil and Seed Treatments on Growth and Yield of Peas[1]

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Abstract. A broadcast $MnSO_4$ treatment of 38 Kg Mn/ha resulted in 2½-fold increase in both plant growth and shelled pea yields of 'Darkskin Perfection' peas. Pods per plant and peas per pod, 2 components of the yield equation, were reduced by Mn deficiency. Seed treatments of Mn EDTA were not effective in correcting the deficiency.

Manganese deficiency in peas, *Pisum sativum* L., has been associated with the physiological disorder of marsh spot for the last 2 decades (2, 3, 5, 7). However, there is limited information on the effects of Mn deficiency on plant growth and shelled pea yields.

Heilman[3] was the first to report Mn deficiency in peas and other crops grown in northwestern Washington. In 1969, several sources of Mn were tested in broadcast and in in-furrow treatments. Foliar deficiency symptoms were corrected with Mn treatments but yields were not significantly improved. There were trends of improved yields associated with broadcast treatments of $MnSO_4$ but heterogeneous soil conditions apparently confounded the yield data. The deficiency symptoms occur in irregular patterns in the fields where this disorder principally occurs. Eaton and John (1), reported that lime applications on Mn deficient soils aggravate Mn deficiency in peas. Soils in northwestern Washington are acidic and have had continuous heavy applications of lime for many years.

Materials and Methods

The location for the 1970 Mn study was selected where aerial photographs taken during the 1969 growing season showed a uniformly chronic manganese chlorosis occurring in the peas. Preliminary soil tests analyzed by Washington State University Soil Testing Laboratory indicated the following range in pH 5.8-6.2; percent organic matter, 4.0-4.4; and ppm Mn, extracted with diethylenetriamine pentaacetic acid, 0.28-0.48. The soil at the site is classified as a Puget fine sandy loam.

The soil was prepared by plowing and discing. Broadcast $MnSO_4$ treatments were applied and incorporated into the soil with another discing. The treatment plots were seeded to 'NWR-Darkskin Perfection' peas with an 11-row grain drill. Data was obtained from the population of plants growing in the 3 center rows comprising the area of one square meter and included an average of 92 plants in each plot (Table 3).

The Mn seed treatment consisted of mixing Geigy sequestrene Mn EDTA in the Captan seed treatment. Seed treatment rates were 135, 675, 1350, 2025, 2700, and 3375 mg Mn per Kg seed. The basal seed treatment consisted of a slurry of 10 gm Captan-75 and 50 ml water per 9 Kg seed. The seed surface was uniformly covered by blending seed and slurry in a concrete mixer.

Weeds were controlled with a preemergence application of 3.4 Kg/ha Dinoseb-amine salt. Insects were controlled with a single aerial application of 0.6 Kg/ha Parathion at full bloom. Foliage samples were composed of petiole and blade tissue of the first expanded leaflet.

Duplicate foliage samples for each treatment were analyzed for each harvest by pooling tissue from odd and even number replications. The procedure for analyzing Mn was to rinse the tissue 3 times in distilled water, dry in a 70°C forced draft oven, ash in a muffle furnace and dissolve the ash in 1N HCl and determine the concn by atomic absorption spectrophotometry.

Yields and growth measurements were obtained in a 3 day period beginning 74 days after planting. Either 3 or 4 replications were harvested per day. The plants were hand pulled, counted and fresh wt determined. Ten plants per plot were measured for number of nodes and plant ht. The pods were harvested and separated into immature and filled groups. The filled pods were hand shelled and both measurements of seed wt and wt of 100 seeds were taken.

Recently, Gritton and Chi (4) determined that random selections of 16 plants per replicate and 8 replications per treatment, adequately measured the yield components of peas. Our randomized block design with 10 replications per treatment and the average of 92 plants per replication, effectively delineated treatment differences. Yield and growth measurement were analyzed by analysis of variance and the Duncan's multiple range test (8).

