Variations in Chemical Composition of Bluebunch Wheatgrass, Arrowleaf Balsamroot, and Associated Range Plants

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BLUEBUNCH wheatgrass (*Agropyron spicatum*) and arrowleaf balsamroot (*Balsamorhiza sagittata*) are widely distributed throughout the West, being especially abundant on many sagebrush-grass ranges which are commonly grazed in spring and fall. On such ranges in good condition on the upper Snake River Plains, herbage production of these two species may be approximately half of the grass and forb total (Mueggler, 1950). Since both are palatable to livestock, they furnish a high proportion of the diet of grazing animals. Knowledge of chemical composition of these species, then, should be useful in evaluating the quality and quantity of nutrients and in the development of sound management practices. Although chemical analysis does not directly measure nutritive value, the close relation between digestibility and chemical composition (Forbes and Garrigus, 1947; Morrison, 1937; Sotola, 1940) indicates that composition is a good index of nutritive value.

This paper describes seasonal variations of wheatgrass and balsamroot over a 4-year period and includes similar information on some associated species: Sandberg bluegrass (*Poa secunda*), hawksbeard (*Crepis acuminata*), threetip sagebrush (*Artemisia tripartita*), and bitterbrush (*Purshia tridentata*). These additional species were selected because of their abundance and their wide range in phenological development.

Review of Literature

Stoddart (1946) reported a decrease in crude protein and phosphorus and an increase in lignin of bluebunch wheatgrass as the herbage matured. McCall (1940) found mature bluebunch wheatgrass low in crude protein and fat and high in crude fiber and concluded that this grass had been over-rated as fall sheep feed. Analysis of arrowleaf balsamroot herbage was reported by McCreary (1931), but seasonal trends in chemical composition were not studied. Stoddart and Greaves (1942) made analyses of bitterbrush on Utah summer range and found it to be high in fat and nitrogen-free extract as compared to grasses and forbs and showing much less seasonal variation in chemical composition.

Investigators of other range plants generally found wide seasonal variation and concluded that stage of maturity is the most important factor causing variation in chemical composition (Cook and Harris, 1950; Hart, *et al.*, 1932; Stanley and Hodgson, 1938; Watkins, 1943). These studies show that grasses and forbs usually vary from protein-rich feeds in early growth stages to rather poor roughages at maturity, whereas shrubs have a much smaller seasonal fluctuation. Nutrients in matured herbage of grasses and forbs are further decreased by leaching (Guilbert, *et al.*, 1931; Hart, *et al.*, 1932).

Methods

Herbage collections were made at the U. S. Sheep Experiment Station near Dubois, Idaho. (Herbage is defined as all nonwoody, aerial portions of plants.) This semiarid area has an elevation of about 5,500 feet and is typical of much of the sagebrush-grass range of the upper Snake River Plains. The fine sandy loam soil, basaltic in origin, varies in depth from a few inches to several feet. The frost-free period averages 120 days, and the average annual precipitation is 10.8 inches. Summers are dry and soil moisture generally falls below the wilting coefficient in late June.

Bluebunch wheatgrass and arrowleaf balsamroot were collected from an 80-acre ungrazed area over a 4-year period, 1937–40. Collections were made each spring at five dates spaced at 15-day intervals, beginning on the date that wheatgrass averaged two inches in height (about April 25). In addition a single fall collection was made each year about November 1. The spring collections, therefore, coincided with the normal spring grazing period; and the fall collection, with the middle of the fall grazing season. Careful phenological records were kept throughout the period of the study.

Plants for clipping were located along six belt transects placed at random within the 80-acre enclosure, 120 plants of each species being staked along each transect. Twenty in each transect were clipped at each date to a height of one inch above the ground level, placed in paper sacks, and air dried. This system provided herbage collections at each date from a new series of previously unharvested plants.

Samples were analyzed by the Agricultural Chemistry Department of the University of Idaho according to procedures recommended by the Association of Official Agricultural Chemists (1935). In 1937 each sample constituting a 20-plant series was analyzed for crude protein, calcium, and phosphorus. Since statistical analysis showed no significant variation in chemical composition between collections on the six transects for each date, subsequent analyses of crude fat, crude fiber, and nitrogen-free extract were made from a composite sample of the six transects. This latter procedure was followed for samples collected in following years. Associated species were also collected and analyzed for crude protein, calcium, and phosphorus.

