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A SURVEY OF THE NUTRIENT STATUS OF BEANS GROWN IN SOUTHERN IDAHO[1/]

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INTRODUCTION

Approximately 150,000 acres of beans are grown each year in southern Idaho. Zinc deficiency has been widespread throughout the area and is the only micronutrient deficiency commonly recognized for this crop. Corrective procedures have been developed (3) and Zn fertilizer is generally applied to about half of the bean acreage each year. The need for other micronutrients is continually questioned by growers and fieldmen, but deficiencies have not been found by field observation or plant analysis. A survey of the micronutrient status of beans grown in the area was conducted to determine (a) the general micronutrient status of the crop and (b) to delineate areas and conditions showing possible deficiencies or excesses of the various elements.

PROCEDURE

Plant and soil samples were obtained in 1974 from 58 bean fields. One soil sample was lost and thus soil analyses are reported for only 57 samples. The fields sampled were selected with cooperation of fieldmen representing several commercial bean companies. The beans were both dry edible and garden types and included 35 different varieties. Within each field a representative area of about 1 or 2 acres was selected for sampling. The plant samples consisted of separate samples of whole-tops and the most recently matured, trifoliate leaves. Soil was sampled to a depth of 12 inches. All samples were obtained during the period July 12 to July 31 while the beans were in the bloom stage of growth. None of the fields had received foliar sprays containing micronutrient elements before sampling, although some had been fertilized with Zn before planting or in previous years.

The plant samples were washed in distilled water, dried at 55 C, ground to pass a 40-mesh screen in a stainless steel Wiley mill, and analyzed for the total or acid-soluble fraction of selected mineral elements. Total N including NO_3-N was determined by using a semimicro Kjeldahl method (2). Total S was determined on samples dry ashed at 550 C in the presence of magnesium nitrate. Acid-soluble S and P were determined on 2% acetic acid extracts using charcoal to obtain clear,

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colorless solutions. Total P and the other elements were determined after wet ashing the plant material in a mixture of nitric and perchloric acids. The metal cations and Mo were determined by atomic absorption spectrophotometry using a heated graphite furnace attachment for Cu and Mo. Phosphorus was determined colorimetrically (4) and S turbidimetrically (8).

The soil samples were dried at 50 C, crushed to pass a 1-mm sieve, and analyzed for sodium-bicarbonate-soluble P (7) and K, and DTPA-extractable Cu, Fe, Mn, and Zn (5). The micronutrients were determined by the same methods as those used for the leaf samples. Potassium was determined using a flame photometer.

RESULTS AND DISCUSSION

The nutrient concentration in the leaves and the soil test values are given in Table 1. The plant tops were also analyzed but data are not presented because they paralleled those for leaves. In addition better interpretative information was available for leaves than for whole plant samples.

Leaf Analysis

Table 2 gives the nutrient concentration ranges used for delineating four tentative nutritional categories for bean leaves. The concentration ranges used are based on information compiled for a four-state area in the Midwest (1) and on our own experience. Using these criteria the bean fields sampled were summarized (Table 3) with respect to the nutrient concentrations in the leaf samples. The results indicate a generally high fertility level, except for Zn, which was marginal (15 to 20 ppm) in 10 of 58 samples. Although Zn deficiency is well-known in the area, only two fields showed Zn deficiency symptoms when sampled at bloom stage, a critical time for symptoms to show.

The relatively large number of samples showing marginal levels for N (3.25 to 4.00%) probably resulted from inacccurately delineating the category limits of this element rather than from a shortage of N. Beans grown in the area are generally adequately supplied with N by the nitrogen-fixing nodules on their roots. Consequently, few if any beans grown in the area are low in N. Calibration data were not available to reliably establish concentration limits of the low and marginal categories.