Results and Discussion

Mild Mn deficiency symptoms were first observed on the control and Mn chelate seed treatment plots 37 days after seeding (Table 1). Interveinal chlorosis of new growth, and

Table 1. Appearance ratings[z] of plants between broadcast $MnSO_4$ and Mn EDTA seed treatments at specified time intervals from planting.

Treatment	Days after planting					
	37	44	50	57	62	69
Control	7 ab	6 ab	6 a	6 a	5 ab	4 a
Broadcast (Kg Mn/ha)						
38	8 c	8 c	10 b	8 b	8 c	7 b
56	8 c	9 c	9 b	9 b	9 c	8 b
75	8 c	9 c	10 b	9 b	9 c	8 b
Seed (Mg Mn/Kg seed)						
135	6 a	5 a	6 a	6 a	4 a	3 a
675	6 a	5 a	6 a	6 a	5 ab	3 a
1350	6 a	5 a	6 a	6 a	5 ab	3 a
2025	7 ab	7 ab	7 a	7 a	6 ab	4 a
2700	7 ab	7 ab	7 a	7 a	6 ab	4 a
3375	6 a	6 ab	6 a	6 a	5 ab	4 a

[z]Mean separation, within columns, by Duncan's multiple range test at the 5% level. 1, death; 2 - 3, tip die back; 4 - 5, severe chlorosis; 6 - 7, mild chlorosis; 8 - 9, slight chlorosis - normal senescence approaching harvest; 10, no chlorosis.

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[3]Heilman, P. E. 1969. Trace element problems of vegetables in northwestern Washington. Proc. Western Washington Hort. Assoc. 59:6-8.

general stunting, deficiency symptoms, continued to increase in severity as the plants developed. In contrast, the peas planted in plots with pre-plant broadcast treatments of $MnSO_4$ continued to maintain a normal green appearance. Concentration of foliar Mn was related to symptom expression (Table 2). These

Table 2. Mean Mn content of tissues at intervals from planting[z].

	PPM Mn dry wt basis				
	Days after planting				
Treatment	37	45	50	58	71
Control	15 a	14 ab	11 bcd	10 a	10 ab
Broadcast (Kg Mn/ha)					
38	27 c	26 c	19 e	14 c	18 c
56	37 d	34 d	23 f	18 d	21 d
75	49 e	35 d	21 f	18 d	22 d
Seed (Mg Mn/Kg seed)					
135	14 a	14 ab	9 ab	11 b	11 ab
675	14 a	17 ab	8 a	15 c	11 ab
1350	14 a	17 ab	10 abcd	12 b	12 b
2025	18 ab	13 a	12 cd	13 b	12 b
2700	21 b	18 b	11 bcd	8 a	9 a
3375	15 a	14 ab	13 d	11 b	11 ab

[z]Mean separation, within columns, by Duncan's multiple range test at the 5% level.

deficiency symptoms developed when foliage Mn fell to 15 ppm. Manganese in the foliage of the control and on seed treated plots continued to fall with time to about 10 ppm at 71 days. Initially, broadcast Mn treatments effectively supplied Mn to the plants since each increase in soil applied Mn was associated with a corresponding increase of foliar Mn. The tissue Mn dropped rapidly in the broadcast treatments during the period of rapid vegetative growth which included the 45 and 50 day sampling periods. This phenomenon was probably correlated with moisture stress conditions that reduced nutrient absorption of the roots near the soil surface. The general increase in tissue Mn from 56 to 71 days probably resulted from the 0.75 inch summer rain that occurred between the 2 sampling dates.

Table 3. Effect of broadcast $MnSO_4$ treatments on plant populations and on vegetative growth[z].

		Vegetative growth		
Kg Mn/ha	Plant population (Number)	Nodes (number)	Ht (cm)	Fresh wt/plt (g)
0	91 a	16 a	52 a	19 a
38	89 a	18 b	67 b	44 b
56	94 a	18 b	67 b	48 b
75	89 a	18 b	68 b	48 b

[z]Mean separation, within columns, by Duncan's multiple range test at the 5% level.

