Micronutrient Supplying Power Of Selected Virginia Soils

As Related to Soil Tests And Soil Properties

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by

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SUMMARY

The laboratory and greenhouse investigations were conducted to determine the micronutrient supplying powers of 16 Virginia soils and to evaluate relationships among the micronutrient supplying powers and contents of extractable micronutrients and properties of the soils. Dry weight of corn plants was increased by B application on only Lloyd silty clay loam, and by Zn application on Dunmore silt loam, Klej fine sand, and Hagerstown and Lloyd silty clay loams. Fourteen of the 16 soils were used in Cu investigations and 13 in Mn investigations. Either Cu or Mn application increased dry weight of corn plants grown on 2 of these soils, Sassafras fine sandy loam and Lloyd silty clay loam. Dry weight data showed that the amounts of B, Cu, Mn, and Zn applied to the soils did not result in a micronutrient toxicity.

A significant coefficient of simple correlation (r = 0.663) was found to exist between 2.0 N $MgCl_2$ extractable Zn and the Zn supplying power of the soils. Water soluble B, 1.0 N HCl extractable Cu, and 0.1 N HCl extractable Mn did not correlate significantly with the B, Cu, and Mn supplying powers of the soils, respectively.

A 2-variable regression equation consisting of 1.0 N HCl extractable Cu and soil pH correlated significantly (R = 0.761) with the Cu supplying power of the soils; inclusion of the variables, contents of soil organic matter, and clay in the equation did not significantly increase the magnitude of the coefficient of multiple correlation. Multiple and partial correlation data indicated that regression equations consisting of water soluble B, 0.1 N HCl, extractable Mn, or 2 N $MgCl_2$ extractable Zn and combinations of the soil variables did not give a better estimate of the micronutrient supplying powers of the soils than the extractable micronutrients alone.

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In simple correlation analyses, uptake of applied Zn correlated significantly with soil pH and contents of soil organic matter and clay. However, partial correlation data showed that a direct relationship existed only between uptake of applied Zn and soil pH; i.e., uptake of applied Zn varied inversely with soil pH. Uptake of applied B and Mn did not relate significantly by simple correlation to soil pH and contents of organic matter and clay.

INTRODUCTION

Although only minute amounts of B, Cu, Mn, and Zn are required by crop plants, field investigations have shown that many soils supply inadequate amounts of the micronutrients. The micronutrient deficiencies occur most frequently on sandy textured soils, but also occur on heavy textured soils. The high prevalence of the deficiencies on sandy textured soils has been attributed to the low amount of the micronutrients in the parent material from which they are derived (1,2). In contrast, the deficiencies on heavy textured soils are usually associated with other soil properties, such as high pH, which decreases the availability of the micronutrients (1,3).

The most accurate method of determining micronutrient requirements is by field experimentation. Field experimentation, however, is not readily adaptable to determining the micronutrient supplying power of large numbers of soils. Consequently, an effort has been made to determine the plant availability of soil micronutrients by laboratory techniques. Water soluble boron has been shown to give a satisfactory measure of the boron supplying power of some soils (4). Acid extractable Cu, Mn, and Zn have been shown to relate directly to the availability of the micronutrients in certain soils (5, 6, 7, 8). Both dithizone and 2 $\underline{N}$ $MgCl_2$ extractable Zn have also been shown to give a reliable estimate of the Zn supplying power of some soils (9,10). Regression equations consisting of acid or dithizone extractable Zn and soil pH as variables were shown to give a better estimate of the zinc supplying power of soil than either acid or dithizone extractable Zn alone (10,11).

The present investigation was designed to assess the B, Cu, Mn, and Zn supplying powers of Virginia soils using greenhouse and laboratory techniques. During the course of the investigation, studies were also carried out to evaluate the effectiveness of chemical extracts in assessing the available B, Cu, Mn, and Zn properties on uptake of applied micronutrients.