Acid-soluble P and S are not included in the summary given in Table 3 because categories for this form of these elements have not been established. Good relationships exist, however between total and acid-soluble P ($r = 0.925$) and total and acid-soluble S ($r = 0.862$) for the leaf samples. Therefore, tentative critical levels for acid-soluble P and S may be calculated from the established critical levels for total P and S by using linear regression equations. These calculations indicate that when total P is 0.30%, acid-soluble P is about 0.10% and when total S is 0.20%, acid-soluble S is about 100 ppm. Experimental results are needed to reliably determine the critical levels, but the calculated values may be useful for tentatively assessing the P and S status of the crop.

Critical nutrient levels may differ among the varieties included in the survey. Information dealing with critical nutrient levels for different varieties, however, was insufficient to allow interpreting the data for each variety separately. The critical levels used here are probably high enough to indicate adequate levels for all varieties, but some varieties may grow normally at lower levels of some nutrients.

Although many samples were high in some elements, none were excessive to the point of being deleterious to the crop. For example, 14 samples contained more than 0.50% P and 6 samples contained more than 100 ppm Mn. These levels are higher than necessary, but certainly not excessive. One striking feature of the data was the high Mo levels (0.3 to 11.4 ppm) in the leaves. Again these levels are not detrimental for plant growth but indicate a high availability of Mo in the calcareous soils in the area. A critical Mo level in bean leaves is not known but less than 0.5 ppm Mo has been established for alfalfa and soybean leaves (6); beans are expected to require a similar concentration of this element. In general, the concentrations found in the bean leaves seem adequate for most nutrients.

Soil Analysis

The soil test levels were separated into four categories based on concentration ranges developed for calcareous soils by the University of Idaho (9) or Viets and Lindsay (10). The ranges for the categories are given in Table 4 and the soil test values for the survey are summarized in Table 5. These data indicate that the fields sampled generally are at a high fertility level except for Zn. Twenty-three samples had less than 1.0 ppm Zn, thus indicating that many farms within the bean growing area of southern Idaho are marginal with respect to this nutrient. In contrast, the soil test for P was high (> 12 ppm) for 45 of the samples tested, whereas only three samples were marginal (< 8 ppm). In addition, all samples tested were adequate or high in K, Cu, Fe, and Mn.

SUMMARY

No definite deficiencies of K, Cu, Fe, Mn, Mo, S, Mg, and Ca have been encountered on beans within the area. Levels of these nutrients in the leaf samples and levels of K, Cu, Fe, and Mn in all soil samples and P in most of them are high and indicate adequate levels of these nutrients for growing high-yielding bean crops, if other nutrients and management factors and climate are favorable. The data from the survey revealed no areas where nutrient concentrations in foliage or soil are unusual. The survey indicates a general high level of fertility throughout the area with individual field differences that have probably resulted from different management and fertilizer practices.

Table 1. Nutrient concentrations in bean leaves and in soil from 58 fields sampled at the bloom stage of growth.

