RESPONSE OF CORN TO BORON FERTILIZATION OF SIX NORTHERN VIRGINIA SOILS

RESEARCH DIVISION
VIRGINIA POLYTECHNIC INSTITUTE

MARCH 1967

RESEARCH REPORT 120

DEPARTMENT OF AGRONOMY

RESPONSE OF CORN TO BORON FERTILIZATION OF SIX NORTHERN VIRGINIA SOILS

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SUMMARY

Boron fertilization increased corn grain yield on Chester loam at 1 location in 1964; however, boron fertilization did not increase corn yield on 5 soils in 1965. Increasing the rate of boron fertilization from 1 lb. to 2 lbs. boron per acre increased the boron content of tissue but did not increase yield of corn grown on the 6 soils. Boron applied in the row was generally a more efficient method of supplying boron to plants than broadcast application. Little relationship was shown to exist between the water soluble boron content and the boron supplying power of the 6 soils studied.

INTRODUCTION

Maze (7) in 1915 studied the nutritional requirements of corn plants (*Zea mays*, L.) and found that lack of boron caused poor kernel development. Detailed descriptions of boron deficiency symptoms of corn plants have since appeared in the literature. Schropp and Arenz (10) reported that a lack of boron resulted in derangements in emergence of tassels, distortion of spikelets, and absence of anthers; white stripes parallel to midribs were present on corn leaves and corn ears produced no grain. Similarly, Berger *et al*. (3) reported that lack of boron resulted in blank stalks and barren ears, and that leaves of boron deficient plants exhibited a white stripe due to coalescence of small white chlorotic spots.

Investigations by Berger *et al*. (3) first indicated that some soils supply inadequate amounts of boron to corn plants. The investigations were carried out on 54 Wisconsin soils which were low in organic matter. Boron fertilization increased yields on 6 of these soils. The yield increase was attributed to a decrease in the number of blank ears and to better kernel fill and ear development.

Boron deficiency frequently occurs during droughty periods (1, 2). The decrease in boron availability during dry years has been attributed to the inability of roots to feed in topsoil, which

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contains the major portion of available soil boron (1). It has also been suggested that drying of soil decreases microbial release of boron from soil organic matter (2) and increases fixation of boron by certain clay minerals of soil (8).

It seems probable that the occurrence of boron deficiency will increase as soils are in crop production for longer periods. It is also reasonable to assume that boron deficiency of corn plants will become more prevalent due to the increased use of high analysis fertilizers, which contain less boron as a contaminate, and due to the greater removal of soil boron along with higher crop yields. The fact that boron deficiency of corn is now occurring on some soils and the evidence that the deficiency will become more widespread emphasizes a need for periodic investigation of the boron supplying power of soils.

The present investigation was carried out on 6 Northern Virginia soils to determine relationships among corn yield, boron content of corn tissue and placement of boron fertilizer. During the course of the investigation, experiments were also run to determine if content of water soluble boron gives a reliable indication of the boron supplying power of soil.

EXPERIMENTAL PROCEDURE

Soil Studied

A field experiment was carried out in 1964 on Chester loam at the Northern Virginia Forage Research Station, Middleburg. In 1965, field investigations were conducted on Belvoir loam, Dyke loam, Brandywine loam, and 2 Chester loams located on farms in the vicinity of the research station. Selected chemical and physical properties of the soils studied are shown in Table 1. The

Table 1. Selected Chemical and Physical Properties of the Soils.

Location	Soil Type	Water Soluble Boron	pH	Organic Matter	Clay
		ppm		%	%
1	Chester loam	0.54	6.1	1.2	37
2	Chester loam	0.57	5.5	1.4	37
3	Belvoir loam	0.29	5.7	1.3	29
4	Dyke loam	0.58	6.1	2.4	29
5	Brandywine loam	0.42	5.6	1.8	27
6	Chester loam	0.37	5.5	0.8	27

investigations were carried out at Location 1 in 1964 and at Locations 2 through 6 in 1965. Soil pH was run on a Beckman Model G pH meter using a 1:1 soil to water ratio and a half-hour period of equilibration. Water soluble boron, obtained by refluxing 10 gm of soil with 20 ml of deionized water for 5 minutes was determined colorimetrically by a Curcumin method (6). Organic matter was determined by a wet oxidation procedure (11) and clay by a hydrometer method (4).

Field and Laboratory Procedures

Each of the field experiments consisted of 5 treatments replicated 4 times on plots 4 corn rows wide by 30' long. The 5 treatments were 1 and 2 lbs. boron/A broadcast on the entire plot, 1 and 2 lbs. boron/A placed in a narrow band on the surface adjacent to the corn rows, and a check. Boron as Borate-46 (14.3% boron) was applied when corn plants were 6 to 10" tall. The rate of N, P and K applied to the soils, and corn populations used are shown in Table 2.

Table 2. Variety and Population of Corn Plants and Rate of N, P and K Fertilization Used in the Field Experiments on 6 Loam Soils.

