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Protein and Mineral Content of Forage Legumes and Grasses in Idaho

J. V. JORDAN

UNIVERSITY OF IDAHO
College of Agriculture

OVER 90 Idaho forage legumes and grasses have been analyzed for protein and 11 mineral elements. On the basis of the analyses, there is evidence that some Idaho soils are deficient in phosphorus, and possibly boron, copper, zinc and manganese. However, these mineral deficiencies exist in the plants and not necessarily in farm animals.

The information in this bulletin represents a relatively few areas in the state. There are undoubtedly soil deficiencies, particularly phosphorus, in other areas which were not sampled. Soil deficiencies, when established, are generally corrected by a sound fertilizer and management program.

Protein and Mineral Content of Forage Legumes And Grasses in Idaho

J. V. JORDAN*

IN 1954 the Idaho Extension Service requested the Agricultural Experiment Station to run chemical analyses on a series of forage legumes and grasses to determine whether or not trace element deficiencies existed in forage crops in certain areas. Subsequently, the analytical program was expanded in order to obtain further information on the nutrient status of the samples.

Extension Service personnel, mainly county extension agents, collected plant samples at locations they selected to be of prime interest. In this manner the Agricultural Chemistry Department received 94 plant samples from 14 counties in the state. Eleven mineral elements and protein were determined in these samples, most of which represent forages consumed by dairy and beef cattle in the sampled areas.

There are limitations in this type of report in that the nutrient deficiency of plants cannot be adequately detected by analysis of the plant tissue. Rather, there are at least four other methods involved. These may be cited as follows: (a) deficiency symptoms, if any, of crop in field; (b) soil type; (c) fertilization and field management; and (d) plant response to added fertilizer where suspected deficiency is followed through with a fertilizer trial.

Elements Essential for Plant Growth

There are 16 elements known to be essential for plant growth; that is, they are necessary for healthy growth and reproduction. These elements may be classified as major; secondary; and minor, trace or microelements. In the first two categories are carbon, hydrogen, oxygen, nitrogen, potassium, phosphorus, calcium, magnesium, sulphur and sodium. In the minor, trace or microelement category are molybdenum, copper, boron, zinc, iron and manganese. In addition, selenium is required in trace amounts by some plants. Many elements are found in plants which are not essential to plant growth. A few of these elements are lead, uranium, silicon, arsenic, lanthanum and chlorine.

The terms major, secondary and micro, minor or trace refer to the quantities of certain elements found in plants and have no bearing on their importance. For example, 5 parts per million, i.e., 0.00005 per cent molybdenum, is just as vital for the normal growth of plants as is 5 per cent nitrogen.

Idaho soils are not always able to supply the necessary amounts of the essential elements, or nutrients, to crops. Deficiencies in the nutrient supplying power of soils are reflected, of course, in the yield and/or nutritive quality of crops. Most soil deficiencies may be corrected by standard fertilizer and management programs.

Elements Essential for Animal Nutrition

Nutrient requirements of animals are not the same as plant requirements. For normal growth and reproduction, animals require carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, sodium and the micronutrients, iodine, iron, cobalt, copper, manganese, chlorine and sulphur. In addition, zinc has been found essential for some animal species and minute amounts of fluorine and molybdenum may be essential. Animals have little, if any, need for boron. However, soil deficiencies in this element may result in the growth of low quality feeds, thus indirectly affecting the animals that consume them. On the other hand, animals require iodine. This micronutrient is normally present in plant tissue, the plant absorbing it from the soil, yet iodine has no known value for plant growth. Because crop plants are grown primarily for food or feed, it is important to consider the nutrient status of crops in relation to the needs of both plants and animals.

REVIEW OF LITERATURE

Although the literature abounds with chemical analyses of crop plants, there has been no study in Idaho reporting the nutrient status of forage and other crops. There are three references citing studies with zinc (1), boron (2) and arsenic toxicity in Idaho, and there are occasional reports showing analyses of commercial feeds in Idaho (7).

