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BORON DEFICIENCIES FOR ALFALFA IN OHIO

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Several times during the past 25 years boron fertilization of alfalfa and other crops, that are sensitive to low boron availability in soils, has been tried in Ohio without any positive indication of boron deficiencies. These trials, however, were not extensive and they did not offer substantial evidence that boron deficiencies in the State did not exist. The present study was initiated to gain additional information concerning possible boron deficiencies for alfalfa in Ohio. The work was supported by a grant from the Pacific Coast Borax Company.

FIELD PLOT WORK IN 1951

A preliminary survey during the summer of 1950 of apparent foliar symptoms of boron deficiency in alfalfa along with the amounts of water soluble boron in soils indicated that certain counties would be more likely to have boron deficiencies than other counties. From such information sites were selected for field plots in six counties.

During the spring of 1951 soil samples were taken for from ten to sixteen sites in each of the six counties. Field plots were set out on from two to six sites in each county. The sites selected for field plots were those where the water soluble boron of the soil was equal to or less than 1.00 ppm. The field plot design was one in which three treated plots alternated with three check plots. The treatment consisted of 30 lb. borax per acre. The plot size was 18 by 100 feet. The borax was put on during March of 1951 with a Gandy spreader to insure uniform application to each treated plot.

Harvests of alfalfa were made where possible on the second and third cuttings of alfalfa. On each plot three areas of 1/5000 of an acre were harvested and the dry weight of each area determined. The weights were converted to an acre basis.

The results are given in Table 1. There were no differences that were significant. The average increase in yield was 65 lb./acre for the second cutting and 77 lb./acre for the third cutting.

There was no significant relationship between the amount of water soluble boron in the soils and the small decreases or increases in yields that were measured. Visual appearances of the plots showed no evidence of the elimination of discolorations of the foliage when discolorations were found in the plot areas. This lack of reduction in foliar discoloration by boron treatment indicated that the discolorations were caused by factors other than boron deficiencies. The most likely cause was leaf hopper injury.

In this work no attempt was made to eliminate deficiencies of other elements. The pH values of the soils at all sites were favorable for the growth of alfalfa but no knowledge was gained concerning the potash and phosphorus availability in these soils.

TABLE 1.—Water soluble boron in the soil and increase in dry weight yields of alfalfa from 30 lb. borax per acre at 26 locations in six counties in Ohio

County	Site	Water soluble boron ppm	Increase in yield, lb/acre	
			Second cutting	Third cutting
Fairfield	1	0.75	+185	+ 75
	2	0.50	— 30	
	3	0.40	— 25	+120
	4	1.00	+185	+440
	5	0.50	+220	+ 75
Fulton	6	1.00	+ 65	
	7	0.75	+200	
	8	0.40	— 25	
	9	0.50	+170	
	10	0.30	+175	+ 15
Harrison	11	0.40	—180	
	12	0.40	+175	
Ross	13	0.50		—220
	14	0.40		+235
	15	0.40		— 50
Stark	16	0.50	+ 55	
	17	0.40	+ 65	
	18	0.50	+ 20	+ 45
	19	0.40	+ 30	
	20	1.00	+145	
	21	0.40	+115	
Warren	22	0.50	+ 75	
	23	0.75	+ 80	+300
	24	0.50	+ 55	— 40
	25	0.40	— 40	
	26	0.40	—175	

FIELD PLOT WORK IN 1953

The plot work in 1951 was of such a nature that a simple design was needed. In 1953 a more elaborate plot design was used. Also, potash and phosphate were added to eliminate possible deficiencies of these two fertilizer elements.

During the spring of 1953 eight field trials were set out on farmers fields. The treatments are listed in the first column in Table 2. The fertilizers were spread on the surface using a small Gandy spreader. The plots were 9 by 15 ft. Three replications were used. The plots were set out in March. Only the first cutting was used to evaluate the effects of the treatments on yields of forage. At other harvest dates notes were taken on the appearance of the forage in the plots. The fields were all second or third year alfalfa meadows.

