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Study of Composition of Missouri Grown Roughages

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W. H. Cloninger and H. A. Herman

ABSTRACT

A study was made of the chemical composition and quality of roughages utilized in feeding dairy cattle in major farming areas of Missouri. During the period 1950-51-52, inclusively, 215 different samples of dried roughages and 29 samples of ensilages grown by Missouri dairymen were collected and analyzed. The amount of annual rainfall, date of cutting, weather conditions at harvest time, and method of harvesting were a part of this study.

Each sample was analyzed for foreign matter, green color, leaf percentage, dry matter, crude protein, ether extract, crude fiber, lignin, nitrogen-free extract, ash and carotene. The ash was analyzed for calcium, phosphorus, potassium, manganese, iron, sulphur, chlorine, magnesium, copper, cobalt, zinc, boron and iodine.

The three year average leaf percentages were 52.5 for first cutting alfalfa, 51.9 for second cutting and 51.0 for third cutting alfalfa hay; 52.2 for first cuting and 61.2 for second cutting red clover hay; 68.0 for Korean lespedeza hay; 55.8 for soybean hay, and 78.9 for ladino clover hay. In general, samples with the highest leaf content had a higher percentage crude protein and ash content and a lower percentage of crude fiber.

The average carotene content of all hays was lower during the year of 1951 which was characterized by heavy rainfall. Korean lespedeza hay averaged 42.73 micrograms of carotene per gram for the three year period which was 3½ to 5½ times the average carotene level for all other hays.

The average percentage of ash and calcium was increased and the average percentage of P_2O_5 was decreased in second cutting alfalfa hay for the moisture deficient year 1952. Similar trends were found for the composition of red clover hay produced in 1952.

Timothy hay contained only 45 percent as much crude protein, 79 percent as much ash, 22 percent as much calcium and 68 percent as much P_2O_5 as first cutting alfalfa hay. It contained, however, 14 percent more crude fiber and 16 percent more nitrogen-free extract than first cutting alfalfa hay. Ladino clover hay was similar to third cutting alfalfa hay in composition.

When grown in combinations with alfalfa, bromegrass hay was found to contain only 35 percent as much calcium as first cutting alfalfa hay. Otherwise the two roughages were similar in composition.

Average crude protein content of alfalfa hay grown in Lawrence county was 20.9 percent; in Northwest and Northeast Ozark areas 17.6 percent; Morgan county 16.9 percent, and in the Southeast areas 15.9 percent. Average crude protein content of Korean lespedeza hay grown in the Ozark area was 13.8 percent, compared to 16.6 percent for that grown in Morgan county. Indications were found that there may be a relationship between low P_2O_5 and crude protein content in Korean lespedeza hay.

Korean lespedeza and red top hays had a lower chlorine content than other hays studied. Copper content of Missouri grown roughages was found to be adequate by all present standards for normal nutrition of livestock.

In general, roughages grown in the Ozark area, Lawrence and Jasper counties, had a higher cobalt content than those grown in Morgan county and Northwest and Northeast areas. Average cobalt content of alfalfa and soybean hay was found to be 0.10 p.p.m.; ladino and red clover 0.15 p.p.m.; K. lespedeza 0.17 p.p.m.; timothy 0.07 p.p.m.; bromegrass 0.045 p.p.m.; and red top hay 0.13 p.p.m.

Rainy weather during the harvest period reduced carotene content of alfalfa hay from 11.62 to 4.54 micrograms per gram, and from 15.31 to 3.92 micrograms per gram in red clover.

Field chopped hay had 5.5 percent less leaf content, 2.30 percent less crude protein, and 2.80 percent more crude fiber than loose hay. Stem crushed hay had a slightly higher leaf content and contained more carotene than baled hay.

Total digestible nutrients and phosphorus were found to be the most variable nutrients and the ones most likely to be deficient in an all roughage ration for high producing dairy cows.

Wide variations were found in composition of silages made from mixtures of legumes and grasses. Dry matter content of grass silage ranged from 19.2 to 55.0 percent.

The importance of cutting roughages before they are too mature and conservation of leaves during the harvesting and storage process is emphasized by this study.

PURPOSE OF INVESTIGATION

In order to meet the needs for human foods, and yet conserve our soil resources, the production of high quality forages for livestock utilization has become the basic program of American agriculture. Land not adapted to profitable tillage will produce effectively in a well managed grassland farming system. Crops that are not directly usable for human food can be profitably utilized by livestock, especially cattle and sheep, for the production of milk and meat which provide the chief portions of the diet.

It is the task of agriculture to produce enough food and fiber to feed and clothe the world. Ability of ruminants, in particular, to consume coarse fibers and convert them into edible products is of paramount economic importance in feeding man the world over.

The cost of producing a pound of digestible nutrients varies with its source. Hodgson (1949) presented data which show that it costs less to produce a pound of feed nutrients in the form of pasture and hay than in corn and other grains.

Scientific and intelligent livestock feeding and animal nutrition depend upon a knowledge of animal body needs, and the chemical compounds which make up plants and animals. A knowledge of the chemical composition of animals and their products, milk, eggs, etc., is necessary to understand their food requirements. Likewise, information on the substances found in plants (roughages) is necessary because they furnish most of the food utilized by livestock.

Due to advances in chemistry, physiology, and related sciences during the past few years, our knowledge of livestock nutrition and plant composition has been greatly increased. These newer findings, particularly those concerning vitamins, enzymes, and hormones, have replaced many of the theories and beliefs of the past. It is now fully recognized that not only must an animal have a generous quantity of feed, but the feed must have quality as it relates to digestible nutrients, available vitamins, minerals, etc.

Only where complete information regarding the composition of roughages and an appreciation of their quality exist can a scientific and economical job of feeding be done. The study to be reported herein is one of the most extensive to be conducted in Missouri on composition of roughages fed Missouri dairy cows. The possible value and application of such information is easily understood when attention is called to the fact that Missouri farmers have devoted approximately 11.0 million acres to pasture production and 3.4 million acres to the production of hay crops to feed 3.28 million dairy and beef cattle and 1.16 million sheep (1950 U. S. census of agriculture).

Morrison (1950) has compiled the average composition of most feeds in table form. His figures are widely used by students, teachers, and farmers. However, these are average composition figures. For roughages, they may not be applicable in all areas of this state. Variations in composition occur, as reported by Eckles and associates (1926) and Burke and associates (1927).

With quality and production of roughages having such an effect upon Missouri agriculture, and knowing that wide variations in quality and yield occur, it is surprising that this field has not been more fully investigated.

It is hoped that this investigation will furnish Missouri farmers with more complete information on the composition of Missouri grown roughages in order that more profitable and economical feeding of dairy cattle may result.

PREVIOUS WORK

History of Missouri Investigations. The first report on chemical analysis of Missouri grown roughage was made by Schweitzer (1889) in his report on *Green Versus Dry Storage of Fodder.* He reported composition of field corn dry fodder as follows: water 15.53 percent, ash 2.77 percent, crude protein 1.75 percent, ether extract 0.18 percent, crude fiber 17.31 percent, and carbohydrates 62.46 percent. Additional data on chemical composition of green sorghum, green sweet corn, green field corn, sweet corn silage and field corn silage were included in this report.

Most analyses of Missouri grown roughages have been made in connection with digestion and feeding trials conducted by the Dairy and Animal Husbandry Departments; by workers in the Field Crops Department; and by workers in the Soils Department of the Missouri Agriculture Experiment Station. The Department of Agricultural Chemistry has analyzed samples of feedstuffs in connection with investigations, and in filling requests of farmers and feeders. A report of their analyses of various feedstuffs was summarized by Haigh (1952).

Albrecht and associates (1951) reported the range in cobalt, copper, manganese and zinc content of three cuttings of alfalfa hay grown in Missouri. They were able to detect cobalt in only one sample of the hay. Copper content of this forage varied from 0.16 to 15.8 parts per million; the manganese from 27 to 193 parts per million; and the zinc from none to 15.5 parts per million. The chemical composition of various Missouri grown roughages, as reported by different investigators, is summarized in Table 1.

Factors Influencing Chemical Composition of Roughages

Ellis and Caldwell (1936) concluded from their work that mineral content of hays depends upon the soil, plant species, climate and seasonal variations, stage of maturity at which the crop is cut, conditions under which the crop is cured, and in some cases, the fertilizer treatments. Huffman (1939) and Herman (1944) after reviewing the subject concluded that chemical composition of roughages depended upon the botanical composition, stage of maturity at time of harvest, and type and fertility of soil, as well as climatic conditions.

Species or Botanical Composition. A good comparison of species differences is afforded by comparing the chemical analysis of alfalfa, red clover, and timothy.

Fagan (1928) found that an increase in the percent of legume in a legume-grass mixture increased protein and mineral content of hay, especially calcium content. Sprague and associates (1934) reported 35 percent white clover in a pasture mixture produced herbage with 20.59 percent protein

TABLE I--THE CHEMICAL COMPOSITION OF MISSOURI GROWN ROUGHAGES AS REPORTED BY INVESTIGATORS[a]

Kind	Dry Matter	Crude Protein	Crude Fiber	N-F-E	Ether Extract	Ash	Ca	P	Lignin	K	Caro-tene	Mg	No. Samples	Investigator
	%	%	%	%	%	%	%	%	%	%	μ/gm	%		
Alfalfa														
Av.		16.8						.31		2.23			2	Schweitzer (1892)
Av.	94.18	13.37	34.66	35.58	1.97	8.59							2	Eckles (1911)
Range		13-14	33-36	35-36	1.6-2.4	8.-9.0								
Av.	93.45	15.06	30.77	36.28	2.39	8.62							3	Eckles (1911a)
Range	91-95	14-16	29-33	35-38	2-3	8-9								
Av.	91.02	15.51	25.71	38.10	3.09	8.49							6	Eckles (1913)
Range	89-92	13-18	23-29	36-41	2-4	7-10								
Av.	90.59	14.41	29.21	36.52	2.56	7.86							2	Allison (1917)
Range	88-93	13-15	27-32	34-39	2-3	7.5-8								
Av.	92.91	14.81	36.31	32.58	1.64	7.56							2	Allison (1917a)
Range	92-93	13-16	35-37	30-35	1.6-1.7	7-8								
Av.	93.78	13.18	29.65	39.95	1.84	9.15							1	Trowbridge (1924)
Av.		15.81											5	Miller and associates (1929)
Range		11-20												
Av.	92.38	19.06	23.49		2.87	8.24	1.29	.37					1	Etheridge and associates (1930)
Av.		17.61	28.45	42.44	2.32	9.17			11.16				2	Swanson and Herman (1943)
Range		17-18	27-30	41-43	2.-2.5	9-9.5			11-11.5					
Av.									13.6		10.77		2	Stallcup and Herman (1950)
Range									11-14		8-13			
Av.	92.3	14.91	29.84	37.0	2.02	8.45	1.21	.24[b]					142	Haigh (1952)
Range	86-95	7-20	15-41	35-44	1-4	7-10	.8-1.4	.18-.29						

TABLE 1--CONTINUED

Kind	Dry Matter %	Crude Protein %	Crude Fiber %	N-F-E %	Ether Extract %	Ash %	Ca %	P %	Lignin %	K %	Caro-tene μ/gm	Mg. %	No. Samples	Investigator
Red Clover														
Av.		14.9						.26		2.19			2	Schweitzer (1892)
Av.	90.81	9.82	27.41	44.59	2.71	6.28							1	Allison (1917)
Av. Range									15.2 13-17		7.5 7-8		2	Stallcup and Herman (1950)
Av. Range	92.01 88-93	14.58 8-23	26.38 16-35	40.9 37-45	2.35 1-3	7.80 6-12	1.37 1.-1.7	.20 .09-.38		1.79		.36 .3-.4	66	Haigh (1952)
Ladino Clover														
Av.	93.6	19.2	17.8	39.9	1.6	15.1	1.17	.31	(Young Growth)				1	Haigh (1952)
K. Lespedeza														
Av.	92.86	16.19	25.97	40.0	3.27	7.43	1.23	.35					1	Etheridge and associates (1930)
Av. Range	100% Basis	14.49 12-17	31.92 30-37	46.32 41-50	2.91 2-4	5.07 4-6			18.63 16-23				7	Swanson and Herman (1943)
Av. Range		14.1 12-15							21.4 20-24				10	Albrecht and associates (1949)
Av. Range									16.7 15-18		44.0 40-51		3	Stallcup and Herman (1950)
Av. Range	92.89 89-94	13.64 10-18	26.53 22-29	43.00	2.36 2-6	7.36 5-10	.92 .67-1.09	.21 .15-.30		1.06		.23	69	Haigh (1952)
Prairie Hay														
Av.		3.9	31.1		1.8								1	Haigh (1952

TABLE 1--CONTINUED

Kind	Dry Matter	Crude Protein	Crude Fiber	N-F-E	Ether Extract	Ash	Ca	P	Lignin	K	Carotene	Mg.	No. Samples	Investigator
	%	%	%	%	%	%	%	%	%	%	μ/gm	%		
Soybean														
Av.		13.97											2	Miller and associates (1929)
Av.		17.63											12	Uhland (1930)
Range		15-22												
Av.		16.21			3.78				16.97				14	Turk (1932)
Range		14-20			2-5									
Av.		16.4					.49	.20		1.20		.37	16	Graham (1938)
Av.		13.7					.496	.24		1.54		.24	12	Ferguson and Albrecht (1941)
Range		7-20								.7-2.9				
Av.	92.53	15.80	27.61	36.14	3.67	9.30	1.24	.26					13	Haigh (1952)
Range		15-18	22-28	34-40	2-5	8-11	1.2-1-3	.24-.29						
Timothy														
Av.	86.81	5.86	30.45	43.86	1.66	4.98							1	Von Herff (1889)
Av.		7.17						.38		1.34			2	Schweitzer (1892)
Av.		5.87											30	Miller and Lovvorn (1933)
Range		5-7												
Av.	94.48	5.58	29.87	51.05	2.35	5.63	.17	.18		1.30			16	Haigh (1952)
Range	93-95	5-9	24-31	47-52	2-4	5-8	.15-.19	.16-.22		1.2-1.9				
Orchard Grass														
Av.	95.9	13.2	26.3	43.5	3.3	9.6	.43	.23					14	Haigh (1952)
Red Top														
Av.	95.9	12.3	25.0	46.2	2.7	9.5	.49	.22					14	Haigh (1952)

a - Range figures rounded to nearest whole number in most instances
b - average on 5 samples

content and that an increase from 5 to 25 percent clover in the mixture increased phosphorus content of the herbage 50 percent.

TABLE 2 -- CHEMICAL COMPOSITION OF DIFFERENT SPECIES OF HAY CROPS: MORRISON (1950)

Plant	Dry Matter Percent	Crude Protein Percent	Fat Percent	Crude Fiber Percent	N-F-E Percent	Ash Percent	Ca. Percent	P. Percent
Alfalfa	90.5	14.8	2.0	28.9	36.6	8.2	1.47	0.24
Red Clover	88.1	11.8	2.6	27.2	40.1	6.4	1.35	0.19
Timothy	89.0	6.5	2.4	30.2	45.0	4.9	0.23	0.20

Hilton, Hauge, and Wilber (1933) found that when timothy, alfalfa, and soybean hays were fed to cows, they produced butter with 11, 32, and 24 units of vitamin A per gram, respectively.

Different strains within a species appear to have different chemical compositions. Hopper and Nesbitt (1930) found marked differences in two strains of brome grass grown under the same experimental conditions. Strain A contained 7.14 percent ash, 6.56 percent crude protein, 32.72 precent crude fiber, 1.74 percent fat, and 36.8 percent nitrogen-free extract, compared to strain B containing 10.43 percent ash, 12.39 percent crude protein, 26.20 percent crude fiber, 2.10 percent fat and 33.8 percent nitrogen-free extract. Strain B also contained a higher percentage of phosphorus, potassium, calcium, magnesium and sulphur.

Pickett (1950) reported a difference in carotene and crude protein content in two strains of brome grass.

Thompson (1949) in a study of varieties and strains of alfalfa found Ladak had the highest carotene content and Turkistan the lowest. Strains varied from 235 to 301 micrograms of carotene per gram at harvest time. Tisdale and associates (1950) found two strains of alfalfa that were different in uptake of sulphur and nitrogen, and synthesis of methionine and cystine.

Effects of Stage of Maturity at Time of Harvest. Kellner (1879), Jordan (1882), and Wilson (1886) demonstrated that nitrogenous material and ash content are highest in early cuttings of timothy plants and decrease in the ripening stages. The reverse condition prevails with respect to nitrogen-free extract.