EXPERIMENTAL PROCEDURE

Soil samples of the Ap horizons of 16 different series were collected from various areas of Virginia. Fourteen of the soils were classified as well-drained and 2 as moderately well-drained. The soils were air-dried and crushed to a fineness of 6 mm. or less prior to use in greenhouse studies. Air-dried soil used in laboratory analyses was passed through an 18 mesh screen.

Greenhouse Procedure

A greenhouse experiment employing a randomized complete block design consisting of 3 blocks was conducted to determine yield response of corn plants (*Zea mays*, L.) to B, Cu. Mn, and Zn application and to determine plant uptake of native and applied micronutrients. Reagent grade chemicals containing 0.75 mg. B, 1.5 mg. Cu, 3.0 mg. Zn, 4.0 mg. Mn, 82 mg. N, 178 mg. K, 89 mg. P, 42 mg. Mg, and 61 mg. S were mixed with 1500 g. of the 6 mm. soil and placed in plastic lined pots for the check treatment. Treatments without B, Cu. Mn, and Zn received the same application of elements as the check, except that the respective element was not applied. Four single-cross hybrid corn plants were grown in each pot. The plants were watered to approximately field moisture 3 times daily. Following a 35-day cropping period with day length controlled at 16 hours, top growth was harvested, oven-dried for 48 hours at 70°C, weighed and ground in a Wiley Mill to pass a 20 mesh stainless steel screen.

Tissue Analyses

In preparation for total Cu, Mn, and Zn determinations, one g. of ground tissue was dry-ashed at 450°C for 2 hours. The ash was shaken for one hour with 15 ml. of 6 *N* HCl and filtered. The filtrate was then dried on a hot plate and the precipitate was dissolved in 15 ml. of 0.5 *N* HCl. Copper, Mn, and Zn in the 0.5 *N* HCl solution was determined on a Model 303 Perkin Elmer Atomic Absorption Instrument. Total B in the ground tissue samples was determined by a curcumin procedure (12).

Soil Analyses

Copper was extracted from soil with 1.0 *N* HCl and Mn with 0.1 *N* HCl. Copper and Mn extracted by shaking 5 g. of soil with 50 ml. of the appropriate acid was determined by atomic absorption techniques. For 2 *N* $MgCl_2$ extractable Zn determinations, 20 g. of soil were shaken for 2 hours with 100 ml. of 2 *N* $MgCl_2$. Zinc present in 50 ml. of the aqueous phase was extracted by shaking with 20 ml. of *N* CH_3COONH_3 and 25 ml. of 0.01% dithizone in CCl_4. Zinc in the 0.02 *N* HCl phase was also determined by an atomic absorption technique.

Per cent of soil clay was determined by a hydrometer method (13) and of soil organic matter by a wet oxidation procedure (14). Soil pH measurements were run on a Beckman Model G pH meter using a 1:1 soil-water ratio and a 30-minute period of equilibration.

Statistical Analyses

Correlation and regression analyses were run on an IBM 7040 system.

RESULTS AND DISCUSSION

Chemical and physical properties of the soils used in the investigation are shown in Table 1. The soils were slightly to very acid and ranged in organic matter content from 0.7 to 2.8% and in clay content from 17.6 to 45.6%. Some of the soils contained large amounts of specific extractable micronutrients. For example, the content of water soluble B in Etowah silt loam, of 1 N HCl extractable Cu in Hagerstown and Lloyd silty clay loams, and of 2 N $MgCl_2$ extractable Zn in Matapeake sandy loam were much higher than in the other soils investigated. In general, 0.1 N HCl extractable Mn was high in soils that contained relatively large amounts of organic matter and clay; Tatum silt loam with moderate levels of organic matter and clay and a low amount of 0.1 N HCl extractable Mn was an exception.

