Zinc Fertilizer Tests on Sugar Beets in Washington[1]

LOUIS C. BOAWN AND FRANK G. VIETS, JR.[2]

Introduction

The recognition by Viets (1)[3] in 1949 that zinc deficiency of both beans and corn was widespread on the irrigated lands of the Yakima Valley and Columbia Basin pointed to the possibility that other field crops would respond to zinc fertilization. Sugar beets are among the other crops on which enough experimental evidence has been obtained to justify some fairly definite conclusions as to their possible benefit from additional zinc. This paper will present the results of a number of observations and experiments made during the past three or four years to determine the response of beets to zinc fertilizers.

Experimental Results

Experiment at Prosser.

In 1952, sugar beets were included in an experiment in which 26 field crops were grown with and without zinc fertilization (2). This experiment was conducted on the Roza Unit of the Irrigation Experiment Station at Prosser at two locations: on an area which had grown zinc-deficient corn the previous year and an adjacent area where growth of corn had been normal. The soil was predominately a Burke very fine sandy loam. In this experiment, the zinc was sideplaced in the same band with nitrogen at the time of planting. Zinc was applied as $ZnSO_4$ at a rate of 23.2 pounds of zinc per acre and nitrogen at 100 pounds per acre as NH_4NO_3. The plot in this experiment was two 23-foot rows of beets, 30 inches apart. One row in each plot was sidedressed with zinc, the other was not. There were four replications for each area.

Although several crops showed deficiency symptoms and responded to both soil-applied zinc and to zinc sprays, sugar beets did not show any indication of poor growth on either the "deficient" or "normal" areas. There was no indication of a response where the beets were sidedressed or sprayed with zinc.

The analysis of leaf blades (Table 1) taken June 24 shows essentially no increase in zinc uptake from the applied zinc. Because of plant-competition variables imposed by different crops bordering treated and untreated rows, no attempt was made to determine the effect of zinc on root yield, but there was no indication that it was affected.

Alkali Soil Reclamation Experiment at Toppenish.

Zinc-fertilizer plots were included in an alkali soil-reclamation project carried out on the Hadley farm near Toppenish, Washington, in 1953. The soil is Umapine fine sandy loam. In an experiment which included plowing to a depth of three feet and gypsum treatments, one-half of each plot

---

[1] Contribution from the Soil and Water Conservation Research Branch, Agricultural Research Service, U. S. Department of Agriculture in cooperation with the Irrigation Experiment Station, State College of Washington, Prosser, Scientific Paper No. 1457, Washington Agricultural Experiment Stations, Pullman.

[2] Soil Scientist, U. S. Department of Agriculture Prosser, Washington and Technical Staff Specialist, U. S. Department of Agriculture, Fort Collins, Colorado.

[3] Numbers in parentheses refer to literature cited.

Table 1.—Zinc Content of Beet Leaves from Beets Grown at Prosser, Washington with and without Zinc Fertilization.

Treatment	Zinc content, p.p.m.	
	"Deficient Area"	"Normal Area"
No Zn	21.5	19.2
Zn applied[1]	21.5	22.8

[1] Zinc was sidedressed at time of planting at a rate of 23.2 pounds zinc per acre in the same band with N at a rate of 100 pounds per acre.

was given an application of $ZnSO_4$ broadcast at a rate of 16 pounds of zinc per acre. The application was made prior to seedbed preparation in the spring.

On August 21, a very definite growth response to the zinc fertilizer could be observed. Where no zinc was applied, the plants were smaller. Leaf blades were reduced in size and yellowish with leaf margins and tips particularly yellow. These symptoms were not present where zinc was applied.

Data based on 20 mature leaf blades sampled at random on August 21 (Table 2) show that zinc fertilizer increased both the weight and zinc concentration of leaves. The analysis of root yields from these plots (Table 2) shows that zinc increased yields about five tons per acre[4].

Zinc Tests by the Utah-Idaho Sugar Company.

In 1954, fertilizer trials were conducted by the Utah-Idaho Sugar Company at eight locations in the Yakima Valley and Columbia Basin which included zinc treatments replicated three times at each location. The zinc

Table 2.—Zinc Concentration in Leaves and Yields of Sugar Beets Grown at the Hadley Farm, Toppenish, Washington.

Treatment[1]	Yield	Dry weight of 20 leaves gms.	Zn in leaves p.p.m.
	tons/acre		
Check	20.4	38.99	7.6
Check + Zn	25.7	47.60	13.0
Gypsum	20.3	32.90	9.6
Gypsum + Zn	23.7	46.15	12.7
Plowed	15.7	—	—
Plowed + Zn	23.9	—	—
Plowed + Gysum	20.3	—	—
Plowed + Gypsum + Zn	22.6	—	—
L.S.D. (.05)	4.0	11.9	3.0

[1] Zinc was broadcast and disked in. The rate was 16 pounds Zn/acre as $ZnSO_4$.

[4] The yield data were obtained from Dr. C. D. Moodie, Associate Professor of Soils at the State College of Washington, Pullman.

[5] Stripping acid residue is a smelter by-product. It is marketed locally under the trade name Zn-M N-S by the Balfour, Guthrie & Co., Ltd., Seattle, Washington.

was applied broadcast at time of seedbed preparation as stripping acid residue[1] at a rate of five pounds of zinc per acre.

On August 8, leaf-blade samples consisting of 20 leaves were taken from check plots and zinc-treated plots at three locations in the vicinity of Toppenish, Washington.

The analysis of these samples, along with the yield of beets, is given in Table 3. Although significant increases in the concentration of zinc in the leaves occurred, zinc application apparently did not influence beet yields.

Table 3.—The Effect of Zinc Fertilizer on the Yield and Leaf Zinc Content of Beets Grown at Three Locations in the Yakima Valley.