Richardson (1883) found that from June 19 to July 10 timothy ash declined from 8.58 to 5.63 percent, fat declined from 6.10 to 3.72 percent, nitrogen-free extract increased from 47.22 to 55.39 percent, and crude fiber increased from 23.95 to 27.08 percent. Ladd (1888) analyzed the timothy plant at four stages of maturity. He reported an increase in sugar and starch after blooming and a rapid decrease in moisture.

Schweitzer (1889a) studied composition of the whole corn plant at successive periods of growth from early June through September. He found that dry matter increased from 13.91 to 23.41 percent, and carbohydrates from 43.33 to 67.27 percent; while ash decreased from 8.46 to 3.88 percent, fat from 3.39 to 1.03 percent, and crude protein from 25.0 to 8.89 percent. Crude fiber increased from 19.82 percent on June 11 to 32.12 percent on July 16, then decreased to 24.28 percent on August 27. Analysis on September 10 showed the leaves contained 13.24 percent ash and 10.56 percent crude protein, while the stalks contained only 3.21 percent ash and 4.75 percent crude protein.

Morse (1890) cut timothy grass at weekly intervals during June and July to study changes in chemical composition associated with maturity. He found a steady decrease in moisture and increase in dry matter content with maturity. Ash was more abundant during the rapid growth of the plant than after growth had ceased. Ether extract decreased until blooming, then increased until the seed began to form. From this point, it again decreased, reaching a low mark as the seed began to harden. Crude fiber increased steadily until the formation of seed, after which there was a slight decrease. Nitrogen-free extract remained nearly constant after the grass reached its full height. Crude protein declined steadily with the growth of the plant, although it remained nearly constant after blooming. Timothy yielded the highest amount of digestible matter when cut at the beginning bloom stage. These results were later confirmed by P. F. Trowbridge and associates (1915), Dustman and Van Landingham (1930) and Hopper and Nesbitt (1930).

Crozier (1879) and Ellett and Carrier (1915) determined chemical composition of grass when cut at the grazing stage. Crude fiber varied from 18.2 to 41.2 percent and crude protein from 12.4 to 21.9 percent on a dry matter basis.

Mortimer and Ahlgren (1936) studied chemical composition of bluegrass cut every two weeks (when 4 to 5 inches tall) throughout the growing season with and without fertilizers. Crude protein content of the grass averaged approximately 20 percent on a dry matter basis. In uncut control areas the nitrogen content of herbage decreased as plants approached maturity.

Peters (1900) and Fagan (1928) observed similar changes of composition with maturity in bluegrass and rye.

Woodman and associates (1928) and (1929) studied chemical composition of pasture grasses cut every two weeks. Crude protein varied from 21.3 to 27.9 percent, ether extract from 5.79 to 5.87 percent, crude fiber from 16.6 to 12.9 percent, nitrogen-free extract from 47.6 to 42.7 percent, ash from 10.5 to 8.6 percent, CaO from 1.56 to 1.29 percent, and P_2O_5 from 1.15 to 1.03 percent in the dry matter.

The fact that grasses have a higher protein and mineral content and a lower crude fiber content at the young growth stage than at the more mature stages was confirmed by Woodman, Norman and French (1931); Woodman and Norman (1932); Patterson (1933); and Capen and LeClerc

(1933). Similar results were reported for cereal grasses by Sotola (1937).

In studying the total sulphur and sulfate sulphur in pasture grasses, Woodman and Evans (1933) found that both total sulphur and sulfate sulphur decreased as the time between clippings increased from weekly to fortnightly to monthly intervals.

Hunt and associates (1936) studied content of vitamins B_1 and G in hay and pasture grasses. Vitamin G content in alfalfa declined from 10 to 12 units per gram on May 31 to 6.6 units per gram on July 28. In timothy it was 6.6 units per gram on June 12 and only 2.5 units per gram on July 13. The B_1 content of timothy declined from 0.8 units to 0.5 units per gram between June 12 and July 13.

From June 16 to July 19 Hibbs and Evans (1950) observed a decline from 147 to 29.4 micrograms of carotene per gram in timothy.

Studying seasonal variation in tannin content of *Lespedeza sericea* Clark and associates (1939) found the total tannin increased in leaves from 7.5 to 18.0 percent and in stems from 1.0 to 1.6 percent between May 7 and July 31.

Phillips and Goss (1935) determined composition of the barley plant, cut at weekly intervals, on a dry matter basis. After an initial increase, the percent of ash and crude protein declined steadily with maturity. Percentages of cellulose and pentosans increased rapidly, then levelled off after about the tenth week. Lignin percentage increased as the plant matured. Lignin in mature plants was different from that found in younger ones. As plants matured there was a rapid methylation of hydroxyl groups until 75 to 80 percent of the firmly bound methoxyl groups were found in the lignin.

Swanson and Herman (1943) studied the composition and digestion coefficients of intermediate and late cut lespedeza hay. They found the following composition in leaves and stems:

Component	Percent in Stems	Percent in Leaves
Lignin	17.60	23.43
Crude Protein	7.60	19.10
Ether Extract	1.56	4.11
Mineral Matter	3.37	7.44
Crude Fiber	45.30	22.02

The chemical composition of alfalfa when 6.5 inches tall, 18 inches tall, in full bloom, and in leaf withering stages was determined by Widtsoe (1897). When the first cutting was 6.5 inches tall, the protein, ash and fiber contents were 28.0, 12.25 and 12.35 percent, respectively. At the full bloom stage, these values had changed to 12.99, 8.04 and 36.77 percent. Similar results were obtained from second and third cuttings.

Widtsoe also studied composition of leaves and stems. At the full bloom stage, he found that leaves made up 33.9 percent, stems 59.85 percent, and flowers 6.25 percent of the dry matter. Leaves contained 20.40, 11.50 and 15.93 percent, respectively, of protein, ash, and fiber. These values for the stems were 8.75, 5.93, and 50.75 percent.

Widtsoe (1897) observed the following changes in composition of the alfalfa plant as it matured:

1. Total dry matter increased until the death of the plant.
2. The greatest dry matter gain occurred between budding and medium bloom. After late bloom dry matter gains were insignificant.
3. Nitrogen-free extract increased in total quantity to the death of the plant.
4. Crude fiber increased in total quantity and in proportion to other constituents through the life of the plant. It formed most rapidly during the flowering period.
5. Albuminoids increased to the first week of bloom, from blooming on there was a decrease. The proportion of albuminoids was highest in young plants and decreased as plants grew older.
6. Non-albuminoids, at the time of budding, were rapidly converted to albuminoids.
7. The crop did not lose beef producing power as plants passed from budding to first full flower stage.
8. To obtain the greatest yield of dry matter, the crop should not be cut before early bloom or later than the first week of the early bloom stage.
9. Period for period and pound for pound the three cuttings had about the same food value. The second cutting had slightly less value.
10. Bloom appeared when there was 50 to 60 percent stem and 40 to 50 percent leaf content.
11. At cutting time, leaves contained two-thirds, or more, of the total dry matter.
12. Leaves had one-third to one-fourth as much crude fiber as the stems.
13. Leaves carried two to three times as much albuminoid as the stems.

These results and conclusions have been confirmed by work of Kiesselback and Anderson (1926), Salmon and associates (1925), Sotola (1927) and Green (1934).

Baltzer and associates (1942) investigated changes in carotene content of alfalfa associated with growth and maturity of the plant. They found a gradual decline in carotene content from 432 micrograms per gram, when plants were only five inches tall, to 150 micrograms per gram of dry matter at the early bloom stage.

Thompson (1949) studied carotene content of alfalfa at different hours of the day. He found carotene content to be the highest at 4:15 a.m. It decreased 18 percent by 10:00 o'clock and remained at about that level for the remainder of the day.

Boyd and associates (1938) reported prussic acid content of sudan grass to be highest in young plants. Martin and associates (1938) studied hydrocyanic acid content of different parts of the sorghum plant. Leaves and suckers contained 3 to 25 times more HCN than the stalks.

Uhland (1930) studied changes in protein content of soybeans at different stages of growth and pounds of protein produced per acre. He observed a gradual decline in protein content as plants grew to maturity.

Hilton and associates (1931) found that relatively late cut soybean hay produced greater yield of dry matter, milk, and butterfat per acre.

Turk (1932) studied composition of soybean plants at various growth stages. He found a gradual decline in nitrogen and ether extract until the last month of growth, involving seed development, when both the nitrogen and ether extract content increased. Cellulose, pentosans and lignin showed gradual increases with plant maturity.

Relation of Soil and Fertilizer to Composition of Roughage. Plants are materially affected by the mixture or make-up of the soil on which they grow. Literature on this subject is voluminous. There are certain soil and pasture areas that are known to produce nutritional disorders because of mineral deficiencies; in some cases, toxic elements are present. Midgley (1937) pointed out that lack of minerals, such as calcium and phosphorus in herbage, are perhaps most common. When phosphrous content of dry matter in pasture grasses and hay was less than 0.12 percent there was an acute effect upon appetite, growth, production, and reproduction in cattle and sheep. Goiter is prevalent in areas where iodine content of the soil and plants is low. An excess of fluorine may produce tooth disorders and some soil may produce vegetation carrying lethal doses of selenium. Anemia was found in cattle on some soil types which produce roughage with insufficient amounts of copper and iron, Midgley (1937), and manganese, Evans and Purvis (1948).

Forbes and associates (1910) observed that naturally rich soils produced bluegrass which was high in mineral elements. In comparing the composition of bluegrass grown on Kentucky and Ohio soils and harvested at the same stages of growth, the ash content varied between 4.80 and 8.66 percent, calcium between 0.135 and 0.424 percent, potassium between 1.41 and 2.85 percent, and phosphorus between 0.164 and 0.403 percent.

Eckles and associates (1926) found the phosphorus content of alfalfa and prairie hay was affected by soil and the amount of rainfall during the growing season. The bone-eating habit in cattle was traced by Burke and associates (1927) to phosphorus deficiency in grasses and hay and was found to be confined largely to swampy areas. Such grasses were shown to be lower in phosphorus than those grown on upland.

Miller and Lovvorn (1933) reported the three-year average protein content of timothy hay from four unfertilized check plots, representing three soils types, as follows: Marshall silt loam 6.07, Putnam silt loam 5.80 and Union silt loam 6.30 percent. Albrecht and associates (1949) studied effects of soil treatments on protein content of Korean lespedeza grown on five soil types. Average protein content of hay from untreated plots ranged from a low of 11.98 percent on Eldon silt loam to a high of 15.18 percent on Putnam silt loam. Marshall (1944) found the strontium content of red top and Korean lespedeza to be higher when grown on Putnam silt loam than on Lindley silt loam.

Mitchell and associates (1928) reported that the addition of limestone to soil increased the calcium content of soybean and grass hays 20 percent. Increase in calcium content of oats was not so noticeable. Magnesium content of the hays was also increased. Similar results were secured by Vinall and Wilkins (1936). Miller and associates (1929) report the addition of limestone to soil increased protein content of soybean hay from 10.06 to 17.8 percent, and alfalfa hay from 11.19 to 16.81 percent.

Response to soil treatments was found by Lush and Fletcher (1934) to be greater growth rather than changes in plant composition. They reported 15.6 percent increase in the yield of hay from application of two tons of limestone per acre.

Leukel and associates (1934) studied the effect of mineral deficiencies upon plants. They found that calcium deficiency resulted in an accumulation of carbohydrates in large quantities due to the fact that nitrate absorption and assimilation was retarded. Liming soil tends to reduce the phosphorus content of hay. Snider (1946) found this reduction varied from 0.2 to 1.2 pounds per ton of hay. Rogers (1948) discovered that the addition of limestone to the soil reduced the potassium content of peanut vines 30 to 46 percent.

Aston (1928) reported maximum yields of hay were obtained with an application of 200 pounds of treble superphosphate, instead of the 1,000 to 2,000 pound applications found necessary to give extremely high phosphorus content in hay. With these heavy applications, practically all the phosphorus increase was confined to the inorganic phosphorus fraction.

Blair and Prince (1932) increased phosphorus content of pasture grasses from 0.75 to 0.95 percent by the application of 670 pounds of superphosphate per acre. They attributed this difference to a change in vegetation. There was more clover on the treated than on the untreated plots. Applications of 125 to 200 pounds of treble superphosphate per acre to native meadows where cattle were chewing bones, increased both the yield (as much as 140 percent) and the phosphorus content of the hay, according to Burke and associates (1933). Application of 500 pounds of rock phosphate per acre gave no response.

Ellis and Caldwell (1936) concluded that the application of phosphate fertilizers to soils may not result in an increased phosphate content of the hay, if normal crop yields are produced without fertilizer treatment.

Lush (1938) found that the addition of nitrogen or phosphorus fertilizers had no effect on yield or composition of bench land or alluvial land pastures.

The literature is generally in agreement on the fact that nitrogen fertilizer applications result in an increase in protein content of a crop. Thomas and Moon (1938) found that applications of sulphate of ammonia increased protein content of pasture grasses from 19.42 to 21.75 percent, when applied at four-week intervals. There was also a marked increase in carotene content from 43.4 to 58.0 mg. percent in the dry matter. The yield increased from 502 to 714 pounds per acre for the four-week period. Similar increases in protein content of pasture grasses treated with 100 pounds of sulphate of ammonia were obtained by Greenhill (1930).

Fagan (1928) reported that application of nitrogen fertilizer increased protein and reduced crude fiber content of the hay produced. Enlow and Coleman (1929) made monthly application of nitrogen fertilizer to Bahia and centipede grasses. Total application was 140 pounds of nitrogen per acre per season. The Bahia grass increased in yield of dry matter from 2,073 pounds (which contained 1.71 percent nitrogen) to 4,744 pounds per acre with 2.10 percent nitrogen. Centipede grass increased in yield of dry matter from 876 pounds, to 2,798 pounds per acre, with an increase in nitrogen from 1.32 to 1.93 percent.

Similar results were obtained by Foley and associates (1930) and Dexter (1936). Mortimer and Ahlgren (1936) found that application of nitrogen fertilizer lowered the calcium and phosphorus content of bluegrass, and that protein content and total crude protein per acre varied directly with the nitrogen application.

Magnesium has been shown by Willstatter (1906) to be a constituent of chlorophyll. A deficiency in this element results in a disturbance in chlorophyll formation.

Carotene content of grass was found by Thomas and Moon (1938) to be related to the percentage of protein present. A correlation of plus 0.530 was calculated, which was reported to be highly significant at P equals 0.01. Similar carotene and protein relationships for soybeans and bromegrass were reported by Guthrie (1929) and Pickett (1950).

Archibald and associates (1938) increased the percentage of iron in a mixture of timothy and red top from 0.0286 to 0.0431 percent by applying 100 pounds of elemental iron in the form of ferric ammonium citrate per acre.

Evans and Purvis (1948) found that addition of manganese sulphate to soil increased the manganese content from 8 to 108 parts per million and decreased iron content from 310 to 178 parts per million for alfalfa hay. It increased manganese content of red clover hay from 8 to 140 parts per million and decreased iron content from 842 to 380 parts per million.

Tisdale and associates (1950) studied methionine and cystine content of alfalfa hay, as influenced by concentrations of 0, 1, 3, 9, and 81 parts per million of sulfate ion. An increase from 0 to 9 p.p.m. in concentration of sulfate ion in the soil resulted in an increase in methionine content from 0.102 to 0.160 percent, cystine from 0.085 to 0.180 percent, and total sulphur from 0.121 to 0.200 percent. Nitrogen content of the hay decreased from 3.45 to 3.39 percent. The higher level of sulphate ion concentration in the soil failed to give further significant increase in methionine and cystine content of the hay.

Fertilized pasture grasses appear to have some nutritive value not detected by chemical analysis, according to studies made by Crampton and Finlayson (1935). They measured this by the gains in weight of rabbits fed grass from fertilized and unfertilized areas. Rabbits gained 261.25 grams in weight when fed grass from the fertilized area, while the control goup lost 55 grams in weight when fed from the unfertilized area. Rabbits gained 370 grams in weight when fed fertilized grass plus cystine compared to a gain of 70 grams for the group fed unfertilized grass plus cystine. The gain in weight for the group fed fertilized grass plus cystine plus casein was 643 grams and for the group fed unfertilized grass plus cystine plus casein was 553 grams. The total feed intake was 4.5 percent greater for the group on fertilized grass in the first trial, but it was controlled so that all groups consumed the same amount of feed in all trials with cystine and casein supplements. Similar results with guinea pigs from the grass-juice factor were secured by Johnson and associates (1941).

According to Miller (1938), potash applications tended to increase phosphorus content of alfalfa. Applications did not affect red clover. They decreased phosphorus content of sweet clover.