Sample No.	Nutrient Concentrations in Bean Leaves													Soil Test Values					
	N	Total		Acid-Soluble		K	Ca	Mg	Cu	Fe	Mn	Zn	Mo	P	K	Cu	Fe	Mn	Zn
		P	S	P	S														
	%								ppm					ppm					
1	4.17	0.43	0.24	0.15	0.033	2.54	1.75	0.48	12	207	43	22	3.1	18.0	172	1.8	18	15	3.1
2	4.18	0.34	0.25	0.09	0.044	2.37	1.72	0.49	13	280	72	27	0.3	5.9	158	1.4	14	11	0.9
3	4.17	0.39	0.24	0.13	0.038	2.43	2.13	0.55	12	310	52	25	2.1	9.0	122	1.4	10	9	0.7
4	4.49	0.42	0.28	0.13	0.044	3.03	2.13	0.50	11	219	56	29	4.8	24.3	305	1.5	11	11	2.9
5	4.48	0.43	0.28	0.13	0.052	3.03	2.26	0.52	12	167	71	39	3.4	12.0	202	1.5	13	12	2.9
6	3.60	0.43	0.25	0.16	0.078	2.88	1.56	0.42	11	134	165	30	1.4	56.0	440	1.0	9	11	2.9
7	3.42	0.34	0.21	0.11	0.041	3.08	1.44	0.42	10	119	66	23	3.3	39.0	336	1.2	10	11	2.9
8	3.54	0.31	0.22	0.10	0.032	2.88	1.65	0.44	9	100	61	21	3.1	25.1	270	1.3	9	10	2.7
9	4.40	0.36	0.24	0.13	0.038	3.23	1.92	0.55	11	189	51	32	2.9	29.8	309	1.5	13	9	2.8
10	4.56	0.43	0.28	0.17	0.070	3.71	1.77	0.54	11	91	36	24	1.5	--	---	---	--	--	---
11	4.29	0.38	0.23	0.12	0.033	3.59	1.77	0.47	10	123	83	17	0.7	12.8	240	0.8	9	9	0.5
12	5.34	0.63	0.33	0.23	0.079	3.61	0.97	0.43	14	144	41	45	1.6	16.6	230	1.1	9	8	1.7
13	4.10	0.44	0.26	0.18	0.065	2.67	1.48	0.49	9	340	113	18	4.4	18.8	134	1.3	88	64	0.7
14	4.58	0.56	0.29	0.27	0.077	3.36	2.09	0.68	10	195	53	19	2.3	27.6	165	1.2	82	60	1.1
15	3.79	0.40	0.22	0.14	0.027	2.41	1.31	0.45	10	172	63	21	1.0	10.4	140	2.2	218	166	1.3
16	4.81	0.63	0.31	0.25	0.079	2.93	1.96	0.43	11	155	51	37	2.2	28.0	510	1.6	40	18	2.5
17	4.15	0.56	0.27	0.21	0.072	2.85	1.62	0.37	10	162	40	27	3.5	25.0	550	1.2	61	30	3.2
18	4.20	0.42	0.24	0.15	0.033	3.00	2.16	0.46	9	207	36	22	3.1	32.3	345	1.4	68	42	2.3
19	4.12	0.39	0.23	0.14	0.025	3.44	1.71	0.37	11	191	27	18	4.0	16.4	650	1.0	46	20	0.7
20	4.56	0.36	0.24	0.12	0.027	2.73	2.24	0.59	10	137	141	21	0.5	17.9	160	1.1	8	8	0.8
21	5.68	0.55	0.31	0.17	0.051	2.44	1.68	0.51	14	166	49	47	1.0	11.0	160	1.2	6	9	1.2
22	5.25	0.63	0.29	0.20	0.051	2.54	1.35	0.45	14	203	61	39	0.5	13.0	165	1.6	8	6	0.5
23	4.75	0.66	0.25	0.28	0.033	3.60	1.37	0.46	11	144	33	17	4.9	25.6	275	1.5	21	13	0.7
24	4.88	0.63	0.24	0.25	0.032	2.58	1.07	0.46	8	330	44	35	10.2	51.2	230	1.7	64	39	2.9
25	4.68	0.45	0.25	0.16	0.029	2.52	1.78	0.49	8	220	79	29	6.6	58.7	515	1.5	31	19	3.2
26	4.73	0.39	0.27	0.14	0.045	3.08	2.33	0.62	10	164	63	29	3.6	34.0	310	1.4	14	12	4.1
27	3.69	0.34	0.20	0.14	0.017	2.63	1.60	0.47	10	136	54	24	3.3	15.3	250	1.2	10	8	2.5
28	4.04	0.36	0.23	0.13	0.025	3.15	2.13	0.56	11	208	48	21	5.0	15.2	230	1.1	5	4	0.9
29	4.34	0.31	0.23	0.13	0.016	2.30	2.68	0.72	10	199	79	19	0.9	13.2	190	1.4	12	10	0.5
30	4.98	0.39	0.26	0.14	0.023	3.15	1.65	0.46	11	117	126	20	0.5	16.4	280	1.1	8	7	0.7

Table 1. Nutrient concentrationsin bean leaves and in soil from 58 fields sampled at the bloom stage of growth (Continued)