Growth and Chemical Composition

Wheatgrass and Balsamroot

During the 4-year period in which collections were made, the study area was free of snow by about April 1; growth of bluebunch wheatgrass and arrowleaf balsamroot began about 10 and 20 days later, respectively (Table 1). Flower stalks of balsamroot appeared within a few days after growth began and the plants finished blooming about a month afterwards (June 1), whereas development of flower stalks of wheatgrass was more than two weeks later. Seed of balsamroot ripened by mid-June and was disseminated a week later, but seed of wheatgrass was not ripe until late June and was not disseminated until late July, several weeks after the last spring herbage collection. Balsamroot reached its production peak early in June and then declined slightly as a result of seed dissemination and shattering of leaves; however, growth of wheatgrass continued until the latter part of June.

As the plants matured, the percentage of crude protein and phosphorus decreased rapidly, whereas that of nitrogen-free extract and crude fiber increased (Table 2). The proportion of crude fat in wheatgrass remained constant or made slight increases, but in balsamroot it de-

TABLE 1

Developmental stages of bluebunch wheatgrass, arrowleaf balsamroot, and four associated species

STAGE	BLUEBUNCH WHEATGRASS (average 1937–40)	ARROWLEAF BALSAMROOT (average 1937–40)	SANDBERG BLUEGRASS (1942)	HAWKSBEARD (1942)	BITTERBRUSH (average 1941–45)	SAGEBRUSH (average 1941–45)
Leaf growth started	Apr. 11	Apr. 19	—	Apr. 11	Apr. 21	Apr. 21
Twig growth started	—	—	—	—	June 15	May 17
Flower stalks appear	May 16	Apr. 28	May 2	May 18	—	—
Flower buds appear	—	—	—	—	May 13	June 14
Heads showing	May 28	—	May 11	—	—	—
Heads fully out	June 6	—	May 22	—	—	—
First bloom	—	May 14	—	June 26	June 1	Sept. 5
Full bloom	June 18	May 24	June 16	July 6	June 15	Sept. 18
Blooming over	—	June 1	—	July 12	June 23	Sept. 29
Seed ripe	June 28	June 14	June 28	July 12	July 19	Oct. 14
Seed disseminated	July 21	June 20	July 9	—	Aug. 3	—
Leaves drying	June 7	June 15	May 24	July 3	Aug. 10	—
Plant dried	—	July 24	July 4	July 20	—	—

TABLE 2

Dry weight and percentage chemical composition of bluebunch wheatgrass and arrowleaf balsamroot at various dates (averages for 20 plants, 1937–40)

CLIPPING DATE	DRY WEIGHT	CRUDE PROTEIN	CRUDE FAT	NITROGEN FREE EXTRACT	CRUDE FIBER	CALCIUM	PHOS-PHORUS	Ca/P RATIO
Wheatgrass								
	Grams	*Percent*						
1937								
Apr. 26	6.1	28.0	1.6	38.0	17.4	0.45	0.36	1.2
May 10	19.5	24.7	1.2	37.2	21.9	.42	.29	1.4
May 25	59.0	15.9	1.6	40.4	26.7	.42	.20	2.1
June 10	58.2	12.5	2.0	40.1	27.7	.45	.16	2.8
June 28	71.3	9.1	2.6	43.6	28.5	.58	.10	5.8
Nov. 1	—	3.5	1.5	42.6	32.5	.39	.04	9.8
1938								
Apr. 27	6.0	28.4	1.6	32.1	21.2	.45	.35	1.3
May 13	34.0	21.1	1.5	38.0	23.1	.41	.29	1.4
May 27	51.0	16.0	1.5	38.6	26.9	.41	.21	2.0
June 13	84.0	10.6	1.8	43.6	28.5	.46	.16	2.9
June 28	90.0	8.0	2.2	43.9	29.8	.58	.10	5.8
Nov. 22	—	2.5	2.6	—	34.1	.44	.04	11.0
1939								
Apr. 26	11.0	23.3	1.4	36.4	22.1	.47	.37	1.3
May 11	33.0	18.6	2.1	37.0	24.0	.54	.24	2.2
May 25	47.0	13.4	2.0	40.4	28.0	.45	.19	2.4
June 10	62.0	9.2	2.6	45.7	29.5	.47	.13	3.6
June 26	55.0	6.9	2.6	44.4	31.6	.56	.10	5.6
Nov. 1	—	3.0	1.5	44.3	31.1	.34	.03	11.3
1940								
Apr. 17	13.5	22.1	2.4	38.6	21.6	.44	.27	1.6
May 2	25.7	18.0	2.2	40.4	24.0	.49	.24	2.0
May 16	45.3	13.2	2.6	41.6	27.0	.43	.21	2.0
June 1	60.5	9.0	2.6	44.0	29.8	.41	.18	2.3
June 19	70.8	7.0	3.2	44.6	30.9	.46	.12	3.8
Nov. 1	—	5.9	1.3	—	37.8	.31	.07	4.4