Bear (1950) studied the cation and anion relationship in plants. He found the total milliequivalents of cations, potassium, calcium, magnesium, and sodium tended to remain constant per unit of dry matter, even though there was variation in individual elements. The total milliequivalents for the anions nitrogen, phosphorus, sulphur, chlorine and silicon tended to remain constant per unit of dry matter. When chlorine was applied to the soil as KCl it tended to substitute for nitrogen, sulphur, and phosphorus in the plants and lowered their protein content.

Evans and associates (1950) studied the effect of deficient or toxic levels of nutrients in solutions on the mineral content of soybean leaves. They found solutions deficient in Ca caused increases in Mg, P, K and B content. Solutions deficient in K caused increases in the Ca and P content. Solutions deficient in P caused increases in K content. Solutions deficient in K caused decreases in Mn, Cu, Fe and B content. Solutions deficient in Mg increased K content twofold. Solutions toxic in Mg reduced Ca and K content of leaves to trace amounts. Solutions deficient in Mg inhibited the uptake and translocation of P and B. Solutions deficient in B repressed the uptake of Mn and K but favored uptake of Mg by the plants. Solutions deficient in Mn produced soybean leaves higher in P, K, and B content, but had no effect on uptake of other elements by the plants.

Climatic Conditions. Headden (1896) compared chemical composition of alfalfa hay damaged by rain with that of hay dried in an air bath. The difference in composition was attributed to rain damage. Comparison is given in Table 3.

TABLE 3 -- EFFECT OF RAIN UPON ALFALFA HAY COMPOSITION

	Alfalfa Dried In Air Bath Dry Basis	Alfalfa in field May 28 to June 12, Rainfall 1.76" Dry Basis
	%	%
Ash	12.18	12.71
Crude Fiber	26.46	38.83
Crude fat	3.94	3.81
Crude protein	18.71	11.01
Nitrogen-free extract	38.71	33.64

Temperature during this period ranged from 72° to 81° F., and the weather was cloudy. A mechanical loss of leaves was noted. It is obvious that any weather or mechanical condition that increases loss in leaf content will result in a decrease in crude protein and an increase in crude fiber content of the hay. Forbes and associates (1910) observed that an abundance of moisture during growth increased, to a slight extent, the phosphorus content of bluegrass and certain other plants. Eckles and associates (1926) observed that the phosphorus content of alfalfa, prairie and timothy hay was lower in the dry year 1923, with a total rainfall of 17.49 inches, than in 1924, with a rainfall of 21.98 inches. There was a tendency for the calcium content to increase during the dry year.

Amount of growth of pasture grasses fluctuates with the amount and distribution of rainfall. Composition also follows distribution of rainfall closely, resulting in a higher phosphorus and protein content and feeding value during periods of heavy rainfall; according to results secured by Enlow and Coleman (1929), Archibald and Bennett (1933), Shutt and Hamilton (1934), Elting and associates (1937), Pratt and Holdaway (1937) and Swift and associates (1948).

Ames and Boltz (1912) treated dry alfalfa hay with water, which removed 50 percent of the nitrogen and 75 percent of the phosphorus.

MATERIALS AND PROCEDURES

Samples of the major hay and silage crops grown by Missouri dairymen were collected, graded and analyzed for the 1950, 1951 and 1952 growing seasons.

Collection of Samples

Samples of roughage for analysis were obtained from counties representing the major farming areas in Missouri. County extension agents selected from three to five farms located on the predominating soil type in the county, and assisted in collecting samples of all hay crops produced by the farm operator. Location of the counties sampled is shown in Figure 1.

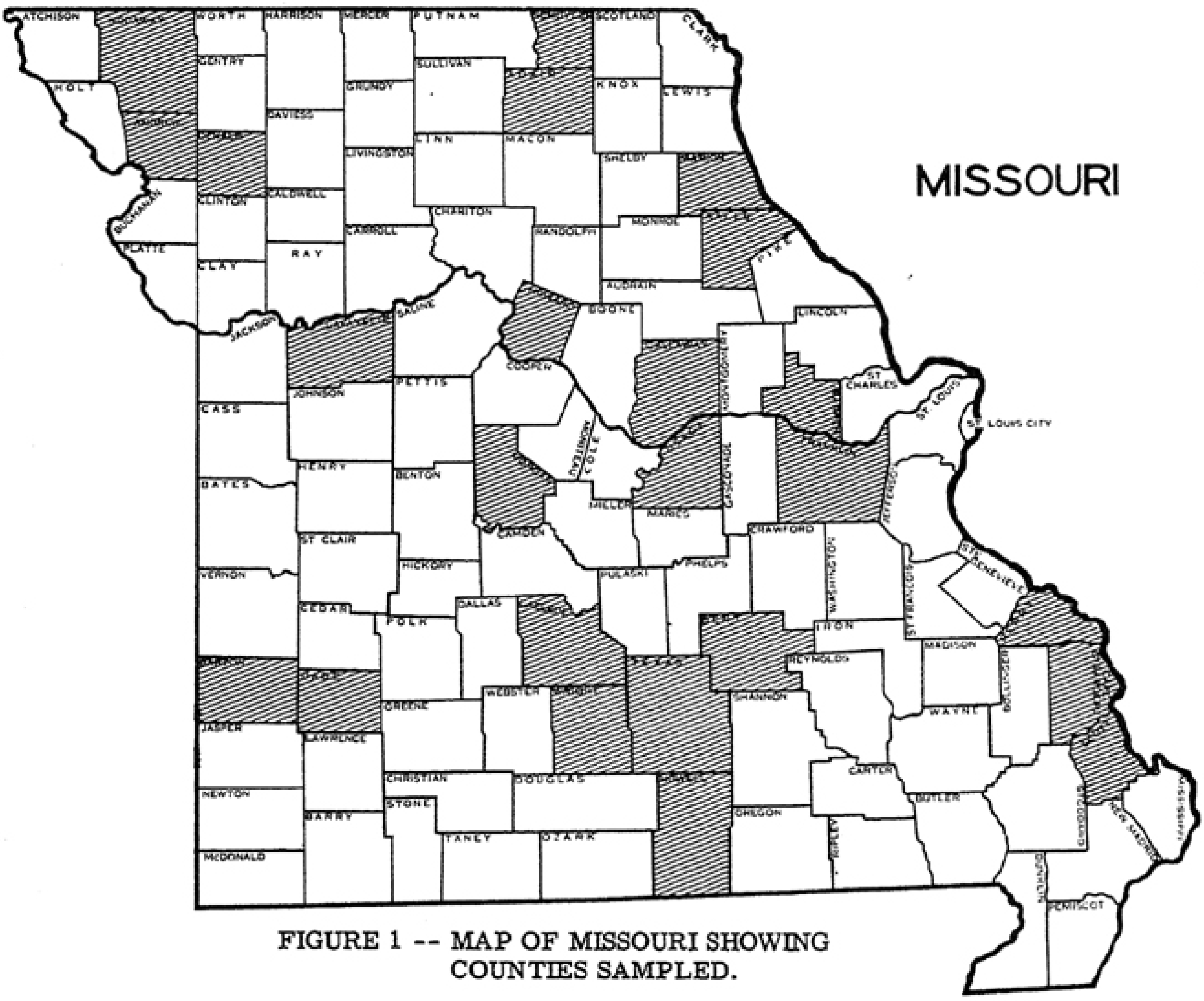

FIGURE 1 -- MAP OF MISSOURI SHOWING COUNTIES SAMPLED.

Individual samples of hay were obtained by taking equal portions from the middle flake of five bales selected at random, or from five different locations for unbaled hay.

The combined sample was placed in a laundered white feed sack, or in a large new paper bag the size of an ordinary feed sack, and transported to the Department of Dairy Husbandry by automobile. Extreme care was taken during the sampling process to prevent loss of leaves. With the hay sample, information was obtained on soil type where the hay was grown; results of soil test for organic matter, available phosphorus, potassium, magnesium, calcium, and pH, where available; cropping history and soil treatments for the imediate past three years; yield per acre, date and method of harvesting; and weather conditions at harvest time. The data sheet used in recording information on roughage samples is shown in Figure 2. Silage samples were taken directly from the silo, sealed in glass fruit jars, and delivered directly to the Department of Dairy Husbandry. Upon arrival samples were stored at minus 23° C. until analyzed.

Yield per acre was estimated by taking the average weight of several bales and multiplying it by the number of bales produced and dividing by the acres in the field as determined by the P. M. A. County Committee. Yield for hay stored loose in the mow or stacked was estimated by using 485 cubic feet per ton for legume hays and 600 cubic feet per ton for grass hays.

Preparation for Chemical Analysis

Each sample of hay was spread on a piece of heavy canvas, rated for percent green color, and analyzed for the proportion of foreign matter. Mixed samples of legumes and grasses were separated into legume and grass fractions for chemical analysis. Legumes were further separated into leaf and stem fractions. Weights of all fractions were recorded and used to determine the percentage of foreign matter, leaf and stem in the sample. Foreign matter was discarded. The remainder of the sample was ground with a Wiley mill (No. 1) fitted with a one millimeter screen. The mill was thoroughly cleaned by brushing before grinding each sample. Ground hay was placed in a number 16 paper bag. The top of the bag was folded over to prevent spilling. Bags were inverted 50 times to mix samples.

After a sample was mixed, a portion was placed in a screw top bottle to be used for carotene determination. Another portion was placed in a quart Mason fruit jar fitted with a new top to prevent loss of moisture. Samples for carotene determination were stored at approximately minus 18° C. until analyzed. During the period of actual analysis, samples were moved into a refrigerator at 10° C. Samples placed in the Mason jars were stored at room temperature and used for all analyses, except carotene, for the 1950 growing season.

Samples for the 1951 and 1952 growing seasons were prepared the same way, with the exception that a portion of the sample was taken when spread on the canvas for grinding in a mill fitted with a one millimeter iron screen and storing at room temperature for use in the determination of iodine, manganese, copper, cobalt, zinc and boron.

Due to a shortage of technical help, equal portions of samples from the same species grown in the same area of the state were combined into a com-

INFORMATION ON HAY SAMPLE - Roughage Analysis Project
(Department of Dairy Husbandry - University of Missouri)

Name of Farmer ______________________________ County __________

Address ______________________________ Date Sample Sent __________

Kind of Hay ______________ Cutting ______________ Soil Type ________

Soil Test: Date Soil Sampled __________

O.M.______, P______, K______, Mg______, Ca______, pH__________

Soil treatment: Kinds and amounts per acre and crops grown.

1950 Treatment: Lime, fertilizer, etc.______________________________

1949 Treatments ______________________________ Crop Grown __________

1948 Treatments ______________________________ Crop Grown __________

Remarks: Concerning Soil Treatments ______________________________

____

____

Yield per acre (pounds)____________________ Date cut ______________

Method of harvesting ____
(Example: Mowed - raked (sidedelivery) baled (pickup).

____

Was hay wet by rain? - Yes or No (Circle correct answer).

Weather during curing: Rainy__________ Cloudy________, or Bright________

General Remarks: ____

____

____

(Return this information sheet with the hay sample.)

Figure 2—Form used to collect information on hay samples.

posite sample for use in determining sulphur, chlorine, manganese, copper, cobalt, zinc, boron, and idoine content.

All chemical analyses except soil testing were made in the Agricultural Experiment Station laboratories under the supervision of the Department of Agricultural Chemistry.

Chemical Analyses

Soil tests were made in the county soil testing laboratories by the procedure outlined by Graham (1950).

Nitrogen, crude fiber, phosphorus and sulphur determinations were made according to methods of the Association of Official Agricultural Chemists (1950), hereafter referred to as A. O. A. C.

Moisture was determined by a modification of the A. O. A. C. method in which the sample was dried at 65° C. for 24 hours under vacuum. Crude fat was determined by a modification of the A. O. A. C. method by ether extracting the moisture free sample seven hours on a Gold Fish extractor. Ether was removed from the sample by allowing it to stand over night, or by placing it in a vacuum oven with the water aspirator turned on for five hours. After removing the ether, the sample was dried at 65° C. for 24 hours under vacuum as for moisture determination.

Lignin was determined by the method of Crampton and Maynard (1938). Ash was determined by a modification of the A. O. A. C. method. A 10 gram sample was placed in a cold Cenco-Cooly furnace equipped with a powerstat control, and the temperature gradually brought to 550° C. and held there for 4 to 6 hours. The entire process took 16 hours.

Calcium was determined by an unpublished modification by Gehrke (1953) of the Cheng and Bray method (1951), in which the ash solution was prepared by the method of Piper (1950). An aliquot of the ash solution was adjusted to pH 4.0 to 5.0 with 10 percent solution of KOH, then passed through an anion exchange column (Amberlite IR-4B) to remove phosphate. The total effluent was then titrated by using a standard solution of versenate using murexide as the indicator.

Potassium was determined by the flame photometric method by Mitchell (1948). Magnesium was determined by a colormetric method employing thiazole (titan) yellow, adapted from an article by Young and Gill (1951). Chloride was determined by the A. O. A. C. method, except the solution was titrated with a 0.1 N solution of $AgNO_3$ using 0.1 percent dichlorofluorescein as the indicator, according to the procedure of Rieman, Neiess, and Naiman (1942). Iodine was determined by the method of Houston (1950).

Manganese was determined colormetrically as permanganate by A. O. A. C. method. Boron was determined colormetrically by curcumin developed by Dibold, Berger, and Truog (1951), which is similar to the method of Naftel (1939).

Copper, cobalt, and zinc were determined spectrographically, following preliminary chemical concentration, by means of the organic reagent dithizone. The chemical concentration procedure was similar to that of Beeson and Gregory (1950). Spectrographic determination procedure for copper, cobalt, and zinc was developed at this station (Pickett 1952) which was a modification of the copper spark method by Nachtrieb (1950). Iron was determined colormetrically by O-phenanthroline method of A. O. A. C.

Carotene was extracted from the hay by the method of Moore and Ely (1941) and determined by a modification of the method by Moore (1940). The modification consisted of placing a narrow band of 1:1 mixture, by volume, of activated MgO and Hiflo Supercel (Johns-Manville) in the absorption column to hold back lycopene and chryptoxanthine.

PRESENTATION OF DATA

Chemical composition revealed by these analyses of first, second, third and fourth cutting alfalfa and of red clover, lespedeza, timothy, red top, soybean, ladino clover, birdsfoot trefoil, bromegrass, orchard grass, sudan grass, prairie, and mixed hay crops is presented in Tables 4 to 11. Additional descriptive information, such as date of harvest, percent foreign matter, and (for legume crops only) the percent green color and leaf content is included.

Lignin content of samples collected in 1952 has not been determined due to a scarcity of technical help. These samples have been saved for future lignin determinations.

Percent foreign matter includes everything in the sample except particles of the species of plant for which the sample is listed. In some samples of mixed legume and grass hay, analyses were made on both the legume and the grass fractions of the sample. These mixtures consisted primarily of alfalfa-bromegrass, red clover-timothy, and ladino clover and either orchard grass or timothy. The high percent foreign matter listed for some samples of the above named species is primarily the percent of other species in the mixture. This is especially the case for the foreign matter content listed for bromegrass hay in Table 10. Foreign matter content of lespedeza hay consisted primarily of weeds and straw from cereal crops as the use of a one-year crop rotation of small grain and lespedeza is widely practiced in this state.

The species composition or fineness of chopping made it impossible to separate some samples of mixed grasses into their various fractions. These samples were ground and analyzed and are listed as mixed hays in Table 11. The percent stem content of legumes is omitted from tables as it is a reciprocal of the percent leaves.

Chemical composition of various kinds of silages is presented on a fresh basis in Table 12, along with information on the type of silo and preservative used. The type of silo used was not secured with some of the samples for the 1951 season.