ANALYTICAL METHODS

Copper, boron, molybdenum, manganese and iron were determined spectrographically. The samples were wet ashed, ground in an agate mortar and arced between graphite electrodes. A Jarrell-Ash (diffraction grating) spectrograph was used for these determinations. The standard powders were prepared according to the method of Vanselow (9) and approximated the composition of the samples only.†

Cobalt was determined by the Kidson and Askew method (5) using nitroso-R-salt. Zinc was determin-

*Associate Agricultural Chemist, Agricultural Experiment Station, University of Idaho, Moscow, Idaho.

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ed by a modified dithizone extraction procedure suggested by Prince (6).

Protein was calculated from the nitrogen value, which was determined using a modified Kjeldahl procedure (4), calcium by a modified Shapter method (5), and potassium and sodium by a Perkin-Elmer flame photometer (8). Phosphorus was determined by the vanado-molybdate method (3).

NUTRIENT CONTENT OF PLANTS

In Table 1 are presented the commonly accepted amounts of nutrient elements and proteins found in forage crops and others. Values for protein, phosphorus, potassium, calcium and sodium are reported as per cent found in the air dry weight of plant tissue. Cobalt, molybdenum, copper, boron, iron, manganese and zinc are reported as parts per million (ppm) found in the ash of plant tissue. The term "parts per million" is readily convertible to per cent by dividing the parts per million value by ten thousand.

Protein content varies considerably with the crop and time of cutting. The younger the plants, the higher they are in protein. However, quality of protein is an important factor. Many of our common feeds contain insufficient of the essential amino acids. But, fortunately, feeds that have poor quality proteins are not all deficient in the same amino acids. In contrast, meat, milk and eggs contain greater abundances of the essential amino acids and so are employed as protein supplements in the animal diet.

The **sodium** and **chlorine** content of plants is generally low but neither element is essential in plant nutrition. Since the salting of farm animals is a normal procedure, "common salt" deficiency is seldom found under ordinary conditions. While analysis for chlorine was not run on these samples, it is mentioned here since the two are generally included together.

Calcium content varies considerably with locality. Legumes are relatively higher in calcium than grasses, therefore the presence of legumes in pasture mixes tends to increase the calcium content. Calcium deficiency is more likely to develop on acid soils, and since calcareous soils predominate in south Idaho, calcium deficiency there is unlikely. On acid soils of such northern counties as Latah, gypsum or lime may be included in the fertilizer program to maintain the calcium inventory.

Potassium is widely distributed over the earth's surface as a common constituent of many clay minerals. The amount found in most soils is high compared to that of nitrogen and phosphorus. However, sandy loams and peaty soils may be low in available potassium. While this element is used in major amounts by plants, it is used only in micro amounts by animals. Potassium deficiency in animals does not occur under natural conditions.

Cobalt is not an essential plant nutrient but pla do absorb it from the soil in varying amounts depe ing on its availability in the soil. Cobalt, esse for the well being of animals, is a constituent of vita B_{12}, which is essential in animal nutrition. This min can be produced by microorganisms in the ru... of cattle and other ruminants when cobalt is present.

Molybdenum is essential for plants, not animals. However, molybdenum toxicity can develop in animals consuming herbage containing 30 to 80 parts per million.

Boron is not required by animals. However, boron deficiency in plants affects the yield and the quality, thereby affecting animals indirectly.

Iron in plants varies considerably, depending on the type of plant and soil availability.

RESULTS AND DISCUSSION

Obviously, the analytical results of 94 samples do not constitute a survey of the nutrient status of Idaho feeds and forages. However, all the samples were collected from areas where analytical information is needed.

The analyses are presented in Table 2 and discussed by county. Values considered to be low are noted by one asterisk (*), while values considered to be definitely deficient are noted by two asterisks (**). In Table 1 the minimum values or range of values quoted for the various elements have been selected as the minimum value for alfalfa. However, there is no criterion for judging what the minimum boron content should be in a grass-alfalfa mixture.

Analytical values for some nutrients in a relatively few samples are not shown. In all such cases, the particular nutrient was not determined for one reason or another; e.g., the sample was lost or insufficient sample was received.

