ZINC DEFICIENCY SYMPTOMS OF BEANS[1]

J. W. Brown and G. E. Leggett[2]

Zinc deficiency is common (2) on bean plants grown on calcareous Portneuf silt loam in the Magic Valley of southern Idaho. Ten pounds of zinc per acre every third year is recommended for prevention (4). Land leveling or deep plowing brings to the surface the highly calcareous subsoil and intensifies the zinc deficiency problem. Beans grown following sugar beets or high manure or phosphate fertilizer applications are more likely to exhibit zinc deficiency symptoms (4).

Bean varieties grown in southern Idaho vary in sensitivity to zinc deficiency, and in zinc deficiency symptoms shown. Interveinal chlorosis, bronzing and shortening of the internodes are common symptoms; some varieties, however, show symptoms resembling those of iron chlorosis, and others grow almost normally. These tests were designed to determine which varieties were most sensitive to zinc deficiency and to describe the visual symptoms.

EXPERIMENTAL PROCEDURE

Ten commercial bean varieties (Phaseolus vulgaris) were grown in the greenhouse in plastic pots containing 2 kg of the 8- to 18-inch layer of Portneuf silt loam. This soil was known to be low in available zinc as indicated by previous crop response to soil-applied zinc and by soil tests (5). This soil contained 4 ppm of zinc extractable in 0.1 N HCl, and its titratable alkalinity was 84.5 meq/100 g.

Each variety was grown at 0 and 10 ppm zinc applied as powdered (200-325 mesh) zinc oxide. All treatments were replicated three times. Supplemental fertilization consisted of 100 ppm N as ammonium nitrate, 25 ppm P as monocalcium phosphate, 50 ppm K as potassium sulfate and 1 ppm Cu, 5 ppm Mn and 5 ppm Fe applied as copper sulfate, manganese sulfate and ferrous sulfate, respectively. All fertilizer materials were reagent grade and were mixed with the dry soil.

Six bean seeds were planted in each pot. Soon after emergence the cotyledons were removed from the plants and 12 days after planting the seedlings were thinned to 3 per pot. The plants were irrigated by adding redistilled water daily to bring the pots to a predetermined weight (25 percent water). Soil temperatures were controlled by placing the pots in a water bath controlled at 20° C.

The plant tops were harvested 45 days after planting (late bloom). They were washed, dried and weighed. The zinc content was determined by atomic absorption after digesting the ground plant material with a mixture of nitric and perchloric acids.

---

[1]Proceedings, Eighteenth Annual Fertilizer Conference of the Pacific Northwest, Twin Falls, Idaho. July 11-13, 1967.

[2]Research Chemist and Research Soil Scientist, respectively, Snake River Conservation Research Center, Kimberly, Idaho.

In a second experiment, 20 varieties, including 9 of those of the first experiment, were grown under the same treatments and conditions as the first experiment. All varieities were Phaseolus vulgaris except Henderson bush lima (Phaseolus lunatus) and Adzuki (Phaseolus angularis). The varieties used are listed in Table 1 along with some of their distinguishing characteristics and the zinc content of the seeds. The seed weight and zinc content of the seeds should not be construed as being typical for these varieties since seed from a single lot was used. These data, therefore, may reflect only the conditions under which the seed was grown. Dry weight and zinc content of the foliage were not determined in the second experiment because some of the leaves were removed for photographic purposes.

RESULTS AND DISCUSSION

About two weeks after planting, the plants not fertilized with zinc showed a wide range of zinc deficiency symptoms. The varieties exhibited different severity and type of symptoms and the symptoms became more intense with time. No deficiency symptoms were exhibited by plants fertilized with zinc. The yield, zinc concentration, and zinc uptake for the 10 varieties grown in the first experiment are given in Table 2. The 10 varieties have been separated into three groups according to their sensitivities to zinc deficiency (Table 3). The criteria used for rating each variety were severity of symptoms, and the growth and zinc uptake of the zinc-deficient plants as compared with those of their zinc-fertilized counterparts. The groupings should be considered only tentative since some varieties did not fall into a single group on the basis of all criteria used. Additional evidence may shift the order of tolerance and, furthermore, other selections of the varieties may behave differently.