TABLE 4--CHEMICAL COMPOSITION OF FIRST CUTTING ALFALFA HAY

Sample Number	Date Cut	Green Color	Foreign Matter	Leaves	Dry Matter	Crude Protein	Ether Extract	Crude Fiber	Lignin	N-free Extract	Carotene	Ash	Ca	P_2O_5	K	Mg	Fe
		%	%	%	%	%	%	%	%	%	μ/gm	%	%	%	%	%	PPM
28	5-25-50	25	3.1	48.8	90.6	15.7	1.87	28.9	13.6	36.3	1.63	8.85	1.87	.29	1.86	.28	158
66	5-25-50	45	4.7	43.2	89.9	15.7	1.47	30.1	10.6	34.1	4.48	8.62	1.32	.56	1.16	.36	130
70	5-25-50	55	13.6	42.5	89.9	14.1	1.56	30.4	11.7	37.3	4.18	6.65	1.14	.53	2.04	.30	135
10	6-1-50	50	6.1	55.5	92.4	18.6	1.84	25.8	12.0	39.8	5.13	6.44	1.20	.72	1.40	.38	117
34	6-1-50	60	18.3	53.9	91.9	18.3	2.59	27.0	11.8	36.7	8.26	7.22	1.45	.65	1.22	.33	170
7	6-5-50	65	5.6	39.7	91.9	15.8	1.82	32.5	13.2	36.6	3.73	5.09	1.08	.54	0.78	.26	162
35	6-27-50	85	0.9	56.2	93.6	15.4	2.16	26.5	9.8	41.3	15.46	8.25	0.86	.62	2.91	.23	168
1950 Av.		55	7.5	48.5	91.6	16.2	1.90	28.8	11.8	37.4	6.13	7.30	1.28	.56	1.62	.30	148
147	5-15-51	5	1.5	54.6	90.0	19.6	0.71	29.5	16.3	30.0	0.44	10.14	1.96	.64	2.15	.34	132
148	5-15-51	20	2.0	47.0	91.0	16.9	0.88	30.7	12.1	33.9	1.63	8.56	1.65	.47	1.84	.27	103
139	5-16-51	10	2.0	45.6	90.0	16.6	1.02	26.8	10.1	38.5	2.11	7.02	1.76	.45	1.73	.26	128
163	5-20-51	0	0.7	63.6	91.3	20.2	1.38	20.2	19.3	43.9	3.31	7.89	1.36	.62	1.90	.22	140
112	5-25-51	75	2.3	59.8	90.5	18.2	1.63	27.0	10.7	34.9	6.55	8.70	1.30	.51	1.99	.32	163
117	5-25-51	40	4.0	49.7	91.5	19.2	1.55	30.3	10.0	33.1	2.86	7.39	1.46	.54	1.88	.25	108
156	5-25-51	30	16.1	52.2	91.1	16.4	0.90	29.6	10.7	37.5	1.26	6.63	1.45	.34	1.29	.34	202
151	5-29-51	50	12.5	48.0	92.0	17.2	1.31	28.6	9.6	37.8	6.51	6.97	1.51	.50	1.75	.25	117
153	5-29-51	60	15.9	60.2	91.4	18.8	1.21	27.2	9.9	37.9	13.87	6.34	1.52	.58	0.90	.45	155
101	6-4-51	35	9.6	52.9	91.9	17.3	1.05	31.6	12.2	33.9	1.99	8.10	1.48	.56	1.76	.19	55
125	6-5-51	60	3.4	52.1	89.3	18.2	1.34	26.4	8.9	34.2	4.05	8.98	1.58	.47	2.34	.25	145
107	-51	5		47.2	90.9	14.4	1.25	27.2	11.2	42.6	2.68	5.44	1.32	.51	0.60	.37	148
1951 Av.		32	6.4	52.7	90.9	17.8	1.19	27.9	11.8	36.3	3.94	7.68	1.53	.52	1.68	.29	133
216	5-1-52	25	47.0	57.1	92.5	17.2	1.63	23.0	9.7	40.1	10.51	10.57	2.23	.44	1.93	.33	287
233	5-7-52	65	2.8	65.5	90.2	22.9	1.99	21.9	8.4	36.4	19.02	7.04	1.46	.80	1.20	.31	134
203	5-17-52	35	7.5	52.5	92.3	19.7	1.17	26.3	9.9	38.7	15.16	6.44	1.53	.52	1.50	.23	122
228	5-25-52	40	0.1	47.9	91.8	20.0	0.78	27.3	11.6	35.1	4.99	8.65	1.81	.47	2.40	.30	205
242	5-27-52	35	3.6	61.2	91.0	19.4	1.76	22.6	7.8	38.8	11.19	8.47	1.27	.61	2.78	.22	165
271	6-6-52	40	7.4	44.6	90.8	16.1	2.09	25.8	10.9	41.4	4.95	5.43	1.26	.53	1.27	.27	137
225	6-14-52	25	29.4	56.5	92.5	17.8	1.64	22.4	10.0	42.6	9.69	8.12	1.99	.32	1.65	.27	355
252	6-20-52	65	69.9	60.5	91.4	14.6	1.48	26.8	11.9	42.3	6.66	6.16	1.18	.50	1.45	.32	182
1952 Av.		41	21.0	55.7	91.6	18.5	1.57	24.5	10.0	39.4	10.27	7.61	1.59	.52	1.77	.28	198
3 Yrs. Av.		41	11.1	52.5	91.3	17.6	1.48	27.1	11.3	37.6	6.38	7.56	1.48	.53	1.69	.29	156

TABLE 5--CHEMICAL COMPOSITION OF SECOND CUTTING ALFALFA HAY

Sample Number	Date Cut	Green Color	Foreign Matter	Leaves	Dry Matter	Crude Proteins	Ether Extract	Crude Fiber	Lignin	N-free Extract	Carotene	Ash	Ca	P_2O_5	K	Mg	Fe
		%	%	%	%	%	%	%	%	%	μ/gm	%	%	%	%	%	PPM
46	6-24-50	75	3.7	55.7	92.4	16.6	1.55	26.1	9.6	40.3	7.59	7.84	1.01	.41	2.41	.25	139
48	6-24-50	55	2.2	62.9	93.2	16.7	1.78	21.7	8.6	46.1	5.74	6.89	1.04	.45	1.96	.28	83
4	6-27-50	60	3.7	55.8	93.0	18.9	1.67	31.3	12.7	33.7	2.49	7.45	1.06	.62	1.71	.33	167
5	6-27-50	75	9.9	51.8	92.9	18.6	1.83	29.8	12.4	36.3	3.44	6.29	1.03	.62	1.58	.34	179
19	7-1-50	65	12.4	60.9	90.1	15.3	1.83	23.6	10.2	40.9	4.74	8.60	1.33	.29	1.60	.38	300
27	7-1-50	20	6.3	56.9	92.2	19.1	1.95	25.5	11.2	36.0	2.06	9.64	1.23	.42	2.52	.25	382
64	7-4-50	40	9.1	38.7	89.8	14.4	1.38	31.3	14.4	36.0	2.24	6.73	1.07	.57	1.64	.30	112
63	7-5-50	40	11.6	44.5	89.6	17.3	1.60	29.4	13.2	33.2	6.97	8.11	1.22	.59	2.29	.31	90
47	7-6-50	60	1.6	44.3	91.9	17.1	1.51	34.6	13.1	31.3	8.96	7.47	1.01	.63	1.98	.32	100
22	7-7-50	80	0.0	52.1	90.1	17.9	1.69	27.9	12.2	36.5	8.03	5.99	1.22	.60	.93	.40	88
26	7-18-50	75	3.5	49.8	92.6	17.7	3.21	25.7	10.2	38.1	21.65	7.80	0.78	.53	2.78	.30	144
21	-50	40	4.0	35.7	89.7	14.8	0.98	32.1	13.3	33.6	1.75	8.31	0.82	.56	2.90	.22	122
59	-50	20	0.9	42.7	92.3	18.1	0.91	29.5	11.4	37.4	0.21	6.37	1.19	.52	1.22	.36	244
1950 Av.		54	5.3	50.2	91.5	17.1	1.68	28.3	11.7	36.9	5.84	7.50	1.08	.52	1.96	.31	165
121	6-15-51	30	3.3	68.0	91.0	20.4	1.13	21.6	7.6	40.0	1.40	7.80	1.36	.60	2.10	.23	140
166	6-25-51	60	1.0	58.1	91.0	22.5	1.42	22.5	9.3	38.1	2.09	6.47	1.14	.76	1.73	.26	91
132	7-1-51	15	2.5	60.5	91.0	18.9	1.33	26.3	10.1	36.2	12.83	8.20	1.42	.56	2.38	.21	146
113	7-4-51	50	1.5	47.7	92.4	18.6	1.20	28.5	11.0	37.6	1.58	6.45	1.08	.61	1.45	.25	130
103	7-9-51	45	4.1	47.3	92.8	18.6	1.43	29.8	11.1	35.8	3.68	7.08	1.10	.65	1.88	.22	85
155	7-15-51	60	0.3	39.0	91.5	16.4	1.37	31.6	10.5	36.4	4.28	5.78	0.89	.55	1.64	.23	109
142	7-25-51	35	20.8	52.7	91.9	16.6	1.24	28.3	12.3	39.5	4.46	6.28	0.66	.55	2.13	.26	145
135	-51	35			91.1	13.8	1.37	32.2	13.0	37.2	3.90	6.56	0.86	.59	1.55	.32	186
158	-51	55	5.0	45.1	90.4	15.4	0.86	32.2	11.3	34.7	1.16	7.22	1.16	.52	2.15	.20	68
1951 Av.		43	4.3	52.3	91.4	17.9	1.26	28.1	10.7	37.3	3.93	6.87	1.07	.60	1.89	.24	122
212	6-15-52	60	11.8	53.7	92.1	17.3	0.99	25.6	10.8	40.6	54.45	7.63	1.54	.52	1.73	.33	270
202	6-20-52	50	9.9	55.9	92.6	16.9	2.44	24.5	8.8	40.6	31.98	8.15	1.75	.42	1.37	.32	105
243	6-28-52	65	1.7	63.0	90.9	21.0	1.87	22.2	6.0	38.1	9.68	7.67	1.28	.66	1.92	.25	132
219	6-30-52	70	3.5	46.1	93.2	17.9	1.32	25.8	10.1	40.5	12.70	7.71	1.01	.47	1.70	.32	170
269	7-6-52	70	0.9	55.9	90.3	19.9	1.89	24.3	8.9	36.2	4.13	8.06	1.38	.54	1.87	.30	141
270	7-7-52	75	1.3	44.0	90.4	15.9	1.93	26.7	9.4	39.3	18.17	6.65	1.31	.48	1.33	.30	114
249	7-10-52	70	53.7	54.7	92.7	21.3	1.97	21.4	9.1	38.8	25.36	9.29	1.65	.54	1.98	.33	162
238	7-15-52	70	8.2	54.5	92.1	13.4	1.23	31.1	12.2	40.6	15.76	5.71	1.32	.33	1.36	.24	108
254	7-25-52	65	8.1	53.6	91.5	18.2	1.30	23.3	9.9	40.3	5.20	8.36	1.76	.38	1.48	.34	110
224	8-1-52	50	1.7	53.8	91.8	16.4	1.57	22.7	9.7	42.8	33.96	8.31	1.69	.38	1.72	.28	144
234	8-7-52	20	54.4	55.9	90.4	16.6	1.17	27.7	13.3	33.5	4.92	11.46	1.47	.51	1.96	.27	1200
1952 Av.		60	14.1	53.8	91.6	17.7	1.61	25.0	9.8	39.2	19.66	8.09	1.47	.48	1.67	.30	241
3 Yrs. Av.		53	7.96	51.9	91.5	17.5	1.54	27.2	10.8	37.7	9.93	7.53	1.21	.53	1.85	.29	179

TABLE 6--CHEMICAL COMPOSITION OF THIRD AND FOURTH CUTTING ALFALFA HAY

Sample Number	Date Cut	Green Color	Foreign Matter	Leaves	Dry Matter	Crude Protein	Ether Extract	Crude Fiber	Lignin	N-free Extract	Carotene	Ash	Ca	P2O5	K	Mg	Fe
		%	%	%	%	%	%	%	%	%	μ/gm	%	%	%	%	%	PPM
							Third Cutting										
9	8-6-50	70	13.1	51.1	92.8	20.2	1.99	28.0	12.8	36.0	5.30	6.59	0.97	.66	1.88	.34	108
60	8-10-50	75	8.0	54.1	93.4	18.6	1.89	26.5	10.3	39.7	22.18	6.74	0.99	.66	1.56	.43	135
31	8-15-50	70	0.5	42.4	92.6	17.1	2.17	26.8	12.0	40.1	6.24	6.50	1.17	.58	1.54	.36	132
41	8-15-50	50	35.1	63.5	92.8	19.4	2.66	20.4	10.9	40.7	9.75	9.63	1.14	.63	2.29	.40	128
69	8-15-50	80	6.2	53.6	90.0	16.1	1.59	25.6	9.8	38.8	11.46	7.86	1.05	.57	2.30	.26	106
32	8-30-50	60	13.7	46.7	92.7	17.2	2.58	26.6	12.2	38.2	12.45	8.00	0.99	.69	2.12	.38	161
24	9-5-50	65	26.9	46.9	91.6	16.9	2.26	29.1	13.7	36.4	11.46	6.85	0.88	.46	1.77	.34	268
65	9-5-50	60	5.7	52.4	90.3	13.6	1.71	25.3	10.3	39.6	7.38	10.09	1.62	.66	1.72	.39	152
58	-50	70	1.0	51.4	92.2	16.4	1.71	25.6	11.5	40.8	11.91	7.64	1.40	.42	1.50	.36	111
1950 Av.		67	12.2	51.3	92.0	17.3	2.06	26.0	11.5	38.9	10.90	7.77	1.13	.59	1.85	.36	146
140	7-20-51	50	39.6	46.4	92.5	16.2	1.34	29.0	12.2	39.4	6.29	6.51	.69	.54	2.44	.25	101
108	7-25-51	55	3.8	61.3	90.3	19.5	1.37	22.0	8.4	39.5	5.85	7.95	1.24	.62	1.69	.23	65
164	8-3-51	60	10.9	57.6	90.8	21.2	1.63	19.7	9.1	42.6	7.59	5.61	1.22	.61	1.30	.25	80
120	8-20-51	40	2.0	36.2	91.1	16.1	1.60	34.7	11.2	30.7	1.52	7.97	0.87	.65	3.07	.20	40
104	8-22-51	60	3.8	53.2	91.1	16.8	1.25	24.2	10.5	42.4	4.63	6.49	1.29	.51	1.48	.27	97
138	9-1-51	80	51.4	57.8	91.3	19.1	1.68	24.0	11.5	39.3	45.85	7.28	1.37	.69	2.03	.21	90
118	9-13-51	80	14.9	49.1	91.6	19.9	1.38	25.2	11.8	37.8	9.37	7.22	1.20	.66	1.88	.24	95
136	-51	30	0.9	47.9	90.5	18.0	1.05	28.7	10.3	33.9	17.34	8.82	1.15	.64	2.72	.18	139
1951 Av.		57	15.9	51.2	91.1	18.3	1.41	25.9	10.6	38.2	12.30	7.23	1.13	.61	2.08	.23	88
229	7-30-52	35	6.3	54.9	91.8	21.6	0.77	22.8	9.4	39.1	1.14	7.53	1.70	.62	1.81	.26	245
241	8-10-52	75	8.0	47.0	92.1	16.4	1.75	24.1	9.8	41.5	32.14	8.23	2.01	.54	2.25	.22	109
273	8-15-52	70	2.1	50.0	90.2	17.6	2.08	24.5	9.3	38.6	12.74	7.38	1.36	.46	1.52	.26	121
215	8-29-52	20	26.5	32.5	91.6	14.7	0.67	33.0	14.7	33.1	3.36	10.10	1.34	.33	0.76	.30	1180
255	9-1-52	70	28.9	54.1	92.0	17.9	1.70	24.3	10.3	40.0	22.22	8.06	1.20	.45	2.27	.23	100
266	9-1-52	75	2.6	52.7	89.8	19.4	2.51	22.2	8.3	38.7	21.71	7.02	1.57	.48	1.32	.35	147
210	9-3-52	80	0.4	55.0	93.1	20.4	0.97	27.7	10.2	34.5	29.33	9.50	1.46	.59	2.88	.20	76
221	-52	45	8.0	56.1	93.2	18.2	0.92	24.0	11.3	42.0	2.86	7.96	1.55	.42	1.59	.28	240
1952 Av.		59	10.4	50.3	91.7	18.3	1.4[illegible]	25.3	10.4	38.5	15.69	8.22	1.52	.49	1.80	.26	277
3 Yrs. Av.		61	12.8	51.0	91.7	18.0	1.65	25.8	10.9	38.5	12.88	7.74	1.26	.57	1.91	.29	169
							Fourth Cutting										
165	9-2-50	50	0.0	61.8	90.9	21.2	1.80	20.1	7.4	40.7	5.23	6.85	1.60	.51	1.76	.26	105
106	9-26-51	75	7.2	54.8	90.3	18.8	1.33	21.6	9.3	40.1	17.10	8.29	1.66	.46	1.54	.25	125
105	10-1-51	75	3.6	62.4	89.7	20.2	1.29	19.9	9.0	40.1	11.50	8.35	1.82	.50	1.64	.25	184
Av.		67	3.6	59.7	90.3	20.1	1.47	20.6	8.6	40.3	11.28	7.83	1.69	.49	1.65	.25	138