Location	Soil Series	Variety of Corn	Plants/A	Macronutrient Fertilization		
				N	P	K
1	Chester	Pioneer 309A	15,200	100	44	83
2	Chester	Pioneer 309A	8,000	125	40	66
3	Belvoir	Funks G96	9,800	135	60	58
4	Dyke	Funks G83	15,900	135	60	58
5	Brandywine	DeKalb XL65	13,100	214	58	110
6	Chester	SS 850	11,000	100	44	83

Corn leaf samples, the second leaf from the plant apex, were collected at the silking stage in mid-July of 1964 and 1965. The leaf samples were dried for 48 hours at 70° C and ground to pass a 20-mesh screen. Total boron in the samples was determined by a Curcumin procedure (6). Corn grain yield was determined at maturity and is reported herein as bushel per acre at 15.5% moisture.

RESULTS AND DISCUSSION

Corn plants grown in 1964 on Chester loam were more vigorous early in the growing season where boron was applied. Yield of the corn grain was higher where boron was applied in the row than on the check or broadcast boron treatments; the increase in yield was significant at the 5% level of probability only where the lower rate of boron (1 lb. B/A) was applied (Table 3). Because of the

Table 3. The Effect of Boron Fertilization on Yield, Boron Content, and Ear and Kernel Development of Corn Grown on 6 Soils.*

Location	Soil Type	Treatment	Yield†	Boron Content††	Barren Ears	Blank Stalks
			Bu/A	ppm	%	%
1	Chester loam	1 lb. B/A row	79^{b}	27^{ab}	1.2^{a}	1.8^{a}
		2 lbs. B/A row	76^{ab}	34^{b}	1.7^{a}	1.4^{a}
		1 lb. B/A broadcast	67^{a}	29^{ab}	2.7^{a}	3.4^{a}
		2 lbs. B/A broadcast	64^{a}	28^{ab}	1.4^{a}	5.8^{a}
		Check	69^{a}	23^{a}	1.3^{a}	3.9^{a}
2	Chester loam	1 lb. B/A row	84^{a}	60^{a}	0.0^{a}	0.0^{a}
		2 lbs. B/A row	85^{a}	79^{b}	0.0^{a}	1.3^{a}
		1 lb. B/A broadcast	94^{a}	56^{a}	0.0^{a}	0.0^{a}
		2 lbs. B/A broadcast	90^{a}	67^{ab}	0.0^{a}	0.9^{a}
		Check	96^{a}	56^{a}	0.0^{a}	0.0^{a}
3	Belvoir loam	1 lb. B/A row	74^{a}	59^{b}	1.7^{a}	4.4^{a}
		2 lbs. B/A row	75^{a}	77^{c}	0.7^{a}	4.0^{a}
		1 lb. B/A broadcast	79^{a}	46^{ab}	0.7^{a}	4.3^{a}
		2 lbs. B/A broadcast	69^{a}	56^{b}	0.7^{a}	4.2^{a}
		Check	72^{a}	38^{a}	3.1^{a}	5.9^{a}
4	Dyke loam	1 lb. B/A row	53^{a}	50^{bc}	6.8^{a}	28.4^{a}
		2 lbs. B/A row	54^{a}	53^{c}	7.5^{a}	26.2^{a}
		1 lb. B/A broadcast	53^{a}	48^{bc}	7.1^{a}	21.8^{a}
		2 lbs. B/A broadcast	56^{a}	42^{ab}	3.3^{a}	22.8^{a}
		Check	38^{a}	38^{a}	9.1^{a}	30.3^{a}

Table 3. (Continued)

Location	Soil Type	Treatment	Yield†	Boron Content†	Barren Ears	Blank Stalks
			Bu/A	ppm	%	%
5	Brandywine loam	1 lb. B/A row	71^{a}	62^{b}	1.0^{a}	0.5^{a}
		2 lbs. B/A row	89^{a}	55^{ab}	2.5^{a}	4.5^{a}
		1 lb. B/A broadcast	82^{a}	48^{ab}	1.6^{a}	1.5^{a}
		2 lbs. B/A broadcast	81^{a}	52^{ab}	0.9^{a}	4.0^{a}
		Check	86^{a}	39^{a}	1.5^{a}	0.5^{a}
6	Chester loam	1 lb. B/A row	63^{a}	50^{b}	2.5^{a}	4.4^{a}
		2 lbs. B/A row	53^{a}	75^{c}	2.6^{a}	7.9^{a}
		1 lb. B/A broadcast	60^{a}	44^{b}	0.0^{a}	3.5^{a}
		2 lbs. B/A broadcast	63^{a}	69^{c}	1.4^{a}	6.4^{a}
		Check	56^{a}	25^{a}	0.7^{a}	5.3^{a}

*There were significant differences at the 5% level of probability in yield and boron content. Barren ears refers to ears with less than 5% kernel development and blank stalks refers to plants without a cob.

†Means within a column of each soil type followed by the same letter are not significantly different at the 5% level of probability.

indication that boron was limiting the yield on Chester loam in 1964, investigations were conducted to determine if a yield response could be obtained on 5 soils in 1965. Data in Table 3 show that boron fertilization did not increase corn yield at the 5% level of probability on these 5 soils.