TABLE 2—*Continued*

CLIPPING DATE	DRY WEIGHT	CRUDE PROTEIN	CRUDE FAT	NITROGEN FREE EXTRACT	CRUDE FIBER	CALCIUM	PHOSPHORUS	Ca/P RATIO
Balsamroot								
1937	*Grams*	*Percent*						
May 10	33.0	30.5	4.3	31.7	14.3	1.21	0.64	1.9
May 25	189.0	19.2	3.3	39.3	15.5	1.64	.29	5.7
June 10	255.0	13.9	2.4	42.0	19.1	1.75	.17	10.3
June 28	244.3	9.6	2.1	46.0	20.2	2.21	.12	18.4
Nov. 1	—	3.1	1.2	40.6	30.4	2.04	.04	51.0
1938								
May 13	91.0	24.3	6.1	31.1	17.0	1.33	.53	2.5
May 27	262.7	16.6	4.7	37.0	20.1	1.39	.19	7.3
June 13	302.0	11.8	3.0	39.2	24.1	1.76	.16	11.0
June 28	261.8	8.2	2.5	40.9	24.5	1.98	.11	18.0
Nov. 22	—	4.0	1.2	38.7	28.0	2.02	.08	25.2
1939								
Apr. 26	3.0	28.9	6.4	32.1	14.7	0.88	.56	1.6
May 11	127.0	20.4	4.6	37.5	15.7	1.94	.38	5.1
May 25	236.0	15.1	3.5	41.4	17.0	1.96	.29	6.8
June 10	287.0	11.5	3.0	46.3	18.0	2.16	.20	10.8
June 26	246.0	8.3	3.0	48.2	19.6	2.32	.14	16.6
Nov. 1	—	3.8	1.6	38.0	29.0	2.40	.06	40.0
1940								
Apr. 17	3.2	31.4	3.4	34.5	14.9	0.64	.41	1.6
May 2	56.3	23.9	5.5	37.4	14.0	1.56	.45	3.5
May 16	145.5	17.0	3.9	40.8	16.0	2.18	.24	6.4
June 1	226.9	12.2	2.6	44.6	20.6	2.18	.24	9.1
June 19	185.5	8.6	3.1	47.1	19.1	2.44	.19	12.8
Nov. 1	—	3.5	1.1	39.7	33.2	1.73	.07	24.7

creased markedly with maturity. Percentage calcium also remained fairly constant in wheatgrass, but increased considerably in balsamroot. The increase in calcium-phosphorus ratio in wheatgrass, then, was caused mostly by decrease in phosphorus, whereas the greater increase of this ratio in balsamroot was caused by both increase in calcium and decrease in phosphorus. The low content of crude protein and phosphorus and wide calcium-phosphorus ratio were the most striking features of the fall herbage collections.

There was considerable annual variation in flowering of both wheatgrass and balsamroot. Wheatgrass produced 5.8, 11.8, 28.3, and 13.4 flower stalks per plant during the 4 years, 1937–40; corresponding flower stalk production of balsamroot was 0.6, 14.8, 0, and 0.6. Despite these annual variations in flower stalk production and in herbage yield (Table 2), chemical composition and seasonal trends were similar in each of the 4 years. Apparently both reproductive activity and yield were more sensitive to variations in weather than was chemical composition.

