

The Micronutrient Status of Soybeans in Indiana as Determined by Foliar Analysis¹

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Introduction

Foliar analysis as a means of determining the nutritional well being of a crop, is a well established procedure for selected crops in several countries. The micronutrient status of soybeans in Indiana appears likewise to be capable of definition by analysis of leaf samples collected in a recent survey. The plant status in turn reflects the micronutrient supplying power of the soils on which the plants were grown. Data from a recent survey are herein reported.

Experimental Procedure

In August of 1957, 64 soybean fields were sampled in an area approximately 50 miles wide extending from Walkerton to Evansville, Indiana. The plant samples consisted of leaflets and petioles from the 3rd, 4th and 5th nodes from the stem apex. Approximately 40 plants were sampled in each field at a distance of about 100 feet from the highway right-of-way. Soil samples were taken at most of the sample sites. The plant samples were oven-dried at 170°F., and ground in a Wiley mill equipped with a chromium plated screen. Portions of the sample were forwarded to the University of Illinois Agronomy Department for spectrographic analyses for 11 mineral elements. Molybdenum analyses were by courtesy of Dr. S. A. Barber of the Purdue University Agronomy Department. The results of the spectrographic analyses were tabulated and reported for the 6 micronutrient elements; iron, copper, zinc, maganese, boron, and molybdenum. Growth and sampling information were obtained by the courtesy of Athow and Probst (1). Due

TABLE 1. Optimal and Threshold Concentrations of Micronutrients in Soybean Leaves.

Micronutrient	Deficiency Threshold, ppm	Optimal Range, ppm
Molybdenum	?	0.5-1.0?
Copper	10?	10-20
Manganese	20	40-200
Boron	16	20-100
Zinc	15	15-30
Iron	? ¹	? ¹

¹ Total iron is not a reliable index of sufficiency.

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TABLE 2. Micronutrient composition of soybean leaflet and petioles as influenced by soil region and sub-class.

Soil Region	Sub-class	range ave.	No. of Samples	Parts per Million					
				B	Mn	Fe	Cu	Zn	Mo
A	Level, well- drained	range ave.	4	37-53 49	41-93 69	79-98 86	6-11 9	15-74 44	.38-1.32 .96
A	Level, poorly- drained	range ave.	13	30-74 50	4-60 23	63-192 133	6-20 13	36-56 42	.15-2.65 .92
C	Level soils	range ave.	5	35-77 46	13-86 39	56-397 171	9-21 13	28-45 35	.40-2.32 1.23
D		range ave.	3	50-85 73	22-55 42	56-220 131	13-17 15	42-51 47	.48-1.70 .54
E	Level, light colored	range ave.	4	54-70 64	13-151 89	125-620 353	12-17 15	47-59 52	.58-1.60 .72
E	Sloping, light colored	range ave.	4	50-76 66	16-127 81	81-262 147	13-23 18	42-60 49	.48-1.85 .88
E	Dark colored	range ave.	3	48-66 55	10-23 18	85-97 89	15-20 18	43-49 46	.38-1.08 .79

G	range ave.	4	30-71 48	4-95 37	52-900 310	14-19 16	32-49 38	0.2-5.1 1.47
H	Loams and heav- ier textures	6	45-118 73	32-217 99	149-385 228	12-26 18	36-75 52	.12-.52 .4
I	Level	3	32-33 33	51-86 73	97-270 165	10-12 11	10-57 39	.25-.42 .34
I	Sloping	2	48-69 59	35-142 89	160-1000 580	16-17 17	48-60 54	0.3-0.9 0.6
N		2	48-48 48	12-33 23	128-435 282	17-19 18	37-37 37	.72-.92 .82
O		5	25-71 44	12-256 101	66-820 314	9-20 13	32-90 49	.35-.65 .43
P		6	35-61 50	19-77 42	60-470 194	12-18 15	28-72 45	.35-1.1 .67
TOTAL			25-118 54	4-256 56	52-1000 208	6-26 15	10-90 44	.12-5.1 .99
RANGE AVERAGE								

to the nature of the survey, perfect replications of variables were not obtained. Although these data have certain limitations with regard to replication, these results were considered to be useful in evaluating micronutrient supplying power of the various soils regions.

Results and Discussion

The agronomic information collected with each sample is not reported in this paper. It is available in progress reports (7) and should be used in evaluating the full significance of any sample data.

Table 1 contains the concentrations of micronutrients tentatively considered optimal for adequate mineral nutrition of soybeans. The values are those suggested by Ohlrogge (5) after a survey of the literature.

It is recognized that the optimal concentration of nutrients will vary with physiological age and growth conditions. However, this table serves as a first approximation of the standard for comparison needed to evaluate the results of this survey.

Table 2 is a compilation of the ranges and averages observed for each micronutrient in plant samples taken from various soils regions. The soils regions are similar to those used by Barber and Bronson (2). Caution must be used in interpreting differences in elemental composition found in this survey due to the broadness of the soil classification, lack of background information concerning cultural practices used in the fields sampled, and the number of other variables in this survey. However, since the samples were more or less randomly selected, they should indicate possibly deficient or potentially deficient

TABLE 3. Influence of variety and physiological age on micronutrient content of soybean leaves.