Yield

The effect of micronutrient application on yields of corn plants grown in the greenhouse on certain Virginia soils is shown in Table 2. Zinc application increased yield of corn plants on 4 of the soils, Dunmore silt loam, Klej fine sand, and Hagerstown and Lloyd silty clay loams. A symptom of zinc deficiency, White Bud, was observed on corn plants grown on Dunmore silt loam and Klej fine sand. Copper and Mn application increased yield of corn plants on Sassafras fine sandy loam and Lloyd silty clay loam. Boron application also increased yield on the latter soil. Applied B, Cu, Mn, and Zn did not decrease corn plant yield on any of the soils, indicating that toxic amounts of the micronutrients were not supplied to plants by native and applied micronutrients.

Micronutrient Content of Corn Tissue

The normal B, Cu, Mn, and Zn contents of plant tissue are 10-100, 1-20, 10-200, and 5-100 ppm., respectively (12). The B, Cu, and Zn contents of corn tissue were in the low end of the normal range (Table 3). The Mn contents of the corn tissue fell within the normal range, except for plants grown on Bolton loam and Woodstown fine sand, which contained over 300 ppm. of Mn. Toxicity symptoms were observed during the early part of the experiment on plants growing on the latter soils. By the fourth week, the symptoms were no longer visible. Manganese application did not decrease dry weight of corn plants on the 2 soils (Table 2), indicating that the toxicity was not severe enough to affect plant growth.

The contents of B, Cu, Mn, and Zn in plant tissue (Table 3) did not relate closely to the yield response resulting from application of the micronutrients (Table 2). For example, a yield response to Zn application was obtained where plants contained 8.6 to 18.2 ppm. of Zn, whereas a response was not obtained where plants contained 8.0 to 16.0 ppm. of Zn. Higher or nearly equal Cu contents in Cu deficient plants as compared to normal plants has been attributed to concentration of Cu in the plant by continued uptake after growth ceases (15).

A similar interpretation would explain the negligible relationship observed between the B, Cu, Mn, and Zn contents of corn tissue and yield response to application of the micronutrients observed in the present investigation.

A Comparison of Uptake by Corn and Chemical Extraction of Micronutrients

Statistical data for evaluating relationships among uptake of micronutrients by corn plants and extractable micronutrients and soil properties are shown in Table 5. The statistical analyses were run to determine if extractable B, Cu, Mn, or Zn and soil variables would give a better estimate of uptake of the respective micronutrients than contents of the extractable micronutrients alone.

Etowah silt loam was not included in statistical analyses relating B uptake to water soluble B and soil variables, because the soil supplied much higher amounts of B to corn plants than the other soils investigated (Table 4). Of the variables, water soluble B, soil pH, and contents of organic matter and clay, only soil pH was related significantly to B uptake by simple correlation analyses (Table 5). As shown by nonsignificant coefficients of partial and multiple correlation, the independent variables, water soluble B, soil pH, and contents of organic matter and clay did not give a better prediction of B uptake than soil pH alone.

Data from 12 of the 16 soils were used in statistical analyses relating Cu uptake to 1.0 N HCl extractable Cu and soil variables. Klej fine sand and Lodi loam were not included in the analyses because Cu uptake was not determined on these soils (Table 4) and Hagerstown and Lloyd silty clay loam were not included because of their very high 1.0 N HCl extractable Cu content (Table 1). Simple correlation data (Table 5) show that 1.0 N HCl extractable Cu, soil pH, and contents of organic matter and clay were not significantly related to Cu uptake. In multiple correlation analyses, a significant relationship (R = 0.847) was obtained between the 4 variables and Cu uptake. As shown by significant coefficients of partial correlation, only 1.0 N HCl extractable Cu and soil organic matter contributed significantly to the magnitude of the coefficient of multiple correlation. A significant coefficient of multiple correlation coefficient of 0.761 was obtained between the independent variables, 1.0 N HCl extractable Cu and soil organic matter content and the dependent variable, Cu uptake. The relationship indicates that interactions between the 2 variables account for 58.0% of the variation in Cu uptake.