Ada County

In the 10 samples analyzed from this county there are a few deficiencies, notably in boron. Three alfalfa samples contain less than 15 ppm. One sample appears deficient in zinc and one in copper. Samples 30 and 88 appear to be low in protein, but, as already explained, low protein values may be attributed to a number of factors. There is no evidence of mineral deficiency or low protein in the 5 samples of pasture mixes, Nos. 23, 24, 26, 27, 28.

Table 1.—Optimum and Minimum Amounts of Nutrients in Crops

	Normal content for pasture		Normal content for pasture
Protein	varies	Molybdenum	0.1-5 ppm.
Phosphorus	0.2-0.8%	Copper	7.5 ppm. (pastures & hays)
Potassium	varies	Boron	15 ppm. in alfalfa
Calcium	varies	Iron	varies
Sodium	varies	Manganese	20 ppm. (forage)
Cobalt	0.04-0.07 ppm. (forage)	Zinc	8-13.8 ppm. (alfalfa)

Bannock County

Of 7 samples from this county, two are deficient in zinc and one in copper. The high value for iron, 1040 ppm., in No. 20 is likely due to soil contamination of the sample, causing a high iron assay.

Bear Lake County

The wild hay sample from this county is relatively high in all nutrients except zinc.

Blaine County

The alfalfa sample submitted from this county is deficient in copper and relatively low in cobalt although it does contain slightly more than the 0.04 ppm. minimum requirement for cobalt.

Butte County

There are deficiencies in the 3 samples collected in this county. In No. 61, manganese is low at 10 ppm. Sample 68 is low in protein content and No. 71 is low in phosphorus and deficient in boron and zinc.

Canyon County

There are several deficiencies in the 10 samples from this county. Zinc is definitely deficient in alfalfa samples 32 and 33, and in the pasture mix sample 36. Boron deficiencies exist in three other samples and there is a copper deficiency in one of these latter samples. The data on the bean leaf sample is included for interest and information.

Clark County

Of these two alfalfa samples, No. 67 is deficient in boron and zinc. Sample 39 is relatively high in all nutrients, although no value appears for zinc.

Custer County

In the three samples from this county, all legume and grass mixtures, there are no apparent deficiencies.

Gooding County

Of the 12 samples submitted, 11 are alfalfa and one is orchard grass hay. Five of the samples are deficient in boron, 8 are deficient in zinc, and 3 deficient in copper. In addition, the protein and phosphorus contents of a few samples are relatively low. The high iron values in samples 55 and 57 are probably due to sample contamination by soil.

Latah County

Although 26 samples are listed from this county, samples 81 and 83 were collected across the state line in Washington. Thirteen samples are deficient in zinc, 15 are deficient in copper, and 7 deficient in boron. This group of samples is also marked by low protein values, the maximum value being 16.00 per cent in No. 82, while 18 of the samples assay below 10 per cent protein.

Owyhee County

This sample is low in copper and has a relatively low protein and phosphorus content.

Payette County

Of the 15 samples submitted, 5 are low in zinc, 2 low in boron, and 4 low in copper. Only No. 5 shows a marked deficiency, with 8 ppm. boron.

Washington County

The alfalfa sample is low in boron and relatively low in protein and phosphorus.

In the foregoing discussion, a number of mineral deficiencies are evident. However, many of these are marginal deficiencies in copper, boron and zinc. Only 11 samples are designated as having a definite deficiency. Since most of these samples were collected from fields where deficiencies were suspected to exist, the incidence of deficiency is remarkably low.

On the basis of the analytical studies presented in this report, there is no evidence that animals consuming the herbage represented by these samples are likely to suffer from mineral-deficient diet. Since the farm animal's diet generally comes from various sources, this possibility is even more remote. However, this statement is not intended to imply that the ultimate in farm animals' rations has been achieved. Such a subject is outside the scope of this study.

There are a number of samples referred to as having a low protein content. By analogy, the nitrogen uptake by these crops was relatively low, possibly due to insufficient available nitrates or moisture. However, many of these low protein values may be due to time of cutting and method of curing.