TABLE 7--CHEMICAL COMPOSITION OF RED CLOVER HAY

Sample Number	Date Cut	Green Color	Foreign Matter	Leaves	Dry Matter	Crude Protein	Ether Extract	Crude Fiber	Lignin	N-free Extract	Carotene	Ash	Ca	P_2O_5	K	Mg	Fe
		%	%	%	%	%	%	%	%	%	μ/gm	%	%	%	%	%	PPM
								First Cutting									
1	5-20-50	40	12.8	32.8	93.2	10.7	1.36	34.4	13.7	41.5	1.06	5.18	0.98	.39	1.01	.24	120
13	6-1-50	10	3.0	35.3	90.5	12.9	1.28	34.5	19.6	36.5	1.87	5.39	1.23	.35	1.04	.36	124
33	6-2-50	30	3.8	59.5	92.3	13.7	2.53	27.7	13.6	42.1	7.70	6.20	1.27	.46	.84	.50	235
20	6-10-50	30	10.1	57.1	88.9	14.9	2.55	22.0	11.1	42.8	17.25	6.69	1.18	.36	1.16	.46	265
12	6-12-50	35	21.7	64.2	91.7	14.3	2.58	21.9	14.2	44.9	4.57	8.01	1.31	.34	2.11	.34	159
14	6-12-50	20	5.9	59.3	92.6	14.6	2.86	22.6	12.6	45.7	7.68	6.85	1.20	.34	1.94	.26	75
17	6-15-50	40	59.1	46.3	90.4	13.7	2.30	28.9	15.9	38.2	4.81	7.24	1.18	.36	1.74	.42	73
29	6-15-50	30	24.9	56.1	91.1	13.6	3.34	26.5	13.6	41.6	12.80	6.29	1.08	.33	1.54	.39	124
40	6-20-50	40	8.0	56.8	92.0	13.0	2.69	31.1	16.4	38.5	4.33	6.78	1.06	.46	1.62	.36	120
2	6-24-50	70	1.3	49.6	92.7	13.6	1.79	30.7	15.3	40.7	2.50	5.91	1.37	.34	.74	.33	120
68	9-11-50	15	61.9	62.5	93.4	15.2	2.61	27.3	15.0	41.1	15.23	7.31	1.26	.42	1.41	.42	152
1950 Av.		33	19.4	52.7	91.7	13.7	2.35	27.9	14.6	41.2	7.26	6.53	1.19	.38	1.38	.37	142
145	5-30-51	15	10.2	62.3	90.7	18.6	1.61	26.0	19.6	37.4	1.32	7.14	0.96	.46	2.05	.35	55
114	6-1-51	30	8.0	39.4	92.0	10.0	1.64	32.0	12.4	43.9	6.99	4.46	.86	.26	0.99	.34	147
123	6-10-51	20	4.6	58.3	90.8	13.7	2.16	30.1	15.1	38.8	8.50	6.01	1.01	.42	1.31	.35	122
146	6-16-51	35	4.6	42.6	92.1	11.9	1.63	32.7	14.5	40.9	4.62	4.92	1.19	.51	1.11	.35	45
1951 Av.		25	6.9	50.7	91.4	13.6	1.76	30.2	15.4	40.2	5.36	5.63	1.01	.41	1.37	.35	92
226	5-10-52	60	22.3	51.1	92.5	13.9	1.96	21.7	12.2	47.6	31.36	7.34	1.61	.35	1.91	.28	171
236	5-27-52	45	37.5	47.8	90.7	13.4	2.09	22.0	9.8	46.7	16.22	6.50	1.11	.26	1.12	.33	156
204	6-1-52	25	28.3	65.0	92.2	15.7	2.01	24.5	14.4	42.4	10.93	7.52	1.64	.40	1.61	.34	197
207	6-1-52	30	0.4	64.2	93.6	14.6	1.76	21.1	11.1	50.1	21.30	6.05	1.59	.33	1.30	.46	75
218	6-10-52	35	0.1	35.2	93.4	14.6	1.63	27.7	13.5	41.0	10.46	8.54	1.57	.54	2.35	.26	116
265	6-10-52	65	5.4	50.0	89.6	13.0	2.26	22.5	10.8	45.8	17.86	5.96	1.09	.43	1.16	.42	113
263	6-12-52	55	65.6	53.1	91.6	8.9	2.12	26.2	13.9	48.6	10.93	5.66	1.28	.25	1.27	.22	210
1952 Av.		48	22.8	52.3	91.9	13.4	1.98	23.7	12.2	46.0	17.01	6.80	1.41	.37	1.53	.33	148
3 Yrs. Av.		36	18.2	52.2	91.7	13.6	2.13	27.0	14.0	42.5	10.01	6.45	1.23	.38	1.42	.35	135
								Second Cutting									
109	8-8-51	25	3.6	57.9	90.8	14.7	1.99	31.6	18.5	36.7	11.00	5.77	1.13	.41	1.19	.35	70
223	7-1-52	65	6.7	56.8	92.6	15.5	1.71	22.4	11.4	46.5	33.85	6.55	1.29	.46	1.28	.41	112
232	7-15-52	25	2.1	58.7	90.4	15.6	1.96	23.3	12.3	44.0	9.75	5.58	1.33	.49	1.48	.34	188
208	7-25-52	55	1.1	60.9	94.0	13.3	1.06	26.2	11.0	46.3	16.37	7.10	1.19	.49	2.10	.23	92
274	8-5-52	30	1.2	60.5	89.3	13.7	2.08	29.1	15.2	38.7	16.91	5.55	1.47	.41	1.00	.38	128
268	8-15-52	70	18.6	58.3	89.9	13.4	2.18	23.7	9.7	45.3	21.14	5.27	1.38	.44	1.07	.40	109
206	9-15-52	30	8.3	74.7	92.9	16.3	1.90	23.8	10.8	44.4	54.47	6.46	1.41	.49	1.35	.62	59
257	9-20-52	45	23.9	61.5	90.7	15.0	2.40	24.0	15.2	43.6	30.32	5.63	1.45	.36	1.27	.37	121
Av.		43	8.2	61.2	91.3	14.7	1.91	25.5	13.0	43.2	24.23	5.99	1.33	.44	1.34	.39	110

TABLE 8--CHEMICAL COMPOSITION OF LESPEDEZA HAY

Sample Number	Date Cut	Green Color	Foreign Matter	Leaves	Dry Matter	Crude Protein	Ether Extract	Crude Fiber	Lignin	N-free Extract	Carotene	Ash	Ca	P_2O_5	K	Mg	Fe
		%	%	%	%	%	%	%	%	%	µ/gm	%	%	%	%	%	PPM
42	6-18-50	60	43.2	65.0	93.8	15.8	4.37	23.6	14.5	44.2	32.46	5.82	1.00	.72	0.89	.42	112
36	7-10-50	70	83.1	64.5	93.7	14.6	3.80	24.2	13.8	45.7	74.64	5.33	0.79	.41	1.36	.36	124
38	7-20-50	65	30.6	71.6	93.2	11.5	2.93	23.2	17.4	50.0	27.82	5.59	0.99	.23	0.60	.36	252
45	7-25-50	75	39.3	61.6	91.5	13.9	3.39	22.9	15.2	46.3	49.02	5.05	0.88	.38	0.86	.40	82
6	7-30-50	60	53.3	77.7	91.1	10.4	3.74	27.1	20.9	45.3	25.67	4.56	0.96	.23	0.87	.24	108
16	7-30-50	60	51.9	73.7	90.0	11.5	3.11	20.8	15.5	49.0	58.90	5.56	0.87	.24	1.16	.32	112
8	8-7-50	70	16.8	62.5	92.6	15.2	2.53	27.2	17.7	43.0	29.59	4.67	0.87	.54	1.16	.26	78
43	8-30-50	70	49.5	75.9	92.7	16.8	2.94	23.9	21.4	43.6	34.87	5.42	0.80	.34	0.67	.35	80
25	9-5-50	50	35.5	60.5	91.6	15.7	3.11	27.7	17.2	40.0	53.47	5.09	0.94	.55	1.16	.47	166
11	9-10-50	55	49.2	65.4	91.8	15.5	2.60	26.6	17.3	40.5	34.37	6.57	1.09	.54	1.34	.27	179
15	9-10-50	40	37.4	66.3	91.4	15.1	1.75	30.2	27.8	37.2	22.00	7.00	1.16	.42	1.06	.26	166
67	9-11-50	60	54.7	62.1	89.9	15.2	2.34	25.3	16.8	39.4	47.35	7.59	0.99	.38	1.00	.32	186
23	9-13-50	75	34.0	67.9	91.0	15.9	3.55	24.3	16.8	41.9	77.30	5.37	1.02	.48	0.92	.37	142
1950 Av.		62	44.5	67.3	91.9	14.4	3.09	25.2	17.9	43.6	43.65	5.66	0.95	.42	1.00	.33	137
128	6-22-51	70	55.6	71.9	90.0	14.0	2.78	26.5	14.4	41.7	18.28	4.99	0.90	.60	0.92	.28	122
126	7-10-51	45	23.3	60.1	90.5	14.1	1.89	30.7	17.4	39.2	26.90	4.68	0.62	.46	1.14	.26	112
169	7-25-51	55	9.7	54.6	90.8	12.7	1.60	31.6	20.6	39.4	28.14	5.47	0.99	.28	0.83	.20	136
133	8-10-51	70	13.3	60.2	90.0	12.6	1.91	28.3	15.3	42.6	32.00	4.51	0.91	.35	0.86	.27	58
134	8-10-51	65	48.7	68.9	90.4	13.2	3.32	21.7	15.4	45.1	62.00	7.14	1.35	.58	1.16	.43	182
127	8-25-51	40	18.4	56.0	89.2	13.8	1.91	32.6	18.1	36.6	23.20	4.28	0.70	.37	0.86	.29	138
154	9-17-51	80	41.3	74.4	90.8	16.2	2.21	23.9	12.9	43.8	91.24	4.66	1.02	.57	1.01	.26	97
119	9-20-51	65	32.4	70.1	91.9	14.8	2.27	30.4	15.9	39.4	38.10	5.01	0.96	.55	1.06	.23	157
167	-51	15	5.0	73.8	90.7	17.3	1.84	26.8	17.1	39.4	12.75	5.36	0.88	.66	1.24	.29	137
1951 Av.		56	28.1	65.5	90.5	14.3	2.19	28.1	16.3	40.8	36.96	5.12	0.93	.49	1.01	.28	127
231	7-15-52	45	70.5	71.1	92.2	16.7	1.76	26.8	20.3	40.7	10.50	6.24	1.12	.46	0.86	.30	169
276	7-20-52	50	31.7	80.4	91.2	16.1	2.34	24.8	16.3	42.9	26.96	5.18	0.73	.61	1.07	.22	175
248	8-2-52	35	28.5	63.3	91.9	15.1	2.37	27.0	16.6	40.5	17.16	6.87	1.30	.38	1.13	.32	161
275	9-1-52	55	25.4	77.6	91.7	14.1	2.67	23.2	13.6	45.5	43.62	6.29	1.09	.51	1.28	.25	322
239	9-6-52	55	64.3	69.8	92.1	18.0	2.40	24.3	12.1	41.0	67.43	6.44	2.18	.57	1.14	.27	118
222	9-18-52	65	27.3	76.9	93.3	17.0	2.43	20.1	13.4	48.1	130.69	5.70	1.43	.41	1.66	.32	150
1952 Av.		51	41.3	73.2	92.1	16.1	2.33	24.4	15.4	43.1	49.39	6.12	1.31	.49	1.19	.28	182
3 Yrs. Av.		58	38.5	68.0	91.5	14.7	2.64	25.9	16.8	42.6	42.73	5.59	1.02	.46	1.05	.31	144

TABLE 9--CHEMICAL COMPOSITION OF TIMOTHY AND RED TOP HAY

Sample Number	Date Cut	Foreign Matter	Dry Matter	Crude Protein	Ether Extract	Crude Fiber	Lignin	N-free Extract	Carotene	Ash	Ca	P2O5	K	Mg	Fe
		%	%	%	%	%	%	%	μ/gm	%	%	%	%	%	PPM
							Timothy Hay								
54	6-10-50	25.6	93.1	6.4	2.01	34.7	13.7	44.9	8.83	5.09	.23	.36	1.42	.17	46
18	6-15-50	41.5	91.3	7.7	1.88	36.4	15.0	38.6	4.64	6.65	.21	.33	2.01	.18	61
30	6-15-50	75.0	93.6	7.9	2.85	32.1	13.9	44.7	11.30	5.99	.30	.32	1.85	.20	68
55	6-15-50	10.1	92.6	5.4	1.56	39.9	17.9	41.8	4.84	3.97	.24	.21	1.08	.14	45
49	6-20-50	1.4	93.1	5.9	1.85	31.7	15.7	46.4	5.13	7.24	.27	.33	1.16	.16	262
1950 Av.		30.7	92.7	6.7	2.03	35.0	15.2	43.2	6.95	5.79	.25	.31	1.50	.17	96
131	6-4-51	76.8	91.2	10.5	1.51	34.4	12.0	38.1	3.60	6.72	.37	.55	1.61	.12	86
157	6-16-51	2.4	90.8	7.6	1.35	37.6	15.2	38.0	4.23	6.26	.17	.38	1.38	.14	71
1951 Av.		39.6	91.0	9.0	1.43	36.0	13.6	38.0	3.91	6.49	.27	.46	1.50	.13	79
217	5-1-52	41.6	93.3	9.6	2.17	32.3	11.9	41.2	6.66	7.99	.40	.53	2.50	.14	140
227	5-10-52	78.8	94.1	9.4	1.95	32.1	12.7	43.9	13.94	6.76	.33	.57	2.40	.15	104
237	5-27-52	63.4	92.1	9.9	3.08	27.3	9.6	46.1	11.20	5.73	.26	.33	1.58	.17	132
277	6-8-52	10.0	91.2	8.6	2.21	29.9	12.3	44.9	7.43	5.63	.29	.38	1.61	.17	115
245	6-11-52	7.5	91.7	10.1	1.85	33.5	15.6	39.0	14.91	7.29	.66	.38	1.73	.22	113
262	6-12-52	38.7	92.3	7.1	2.22	28.9	11.9	49.1	3.15	4.96	.28	.34	1.58	.12	125
267	6-18-52	6.5	92.7	7.0	2.15	32.9	14.4	45.1	27.00	5.58	.33	.30	1.15	.17	65
246	6-19-52	2.6	90.6	9.0	2.11	31.5	16.2	40.1	10.61	7.84	.63	.41	1.84	.23	132
260	6-25-52	25.6	91.4	7.8	2.72	27.0	12.8	48.1	4.78	5.69	.18	.31	1.93	.18	95
205	6-26-52	4.6	93.8	8.1	2.41	29.8	14.5	47.8	1.76	5.69	.27	.41	1.65	.17	166
220	6-27-52	2.8	93.4	6.6	2.31	30.7	13.8	48.2	6.94	5.73	.26	.29	1.44	.16	140
264	6-27-52	15.7	91.8	6.2	2.49	29.2	13.4	49.1	3.08	4.78	.32	.26	1.70	.17	88
211	7-8-52	8.4	93.6	7.2	2.24	27.8	14.3	50.8	8.78	5.56	.32	.25	0.94	.16	119
258	9-20-52	78.1	92.9	11.3	2.49	26.2	12.7	46.9	51.70	5.94	.52	.34	1.80	.27	86
261	-52	11.5	91.8	6.3	2.38	29.6	13.6	49.0	6.32	4.52	.19	.35	1.55	.12	103
1952 Av.		26.4	92.4	8.3	2.32	29.9	13.3	45.9	11.88	5.98	.35	.36	1.69	.17	115
3 Yrs. Av.		28.6	92.4	8.0	2.17	31.6	13.8	44.6	10.04	5.98	.32	.36	1.63	.17	107
							Red Top Hay								
71	6-4-50	16.0	90.0	7.2	1.33	34.1	15.3	41.9	1.87	5.39	.20	.39	1.26	.22	239
39	6-20-50	62.5	93.4	6.9	2.34	34.8	14.8	44.1	2.89	5.24	.29	.35	1.34	.24	71
50	6-20-50	89.0	93.1	6.5	1.95	31.0	15.4	45.0	4.10	8.59	.28	.40	1.34	.18	244
56	7-4-50	12.6	93.6	5.9	2.00	31.3	13.9	48.0	6.47	6.37	.30	.19	1.32	.20	64
37	7-10-50	16.9	92.9	4.8	2.90	30.8	13.2	46.9	5.83	7.51	.19	.39	1.07	.24	92
149	6-23-51	14.6	92.6	5.9	1.51	34.8	15.0	45.8	1.63	4.59	.10	.44	1.16	.15	54
259	6-15-52	44.6	91.8	7.4	1.94	35.9		41.2	2.92	5.40	.27	.43	1.55	.20	64
Av.		36.6	92.5	6.4	2.00	33.2	14.6	44.7	3.67	6.16	.23	.37	1.29	.20	118