There were three fields that showed yield differences that were related to the treatments. The dry weight yields for these three fields are given in Table 2. On the Hiltbrand farm at Seven Mile in Butler County there was a significant increase from the phosphate treatment. The borax treatment decreased the yields as compared to the plots that received potash and phosphate. The mixture of pasture species in this field was alfalfa, ladino clover and timothy. On the Davidson farm in Shelby County both potash and phosphate increased the yields of forage and as was true on the Hiltbrand farm the borax treatments decreased the yields. On the Davidson farm the forage was an alfalfa-timothy mixture. On the Hicks farm in Wood County there were no yield effects from potash or borax but the phosphate treatment increased the yields. The forage was a nearly pure stand of alfalfa.

TABLE 2.—Yields of dry weight of the first cutting of forage for three fertility trials in 1953. The values are in tons per acre

Treatment*	Hiltbrand Farm	Davidson Farm	Hicks Farm
Check	1.32	2.63	2.10
Potash	1.49	3.08	2.18
Phosphate	2.10	2.94	2.70
Potash and phosphate	2.26	3.22	2.62
Potash, phosphate and $borax_1$	2.02	3.08	2.67
Potash, phosphate and $borax_2$	1.61	2.97	2.64
L.S.D. (.05)	0.19	0.17	0.15

*Potash was added at the rate of 120 lb. K_2O per acre, phosphate at the rate of 120 lb. P_2O_5 per acre. The borax treatments were 20 and 60 lb. borax per acre for $borax_1$ and $borax_2$ respectively.

The other fields used were dominantly alfalfa stands, except on the farm of George Jackson in Morrow County where there was a mixture of alfalfa and brome grass. The other fields that showed no response to treatment were located in Marion, Sandusky, and Fulton Counties.

Both fields that showed decreases in yield from the borax treatments contained timothy as at least half the forage yield. The decreases in yields were probably from the effects of borax on the timothy rather than on the alfalfa or ladino clover.

At the dates of harvest of the second and third cutting notes of the appearance and height of the forage indicated that there were no leaf symptoms or height differences that were associated with borax treatments for any of the locations. At several locations at the time of the second cutting there was severe leaf yellowing. However, the borax treatments had no effect on decreasing the severity of the leaf conditions.

During the spring of 1951 a field trial was set out at the Wooster station. The objectives were to measure response of alfalfa to applications of potash and borax and to measure the interaction between potash and borax application. Potash and borax were applied at time of planting in 1951 and again in the spring of 1954.

Three years' yield measurements indicate a general trend of increased yields from potash applications. There was no evidence of a potash-borax interaction and there was no indication of a yield increase from the application of borax. In fact, the average yields for most cuttings were lower where the borax was applied, although the differences were not consistent and not statistically significant.

GREENHOUSE EXPERIMENT

This work was initiated to test the capacity of five soils to continuously supply boron to alfalfa under continuous cropping. Samples of soil were collected from which they were taken.

The soils were air-dried, screened, and then potted. Polyethylene bags, equipped with drainage holes were used to protect the soil from the containers which were 2-gallon glazed clay pots. The drainage from the soil in the polyethylene bag was through a glass tube inserted through the hole in the side of the bottom of the pot in such a manner that there was no connection between the soil and the pot. This separation of the soil from the pot was considered necessary so that boron from the pot could not contaminate the soil in the polyethylene bag.

Alfalfa was planted in the soils after treatment with lime and phosphate and a small quantity of potash. The treatments consisted of three levels of borax, 0, 20, and 40 lbs. per acre and potash at 0, 7.5, and 15.0 lb. K per acre for the first four cuttings and 0, 75, and 150 lb. K per

TABLE 3.—Dry weight of a total of seven cuttings of alfalfa as related to borax application at three levels of potash in five soils. The data represent the average of three applications

Soil from	Borax lb. per acre	Dry weight, grams per pot, at indicated potash level		
		1*	2*	3*
Ross County	0	53 9	66.5	74.9
	20	50.4	68.6	74.2
	40	53.2	67.9	75.6
Warren County	0	50.4	67.2	73.5
	20	51.8	58 8	67.2
	40	51.8	60.2	64.4
Fulton County	0	26.6	39.2	43.4
	20	23.8	42.7	44.8
	40	28.7	42.0	46.2
Stark County	0	70.0	82.6	88.2
	20	77.7	80.5	83.3
	40	68.6	81.2	81.2
Wayne County	0	69.3	84.0	85.4
	20	67.9	81.9	92.4
	40	72.1	78.4	85.4

L.S.D. (Treatment means) (.05)

Ross = 9.6 Warren = 6.8

Fulton = 4.9 Stark = 10.0 Wooster = 8.1

*The first, second, and third potash treatments were 0, 7.5, and 15 lb. K per acre respectively on the first cutting and 0, 75, and 150 lb. K per acre, respectively on the fifth cutting.

acre for the last three cuttings and all possible combination of borax and potash. A total of 7 cuttings were made of three replications for all treatments on all soils.