In comparing the zinc uptake of the plants not fertilized with zinc (Table 2) with the zinc content of the seeds planted (Table 1), it is evident that the seeds contained more zinc than was present in the foliage at harvest. Removing the cotyledons soon after emergence and thinning the plants soon afterward was an attempt to minimize this variable zinc source. The amount of zinc translocated prior to removing the cotyledons and that contained in seeds that did not germinate is unknown and may have influenced the results of the experiment. The zinc uptake by the zinc-deficient plants was generally higher for the varieties whose seeds contained more zinc, but this, in part, may reflect the varieties' capability for absorbing zinc.

Where no zinc was added, the varieties Topcrop, Yellow Eye, Red Kidney and Pinto appeared almost normal throughout the experiment. When compared with their zinc-fertilized counterparts, however, they were definitely smaller and a lighter green. Zinc-deficient plants averaged 44 percent as much dry matter as the zinc-fertilized plants for those varieties. Thus, the deficiency was more severe than was evident by viewing the symptoms.

Golden Gem, Red Mexican and Idelight all exhibited moderate chlorosis, mottling, and deformation at about bloom stage when no zinc was applied. The deformation consisted of shortened internodes, curling, cupping and/or narrowing of the trifoliate leaves and bending or twisting at the stem-petiole joint. Zinc-deficient plants in this group yielded only 33 to 37 percent of that for the zinc-fertilized plants on a dry-weight basis.

Table 1. Some characteristics of bean varieties used in two greenhouse experiments.

Variety	Seed color	Seed weight	Zinc in seeds	
		g/seed	ppm	μg/6 seed
<u>Snap Beans</u>				
Topcrop	mottled brown	0.374	12.6	28.3
Bountiful	light brown	0.398	8.6	20.5
Tendergreen	black mottled	0.363	11.6	25.3
Kinghorn	white	0.309	13.3	24.7
Black Wax	black	0.388	11.3	26.3
Wade	purple	0.373	11.6	26.0
Golden Gem	white	0.257	20.9	32.2
Idelight	brown	0.206	20.2	25.0
Tendercrop	white	0.270	13.7	22.2
Harvester	white	0.380	20.0	45.6
Tenderpod	white-brown eye	0.305	12.0	22.0
Tenderwhite	white	0.308	15.5	28.6
<u>Dry Beans</u>				
Yellow Eye*	white-yellow eye	0.392	12.7	29.9
Red Kidney	red	0.501	11.6	34.9
Pinto*	mottled pink	0.315	12.3	23.2
Adzuki	brown	0.136	9.3	7.6
Red Mexican*	red	0.284	9.0	15.3
Great Northern*	white	0.375	9.1	20.5
Seaway	white	0.209	11.0	13.8
Sanilac	white	0.172	9.6	9.9
<u>Lima Beans</u>				
Henderson	green	0.359	20.6	44.3

*Vine type; all others bush type.

Table 2. The effect of added zinc on dry weight, zinc concentration in the foliage and the uptake of zinc by 10 bean varieties grown in the greenhouse.

Variety	Dry weight		Zinc concentration		Zinc Uptake	
	No Zn	Zn	No Zn	Zn	No Zn	Zn
	g/pot		ppm		μg/pot	
Topcrop	3.94	9.58	7.7	12.2	30	117
Yellow Eye	3.98	7.65	6.5	15.2	26	116
Red Kidney	3.18	7.14	7.0	13.9	21	98
Pinto	2.37	6.41	6.2	19.4	15	126
Golden Gem	2.67	8.15	6.2	14.7	16	120
Idelight	2.16	6.51	6.4	16.8	14	108
Red Mexican	1.52	4.09	7.0	23.9	11	95
Great Northern	1.66	5.26	7.0	23.6	12	124
Seaway	1.34	7.00	6.0	21.5	8	150
Sanilac	0.98	4.93	8.4	23.5	8	116
Treatment <u>vs</u> control	**		**		**	

**All differences highly significant (.01)

Table 3. Fresh weight, dry weight, zinc concentration and zinc uptake for zinc deficient plants for 10 bean varieties grown in the greenhouse as percentage of these factors for plants supplied adequate zinc.