Statistical analyses relating Zn uptake to 2 N $MgCl_2$ extractable Zn and soil variables, were run on 14 of the 16 soils. Data from Etowah silt loam, which had a very high Zn supplying power, and Matapeake sandy loam, which contained a very high amount of 2 N $MgCl_2$ extractable Zn, were not included in the analyses (Table 4). In simple correlation analyses, a significant relationship (r = 0.663) was obtained between Zn uptake and 2 N $MgCl_2$ extractable Zn. The variables, soil pH and contents of organic matter and clay, did not relate significantly to Zn uptake (Table 5). Multiple and partial correlation analyses showed that the independent variables, 2 N $MgCl_2$ extractable Zn, soil pH, and contents of organic matter and clay, did not give a better measure of Zn uptake than 2 N $MgCl_2$ extractable Zn itself.

Because Mn uptake determinations were not carried out on Klej fine sand, Matapex fine sandy loam, and Norfolk loamy sand, and because the Mn supplying powers of Bolten loam and Woodstown fine sand were very high (Table 4), the 5 soils were not included in stepwise regression analyses (Table 6). The F-value of 24.34 (Table 6) indicates that a highly significant relationship exists between Mn uptake and soil pH. The coefficient of simple correlation (r = -0.854) for the relationship shows that soil pH accounts for 72.9% of the variation in the Mn supplying power of the soils. As shown by nonsignificant F-values (Table 6), regression equations consisting of 0.1 N HCl extractable Mn and any combination of the soil variables, pH and contents of clay and organic matter would not account for a significantly higher percentage of the variation in Mn uptake.

Uptake of Applied Micronutrients vs Soil Properties

Uptake of applied B, Mn, and Zn by corn plants grown on selected Virginia soils is shown in Table 7. Uptake of applied Zn was significantly related by simple correlation to each of the soil properties, pH, and contents of clay and organic matter (Table 8). From partial and multiple correlation analyses (Table 9), it can be seen that only soil pH was directly related to uptake of applied Zn. The coefficient of partial correlation of -0.621 shows that the plant availability of applied Zn decreases as soil pH increases. This effect has been attributed to greater complexing of Zn by soil exchange sites at higher pH levels (11). Uptake of applied B and Mn was not significantly related to soil pH or contents of clay or organic matter (Table 8).

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LITERATURE CITED

1. Carter, R. L., J. E. Giddens, F. C. Boswell, H. F. Perkins, O. E. Anderson, and M. B. Parker. Micronutrients and crop production in Georgia. Georgia Agr. Exp. Sta. Bul. 126. pp. 1-90. 1964.

2. Mitchell, Robert L. Trace elements in soils. In F. E. Bear (ed.) Chemistry of the Soil. Reinhold Publishing Corp. pp. 320-368. 1964.

3. Hodgson, J. F. Chemistry of micronutrient elements in soils. Adv. Agron. XV: 119-159. 1963.

4. Berger, K. C. Boron in soils and crops. Adv. Agron. X: 321-348. 1949.

5. Hammes, J. K. and K. C. Berger. Manganese deficiency in oats and correlations of plant manganese with various soil tests. Soil Sci. 90: 239-244. 1960.

6. Hoff, D. J. and H. J. Mederski. The chemical estimation of plant available soil manganese. Soil Sic. Soc. Am. Proc. 22: 129-132. 1958.

7. Hanes, R. E. Influence of certain soil properties on the need for copper fertilization in the North Carolina Coastal Plain. Unpublished M.S. thesis. Univ. of North Carolina, Raleigh. 1964.

8. Wear, J. I. and A. L. Sommer. Acid extractable zinc of soils in relation to the occurrence of zinc deficiency symptoms of corn. Soil Sci. Soc. Am. Proc. 12: 143-144. 1948.

9. Stewart, J. A. and K. C. Berger. Estimation of available soil zinc using magnesium chloride as extractant Soil Sci. 100: 244-250. 1965.