The Mn EDTA seed treatments were ineffective in eliminating deficiency symptoms, increasing the Mn in plant tissue (Tables 1 and 2), and increasing plant growth or shelled pea yields. Other reports have found Mn EDTA soil treatments to be ineffective in correcting Mn deficiencies in vegetables growing in high organic mineral and muck soils (6, 9). This result is attributed to Fe exchanging for Mn in the EDTA molecule. The ineffectiveness of the seed treatments may also be associated with the displacement of Mn with Fe in EDTA.

All 3 broadcast Mn treatments increased vegetative growth (Table 3). There were increases in the number of plant nodes from 16 to 18 and plant ht from 52 to 67 cm. The most dramatic growth measurement was the above-ground fresh plant wt. The broadcast treatments increased the plant wt 2.5 fold from 19 gm/plant in the control to 48 gms/plant.

The shelled pea yields were also increased 2.5 fold with the $MnSO_4$ broadcast treatment of 56 Kg Mn/ha. This treatment raised yields from 3.7 to 9.4 gm/plant.

Pea yields, on a per plant basis are equal to: pods per plant X peas per pod X wt per pea (4). Separating yields into these components it was determined that the component most affected by Mn deficiency was pods per plant. Affected to a lesser degree was the number of peas per pod while ovule wt was not affected. The yield increase due to Mn broadcast treatments is the result of a 2-fold increase in filled pods per plant and 1.4 fold increase in berries per pod.

Table 4. Effect of broadcast $MnSO_4$ treatments on shelled pea yields and on the components of yield.[z]

		Components of yield			
	Yield/plt. shelled peas	Pods/plant			
Kg Mn/ha	g	filled	total	ovules/pod	g/ovule
0	3.7 a	1.4 a	1.7 a	4.4 a	0.53 a
38	8.2 b	2.7 b	3.5 b	6.1 b	0.49 a
56	9.4 b	2.9 b	3.7 b	6.2 b	0.52 a
75	9.0 b	3.0 b	3.7 b	6.0 b	0.50 a

[z]Mean separation, within columns, by Duncan's multiple range test at the 5% level.

The average tenderometer reading for peas from the Mn broadcast treatment plots was 101 compared to 107 from peas from the control treatment plots. The increase in maturity index with Mn deficiency may be associated with fewer numbers of tender peas developing on the younger nodes creating a higher ratio of mature peas or by an actual acceleration of seed maturity.

Literature Cited

1. Eaton, G. W., and M. K. John. 1971. Effect of lime and manganese upon growth and mineral composition of pea cv. Darkskin Perfection. *Agron. J.* 63:219-221.
2. Glasscock, H. H. 1941. Varietal susceptibility of peas to Marsh spot. *Ann. Appl. Biol.* 28:316-324.
3. ————, and R. L. Wain. 1940. Distribution of manganese in the pea seed in relation to Marsh spot. *J. Agr. Sci.* 30:132-140.
4. Gritton, E. T., and Pi-yeong Chi. 1972. Sampling procedures and optimum sample size for estimating yield components in peas (*Pisum sativum* L.) *J. Amer. Soc. Hort. Sci.* 97:451-453.
5. Heintze, S. C. 1938. Readily soluble manganese of soils and Marsh spot of peas. *J. Agr. Sci.* 28:175-186.
6. Knezek, B. D., and H. Greinert. 1971. Influence of soil Fe and Mn EDTA interactions upon the Fe and Mn nutrition of bean plants. *Agron. J.* 63:617-619.
7. Piper, C. S. 1941. Marsh spot of peas: a manganese deficiency disease. *J. Agr. Sci.* 31:448-453.
8. Steel, R. G. D., and J. H. Torrie. 1960. Principles and Procedures of Statistics. McGraw-Hill Book Co. Inc.
9. Wilcox, G. E., and D. J. Cantliffe. 1969. Plant response to manganese source, rate and method of application. *J. Amer. Soc. Hort. Sci.* 94:354-356.