Variety	Severity of symptoms*	Percentage†			
		Fresh wt.	Dry wt.	Zn concentration	Zn uptake
Topcrop	1	63	41	63	26
Yellow Eye	1	68	52	43	23
Red Kidney	1	70	45	50	22
Pinto	1	60	37	32	12
Golden Gem	2	47	33	42	13
Idelight	2	41	33	38	13
Red Mexican	2	44	37	29	12
Great Northern	3	44	32	30	10
Seaway	3	25	19	28	5
Sanilac	3	21	20	36	7

* 1 = slight, 2 = moderate, 3 = severe

† computed as follows: Percentage $= \frac{\text{without Zn}}{\text{with Zn}} \times 100$

Table 4. Ratings for zinc deficiency symptoms as shown by 21 bean varieties grown in the greenhouse.

Variety	*Rating of symptoms for:			
	Chlorosis	Mottling	Deformation	Necrosis
Topcrop	1	0	1	0
Idelight	1	0	1	0
Red Kidney	1	0	1	0
Pinto	1	0	1	0
Yellow Eye	1	1	1	0
Harvester	1	1	1	1
Tenderpod	1	1	1	1
Henderson bush lima	1	1	2	1
Bountiful	1	1	2	1
Kinghorn	1	1	2	1
Wade	1	2	1	1
Golden Gem	2	0	3	0
Red Mexican	2	1	1	1
Black Wax	1	1	3	1
Tendergreen	1	1	3	1
Tendercrop	2	1	3	1
Adzuki	2	2	2	2
Great Northern	3	2	2	2
Seaway	2	2	2	3
Tenderwhite	3	3	3	1
Sanilac	3	3	3	3

* 1 = slight, 2 = moderate, 3 = severe

Great Northern, Seaway and Sanilac were the most sensitive of the 10 varieties used. They developed severe symptoms, and in some cases, the second trifoliates failed to enlarge. The symptoms were characterized by chlorosis, mottling, deformation and necrosis of the leaves. Great Northern made much better relative growth than did Seaway and Sanilac, but because of the severe symptoms shown by this variety, it was placed in the most sensitive group. Dry weight of the zinc-deficient plants in this group ranged from 19 to 32 percent of that for the zinc-fertilized plants.

In the second experiment, 20 varieties, including 9 of those used in the first experiment, were evaluated on the basis of severity and kinds of symptoms shown by zinc-deficient plants. The 9 varieties used in the first experiment generally performed about the same in the second. Idelight was the only exception. In Table 4, all 21 varieties are separated into the three groups delineated in the first experiment. Again the groupings are tentative and additional data may alter the order of sensitivity of some varieties.

The data in Table 4 indicate the diversity of zinc-deficiency symptoms exhibited by the different varieties. Some of the varieties grew almost normally, whereas others showed severe symptoms. In some varieties (Golden Gem, Black Wax, and Tendergreen) deformation was the most distinguishing characteristic; in others, a general chlorosis resembling iron chlorosis was most evident, whereas still others showed a combination of several symptoms. The variety Yellow Eye was unique among the 21 varieties tested in that zinc deficiency symptoms appeared as an interveinal chlorosis of the primary as well as the trifoliate leaves.

The results presented here indicate that bean varieties differ in sensitivity to zinc deficiency and the characteristics of the symptoms. The causes of these differences are not known at present. The differences may be related to the capabilities for absorption, translocation and utilization of zinc by the different varieties. Other factors which may have affected performance in these tests are the zinc content of the seeds and varietal susceptibility to root diseases or a combination of these factors. Additional work is needed to determine the specific factors responsible.

LITERATURE CITED

1. Boawn, L. C. 1966. Zinc fertilizers - the effect of zinc concentration, particle size, and chemical properties. Proceedings Seventeenth Annual Pacific Northwest Fertilizer Conference. p. 173-183.

2. DeRemer, E. D. and R. L. Smith. 1964. A preliminary study on the nature of a zinc deficiency in field beans as determined by radioactive zinc. Agr. Jour. 56:67-70.

3. Judy, W., J. Melton, G. Lessman, B. Ellis, and J. Davis. 1964. Field and laboratory studies with zinc fertilization of pea beans, corn and sugar beets in 1964. Research Report 33, Mich. State Univ. Agric. Exp. Sta., East Lansing.

4. LeBaron, Marshall. 1966. Zinc in Idaho bean production. Idaho Current Information Series No. 31.

5. Nelson, J. L., L. C. Boawn and F. G. Viets, Jr. 1959. A method for assessing zinc status of soils using acid extractable zinc and "Titratable Alkalinity" values. Soil Sci. 88:275-283.