Only one sample may be described as having a marginal manganese deficiency. There is no evidence of cobalt deficiency insofar as animal nutrition is concerned. Generalizations regarding the calcium content of feeds for animal nutrition are unsafe because of the great variations that can occur. However, it is safe to state that crops grown on the calcareous soils of south Idaho are not deficient in calcium. Since the calcium content of those samples from the slightly acid soils of the northern counties is generally the same as those from the calcareous soils, there is little evidence of a possible calcium deficiency.

The potassium analyses cannot be assessed except to note that one sample appears to be unusually low at 0.69 per cent. Similarly, it is difficult to assess the phosphorus status of the plant samples. In the author's experience, Idaho plant samples have generally exceeded 0.2 per cent phosphorus and rarely dropped below 0.15 per cent. On this basis, about 18 of the samples may be considered to be low in phosphorus. Since phosphate fertilization is a recommended practice in Idaho, this is undoubtedly the reason why.

TABLE 2.—CHEMICAL ANALYSES

Legend: A—alfalfa; C—clover; G—grass; LC—ladino clover; RC—red clover; AC—alsike clover; TF—tall fescue; AF—alta fescue; Bl —bluegrass; CW—crested wheat; RG—rye grass; B—brome; SB—smooth brome; O—orchard grass; *—possible deficiency; **—definite deficiency