TABLE 10--CHEMICAL COMPOSITION OF MISCELLANEOUS HAY CROPS

Sample Number	Date Cut	Green Color	Foreign Matter	Leaves	Dry Matter	Crude Protein	Ether Extract	Crude Fiber	Lignin	N-free Extract	Caro-tene	Ash	Ca	P_2O_5	K	Mg	Fe
		%	%	%	%	%	%	%	%	%	μ/gm	%	%	%	%	%	PPM
								Soybean Hay									
51	8-15-50	15	3.4	62.5	90.2	14.2	1.70	26.5	13.1	40.7	8.38	7.00	1.07	.34	.90	.68	297
61	9-25-50	20	0.0	44.4	89.4	15.3	2.22	30.5	11.4	35.2	19.14	6.18	1.07	.51	.79	.68	194
62	9-25-50	20	0.0	47.2	89.2	14.6	2.87	29.4	10.7	35.2	17.25	7.05	1.03	.34	1.24	.50	412
115	8-15-51	10	9.5	50.3	88.7	14.1	1.30	37.6	15.6	27.4	12.54	8.32	1.19	.58	1.89	.43	335
122	9-20-51	30	0.0	63.0	89.2	16.6	3.30	31.2	10.9	31.8	9.56	6.39	0.89	.51	0.93	.44	148
143	10-1-51	30	31.8	53.7	90.9	19.4	1.10	29.6	12.6	29.1	41.89	11.74	1.13	.88	2.08	.45	580
272	9-8-52	20	35.4	69.8	89.2	10.4	2.60	22.1	9.0	41.6	9.38	12.53	1.33	.48	1.93	.33	395
Av.		21	11.4	55.8	89.5	14.9	2.16	29.6	11.9	34.4	16.88	8.46	1.10	.52	1.39	.50	337
								Ladino Clover Hay									
3	6-26-50	50	0.5	91.6	91.6	19.7	1.53	21.1	12.8	40.6	1.63	8.64	1.38	.46	1.50	.38	256
130	6-4-51	30	26.6	89.1	89.2	20.3	1.38	23.9	9.4	34.8	5.08	8.82	1.37	.74	2.43	.32	217
150	-51	60	3.5	85.4	90.9	17.3	1.77	25.4	12.6	38.9	4.95	7.53	1.19	.41	2.25	.28	122
160	-51	65	54.4	81.5	90.1	21.0	1.45	20.3	10.1	39.9	20.44	7.49	0.95	.76	1.11	.38	45
251	6-20-52	60	59.4	46.8	91.7	12.6	1.31	29.5	12.0	41.5	3.71	6.79	1.12	.46	1.66	.36	146
Av.		53	28.9	78.9	90.7	18.2	1.49	24.0	11.4	39.1	7.16	7.85	1.20	.57	1.79	.34	157
								Birdsfoot Trefoil Hay									
116	6-1-51	65	3.3	36.6	91.9	12.3	2.08	27.5	11.9	44.2	15.8	5.78	1.04	.37	1.47	.31	127
								Brome Grass Hay									
73	7-5-50		90.6		95.0	19.1	2.84	29.0	9.6	33.7	12.63	10.39	.66	.90	2.00	.31	98
152	5-29-51		87.4		94.9	15.0	1.43	32.1	10.0	37.8	11.16	8.57	.32	.33	3.32	.19	100
102	6-4-51				91.4	13.4	1.64	34.7	12.2	32.0	3.07	9.67	.48	.88	2.67	.14	95
159	-51		45.6		91.0	18.2	2.06	25.5	8.7	36.8	30.32	8.47	.63	.80	1.46	.38	107
170	-51				91.3	17.3	2.04	27.0	10.4	36.0	2.00	8.95	.47	.76	3.12	.29	120
209	6-1-52		8.7		94.6	9.6	1.09	31.8	13.4	44.6	4.47	7.46	.51	.42	2.14	.14	114
213	6-15-52		92.6		93.0	17.0	3.14	25.0	10.5	39.1		8.77	.69	.88	2.15	.25	160
253	6-20-52		76.6		91.2	10.3	1.96	33.4	12.4	38.8	6.54	6.74	.39	.66	2.21	.26	148
250	7-10-52		52.0		92.3	19.7	3.38	23.8	12.2	36.7	50.80	8.75	.52	.60	2.65	.27	135
256	-52				93.2	18.4	3.05	24.9		38.7	57.93	8.15	.54	.57	2.68	.27	129
Av.					92.8	15.8	2.26	28.7	11.0	37.4	18.76	8.59	.52	.68	2.44	.25	121
								Orchard Grass Hay									
137	9-1-51		48.6		91.3	16.2	4.02	25.2	10.8	37.0	11.62	8.94	.34	.89	3.41	.21	92
201	5-14-52		0		93.5	10.9	2.05	33.3	13.3	40.2	2.17	6.94	.32	.54	2.46	.13	120
								Sudan Grass Hay									
144	10-1-51		68.1		91.4	10.6	.67	34.6	16.1	35.0	2.27	10.51	.35	.68	2.50	.31	225
								Prairie Grass Hay									
52	7- -50		10.4		92.2	5.3	1.92	29.6	15.8	48.3	18.32	7.11	.49	.16	.70	.21	94
53	9- -50		3.4		93.1	8.7	2.08	27.4	13.0	46.8	99.34	8.04	.61	.26	1.00	.23	96

TABLE 11--CHEMICAL COMPOSITION OF SOME MIXED HAYS

Sample Number	Date Cut	Description of Mixture	Dry Matter	Crude Protein	Ether Extract	Crude Fiber	Lignin	N-free Extract	Carotene	Ash	Ca	P_2O_5	K	Mg	Fe
			%	%	%	%	%	%	μ/gm	%	%	%	%	%	PPM
57	6-20-50	Grasses	91.6	6.7	1.26	39.3	20.5	40.2	1.16	4.12	.33	.27	.77	.21	88
44	8-30-50	Wild Swamp Grasses	91.9	5.7	1.61	30.9	19.4	47.1	8.14	6.54	.32	.23	.69	.26	96
111	6-15-51	Chopped grasses-Ladino Clover	93.5	9.9	1.71	31.8	13.6	43.3	2.79	6.82	.70	.48	1.64	.22	127
129	6-22-51	Timothy-Red Top	91.5	5.4	1.87	34.0	12.9	45.0	2.99	5.23	.15	.43	1.19	.14	72
141	7-25-51	Ladino and Pasture grasses	91.9	14.7	1.27	25.8	12.3	43.8	10.28	6.28	.93	.39	1.50	.38	150
168	8-15-51	Grasses	91.2	5.6	1.55	33.6	18.5	47.8	5.58	2.69	.20	.25	.61	.08	87
124	-51	Chopped Alfalfa-grass	91.6	12.6	1.48	30.0	12.4	40.7	11.15	6.75	.87	.65	1.52	.32	97
244	6-6-52	Pasture Grasses	90.6	9.1	1.72	33.7	17.5	37.8	5.98	8.19	.59	.47	2.10	.25	148
214	6-15-52	Chopped Alfalfa Brome	92.1	10.1	1.58	32.5	13.2	41.2	14.90	6.87	.99	.36	1.66	.20	107
230	7-15-52	Pasture Grasses	92.1	7.5	1.63	32.5	14.7	43.2	1.35	7.33	.24	.30	.76	.15	143
235	8-7-52	Pasture Grasses	90.6	12.4	2.42	29.4	14.0	35.5	14.00	10.88	.45	.63	2.66	.34	245
240	9-6-52	Pasture Grasses	92.2	8.6	1.38	33.4	10.6	43.4	20.32	5.55	.77	.48	1.21	.20	136

TABLE 12--CHEMICAL COMPOSITION OF SILAGE FRESH BASIS[a]

Sample Number	Kind	Dry Matter	Crude Protein	Ether Extract	Crude Fiber	N-free Extract	Ash	Ca	P_2O_5	Carotene	Lactic Acid	pH	Preservative Used
		%	%	%	%	%	%	%	%	μ/gm	%		
S-29	Alfalfa	31.0	4.74	1.56	11.33	10.44	2.93	.35	.19	59.60	1.52	4.97	None
S-13	Alfalfa	38.9	6.19	.84	13.11	14.95	3.81	.64	.13	-----	2.20	4.42	70-80 lbs Blackstrap Molasses/Ton
S-14	Alfalfa	43.9	6.77	1.02	14.44	17.87	3.80	.72	.13	-----	2.50	4.35	70-80 lbs Wood Molasses/Ton
S-1	Alfalfa Brome	19.2	2.53	.59	8.08	6.06	1.94	.31	.05	3.09	1.27	5.27	None
S-9	Alfalfa Brome	30.3	5.75	1.59	8.30	12.45	2.21	.34	.09	42.59	3.67	4.03	None
S-2	Alfalfa Brome Ladino	24.0	3.05	.76	8.31	9.03	2.85	.29	.10	25.24	2.47	4.10	100 lbs Ground Corn/Ton
S-3	Alfalfa Brome Ladino	21.0	2.89	.75	6.76	8.52	2.08	.19	.09	0.69	.55	7.02	100 lbs Ground Oats/Ton
S-6	Alfalfa Brome Timothy	34.1	3.34	1.00	11.99	15.04	2.73	.18	.08	15.64	2.06	4.53	None
S-7	Alfalfa Brome Timothy	37.0	5.17	1.08	12.73	15.10	2.92	.36	.09	12.13	2.14	4.35	None---Wilted 1 hr.
S-28	Alfalfa Brome Timothy	38.2	5.48	1.51	10.82	17.39	3.00	.35	.23	36.33	1.92	4.32	None
S-27	Alfalfa Orchard Grass	25.0	3.24	1.13	6.97	9.27	4.39	.22	.13	38.49	1.12	5.10	None
S-20	Orchard Grass Ladino	31.9	4.89	1.21	9.15	14.40	2.25	.22	.18	29.72	2.01	4.40	SO_2
S-22	Orchard Grass Ladino	30.1	1.98	1.20	11.95	12.71	2.26	.12	.08	6.74	1.00	5.05	5 lbs SO_2/Ton
S-23	Orchard Grass Ladino	31.9	5.03	1.34	8.05	15.40	2.08	.42	.14	5.83	2.07	4.20	None
S-33	Orchard Grass Ladino	55.0	4.82	1.99	19.00	23.72	5.47	.17	.19	29.72	1.14	3.95	5 lbs SO_2/Ton
S-34	Orchard Grass Ladino	26.4	4.17	1.19	7.86	11.07	2.11	.23	.20	33.22	1.55	4.34	3 lbs SO_2/Ton
S-12	Red Clover	25.4	2.94	.94	8.81	10.06	2.65	.15	.08	-----	----	----	None
S-8	Red Clover Timothy	30.4	4.03	.98	10.78	12.21	2.40	.34	.07	6.50	2.02	4.20	None
S-11	Sweet Clover	42.2	6.70	2.42	13.08	16.43	3.57	.49	.10	20.83	2.29	4.35	100 lbs Ground Corn, Wilted 1 hr.
S-10	Sweet Clover Timothy	22.3	1.63	.89	12.28	6.65	.85	.14	.02	13.48	.72	4.74	None
S-4	Mixed Pasture Grasses	20.5	3.23	.91	7.71	6.89	1.76	.32	.04	32.18	1.04	5.68	None
S-30	Mixed Pasture Grasses	39.7	4.08	1.11	15.55	15.98	2.98	.31	.16	5.51	.74	4.82	None
S-31	Mixed Pasture Grasses	39.1	4.31	1.12	14.79	15.70	3.18	.30	.19	4.75	.87	4.89	None
S-32	Mixed Pasture Grasses	40.9	4.30	1.22	14.48	17.68	3.22	.26	.18	10.51	1.05	4.55	None
S-26	Sudan Grass	21.7	1.49	.69	7.90	9.91	1.71	.09	.07	7.21	.92	4.54	None
S-25	Millet	32.3	2.40	1.07	10.34	15.33	3.16	.14	.19	19.41	1.65	3.93	None
S-5	Wild Grasses	24.5	1.54	.68	8.49	11.53	2.26	.18	.04	11.39	1.37	4.80	None
S-21	Corn	27.3	2.47	1.03	5.33	17.14	1.33	.09	.09	1.43	2.00	3.82	None
S-24	Corn-Sorgo Mixed	31.2	3.21	1.06	8.44	16.69	1.80	.13	.13	1.67	1.72	3.68	None

[a] Type of Silo Used

1. Upright--Sample Numbers S-11, S-12, S-13, S-14, S-20, S-22, S-23, S-26, S-28, S-29, S-33, and S-34
2. Trench--Sample Numbers S-21, S-24, S-25, S-27
3. Stack--Sample Numbers S-30, S-31, S-32.

TABLE 13--AVERAGE MINERAL CONTENT OF LEGUME HAYS

Area	Total Ash %	Ca %	P_2O_5 %	K %	Mg %	S %	Cl %	Fe PPM	Mn PPM	Cu PPM	Co PPM	Zn PPM	B PPM	I PPM	Number of Samples
Alfalfa															
Lawrence Co.	6.93	1.41	.62	1.50	.26	.26	.35	112	36	5.4	.13	13	12	.06	6
Ozark Area	6.95	.99	.58	1.84	.32	.22	.31	152	47	8.8	.15	20	15	.06	8
Morgan Co.	5.98	1.06	.53	1,16	.33	.20	.27	173	12	8.0	.04	10	14	.25	3
Northwest Area	8.64	1.60	.45	1.81	.28	.31	.21	385	28	9.9	.08	20	13	--	11
Northeast Area	7.78	1.36	.54	1.89	.27	.26	.21	136	22	9.0	.08	14	11	.13	31
Southeast Area	7.18	1.07	.60	1.84	.32	.21	.20	155	42	9.9	.18	29	19	.25	7
Av.	7.60	1.31	.54	1.79	.29	.26	.24	181	29	8.9	.10	17	13	.12	
Lespedeza															
Jasper Co.	6.87	1.30	.38	1.13	.32	.21	.12	161	44	10.6	.19	22	17	--	1
Ozark Area	5.08	.86	.43	1.04	.29	.16	.07	145	105	9.1	.17	14	10	.16	12
Morgan Co.	5.45	1.32	.52	1.18	.34	.19	.06	135	63	10.5	.17	18	11	.15	5
Northwest Area	6.24	1.12	.46	.86	.30	.13	.09	169	44	6.1	.06	16	8	--	1
Northeast Area	7.14	1.35	.58	1.16	.43	.24	.13	182	148	5.1	.26	20	13	--	1
Av.	5.43	1.03	.46	1.08	.31	.17	.07	146	91	9.2	.17	16	10	.16	
Red Clover															
Lafayette Co.	6.55	1.48	.44	1.54	.34	.17	.18	192	35	10.4	.11	30	14		2
Ozark Area	5.91	1.14	.41	1.48	.31	.13	.13	103	48	6.7	.14	9	15	.59	3
Morgan Co.	6.34	1.37	.36	1.26	.47	.14	.27	97	40	11.3	.09	18	10		3
Northwest Area	7.38	1.42	.46	1.91	.30	.13	.10	123	24	10.4	.16	12	10		4
Northeast Area	5.52	1.22	.39	1.14	.37	.13	.19	116	28	9.7	.17	16	14	.31	7
Southeast Area	6.88	.73	.65	1.77	.29	.19	.26	153	62	6.5	.08	16	28		1
Various Locations 1950	6.43	1.22	.37	1.32	.36	.14	.16	146	46	13.0	.17	20	10	.12	8
Av.	6.30	1.26	.41	1.40	.36	.14	.17	129	38	10.5	.15	17	12	.24	
Ladino Clover															
Northeast Area	7.66	1.16	.59	1.85	.34	.19	.29	133	26	7.7	.15	17	13	.30	4
Soybeans															
Northeast Area	7.35	1.04	.54	1.41	.44	.26	.16	241	45	9.1	.10	22	19	.27	2

TABLE 14--AVERAGE MINERAL CONTENT OF GRASS HAYS

Area	Ash %	Ca %	P_2O_5 %	K %	Mg %	S %	Cl %	Fe PPM	Mn PPM	Cu PPM	Co PPM	Zn PPM	B PPM	I PPM	Number of Samples
							Timothy								
Callaway Co.	7.56	.64	.40	1.78	.22	.24	.52	122	93	6.4	.13	14	7	--	2
Ozark Area	5.43	.24	.31	1.59	.16	.20	.25	99	79	16.7	.08	20	4	.04	9
Morgan Co.	5.67	.28	.33	1.44	.17	.15	.30	134	90	5.4	.05	15	4		5
Northwest Area	7.38	.37	.55	2.45	.15	.21	.50	122	20	4.5	.05	10	6		2
Northeast Area	5.76	.43	.32	1.47	.22	.20	.29	76	54	5.7	.05	22	7		2
Av.	5.93	.32	.35	1.65	.17	.19	.32	110	75	10.5	.07	17	5		
							Brome Grass								
Northwest Area	8.11	.60	.65	2.14	.20	.25	.17	137	30	7.2	.03	13	7		2
Northeast Area	8.27	.48	.62	2.57	.28	.25	.59	123	53	8.7	.05	19	3	.24	6
Av.	8.23	.51	.63	2.47	.26	.25	.48	127	48	8.3	.045	18	4		8
							Red Top								
Ozark Area	6.62	.25	.34	1.27	.22	.17	.007	142	181	17.0	.13	16	3	.10	5
							Orchard Grass								
Northeast Area	8.94	.34	.89	3.41	.21	.23	.39	92	32	6.8	.02	17	8		1
Ozark Area	6.94	.32	.54	2.46	.13			120							1

Samples S-1 to S-14, inclusive, were crops grown during the 1951 growing season, and numbers S-20 to S-34 were harvested during the 1952 season.