Associated Species

Growth stages of associated plants for the years in which collections were made are shown in Table 1. Since plant development records were not kept for shrubs between 1937 and 1940, the averages for the 1941–45 period are listed for bitterbrush and sagebrush. As sometimes happens with bluebunch wheatgrass, Sandberg bluegrass began growth in the fall and remained green under the snow during the winter. It was about two weeks ahead of wheatgrass in reaching most of the early stages, but it bloomed and ripened seed at about the same date. Hawksbeard began growth earlier than balsamroot, but all other stages were reached at a much later date. Leaf growth of both shrubs started during the latter part of April, but most of the other stages varied widely, generally occurring much earlier in bitterbrush than sagebrush.

As with wheatgrass and balsamroot, the percentage of crude protein was initially high in all species and decreased as the growing season advanced (Table 3). In bluegrass the proportion of calcium remained fairly constant throughout the spring growing season whereas phosphorus decreased; in hawksbeard both calcium and phosphorus increased as the season advanced. Trends in calcium and phosphorus content of the shrubs were more variable, but in general calcium content remained constant, and phosphorus decreased as the season advanced.

TABLE 3

Crude protein, calcium, and phosphorus content at various dates of four species associated with bluebunch wheatgrass and arrowleaf balsamroot

SPECIES	YEAR	DATE OF CLIPPING	CRUDE PROTEIN	CALCIUM	PHOS-PHORUS	Ca/P RATIO
			Percent			
Hawksbeard	1942	Apr. 30	18.8	0.93	0.39	2.4
		May 6	18.2	.87	.23	3.8
		May 15	16.0	1.15	.30	3.8
		May 27	12.6	1.76	.46	3.8
		June 4	12.1	1.85	.48	3.9
		June 29	6.6	2.23	.56	4.0
Sandberg bluegrass	1942	Apr. 24	18.3	.43	.36	1.2
		May 8	15.6	.38	.23	1.7
		May 18	12.6	.45	.24	1.9
		May 28	9.9	.45	.17	2.6
		June 3	8.9	.44	.19	2.3
		June 16	6.0	.45	.17	2.6
		June 29	5.6	.40	.11	3.6
Bitterbrush	1940	May 23	15.9	.97	.16	6.1
		June 11	14.7	1.04	.20	5.2
		July 18	12.1	1.30	.12	10.8
		Oct. 27	9.6	1.49	.11	13.5
Threetip sagebrush	1937	May 11	16.3	.80	.15	5.3
		May 19	16.0	.78	.23	3.4
		May 27	16.5	.83	.24	3.5
		June 4	12.2	.64	.18	3.6
		June 11	13.7	.88	.29	3.0
		June 19	11.7	.76	.19	4.0
		June 27	10.0	.82	.17	4.8
		Nov. 1	7.0	.49	.11	4.5

Discussion

Despite decreases in percentage composition in some cases, total quantities of the various constituents of wheatgrass and balsamroot increased as the season advanced as a result of increase in amount of herbage. However, at about the middle of the growing season, with a decrease in rate of growth, there was a reduction in total protein and phosphorus. Since an examination of plant yield and development records indicates that only a minor part of these losses can be explained by such factors as seed dissemination and leaf shattering, reductions in total protein and phosphorus are probably the result of their transfer to the root system. Subsequent reductions in these and other constituents between late spring and fall may have been caused in part by transfer to the roots or by seed dissemination in the case of wheatgrass, but as previously mentioned, leaching may have been responsible for much of this loss.

Apparently chemical composition is not closely associated with reproductive activity. Although there was wide variation in flower stalk production during the 4-year period, this variation was not reflected in the chemical composition. Furthermore, seasonal changes in chemical composition of wheatgrass and balsamroot in any one year appear to be more closely correlated with number of days after starting growth than with stage of reproductive development.

Absence of a close relation between chemical composition and reproductive activity is also shown by a comparison of seasonal trends. Although there is a wide variation in dates of relative developmental stages between hawksbeard and balsamroot and between bitterbrush and sagebrush, the trends in chemical composition are similar. It seems, then, that changes in composition follow a fairly constant pattern through the growing season independent of reproductive processes.