Sample No.	County and Sample	Protein	Phosphorus	Potassium	Calcium	Sodium	Cobalt	Molybdenum	Copper	Boron	Iron	Manganese	Zinc
		pct.	pct.	pct.	pct.	pct.	ppm.	ppm.	ppm.	ppm.	ppm.	ppm.	ppm.
	ADA COUNTY												
23	LC—O—B—TF	18.63	0.42	0.96	0.61	0.10	0.12	0.62	10.8	12	520	32	39
25	A	28.63	.46	.93	0.79	.14	.12	.40	13.0	12*	170	13	46
24	O—C—A	18.06	.32	1.83	0.78	.20	.10	.60	9.0	14	720	13	30
29	Ranger A	20.63	.35	1.11	0.70	.24	.20	.38	11.4	12*	320	18	22
26	LC—B—O—TF	20.81	.43	1.25	0.82	.24	.12	.68	12.0	24	210	12	28
27	LC—B—O—TF	18.38	.46	—	0.62	—	.17	.61	10.0	32	190	30	42
28	LC—B—O—TF	17.56	.42	—	—	—	.17	.59	12.0	18	220	29	39
30	A	11.94	.18	.98	0.80	.12	.25	.40	7.2*	16	220	17	9
59	A	15.94	.22	1.34	1.34	.26	.30	.52	14.8	12*	240	19	6*
88	A	12.88	.25	1.05	0.98	.25	.12	.38	9.0	32	250	30	9
	BANNOCK COUNTY												
16	RC—O—B	—	—	—	—	—	.38	.62	10.8	32	800	36	20
17	RC—O—B	—	—	—	—	—	.38	.66	7.8	30	750	29	25
18	A	25.19	.40	—	1.24	—	.52	.55	12.0	30	150	30	42
19	A	23.13	.33	1.14	0.90	.93	.65	.59	7.2*	26	180	24	25
20	A	22.75	.27	1.21	0.92	.07	.73	.58	10.8	16	1040	18	20
21	A	22.06	.29	1.40	0.62	.36	.17	.50	10.8	28	160	20	6*
22	A—O—B	17.38	.20	1.70	0.68	.51	.17	.56	10.8	26	160	30	4*
	BEAR LAKE COUNTY												
94	wild hay	18.75	.25	1.71	0.66	.48	.24	.50	9.0	32	260	36	3*
	BLAINE COUNTY												
65	A	12.75	.17	1.46	1.17	.10	.05	.68	6.0*	18	360	19	—
	BUTTE COUNTY												
61	A	16.88	.20	1.51	0.72	.23	.27	.72	11.4	18	325	10*	13
68	A	7.81	—	.96	—	.14	.05	.68	9.6	16	450	30	—
71	A	12.69	.13	1.98	0.82	.36	.06	.58	9.6	12*	260	36	5*
	CANYON COUNTY												
87	A	14.75	.24	1.45	0.78	.62	.12	.60	11.4	35	1440	36	8
86	A	17.00	.22	1.34	1.26	.24	.13	.68	10.7	32	600	33	5*
31	A	25.81	.27	.93	0.84	.30	.25	.56	5.7*	12*	310	33	11
32	A	22.69	.29	—	1.00	.25	.25	.68	9.0	16	350	29	2**
33	A	22.13	.24	1.34	0.60	.43	.17	.72	8.4	16	330	19	1**
34	A	23.25	.26	1.17	0.75	.27	.15	.59	11.4	12*	440	12	—
35	A	16.88	.22	.96	0.62	.16	.17	.52	12.0	14*	325	29	8
36	LC—RG—B—TF	18.81	.36	.93	0.82	.81	.17	.60	12.0	16	330	34	2**
40	bean leaves	—	—	—	—	—	—	.52	13.0	27	420	11	—
85	A	13.25	.25	1.01	1.15	.60	.12	.88	12.0	32	880	27	8
	CLARK COUNTY												
67	A	17.75	.33	.98	0.96	.68	.05	.68	7.8	14*	370	29	5*
39	A	22.81	.32	1.38	0.64	.17	.15	.38	12.0	25	420	28	—
	CUSTER COUNTY												
44	B—A	15.88	.23	1.85	0.78	.09	.24	.48	13.9	26	210	13	10
45	B—AC—O—A	16.19	.28	—	1.02	—	.27	.88	12.0	26	200	21	—
46	B—AC—O—A	15.50	.21	.99	0.68	.40	.42	.67	15.0	26	120	39	10
	GOODING COUNTY												
52	A	16.75	.15	.99	1.42	.65	.35	.68	9.0	14*	320	25	—
53	A	15.25	.23	.69	0.78	.27	.33	.63	9.0	12*	310	34	5*
54	A	17.44	.16	1.51	0.85	.36	.39	.67	11.4	16	350	14	4*
55	A	27.81	.38	1.01	0.60	.12	.42	.32	6.0*	12*	1200	18	7*
56	A	9.75	.26	1.12	1.02	.20	.24	.50	13.2	12*	360	30	7*
58	O	11.31	.25	1.45	1.14	.12	.25	.60	13.2	12	800	36	22
57	A	15.13	.33	1.06	0.81	.58	.25	.60	9.6	14*	1280	18	22
89	A	9.18	.21	1.17	1.26	.17	.12	.50	9.6	28	600	12	2**
90	A	8.31	.32	1.65	0.62	.17	.08	.39	1.8**	32	590	23	1**
91	A	14.56	.15	1.37	0.67	.09	.14	.36	1.2**	32	600	19	—
92	A	11.25	.16	.93	0.45	.10	.06	.48	1.4**	35	280	27	3*
93	A	6.88	.24	1.84	0.62	.07	.05	.48	12.0	30	150	36	4*

TABLE 2.—CHEMICAL ANALYSES (Cont.)