Variety	Concentration (ppm) of micronutrient				
	Clark		Hawkeye		Harosoy
Stage of Development	6	8-9	6	8-9	6
Number of Samples	3	7	8	7	8
Micronutrient					
Boron, range	44-93	25-71	37-76	32-58	39-85
ave.	69	50	61	41	41
Manganese, range	33-217	33-256	23-151	13-86	15-60
ave.	98	104	86	45	34
Iron, range	165-330	128-820	85-560	57-270	56-397
ave.	225	382	184	239	175
Copper, range	15-26	12-20	6-23	10-14	13-21
ave.	20	15	15	12	16
Zinc, range	51-52	37-90	13-74	10-51	36-51
ave.	52	60	48	36	44
Molybdenum, range	0.12-0.52	0.30-1.0	0.38-1.85	0.25-5.10	0.15-2.65
ave.	0.35	0.58	0.95	1.14	1.10

soils regions or areas. This assumes slight or negligible differences due to variety or state of development.

The level, well-drained soils of region A, and certain of the level, poorly drained soils of region I, appear to produce plants containing less copper than do other soils regions. This does not appear to be simply a soil pH effect on availability of copper because the four soil samples from the well-drained soils from region A have an average pH of 6.2 (range 5.9-6.4) whereas three soil samples from region G also have an average pH of 6.2 (range 6.0-6.6). These data indicate the fruitfulness of future expanded surveys of this kind in identifying soils which may be deficient or potentially deficient in certain micronutrients.

Table 3 is a compilation of micronutrient composition ranges and averages for three varieties of soybeans (Clark, Hawkeye, and Harosoy), at development stage 6 and the former two varieties at stages 8 and 9. These stages are defined by Weber of Iowa. The data indicate that the Clark variety may have the ability to absorb more manganese than does Hawkeye. The effect is indicated at both stages of development, but is more striking at the later stage of development.

Added significance must be given to the manganese difference when the other nutrients are studied. Although the differences in the averages for the other nutrients are small, they are amazingly consistent.

TABLE 4. A comparison of Mn, B, Cu and Mo content obtained in survey to values previously obtained from plants grown on similar soils.

Soil Type	No. of Samples	Range	Ave.	No. of Samples	Range	Ave.
Volk's Samples						
MANGANESE (ppm)						
Maumee	3	23-99	26	5	5-15	9
Plainfield	2	170-220	195	2	70-70	70
Crosby	3	41-56	47	6	13-151	72
Miami	3	16-88	51	3	44-120	84
Brookston	3	12-32	21	6	4-55	21
BORON (ppm)						
Maumee	3	19-38	27	5	30-50	41
Plainfield	2	25-30	28	2	37-52	45
Crosby	3	30-35	33	6	39-70	58
Miami	3	29-51	38	3	50-72	62
Brookston	3	34-36	35	6	30-85	54
COPPER (ppm)						
Maumee	4	9.9-24.7	14	5	9.0-17.4	13
Plainfield	2	6.8- 8.5	8	2	5.9- 9.1	8
Crosby	3	12.7-18.7	15	6	12.1-16.5	14
Miami	3	9.5-14.6	13	3	13.4-17.5	16
Brookston	3	13.0-21.0	16	6	13.6-20.3	16
MOLYBDENUM (ppm)						
Maumee	4	0.00- .45	0.14	5	.52-2.02	0.97
Plainfield	2	.18-3.54	1.85	2	.38-1.32	0.85
Crosby	3	.19- .45	0.34	5	.48-1.60	0.94
Miami	3	.01- .93	0.52	3	.48- .68	0.56
Brookston	3	.22- .67	0.42	6	.1 -1.08	0.54

Fields sampled in the later maturity group are completely different from those in the earlier group. A study of the soil types associated with each sample indicates there is little or no confounding of variety effect by the soil type effects.

Table 4 contains the results of analyses of soybean plants by Knudsen (3) and Volk (6) compared to the results obtained in this survey of samples from the same or similar soil types. Knudsen's and Volk's results are by wet chemical procedures on whole plant samples.

In general, the boron and molybdenum concentrations found by Volk are lower than the recent leaf sample analyses. Copper concentrations show amazingly good agreement. The manganese results are variable and zinc values are not included, because the Volk samples were contaminated with zinc during processing. Both surveys however, clearly classify the same soils into the high and low groups which gives convincing evidence of the usefulness of foliar analysis. It is well known that the Maumee and Brookston soils are potentially manganese deficient and these analyses indicate such. Recent experiments on the Plainfield sand have given significant responses to copper, which also would be predicted by these data.

Summary

Sixty-four soybean leaf samples were collected in a survey of soybean fields in eastern Indiana in 1957. These samples were spectrographically analyzed for their micronutrient contents. Data from an earlier survey were compared to these later results.

Variety difference in manganese contents is indicated. Foliar analysis appears to give a good indication of the nutrient supplying power of the soil. Both surveys ranked five soil types in the same approximate order. The greatest and least precision in the comparison was for copper and molybdenum, respectively.

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