Although data are available for only a few species, certain differences in chemical composition of grasses, forbs, and shrubs are indicated. On the basis of these data, percentage protein in grasses and forbs is high at the start of the growing season, but decreases rapidly as the herbage matures and is low by fall. The protein content of shrubs, however, is much lower at the beginning of the season, but it decreases slowly and is considerably higher than that of the grasses and forbs in the fall. Percentage calcium appears high in forbs, intermediate in shrubs, and low in grasses. In grasses and shrubs percentage of calcium is fairly constant throughout the season, but in forbs it increases as the season advances. There is a noticeable drop in calcium content of wheatgrass between late June and fall, probably as a result of leaching, but forbs are not similarly affected. In general, the proportion of phosphorus is higher in forbs and grasses than in shrubs; however, it decreases rapidly and is low by fall whereas it maintains a more constant level in shrubs.

During the spring grazing season, the high protein, phosphorus, and fat content of wheatgrass and balsamroot and the low proportion of crude fiber indicates that ranges supporting these and other grasses and forbs supply a good diet for livestock. Furthermore, the narrow calcium-phosphorus ratio is well suited to livestock requirements (Maynard, 1947; Morrison, 1937). In the fall, however, the same forage is but a poor roughage, low in protein, phosphorus, and fat and considerably higher in crude fiber with a wide calcium-phosphorus ratio. Although both protein and phosphorus content of mature grasses and forbs during the fall season are much too low to supply minimum requirements of grazing animals (National Research Council, 1949), the presence of shrubs on these ranges at least helps to correct the deficiencies. Shrubs may not be eaten in sufficient quantities to provide an optimum diet, but even the relatively unpalatable sagebrush is utilized to some extent, especially in late fall. Although serious nutritional deficiencies are not apparent on these sagebrush-grass fall ranges, supplemental fall feeding may be a desirable practice, particularly on ranges which support only a few palatable shrubs.

Summary and Conclusions

Chemical composition of bluebunch wheatgrass, arrowleaf balsamroot, and associated species was studied on sagebrush-grass range on the upper Snake River Plains.

As wheatgrass and balsamroot matured, the percentage of crude protein and phosphorus decreased rapidly, whereas that of nitrogen-free extract and crude fiber increased. The percentage of crude fat in the wheatgrass remained about constant, but in balsamroot it decreased markedly with maturity. The proportion of calcium also remained fairly constant in wheatgrass, but increased considerably in balsamroot. The low content of protein and phosphorus and the wide calcium-phosphorus ratio were the most striking features of the fall herbage collections.

With the exception of increase in phosphorus percentage in hawksbeard as the season advanced, trends in chemical composition of hawksbeard and bluegrass were similar to balsamroot and wheatgrass, respectively. Trends in composition of shrubs were more variable, but seasonal fluctuation was much less than for the grasses and forbs.

From the results of this study the following conclusions were drawn:

1. Loss in total quantity of protein and phosphorus from herbage during the growing season appears to be mostly a result of their transfer to the roots; seed dissemination and shattering are of minor importance. Subsequent losses in the matured herbage are probably caused largely by leaching.

2. Although annual variations in weather influence yield and flower stalk production, they apparently have little effect on chemical composition of herbage.

3. Chemical composition of herbage seems little affected by flower stalk production, and trends in composition follow a fairly constant pattern through the growing season independent of reproductive activity.

4. Forbs and grasses show a much wider seasonal fluctuation in composition than shrubs, and although they provide superior forage in the spring, shrubs supply a better fall diet. Therefore, maintenance of such palatable shrubs as bitterbrush is an important consideration in the management of spring-fall ranges.

5. Supplemental fall feeding may be desirable on sagebrush-grass ranges.

Acknowledgments

The authors wish to acknowledge the initiation of the study by J. F. Pechanec, George Stewart, D. W. Bolin, and W. M. Beeson.

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DDT WILL NOT HARM SOIL

The soil is not harmed by DDT in ordinary doses when used to kill crop insects, declares Harold Gunderson, Extension entomologist, Iowa State College. Heat and light break down DDT so very little of it would be plowed into the soil. If the soil is well supplied with organic matter DDT breakdown is hastened. Tests run so far indicate no injury to corn, soybeans, alfalfa and clover, from large amounts of DDT, Gunderson reports.—*Capper's Farmer*.