The percentage of ears without kernels ranged from 0 to 9.1% and of blank stalks from 3.9 to 30% where boron was not applied to the 6 soils (Table 3). Since neither anomaly was corrected by boron fertilization, it appears that the incidence of barren ears and blank stalks under conditions of the present investigation did not result from boron deficiency.

The critical boron concentration of corn plants, below which a yield response would be expected due to boron fertilization, has been shown to be approximately 13 ppm in upper leaves at harvest time (3). In Minnesota, yield responses were not obtained due to boron fertilization on 6 soils tested when upper leaves contained 14 ppm of boron at silking time (9). In the present investigation, boron fertilization increased corn yield on Chester loam when the boron content of the second leaf from the plant apex contained 23 ppm of boron at silking time. The higher boron content of corn leaves at which a response to boron application was obtained, as compared to other investigations (3, 9), may reflect the difference in plant portion sampled. It is also possible that the boron content of the tissue was lower in May and June than at the silking time in July, due to the drought that occurred prior to July (Table 4).

Table 4. Rainfall at the Northern Virginia Forage Research Station, Middleburg, in 1964 and 1965.

Month	Total Rainfall	
	1964	1965
	------- inches -------	
January	4.0	3.2
February	3.8	3.5
March	2.3	4.6
April	3.9	2.6
May	0.5	1.8
June	1.4	1.4
July	3.5	4.2
August	2.3	4.3
September	5.5	2.4
October	2.2	3.0
November	2.2	0.5
December	3.4	0.7
Total	35.0	32.2

Application of 2 lbs. boron per acre resulted in a higher boron content of corn leaves than the 1 lb. rate on 3 of the 6 soils (Table 5); the rate of boron fertilization had little effect on boron content

Table 5. The Effect of Rate of Boron Fertilization on Yield and Boron Content of Corn Grown on 6 Soils.

Location	Soil Type	Rate of Boron Application*	Yield*	Boron Content*
		lb/A	bu/A	ppm
1	Chester loam	1	73[a]	28[a]
		2	70[a]	31[a]
2	Chester loam	1	89[a]	58[b]
		2	88[a]	73[a]
3	Belvoir loam	1	77[a]	53[b]
		2	72[a]	67[a]
4	Dyke loam	1	53[a]	49[a]
		2	55[a]	48[a]
5	Brandywine loam	1	77[a]	55[a]
		2	85[a]	54[a]
6	Chester loam	1	62[a]	47[b]
		2	58[a]	72[a]

*Average yield and boron content of corn tissue where each rate of boron was applied in the row and broadcast. Means within a column of each soil type followed by the same letter are not significantly different at the 5% level of probability.

of corn leaves on the remaining 3 soils. The boron content of corn leaves that received 2 lbs. of boron per acre ranged from 28 to 79 ppm (Table 3). No evidence of boron toxicity was observed on these treatments; this observation is supported by yield data showing that corn grain yield was similar where 1 and 2 lbs. of boron per acre were applied (Table 5).

Row applied boron resulted in a higher boron content of corn leaves than broadcast boron on each of the 6 soils (Table 6); this increase due to row application was significant at the 5% level of probability on 1 soil, Belvoir loam. Row application of boron resulted in higher corn grain yields than the broadcast application on 1 of the 6 soils, the Chester loam. The increase in corn grain yield due to row application of boron in 1964 and the higher content

Table 6. The Effect of Placement of Boron Fertilization on Yield and Boron Content of Corn Grown on 6 Soils.

Location	Soil Type	Placement of Boron	Yield*	Boron Content*
			bu/A	ppm
1	Chester loam	row	78[b]	31[a]
		broadcast	66[a]	29[a]
2	Chester loam	row	85[a]	71[a]
		broadcast	92[a]	70[a]
3	Belvoir loam	row	75[a]	68[b]
		broadcast	74[a]	51[a]
4	Dyke loam	row	54[a]	52[a]
		broadcast	55[a]	45[a]
5	Brandywine loam	row	80[a]	59[a]
		broadcast	82[a]	50[a]
6	Chester loam	row	58[a]	63[a]
		broadcast	62[a]	57[a]

*Average yield and boron content of corn tissue where one and 2 lbs. boron/A were applied in the row or broadcast. Means within a column of each soil type followed by the same letter are not significantly different at the 5% level of probability.

of boron in tissue where boron was applied in the row during 1964 and 1965 indicate that row application is a more efficient means of supplying boron to corn plants than broadcast placement.

Water soluble soil boron has been widely used to assess the boron supplying power of soil. The water soluble boron content of the Chester loam on which a yield response to boron application was obtained was higher or nearly equal to water soluble boron contents of the 5 soils on which boron fertilization did not increase yield (Table 1). It is not surprising then that a rather low correlation ($r = 0.537^{*}$) was obtained between the water soluble boron content of the soils and boron content of the corn leaves. These data suggest that water soluble soil boron was not a reliable indicator of the boron supplying power of the soils studied.

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