10. Massey, H. F. Relationship between dithizone-extractable zinc in the soil and zinc uptake by corn plants. Soil Sci. 83: 123-129. 1957.

11. Martens, D. C. and G. Chesters. Comparison of chemical tests for estimation of the availability of soil zinc. Accepted for publication in J. Sci. Food and Agr. 1967.

12. Johnson, C. M. and A. Ulrich. Analytical methods for use in plant analysis. California Agr. Exp. Sta. Bul. 766. pp. 62-64. 1959.

13. Boyoucos, George John. Hydrometer method improved for making particle size analyses of soils. Agron. J. 54: 464-465. 1962.

14. Walkley, A. and I. A. Black. An examination of the Deggareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil Sci. 37: 29-38. 1934.

15. Patterson, R. P. The influence of copper and soil pH on the yield and chemical composition of wheat and soybeans growing on soils high in organic matter. Unpublished M.S. thesis. Univ. of North Carolina, Raleigh. 1963.

Table 1. Selected Chemical and Physical Properties of the 16 Soils Investigated.

Soil Type	Location (County)	pH	Organic Matter	Clay	Water Soluble B	1$\underline{N}$ HCl Ext. Cu	0.1$\underline{N}$ HCl Ext. Mn	2$\underline{N}$ $MgCl_2$ Ext. Zn
			%	%	ppm.	ppm.	ppm.	ppm.
Bolton l	Russell	4.6	2.6	32.0	0.67	2.22	81.0	0.25
Dunmore sil	Washington	5.7	2.5	40.0	0.49	2.15	80.5	0.12
Etowah sil	Russell	6.4	2.3	31.6	1.80	2.25	91.8	0.79
Frederick l	Smyth	5.0	2.4	34.0	0.67	1.38	87.5	0.31
Groseclose sil	Washington	5.9	2.0	25.6	0.59	2.18	71.2	0.83
Hagerstown sicl	Russell	5.9	2.8	45.6	0.64	5.22	83.3	0.18
Klej fs	Nansemond	4.9	0.7	18.0	0.49	2.40	7.0	0.30
Lloyd sicl	Orange	5.3	2.2	43.6	0.66	10.80	88.5	0.52
Lodi l	Russell	5.2	1.7	28.0	0.58	1.45	95.2	0.16
Matapeake sl	Richmond	5.9	1.7	28.4	0.50	1.84	91.5	1.13
Matapex fsl	Nansemond	5.2	1.2	20.0	0.39	1.67	5.0	0.20
Nason sil	Orange	6.4	2.1	34.0	0.58	1.79	30.0	0.04
Norfolk lfs	Richmond	5.7	0.7	18.0	0.36	0.86	4.6	0.18
Sassafras fsl	Richmond	5.7	1.4	22.0	0.47	1.04	48.5	0.20
Tatum sil	Orange	5.1	2.2	32.0	0.76	1.27	13.0	0.16
Woodstown fs	Nansemond	4.7	0.7	17.6	0.39	0.74	10.5	0.31

Table 2. The Effect of Micronutrient Application on Dry Weight of Corn Plants Grown in the Greenhouse on Selected Virginia Soils.