Sample No.	Nutrient Concentrations in Bean Leaves													Soil Test Values					
		Total		Acid-Soluble															
	N	P	S	P	S	K	Ca	Mg	Cu	Fe	Mn	Zn	Mo	P	K	Cu	Fe	Mn	Zn
	%								ppm					ppm					
31	5.12	0.50	0.24	0.19	0.040	3.52	1.76	0.46	10	144	74	26	0.8	40.6	250	1.5	19	19	1.8
32	4.29	0.36	0.24	0.14	0.038	3.17	2.20	0.50	10	209	70	22	0.8	18.1	155	1.1	15	12	0.7
33	4.62	0.36	0.22	0.13	0.018	2.51	2.21	0.55	11	174	77	26	0.4	12.0	176	1.5	20	16	0.8
34	5.24	0.73	0.28	0.30	0.046	2.89	1.31	0.44	11	197	62	55	2.6	21.0	350	1.6	39	24	0.6
35	5.36	0.45	0.27	0.14	0.027	3.00	1.76	0.41	15	137	66	56	0.4	14.0	210	1.1	9	9	2.2
36	5.35	0.57	0.26	0.19	0.012	3.35	1.57	0.49	12	187	51	27	0.3	16.1	220	1.4	11	10	0.5
37	4.53	0.47	0.24	0.18	0.030	2.77	1.09	0.45	13	187	50	21	11.4	17.7	218	1.7	32	17	0.6
38	4.18	0.39	0.22	0.13	0.010	2.36	0.88	0.39	12	135	38	21	7.6	8.2	180	1.2	32	23	0.5
39	4.61	0.57	0.29	0.21	0.070	3.03	1.26	0.38	12	141	38	25	4.9	20.0	266	1.4	14	13	0.6
40	4.54	0.58	0.32	0.21	0.082	3.21	0.88	0.33	10	130	34	37	2.7	38.8	290	1.7	27	21	3.3
41	4.30	0.38	0.24	0.14	0.030	3.06	1.96	0.63	10	177	72	29	2.7	37.0	254	1.4	14	15	3.0
42	4.15	0.39	0.26	0.13	0.050	2.63	1.68	0.44	12	132	86	25	1.1	13.1	155	1.4	10	10	0.7
43	4.56	0.61	0.26	0.18	0.040	2.39	1.02	0.52	14	127	57	41	3.7	10.9	138	0.9	8	9	0.6
44	3.76	0.33	0.19	0.12	0.011	2.34	1.51	0.48	10	116	79	21	4.3	21.3	232	1.2	7	8	3.9
45	4.44	0.46	0.28	0.17	0.064	3.47	1.38	0.53	12	120	67	38	4.9	23.3	310	1.1	8	12	4.2
46	4.19	0.46	0.28	0.18	0.056	2.48	1.31	0.46	12	151	48	29	2.4	19.0	152	1.6	12	13	1.7
47	4.34	0.31	0.28	0.10	0.057	2.90	1.95	0.81	12	350	128	26	6.7	11.2	228	1.3	7	11	2.0
48	3.93	0.36	0.23	0.13	0.030	2.38	1.64	0.55	12	141	74	28	1.5	9.8	116	1.5	8	10	1.0
49	3.92	0.27	0.20	0.08	0.012	1.35	2.01	0.53	10	183	62	33	0.7	10.8	146	1.2	9	10	1.5
50	4.13	0.30	0.23	0.10	0.029	2.34	2.49	0.55	10	172	78	29	0.7	14.8	254	0.8	7	9	1.5
51	4.49	0.37	0.22	0.13	0.012	2.76	2.68	0.69	10	172	67	25	0.9	20.8	158	1.1	8	9	2.5
52	4.41	0.36	0.22	0.16	0.017	2.68	2.71	0.68	9	201	52	23	1.2	27.0	176	1.1	9	10	2.1
53	3.72	0.33	0.21	0.12	0.022	2.70	1.53	0.38	9	131	104	16	1.8	19.2	332	1.1	17	13	1.9
54	4.19	0.36	0.20	0.13	0.013	3.12	1.78	0.54	9	166	48	19	1.8	28.5	274	1.3	138	117	1.9
55	4.55	0.47	0.25	0.16	0.022	2.42	0.79	0.40	10	133	38	24	7.2	8.2	166	1.6	38	23	0.5
56	4.15	0.34	0.21	0.11	0.007	1.70	2.08	0.61	11	104	55	21	0.9	18.9	148	1.2	10	9	1.4
57	3.96	0.37	0.22	0.14	0.024	2.57	1.60	0.62	11	97	34	23	3.0	16.2	118	1.3	10	9	1.8
58	3.07	0.28	0.17	0.12	0.019	1.63	1.59	0.32	9	153	59	19	0.6	16.0	163	0.7	29	17	0.9