The average content of various minerals and total ash in hay crops grown in different areas of the state is presented in Tables 13 and 14. Crude protein, crude fiber, and ash content for the same hays are presented in Table 15.

Location of counties and areas is shown in Figure 1. Lawrence and Jasper Counties are located in the Southwest part of the state, Morgan and Callaway Counties are near the center, while Lafayette County is in the west

TABLE 15 -- PROTEIN, FIBER AND ASH CONTENT OF HAYS GROWN IN DIFFERENT AREAS

Area	Crude Protein	Crude Fiber	Ash	Number Samples
	%	%	%	
		Alfalfa		
Lawrence County	20.6	22.5	6.93	6
Ozark Area	17.6	28.8	6.95	8
Morgan County	16.9	29.8	5.98	3
Northwest Area	17.6	26.3	8.64	11
Northeast Area	17.6	27.1	7.78	31
Southeast Area	15.9	28.3	7.18	7
		Lespedeza		
Jasper County	15.1	27.0	6.87	1
Ozark Area	13.8	26.3	5.08	12
Morgan County	16.6	24.1	5.45	5
Northwest Area	16.7	26.8	6.24	1
Northeast Area	13.2	21.7	7.14	1
		Red Clover		
Lafayette County	15.6	23.9	6.55	2
Ozark Area	13.1	28.4	5.91	3
Morgan County	14.3	22.3	6.34	3
Northwest Area	14.3	24.5	7.38	4
Northeast Area	13.4	27.6	5.52	7
Southeast Area	12.9	31.0	6.88	1
		Ladino Clover		
Northeast Area	17.8	24.8	7.66	4
		Soybeans		
Northeast Area	15.3	34.4	7.35	2
		Timothy		
Callaway County	9.5	31.7	7.56	2
Ozark Area	6.7	32.2	5.43	9
Morgan County	8.1	29.1	5.67	5
Northwest Area	9.5	32.2	7.38	2
Northeast Area	9.1	29.6	5.76	2
		Bromegrass		
Northwest Area	13.3	28.4	8.11	2
Northeast Area	14.8	29.1	8.27	6
		Red Top		
Ozark Area	6.3	32.4	6.62	5
		Orchard Grass		
Northeast	16.2	25.2	8.94	1
Ozark Area	10.9	33.3	6.94	1

central section. Samples referred to as being from the Northwest area were primarily from Andrew, DeKalb, and Nodaway Counties. The Northeast area was represented mainly by Marion and Ralls Counties, and the Southeast area was represented by Cape Girardeau, Perry, and Scott Counties. The Ozark area was represented primarily by Dent, Howell, Texas, and Wright Counties.

Iodine content of 1952 hays and part of the 1951 hays has not been determined due to a shortage of technical help. These samples have been saved for future determination.

Indications that there is some variation in cobalt content between cuttings of alfalfa hay were secured. From the same farms in 1951, cobalt averaged 0.05 p.p.m. for eight samples of first cutting, 0.07 p.p.m. for five samples of second cutting, and 0.18 p.p.m. for three samples of third cutting in the Northeast area.

Composition of alfalfa and red clover hay made under different weather conditions at harvest time and by different harvest methods is presented in Table 16.

TABLE 16 -- AVERAGE COMPOSITION OF ALFALFA AND RED CLOVER HAY MADE UNDER DIFFERENT HARVEST CONDITIONS

Harvest Conditions	Green Color	Leaves	Dry Matter	Crude Protein	Ether Extract	Crude Fiber	N-free Extract	Carotene	Ash	Number Samples
	%	%	%	%	%	%	%	%	%	
					Alfalfa					
Weather										
Clear	57	52.4	91.5	17.4	1.56	26.1	38.1	11.62	7.55	59
Cloudy	44	52.1	91.3	17.9	1.56	27.1	38.2	6.29	7.49	22
Rainy	36	49.9	91.7	17.4	1.44	28.4	36.0	4.54	8.51	7
					Red Clover					
Clear	44	55.0	91.7	13.8	2.08	26.0	43.9	15.31	6.36	20
Cloudy	30	55.9	91.8	13.3	2.21	27.8	42.4	15.36	6.03	6
Rainy	21	50.8	91.0	14.9	2.01	28.0	39.4	3.92	6.66	4
					Alfalfa					
Harvest Method										
Stems										
Crushed	56	52.1	91.0	17.2	1.45	27.1	37.1	14.13	8.09	8
Chopped	51	48.9	92.0	15.7	1.76	26.9	40.9	14.22	6.79	5
Loose	61	54.4	92.0	18.0	1.82	27.2	38.1	14.57	6.88	12
Baled	50	51.6	91.4	17.6	1.50	26.3	37.9	7.89	7.75	63
					Red Clover					
Stems										
Crushed	25	58.6	90.4	15.6	1.96	23.3	44.0	33.85	6.55	1
Loose	39	55.1	90.9	14.2	2.42	27.7	40.4	10.89	6.17	4
Baled	38	54.3	91.8	13.7	2.02	26.6	43.1	13.47	6.35	25

Weather was classified as "clear" when there was continuous sunshine throughout the harvest period, "rainy" when there was any precipitation, and "cloudy" for all other weather conditions. Total rainfall during the harvest period for most of the hay harvested under "rainy" weather conditions was very small. Some farmers reported trace amounts that they considered only slightly more than a heavy dew.

Baled hay was mowed, cured in the swath, raked with a side-delivery rake and baled with a pickup baler. The same method was used to harvest stem crushed hay, except stems were crushed by a stem crusher attachment at the time of mowing. Loose hay was taken from the windrow and hauled to the barn for storage. Chopped hay was chopped in the field from the windrow by a field chopper, blown into wagons, and again blown into the storage barn.

Monthly and annual rainfall, reported by six stations in the state for the three years samples were grown, is listed in Table 17. It should be noted

TABLE 17 -- MONTHLY PRECIPITATION IN AREAS OF THE STATE IN INCHES*

Year	January	February	March	April	May	June	July	August	September	October	November	December	Total
Cape Girardeau													
1950	15.94	5.03	5.04	8.54	5.34	2.06	3.18	9.62	2.86	1.84	5.18	1.11	65.74
1951	4.36	5.41	2.58	2.84	2.02	6.40	3.55	2.68	7.31	3.83	6.88	3.92	51.78
1952	2.68	3.53	7.43	3.10	2.84	.56	2.68	6.69	3.00	.65	3.93	2.35	39.44
Mount Vernon													
1950	6.26	1.80	1.95	1.35	6.60	4.75	4.20	13.02	2.30	2.54	0.29	0.27	45.33
1951	2.60	5.79	1.92	3.00	2.60	10.28	3.44	1.51	7.02	4.37	4.00	0.83	47.36
1952	1.24	3.90	2.76	2.97	3.40	.33	2.25	5.66	.27	.37	3.67	1.36	28.18
Jefferson City													
1950	3.79	1.89	2.81	5.62	4.57	2.87	3.45	6.07	0.65	1.66	2.70	0.19	36.27
1951	1.72	4.85	3.55	1.94	3.02	9.29	4.72	6.19	7.50	3.77	1.92	1.68	50.15
1952	.94	1.65	1.68	3.07	4.16	1.23	2.83	8.25	1.06	.22	3.53	1.34	29.96
Hannibal													
1950	2.74	1.22	1.54	3.94	2.13	2.22	4.63	5.77	1.22	0.25	1.44	.30	27.40
1951	1.57	3.83	5.21	2.53	3.43	5.22	2.45	3.08	3.72	2.26	2.40	1.15	36.79
1952	1.12	2.26	4.82	3.90	5.24	4.13	2.02	2.99	2.04	.92	3.96	1.90	35.30
Maryville													
1950	1.87	1.58	1.17	1.63	5.88	5.04	7.20	8.22	3.26	1.39	0.66	.28	37.38
1951	.61	2.37	3.66	6.14	4.49	8.24	4.28	8.44	2.20	2.75	2.75	----	-----
1952	.51	----	2.92	4.21	5.69	8.13	3.19	7.66	1.38	0.00	3.84	0.66	-----
West Plains													
1950	8.27	3.15	2.88	3.29	7.59	4.50	4.21	13.34	2.28	0.81	2.26	1.06	53.64
1951	3.51	6.94	2.58	3.66	1.96	8.93	6.03	3.40	3.99	7.66	5.65	1.42	55.73
1952	2.33	1.49	5.64	4.98	3.38	0.11	5.88	3.17	.72	.74	8.07	1.89	38.40

*Data from U. S. Weather Bureau Office, Columbia, Missouri

that there were variations in total annual rainfall between stations and between years at the same station. The 1951 season was considered wet while 1952 was a dry season, especially in the southern half of the state.

Blanks in the data for the Maryville station were the result of incomplete information rather than no rainfall. Totals for months listed for the Maryville station are 45.93 inches for 1951 and 38.19 inches for 1952.

DISCUSSION

Chemical analyses of 215 samples of dried roughages and 29 samples of silage produced in various areas of Missouri during the 1950, 1951, and 1952 seasons indicate considerable variation in composition of the forages studied.

The average harvest dates for first, second, and third cuttings of alfalfa hay were earlier for 1951 and 1952 than for 1950, as indicated in Tables 4, 5 and 6. With earlier harvest, there was a slight increase in average leaf and crude protein content. In 1951, a slight decrease in the average lignin content of second and third cuttings of alfalfa hay was observed.

No significant difference was observed in average leaf content of first, second, and third cutting alfalfa hay. The average values were 52.5 percent for first cutting, 51.9 percent for second, and 51.0 percent for third cutting alfalfa hay. Range in leaf content of alfalfa hay was 39.7 to 65.5 percent for first cutting, 35.7 to 68.0 percent for second cutting, and 32.5 to 63.5 percent for third cutting. In general, samples with a high leaf content had a higher percent crude protein and ash and a lower percent of crude fiber. This is in agreement with the work of Widtsoe (1897) and Swanson and Herman (1943) who found the leaf of Korean lespedeza nearly twice as high in protein and ash as the stem.

Green color and carotene content of roughages varied with weather conditions and time of harvest. Some samples had lost all green color while others were dark green. Carotene content ranged from a low of 0.44 to a high of 45.85 micrograms per gram. The average percent of green color for first cutting alfalfa hay was 41, second 53, and third 61. Carotene content of first cutting alfalfa hay was 6.38, second 9.93, and third cutting 12.88 micrograms per gram.

The lower green color and carotene content of the earliest cutting probably is due to a storage loss of this constituent. There are more high tempearature days in its storage period and the coarser stems are difficult to cure, resulting in heating and oxidation.

Dry matter content was uniform for all roughage samples. It averaged approximately 91.6 percent. The average ash and P_2O_5 content for the third cutting of alfalfa hay was found to be slightly higher than for the first and second cuttings. Calcium content of first cutting alfalfa hay averaged 1.48 percent, second 1.21 and third cutting 1.26 percent.

Second cutting alfalfa hay, Table 5, in the wet year 1951, gave a reduced average ash content. The average percent of P_2O_5 increased, compared to the 1950 values. In Tables 5 and 6, applying to second and third cutting alfalfa hay in the dry year 1952, it will be noted that there was a marked increase in average percent of ash and calcium and a marked decrease in the average P_2O_5 content. The same trends prevailed in first cutting red clover (Table 7). This change in P_2O_5 content is in agreement with observations of Eckles and associates (1926).

The average carotene content of all the hay crops was considerably lower for the wet year 1951. This fact, no doubt, is due to difficulties in curing the crop during inclement weather and oxidation of carotene.

A comparison of red clover with alfalfa hay, Tables 4, 5, 6 and 7, reveals that the average leaf content of first cutting red clover hay and first and second cutting alfalfa was practically the same. Second cutting red clover and fourth cutting alfalfa hay had a higher average leaf content than earlier cuttings and were approximately equal in leaf content.

Green color ratings for red clover were lower than for alfalfa with variations of about the same magnitude. Red clover's average carotene content for first cutting was higher than for either first or second cutting alfalfa hay.

Likewise, the average carotene content of second cutting red clover was higher than that of third cutting alfalfa.

Red clover hay had approximately three percent less crude protein; slightly more ether extract, lignin and nitrogen free extract; and the same crude fiber values as alfalfa hay. The average ash content of red clover was slightly lower than that of alfalfa. Average calcium content of red clover was comparable to that of second and third cutting alfalfa and lower than that of first cutting alfalfa. Phosphorus, expressed as P_2O_5, averaged 0.38 percent for first cutting red clover and 0.53 percent for first and second cutting alfalfa hay. These variations in composition are attributed mainly to species difference.

Farmers reported instances of dairy cattle not eating second cutting red clover hay when given an opportunity to eat other roughages. This was especially true for sample number 274 (Table 7). Average composition of second cutting red clover, as determined in this report or the analyses of sample number 274, does not explain the cause of decreased palatability. However, this sample is below average in crude protein and nitrogen-free extract and above average in crude fiber.

Korean lespedeza hay varied in composition more than any of the other legumes studied. Ranges in composition were as follows: crude protein 10.4 to 18.0 percent, crude fiber 20.1 to 32.6 percent, ether extract 1.60 to 4.37 percent, lignin 12.9 to 27.8 percent, nitrogen-free extract 39.2 to 50.0 percent, carotene 12.75 to 130.69 micrograms per gram, ash 4.51 to 7.59 percent, calcium 0.62 to 2.18 percent, and P_2O_5 0.23 to 0.72 percent. Some samples of lespedeza hay were comparable to alfalfa, although the average composition of lespedeza more nearly approached the average analyses of red clover. Lespedeza averaged higher in leaf, crude protein, lignin, carotene and P_2O_5 and lower in crude fiber, ash and calcium content than red clover.

Korean lespedeza hay consistently gave the highest carotene content and averaged 3½ to 5½ times that of red clover and alfalfa. This is in agreement with observations of Stallcup and Herman (1950).

Lespedeza has the ability to grow on soils so low in fertility that other legumes often fail. In order to make this growth under adverse circumstances it is suggested that lespedeza may make greater adjustments in composition than that occurring in other legumes. When crude protein was plotted against P_2O_5 from data in Table 8, samples below 0.30 percent P_2O_5 were proportionately lower in crude protein. The protein content for all samples higher in P_2O_5 than 0.30 percent varied without regard to the P_2O_5 content. All samples lower than 0.30 percent P_2O_5 were grown on soil very low in available phosphorus.

Indications that there might be a causative relationship between protein and low P_2O_5 content in lespedeza hay was noted early in this investigation. Attempts to secure additional samples of lespedeza with a low P_2O_5 content failed. As a result, it is felt that data presented here are insufficient to warrent more than a suggestion that such a relationship might exist.

From results reported in Table 9, timothy and redtop may be considered as dried roughages with a low crude protein, high crude fiber and nitrogen-free extract levels, and low calcium content.