Sample No.	County and Sample	Protein	Phos-phorus	Potassium	Calcium	Sodium	Cobalt	Molyb-denum	Copper	Boron	Iron	Mangan-ese	Zinc
		pct.	pct.	pct.	pct.	pct.	ppm.	ppm.	ppm.	ppm.	ppm.	ppm.	ppm.
	JEFFERSON COUNTY												
	A	15.88	.20	—	—	—	.12	.36	5.1*	26	460	30	3*
	A	20.88	.23	—	—	—	.17	.65	11.4	24	440	12	8
	LATAH COUNTY												
47	A	13.25	.30	—	1.74	—	.30	.66	2.1*	28	190	36	33
50	A	13.75	.33	1.84	0.76	.38	.39	.68	9.6	25	220	30	5*
48	A	9.31	.27	—	2.32	—	.30	.67	6.0*	32	220	39	48
41	A	14.56	.26	.98	0.60	.06	.25	.41	2.1*	24	410	36	33
49	A	14.81	.28	—	2.00	—	.36	.68	3.0*	30	240	23	48
42	A	9.50	.28	—	1.45	—	.29	.52	9.6	25	430	30	—
51	SB	8.10	.19	1.20	0.60	.07	.30	.30	2.1*	26	260	11	7*
43	SB	7.19	.25	—	0.70	—	.27	.36	5.7*	25	430	33	35
60	A	9.19	.26	1.38	1.00	.12	.27	.65	8.4	16	340	26	4*
62	A	8.50	.20	1.38	1.04	.09	—	.72	7.8	12*	340	17	6*
63	A	8.38	.18	1.12	0.99	.05	.23	.72	5.7*	12*	350	20	4*
64	A	7.81	.17	1.15	0.85	.04	—	.72	1.5**	16	390	27	4*
70	A	5.44	.15	1.17	0.62	.19	.24	.72	12.0	12*	290	17	11
72	O—B	5.56	.17	1.45	0.80	.10	.26	.30	5.7*	12	310	26	4*
73	O—B—A	—	—	—	—	.29	.26	.62	3.0*	8	200	18	4*
74	A	6.63	.22	1.24	0.78	.22	.24	.52	11.4	12*	270	23	3*
75	B—A	6.50	.17	1.07	0.82	.10	.16	.52	6.0*	14	290	17	4*
76	B—O—A	7.81	.18	—	1.37	—	.17	.52	9.0	10	290	18	11
77	A	10.50	.28	1.34	1.05	.17	.18	.62	3.9*	10*	310	36	9
78	A	8.88	.19	1.23	1.08	.14	.15	.62	9.6	12*	340	17	6*
79	B—A	7.25	.19	1.34	1.04	.09	.10	.76	3.9*	16	320	27	5*
80	A	6.31	.17	.98	0.90	.09	.34	.76	1.0**	12*	400	17	14
81	A	7.25	.22	1.42	0.92	—	—	.76	2.7*	16	510	29	25
82	A	16.00	.28	.99	0.84	.16	—	.76	8.4	16	390	13	9
83	A	12.94	.25	.98	0.98	.07	—	.52	9.0	16	750	14	15
84	A	7.88	.21	.85	0.90	.18	.19	.38	13.2	16	760	20	5*
	OWYHEE COUNTY												
69	G—A	8.13	.14	.98	0.84	.07	.24	.36	3.6*	24	310	19	9
	PAYETTE COUNTY												
1	A	16.63	.24	.98	1.34	.07	.17	.48	7.2*	16	400	30	2**
2	RC	12.38	.24	1.10	1.21	.09	.15	.68	7.8	16	460	15	7*
3	O—Bl—AF	19.75	.35	1.08	1.23	.19	.17	.68	12.0	16	400	27	14
4	O—Bl—AF	17.00	.35	1.21	1.26	.20	—	.76	9.0	12	460	25	3*
12	LC—B—O—AF	21.56	.33	1.24	1.32	.21	.15	.60	5.4*	16	510	21	17
13	LC—B—O—AF	16.19	.32	1.07	1.59	.20	.25	.65	10.8	18	550	15	33
7	LC—B—O—AF	16.44	.36	1.11	1.56	.16	.15	.61	9.6	12	500	22	42
8	LC—B—O—AF	15.69	.35	1.19	1.22	.07	.17	.60	12.0	16	1440	15	16
9	LC—B—O—AF	18.19	.42	—	—	—	.17	.56	9.0	18	650	13	54
10	A	23.13	.44	—	—	—	.17	.36	8.4	18	540	15	39
11	A	17.00	.39	—	—	—	.17	.76	6.0*	18	510	17	46
5	A	16.75	.24	.99	1.18	.15	.17	.68	9.0	8**	1440	27	6*
6	A	15.06	.24	1.23	1.62	.35	.17	.60	5.7*	10*	460	29	4*
14	LC—B—O—AF	16.88	.38	1.24	1.30	.21	.25	.68	12.0	16	520	12	17
15	CW	12.13	.32	1.07	0.60	—	.38	.62	14.0	16	340	27	35
	WASHINGTON COUNTY												
66	A	9.31	.12	1.12	0.94	.27	.11	.52	7.8	12*	320	30	—

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