Table 2. Nutrient concentration ranges used for delineating four nutritional categories for bean leaves.

Category	N	P	K	Ca	Mg	S	Cu	Fe	Mn	Zn	Mo
	CONCENTRATION RANGES USED FOR DETERMINING CATEGORIES										
	%						ppm				
Low	< 3.25	< 0.15	< 1.25	—	—	< 0.15	—	< 30	< 15	< 15	< 0.1
Marginal	3.25-4.00	0.15-0.30	1.25-1.50	< 0.35	< 0.30	0.15-0.20	< 6	30-50	15-20	15-20	0.1-0.5
Adequate	4.01-5.00	0.31-0.50	1.51-3.00	0.35-2.00	0.30-1.50	0.21-0.40	6-20	51-350	21-100	21-50	0.5-5.0
High	>5.00	>0.50	>3.00	>2.00	>1.50	>0.40	>20	>350	>100	>50	>5.0

Table 3. The number of bean leaf samples having nutrient concentrations in the nutritional cagegories and the mean and range of concentration found in 58 bean leaf samples.

Category	N	P	K	Ca	Mg	S	Cu	Fe	Mn	Zn	Mo
	NUMBER OF SAMPLES WITHIN CATEGORIES										
Low	1	0	0	--	--	0	--	0	0	0	0
Marginal	10	2	1	0	0	3	0	0	0	10	6
Adequate	40	42	36	42	49	55	58	58	52	46	46
High	7	14	21	16	9	0	0	0	6	2	6
	CONCENTRATION RANGES AND MEANS										
CONCENTRATION	%						ppm				
MEAN	4.38	0.43	2.80	1.72	0.50	0.25	11	172	64	27	2.8
RANGE											
Low	3.07	0.27	1.35	0.79	0.32	0.17	8	91	27	16	0.3
High	5.68	0.73	3.71	2.71	0.81	0.33	15	350	165	56	11.4

Table 4. The nutritional concentration ranges used for delineating soil test categories for beans

Soil Test Category	SOIL TEST LEVELS WITHIN CATEGORIES					
	P	K	Cu	Fe	Mn	Zn
	ppm					
Low	<5.0	<50	<0.2	<2.5	<1.0	<0.5
Marginal	5.0-8.0	50-70	---	2.5-4.5	---	0.5-1.0
Adequate	8.1-12.0	70-90	>0.2	4.6-10	>1.0	1.1-2.0
High	>12.0	>90	---	>10	---	>2.0

Table 5. The number of samples with soil test levels in the various categories and the mean and range of soil test values found in 57 soil samples

Soil Test Category	P	K	Cu	Fe	Mn	Zn
	NO. SAMPLES WITHIN SOIL TEST CATEGORIES					
Low	0	0	0	0	0	1
Marginal	3	0	---	0	---	22
Adequate	9	0	57	25	57	13
High	45	57	---	32	---	21
	MEAN AND RANGES FOR DETERMINED VALUES					
	ppm					
MEAN	21.2	243	1.3	26	20	1.73
RANGE						
Low	5.9	116	0.7	5	4	0.48
High	58.7	650	2.2	218	166	4.20

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