Location	Soil Series	Treatment	Yield[1]	Zn in leaves
			tons/acre	p.p.m.
Andreas Ranch	Wenas	No Zn	23.3	25.7
		Zn Applied	23.6	36.2
Brown Ranch	Ahtanum	No Zn	31.7	24.6
		Zn Applied	32.7	29.5
Moore Ranch	Toppenish	No Zn	28.9	14.9
		Zn Applied	30.9	17.6
Location Means:		Andreas	23.4	30.9
		Brown	32.2	27.0
		Moore	29.9	16.2
Zn Treatment Means:		No Zn	28.0	21.7
		Zn Applied	29.1	27.8
L.S.D. (.05)			5.1	6.9

[1] Credit is due Mr. Don Kidman of the Utah-Idaho Sugar Company for furnishing the yield data and permitting samples to be taken for zinc analysis.

Nitrogen Carrier Experiment at Prosser.

A long-time experiment at Prosser, Washington, on Ritzville fine sandy loam has been designed to study the effects of three nitrogen carriers on plant utilization of both native and applied zinc. Sugar beets were included in this experiment in 1955. The treatments in this experiment have been five levels of zinc—0, 2, 4, 8, and 16 pounds per acre, in factorial combination with three nitrogen carriers, each at three rates. The zinc treatments were made only once, at the start of the experiment in 1953, and were broadcast. The nitrogen treatments are applied annually.

Data are given in Table 4 from certain treatments selected to show the effect of different levels of zinc on beet yields and zinc content of leaf blades. Leaf samples were taken for analysis on August 20, the sample consisting of 20, young, fully-developed leaves without petioles. The results show that, although the high levels of zinc application raised the leaf zinc to 36.2 p.p.m., as compared with 21.7 p.p.m. where no zinc was applied, it did not affect the yield of beets.

Table 4.—Effect of Zinc on Yield and Leaf Zinc Content of Sugar Beets Grown at Prosser, Washington, 1955.

Treatment[1]		Yield	Zn in leaves
N Carrier	Zn rate		
	Pounds Zn/acre	tons/acre	p.p.m.
NH_4NO_3	0	30.61	20.2
	2	28.34	29.5
	4	30.41	26.1
	8	29.89	28.1
	16	29.64	34.8
$Ca(NO_3)_2$	0	31.55	23.2
	2	27.36	27.7
	4	29.59	27.5
	8	32.33	27.6
	16	30.00	37.6
L.S.D. (.05)		N.S.	7.9

[1] The Zn treatments were made in 1953 as a broadcast application of $ZnSO_4 \cdot 7H_2O$. In 1953 the plots were cropped to grain sorghum, in 1954 to potatoes. For both N carriers the rate was 160 pounds N applied every year.

Some Miscellaneous Observations.

Various trials which have been made since 1950 indicate that, even in situations where growth of beets is poor, zinc is not the limiting factor. Several attempts to improve the beet growth on "cuts" by spraying the plants with a $ZnSO_4$ solution have been unsuccessful. In 1951, on a Roza farm north of Prosser, poor growth of sugar beets was observed adjacent to a field of Red Mexican beans showing typical zinc-deficiency symptoms. Zinc sulfate sprays were applied to replicated plots of both the beans and the sugar beets. The beans showed an excellent vegetative response, whereas the growth of beets was not affected. No yields were taken.

In 1954, stunted beets, growing on a cut area of Warden-Wheeler soil near Wheeler, Washington, in the Columbia Basin, were sidedressed with $ZnSO_4$ and NH_4NO_3 as a diagnostic procedure. The material was applied about three inches deep and about three inches from the center of the beet row shortly after thinning. A continued poor growth of these beets and low yield indicated that other factors were the primary cause of the stunting.

In 1955, two "lime-knobs" just north of Prosser, Washington, on Sagemoor soil, where poor growth of crops had been observed for several years, likewise showed no visible improvement in the growth of sugar beets when a strip across each knoll was given a heavy application of zinc (20 pounds per acre) prior to planting.

Discussion

The experimental evidence obtained to date would seem to justify several fairly definite conclusions with respect to the use of zinc fertilizers on sugar beets in the state of Washington. First, it has been shown that, for the most part, soils of the Yakima Valley and Columbia Basin can be expected to supply sufficient zinc for high yields of beets. The one exception, perhaps, is where beets are grown on high pH soils such as the saline-alkali

area in the vicinity of Toppenish. On the Hadley farm, where the results of Table 2 were obtained, the surface soil pH is likely to be 9.5 or higher.

The second conclusion which these data support is that the zinc concentration of young, fully-developed leaf blades taken in mid-August must be below approximately 10 p.p.m. before the beet plant will show zinc deficiency symptoms or respond to zinc fertilization. Most of the leaf samples analyzed show a zinc content well above this figure. An interesting sidelight is that at the Moore Ranch (Table 3), where beet leaves from check plots had a zinc concentration of 14.9 p.p.m., corn grown in 1955 showed a spectacular vegetative response to the zinc applied the previous year.

Finally, there is evidence that sidedressing is not a satisfactory means of application for getting zinc uptake by sugar beets. Zinc applied in this manner, because of its immobility in the soil, is probably above the main rooting area of the sugar beet most of the growing season. Plowing down the zinc seems to offer the best assurance that zinc fertilizers will be contacted by the root system.

References

(1) VIETS, F. G. JR. 1951. Zinc deficiency of corn and beans on newly irrigated soils in central Washington. Agron. Jour. 43:150-151.

(2) VIETS, F. G. JR., BOAWN, L. C., and CRAWFORD, C. L. 1954. Zinc content and deficiency symptoms of 26 crops grown on a zinc-deficient soil. Soil Sci. 78:305-316.