Soil Type	Treatment*				
	Check	No B	No Cu	No Mn	No Zn
	g. tissue/1500 g. soil				
Bolton l	6.5[a]	6.3[a]	5.6[a]	6.1[a]	5.4[a]
Dunmore sil	6.5[a]	6.7[a]	6.4[a]	7.0[a]	4.9[b]
Etowah sil	8.7[a]	8.3[a]	7.5[a]	7.3[a]	8.0[a]
Frederick l	8.1[a]	8.6[a]	8.2[a]	7.4[a]	8.5[a]
Groseclose sil	9.0[a]	8.6[a]	7.9[a]	8.4[a]	8.1[a]
Hagerstown sicl	4.8[a]	5.1[a]	4.7[a]	4.7[a]	4.1[b]
Klej fs	5.4[a]	5.1[ab]	****	****	4.9[b]
Lloyd sicl	7.7[a]	6.3[b]	5.5[c]	6.9[b]	6.7[b]
Lodi l	6.3[a]	6.5[a]	****	6.7[a]	6.1[a]
Matapeake sl	6.5[a]	6.0[a]	6.8[a]	6.0[a]	6.6[a]
Matapex fsl	6.2[a]	6.1[a]	5.7[a]	****	6.2[a]
Nason sl	7.9[a]	8.2[a]	7.7[a]	7.7[a]	7.2[a]
Norfolk lfs	6.0[a]	6.1[a]	5.6[a]	****	6.0[a]
Sassafras fsl	7.4[a]	7.4[a]	5.9[b]	5.7[b]	6.5[ab]
Tatum sil	8.3[a]	7.5[a]	8.3[a]	7.9[a]	7.7[a]
Woodstown fs	5.4[a]	6.2[a]	5.5[a]	5.7[a]	5.3[a]

* Values in a horizontal column followed by different letters are significantly different at the 5% level of probability.

**** Yield was not determined.

Table 3. Micronutrient Content of Corn Plants Grown in the Greenhouse on Selected Virginia Soils.

Soil Type	Micronutrient Content of Corn Tissue			
	B	Cu	Mn	Zn
	ppm.			
Bolton l	17.6	4.3	333.3	13.3
Dunmore sil	17.6	3.0	75.5	8.6
Etowah sil	23.3	2.7	49.5	16.0
Frederick l	14.1	4.9	128.4	10.9
Groseclose sil	14.3	3.1	73.4	12.0
Hagerstown sicl	20.7	7.3	95.3	13.1
Klej fs	17.9	****	****	18.2
Lloyd sicl	19.0	5.9	127.4	12.0
Lodi l	17.9	****	103.7	12.0
Matapeake fsl	20.5	3.1	74.0	14.3
Matapex fsl	18.5	4.1	****	12.7
Nason sil	16.5	2.9	46.4	9.5
Norfolk lfs	18.4	2.8	****	10.0
Sassafras lfs	18.7	4.7	83.1	8.0
Tatum sil	17.4	4.2	79.4	8.9
Woodstown fs	14.9	2.6	394.6	14.6

* The B, Cu, Mn, And Zn contents of corn plants grown on the no B, Cu, Mn, znd Zn treatments, respectively.

**** Copper and Mn contents of corn tissue were not determined.

Table 4. Uptake of Native Micronutrients by Corn Plants Grown in the Greenhouse on Selected Virginia Soils.

Soil Type	Plant Uptake of Native*			
	B	Cu	Mn	Zn
	μg./1500 g. soil			
Bolton l	110.7	23.9	2033.3	71.7
Dunmore sil	118.0	19.1	528.6	41.2
Etowah sil	193.8	20.2	361.7	127.6
Frederick l	121.3	40.1	950.4	92.7
Groseclose sil	122.7	24.6	616.6	97.2
Hagerstown sicl	105.6	34.3	447.8	53.6
Klej fs	91.3	****	****	89.3
Lloyd sicl	120.0	32.6	878.8	80.1
Lodi l	116.1	****	694.8	73.0
Matapeake sl	122.7	21.0	444.0	94.6
Matapex fsl	112.7	23.4	****	78.5
Nason sil	134.9	22.0	356.9	68.1
Norfolk lfs	112.5	15.7	****	59.9
Sassafras fsl	138.5	27.5	473.7	52.0
Tatum sil	130.5	34.6	626.9	68.9
Woodstown fs	92.5	14.5	2249.2	77.3

* Uptake of B, Cu, Mn, and Zn by corn plants grown on no B, Cu, Mn, and Zn treatments, respectively.

**** Micronutrient uptake was not determined.

Table 5. Correlation Data for Evaluating Relations Among B, Cu, And Zn Uptake, Extractable Contents of the Micronutrients in Soils, and Selected Soil Properties.