The results are given in Table 3. There were no increases in dry weight as a result of borax applications indicating that the supply of available boron in these soils was sufficient to supply the needs of the alfalfa. There were, however, consistent increases in yield from the application of potash. There was no evidence of a borax-potash interaction.

SURVEY OF BORON CONTENT OF ALFALFA

During the summer of 1952 alfalfa samples were collected from 61 locations. The samples were dried, ground and analyzed for boron content. The samples were collected during the months of July and August which is the time of year when foliar symptoms, often called boron deficiency symptoms, appear on alfalfa. The alfalfa at nine of the locations showed yellowing of the leaves with shortening of the internodes that is typical of true boron deficient alfalfa. At all other locations the alfalfa appeared normal.

Two plant samples were collected at each of the 61 locations. One sample consisted of the upper 1/3 of the plants and the other consisted of the whole above ground portion of the plant. The upper 1/3 of the plants was kept separate because it is more sensitive to low boron availability in soils than is the whole plant (2).

Boron analysis were conducted by the procedure of Dible, Berger, and Truog (3). In this procedure the plant material is ashed in a muffle furnace. The ash is then dissolved in dilute acid and a colorimetric analysis for boron is made using curcumin.

On the basis of the information in the review by Berger (1) plant samples having less than 15 ppm boron were considered to be deficient in boron or at least there was a high possibility of boron deficiency, plant samples having 15 to 30 ppm boron were considered to have a possibility of being deficient in boron, and samples having above 30 ppm were considered to be always well supplied with boron. The distribution of the alfalfa samples into the categories of boron content as given above is presented in Table 4.

There was no consistent relationship between foliar discoloration or apparent boron deficiency symptoms and the boron content of the alfalfa. Evidently many of the foliar symptoms that are referred to as boron deficiencies result from other causes.

According to Dible and Berger (2) the upper parts of the plant will have significantly lower boron content than the whole plant when the plant is boron deficient. Paired comparisons of the boron content of

TABLE 4.—Distribution of the alfalfa samples from 61 locations into categories of low, medium, high and very high boron content

Description of samples	Number of samples in the indicated range of boron content		
	0 to 15 ppm	15 to 30 ppm	greater than 30 ppm
Foliar discolorations			
Upper 1/3 of plants	2	4	3
Whole plants	0	6	3
No foliar discolorations			
Upper 1/3 of plants	2	23	27
Whole plants	2	23	27

the upper 1/3 of the plants with the boron content of the whole plant at each of the locations that showed foliar symptoms indicated three samples where this difference was found. These comparisons were 23, 18, and 28 ppm boron in the whole plant and 16, 14, and 11 ppm boron respectively in the upper 1/3 of the plants. These differences are the only positive evidence found that indicate boron deficiencies for alfalfa in Ohio. They also indicate that, since these three samples had the same foliar symptoms as six other locations where the boron content did not indicate boron deficiencies, boron deficiencies cannot be accurately diagnosed from foliar appearances.

SUMMARY AND CONCLUSIONS

The results of two years field trials with borax treatment of alfalfa are reported. The capacity of five soils to supply adequate quantities of boron to produce high yields of alfalfa was measured by continuous cropping in the greenhouse. Alfalfa samples from 61 locations in Ohio were analyzed for boron content. The results indicate that the following conclusions are justified:

1. No general recommendation can be made for borax application to alfalfa in Ohio.
2. If there are alfalfa fields where boron is deficient these fields do not occur frequently. Foliar symptoms, such as discolorations and shortening of internodes at the top of the stems, can not be taken as an indication of need for boron. These symptoms may result from other causes.
3. Boron treatments of meadows containing grass species may result in decreased yields of forage. If the stand is one of pure legumes the application of borax is less likely to cause a decrease in yield even though the boron content of the soil is adequate for maximum yields of alfalfa.
4. The water soluble boron in soils does not appear to be a good index to need for boron fertilizer for alfalfa.

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