Variable		Coefficient of			
Dependent	Independent	Simple Correlation	Partial Correlation	Multiple Correlation	Determination
B uptake	Water Sol. B.	0.337	0.356	0.737	0.543
	pH	0.549*	0.657*		
	% organic matter	0.400	0.271		
	% clay	0.275	-0.402		
Cu uptake	1.0 N HCl ext. Cu	-0.016	-0.746*	0.847*	0.717
	pH	-0.256	0.140		
	% organic matter	0.494	0.769*		
	% clay	0.371	-0.564		
Cu uptake	1.0 N HCl ext. Cu	-0.016	-0.666*	0.761*	0.580
	pH	0.494	0.761**		
Zn uptake	2 N $MgCl_2$ ext. Zn	0.663**	0.693*	0.763	0.582
	pH	-0.381	-0.389		
	% organic matter	-0.191	-0.069		
	% clay	-0.287	-0.173		

* Significant at the 5% level.

** Significant at the 10% level.

Table 6. Stepwise Regression Data for Evaluating the Relationship Between the Dependent Variables, Mn Uptake, and the Independent Variables, 0.1 N HCl Extractable Mn, Soil pH, and Contents of Organic Matter and Clay in Selected Virginia Soils.

Step	Variable Related to Mn Uptake	F-value
I	pH	24.34**
II	pH 0.1 N HCl ext. Mn	1.81
III	pH 0.1 N HCl ext. Mn % organic matter	0.26
IV	pH 0.1 N HCl ext. Mn % organic matter % clay	0.00

** The F-value is significant at the 1% level.

Table 7. Uptake of Applied B, Mn, and Zn by Corn Plants Grown in the Greenhouse on Selected Virginia Soils.

Soil Type	Plant Uptake of Applied*		
	B	Mn	Zn
	μg./1500 g. soil		
Bolton 1	30.2	827.9	96.7
Dunmore sil	49.9	7.3	10.9
Etowah sil	88.2	512.0	16.1
Frederick 1	53.8	258.0	41.5
Groseclose sil	69.5	8.2	30.0
Hagerstown sicl	85.4	11.4	0.6
Klej fs	57.4	****	112.0
Lloyd sicl	36.7	236.4	28.7
Lodi 1	49.9	204.5	34.5
Matapeake sl	36.2	85.2	1.9
Matapex fsl	41.9	****	80.9
Nason sil	44.2	25.9	74.4
Norfolk lfs	25.4	****	64.4
Sassafras lfs	84.1	114.8	38.4
Tatum sil	72.8	158.5	72.5
Woodstown fs	40.8	****	130.7

* Uptake of B, Mn, and Zn by plants grown on the check minus uptake of B, Mn, and Zn by plants grown on the no B, Mn, and Zn treatments, respectively.

**** Uptake of applied Mn was not determined.

Table 8. Coefficients of Simple Correlation between Plant Uptake of Applied Micronutrients and Soil Properties of Selected Virginia Soils.

Variable	Soil pH	Contents of Soil	
		Organic Matter	Clay
Uptake of applied B	0.379	0.315	0.198
Uptake of applied Mn	-0.061	0.006	-0.087
Uptake of applied Zn	-0.638**	-0.575*	-0.608*

* Significant at the 5% level.

** Significant at the 10% level.

Table 9. Statistical Analysis of the Relationships between Plant Uptake of Applied Zn and Properties of Selected Virginia Soils.

Dependent	Independent	Coefficients of Simple Correlation	Coefficients of Partial Correlation	Coefficients of Multiple Correlation	Coefficients of Determination
Uptake of applied Zn	pH	-0.638**	-0.621*	0.785**	0.616
	% organic matter	-0.575*	-0.085		
	% clay	-0.608*	-0.255		

* Significant at the 5% level.

** Significant at the 10% level.