When compared with first cutting alfalfa, timothy contained 45 percent as much crude protein, 79 percent as much ash, 22 percent as much calcium and 68 percent as much P_2O_5 and 14 percent more crude fiber and 16 percent more nitrogen-free extract. Timothy hay harvested before approximately June 10 generally had a higher crude protein content than that harvested later in the season. The high protein, late cut sample number 258 was from a second cutting mixture of timothy and red clover. The red clover portion of the sample is No. 257 (Table 7).

Soybean hay showed considerable variation in composition. Its leaf content ranged from 44.4 to 69.8 percent, crude protein from 10.4 to 19.4 percent, ether extract from 1.10 to 3.30 percent, crude fiber from 22.1 to 37.6 percent, nitrogen-free extract from 29.1 to 41.6 percent, carotene from 8.38 to 41.89 u/gram, ash from 6.18 to 12.53 percent, calcium from 0.89 to 1.33 percent, and P_2O_5 from 0.34 to 0.89 percent. The average iron content of soybean hay was found to be higher than for any of the other hays.

Ladino clover and birdsfoot trefoil are rather new crops in Missouri, compared to alfalfa, red clover, soybean and lespedeza. The number of samples of these hays was small. Average composition of ladino clover hay was similar to that of third cutting alfalfa. Leaf content of ladino clover hay was higher and carotene content lower than for third cutting alfalfa. Farmers reported that ladino was difficult to cure, especially if weather conditions were not ideal.

All bromegrass samples reported herein, except sample 209, were grown in a mixture of bromegrass and alfalfa. Bromegrass hay contained only 35 percent as much calcium as first cutting alfalfa hay; otherwise, the average composition of the two hays was quite simliar (Tables 10 and 4). Bromegrass averaged slightly lower in crude protein, but was higher in carotene, ash, P_2O_5 and potassium content than first cutting alfalfa.

The number of samples of orchard grass, sudan grass and prairie hays was too small to warrent conclusions. However, the high carotene content of prairie hay samples should be noted.

Composition of mixed hays varied as shown in Table 11. This variation, no doubt, is the result of difference in species and the ratio of legumes to grasses.

Wide variation in composition of silage when made from a mixture of legumes and grasses (Table 12) would be expected. Dry matter content varied from 19.2 to 55.0 percent, which naturally increased the range in composition when considered on a fresh silage basis. Rather than make comparisons of one kind of silage with another, this part of the investigation was conducted to give dairymen more information on the composition of silages as they are produced and fed under Missouri conditions.

Samples S-30, S-31 and S-32 were from the same stack. Number S-30 was taken from the top one-third of the stack, S-31 from the middle third and S-32 from the bottom one-third of the stack. Sample S-22 was taken from the top one-fourth of the silo and S-33 from the bottom one-fourth of the same silo. This silage was all from the same field and ensiled the same day. The material was dry and water was added as it went into the silo.

Table 15 should be used in conjunction with Tables 13 and 14 in order to study the average composition of hays grown in different areas of the state. Average crude protein content of alfalfa hay ranged from a low of 15.9 percent in the southeast area to a high of 20.9 percent in Lawrence County. Alfalfa grown in Lawrence County had the highest crude protein and lowest crude fiber content of all areas studied. Some dairymen in Lawrence County *raked their hay before it was dry and left it in the windrow until it was dry enough to bale.* These hays had a high leaf content and this practice may have contributed to their high average crude protein and low average crude fiber content. Another factor to consider is that stems were finer and lacked the woody nature encountered in alfalfa grown on "bottom" or highly fertile soils.

Average crude protein in alfalfa from Ozark, Northwest and Northeast areas was about the same. That from Morgan County was slightly lower in crude protein.

Average crude protein content of Korean lespedeza hay was found to be 16.6 for Morgan County and 13.8 percent for the Ozark area.

In general, the ash content was highest in hays grown in the Northwest area and lowest in the Ozark and Morgan County areas. While the highest average ash and calcium content in alfalfa hay was found in the Northwest areas, these hays had the lowest average P_2O_5 content; but all values were in the range of normal composition.

The higher average iron content for alfalfa hay grown in the Northwest area primarily results from two extremely high samples and thus is not necessarily indicative. Remaining samples were about the same as those from other areas.

The lower chlorine content of lespedeza and red top hay is of no significant importance in Missouri dairy feeding as it is a common practice to supplement all rations with common salt (NaCl).

In all areas, the average boron, copper, cobalt, iron, manganese, and zinc contents are within the normal range given by Piper (1950).

Morrison (1950) suggests 5 p.p.m. of copper in the ration as sufficient to prevent deficiencies in sheep and 0.10 p.p.m. of cobalt as sufficient for cattle and sheep. He further points out that sheep show deficiency symptoms when cobalt content of feed is below 0.07 p.p.m., while cattle do not show deficiencies until the cobalt content is 0.04 p.p.m. on a dry matter basis. These data support the fact that Missouri grown roughages are adequate in copper content for normal nutrition of livestock.

Cobalt content of legumes averaged higher than that in grasses. For alfalfa and soybeans, the average cobalt content was 0.10 p.p.m., for ladino and red clover 0.15 p.p.m., for lespedeza 0.17 p.p.m., for timothy 0.07 p.p.m., for bromegrass 0.045 p.p.m., for red top 0.13 p.p.m., and for one sample of orchard grass 0.02 p.p.m.

Variation in cobalt content occurred between areas and species, and between species within the same area. In general, the lower values were secured in the Morgan County and Northeast and Northwest areas, and the highest values in the Ozark area, Lawrence and Jasper Counties. Cobalt content of roughages grown in Morgan County, Northwest and Northeast areas averaged about minimal amounts needed for adequate nutrition of ruminants. Roughages grown in the Ozark area and Lawrence and Jasper Counties had ample cobalt supplies.

Since not all iodine determinations have been made, the information on iodine content is incomplete. Lowest iodine values secured, so far, are from the Ozark area. Highest values are from Morgan County, Northwest, and Southeast areas. The balance of the data on iodine content of roughages is needed before final conclusions are made. Iodine deficiency is characterized by a hairless condition in new born calves and pigs, and enlarged necks in calves.

Rain during harvest reduced leaf, color, and carotene content of both alfalfa and red clover hay (Table 16). Carotene reduction in micrograms per gram was from 11.62 to 4.54 for alfalfa and from 15.3 to 3.92 for red clover. Crude fiber and ash increased slightly in rainy weather, and nitrogen-free extract decreased. In rainy weather, soluble carbohydrates are leached out, or broken down under influence of heating; consequently, a higher content of ash, crude fiber and other less soluble constituents results.

The method of harvesting roughages had a marked effect upon leaf, crude fiber, and carotene content. Field chopped alfalfa hay contained 5.5 percent less leaf matter than loose harvested hay. Reduction in leaf content was accompanied by 2.30 percent less protein and 2.80 percent greater fiber content. Stem crushed hay had a slightly higher leaf content and more carotene than baled hay.

Daily allowances for dairy cattle recommended by the National Research Council are shown in Table 18. Total daily nutrients recommended for a 1000 pound cow giving 30 pounds of 4 percent milk were calculated. Using Morrison's (1950) coefficients of digestion and the average composition of hays studied, the calculated nutrients supplied by the various hays are inadequate to maintain such a cow (Table 19). Total digestible nutrients calculated for 22 pounds of the various hays ranged from 10.9 to 11.9 pounds, compared to 17.6 pounds recommended. Phosphorus ranged from 15 to 29 while 31 grams were recommended. Feeding limited amounts of

TABLE 18 -- RECOMMENDED DAILY ALLOWANCES FOR DAIRY CATTLE[a]

(Based on Air-Dry Feed Containing 90 Percent Dry Matter)

	Expected Gain		Daily Allowances per Animal[1]						
Body Weight lbs.	Small Breeds lbs.	Large Breeds lbs.	Total Feed lbs.	Digestible Protein lbs.	T.D.N. lbs.	Calcium gm.	Phosphorus gm.	Carotene mg.	Vitamin D I.U.
Normal growth of dairy heifers									
50	0.5	---	0.9	.20	1.0	4	3	6[2]	200
100	1.0	0.8	2.0	.40	2.0	8	6	6	400
150	1.3	1.4	4.0	.50	3.0	12	8	9	600
200	1.4	1.6	6.0	.60	4.0	16	11	12	800
400	1.2	1.8	11	.80	6.5	20	15	24	[3]
600	0.8	1.4	15	.85	8.5	18	15	36	
800	1.1	1.2	19	.90	10.0	16	15	48	
1000	---	1.3	22	.95	11.0	15	15	60	
1200	---	1.2	24	1.00	12.0	15	15	72	
Maintenance of mature cows[4]									
800	---	---	14	.50	6.8	8	8	48	[3]
1000	---	---	16	.60	8.0	10	10	60	
1200	---	---	18	.70	9.2	12	12	72	
1400	---	---	21	.80	10.5	14	14	84	
1600	---	---	23	.87	11.4	16	16	96	
Reproduction (Add to maintenance during last 2 to 3 months)									
	2.0	2.0	8.0	.60	6.0	12	7	30	[3]
Lactation (Add to maintenance for each pound of milk)									
	3.0% fat		---	.040	0.28	1	0.7	[5]	[5]
	4.0% fat		---	.045	0.32	1	0.7		
	5.0% fat		---	.050	0.37	1	0.7		
	6.0% fat		---	.055	0.42	1	0.7		
Maintenance of breeding bulls									
1200	---	---	18	1.00	10.3	12	12	72	
1600	---	---	22	1.20	12.9	16	16	96	[5]
2000	---	---	27	1.45	15.6	20	20	120	
2400	---	---	31	1.60	18.2	24	24	144	

[1] Thiamine, riboflavin, niacin, pyridoxine, pantothenic acid, and vitamin K are synthesized by bacteria in the rumen, and it appears that adequate amounts of these vitamins are furnished by a combination of rumen synthesis and natural feedstuffs. Manganese, iron, copper, and cobalt are clearly essential, but the amounts needed are not known. For growth, 0.6 gm. magnesium is needed per 100 pounds of body weight.

[2] Calves should receive colostrum the first few days after birth, as a source of Vitamin A and other essential factors.

[3] While Vitamin D is known to be required, the data are inadequate to warrant specific figures for older growing animals and for maintenance, reproduction, and lactation. The Vitamin D allowance has been increased from 300 to the present 400 I.U. per 100 pounds body weight to provide a safety margin comparable to that of other nutrients.

[4] When calculating the allowances for lactating heifers that are still growing, it is recommended that the figure for growth rather than maintenance be used.

[5] When adequate amounts of Vitamins A and D are fed for normal reproduction, extra amounts will probably not stimulate milk production but will increase the vitamin content of the milk.

[a] By national research council.

TABLE 19 -- CALCULATED DAILY NUTRIENTS REQUIRED AND AMOUNTS SUPPLIED BY VARIOUS HAYS

	Total Feed Lbs.	Digestible Protein Lbs.	T.D.N. Lbs.	Ca gm.	P gm.	Carotene µ/gm
Need for:						
Maintenance, 1000 pound cow	16	0.06	8.0	10	10	60
Production--30 pounds of 4.0 percent milk		1.35	9.6	30	21	---
Total recommended		1.95	17.6	40	31	
Supplied by:						
22 pounds of alfalfa hay	22	2.74	11.4	147	23	64
22 pounds of red clover hay	22	1.79	11.9	122	16	100
22 pounds of lespedeza hay	22	1.62	11.1	101	20	380
22 pounds of soybean hay	22	2.35	11.5	109	22	169
22 pounds of bromegrass hay	22	1.77	11.2	51	29	187
22 pounds of timothy hay	22	.77	10.9	31	15	100

concentrated feeds containing wheat or wheat bran would supply the additional phosphorus. All hays studied would supply adequate amounts of carotene. Soybeans and alfalfa were the only hays calculated to supply recommended daily amounts of digestible protein. Red clover, lespedeza and bromegrass were only slightly deficient in crude protein. Timothy hay failed to supply the recommended daily allowance of all nutrients except carotene.

SUMMARY AND CONCLUSIONS

1. Composition of 215 samples of dried roughages and 29 samples of silages produced by dairymen in major farming areas of Missouri during 1950, 1951 and 1952 was studied.

2. Information on annual precipitation, date of cutting, weather conditions during harvest, and method of harvesting was included in this study.

3. Each sample was analyzed for foreign matter, green color, leaf percentage, dry matter, crude protein, ether extract, crude fiber, lignin, nitrogen-free extract, ash, and carotene. Ash analyses included a determination of calcium, phosphorus, potassium, manganese, iron, sulphur, chlorine, magnesium, copper, cobalt, zinc, boron, and iodine content.

4. The average carotene content of all hay crops was lowest for the year 1951, which was characterized by heavy rainfall. In second cutting alfalfa hay, carotene content was 19.66 micrograms per gram for the "dry" year 1952 but only 3.93 micrograms per gram for the 1951 season. Korean lespedeza hay averaged 42.73 micrograms of carotene per gram for the three-year period, which was 3½ to 5½ times the average found for other hays.

5. Leaf content of alfalfa hay ranged from 39.7 to 65.5 percent for first cutting, 35.7 to 68.0 percent for second cutting, and 32.5 to 63.5 percent for third cutting. Leaf matter in red clover hay ranged from 32.8 to 63.5 percent, in Korean lespedeza hay from 54.6 to 80.0 percent, and in soybean hay from 44.4 to 69.8 percent.

6. In general, samples with a high leaf content had a higher percentage crude protein and ash and a lower percentage of crude fiber.

7. The average percentage of ash and calcium increased and the average percentage P_2O_5 decreased in second cutting alfalfa hay in 1952, when there was a deficiency of moisture. Similar trends were found in composition of red clover hay.

8. Some indications were found of a relationship between low P_2O_5 and crude protein content in Korean lespedeza hay. (Table 8).

9. Timothy hay contained only 45 percent as much crude protein, 79 percent as much ash, and 68 percent as much P_2O_5 as first cutting alfalfa hay. It contained 14 percent more crude fiber and 16 percent more nitrogen-free extract.

10. Ladino clover hay was similar to third cutting alfalfa hay in composition.

11. When grown in combination with each other, bromegrass hay contained only 35 percent as much calcium as first cutting alfalfa hay, but otherwise the two forages were similar in composition.

12. Crude protein in six samples of alfalfa from Lawrence County averaged 20.6 percent and eight samples from the Ozark area, 11 samples from the Northwest area, and 31 samples from the Northeast area all averaged 17.6 percent. Three samples grown in Morgan County averaged 16.9 percent crude protein, and seven samples of hay grown in the Southeast area averaged 15.9.

13. The average crude protein content of Korean lespedeza hay grown in the Ozark area was 13.8 percent, compared to 16.6 percent for that grown in Morgan County.

14. The highest average ash and calcium and the lowest P_2O_5 content in alfalfa hay were found in roughages grown in the Northwest area.

15. Korean lespedeza and red top hays had a lower chlorine content than other hays studied.

16. The copper content of roughages was found to be adequate by all present standards for nutrition of livestock.

17. In general, roughages grown in the Ozark area and in Lawrence and Jasper Counties have a higher cobalt content than those grown in Morgan County, Northwest and Northeast areas. Average cobalt content was found to be 0.10 p.p.m. in alfalfa and soybean hays; 0.15 p.p.m. in Ladino and Red clover; 0.17 p.p.m. in Korean lespedeza; 0.07 p.p.m. in timothy; 0.045 p.p.m. in bromegrass, and 0.13 p.p.m. in red top hay.

18. Rainy weather during the harvest season reduced carotene content from 11.62 to 4.54 micrograms per gram in alfalfa hay and from 15.31 to 3.92 micrograms per gram in red clover.

19. Field chopped hay contained 5.5 percent less leaf content than loose harvested hay. The reduction in leaves was accompanied by a 2.30 percent reduction in crude protein and a 2.80 percent higher crude fiber content. Stem crushed hay had a slightly higher leaf content and a higher carotene content than baled hay.

20. Nutritional requirements of a 1000-pound cow giving 30 pounds of 4 percent milk daily were determined. The following percentages of such a cow's requirements were calculated to be furnished by feeding 22 pounds per day of the hays studied: 50 to 95 percent of the phosphorus, 40 to 100 percent of the digestible protein, 80 to 100 percent of the calcium, and 100 percent of the carotene.

21. Wide variation was found in composition of silage made from mixtures of legumes and grasses. Dry matter content of this silage ranged from 19.2 to 55.0 percent, which increased the range in composition on a fresh, or wet, basis.

22. In general, composition of Missouri grown dried roughages for the 1950, 1951 and 1952 seasons compared favorably with averages found

throughout the north central region. No major deficiency of any of the rare minerals was observed. The importance of cutting roughages before they are too mature and conserving leaves in the harvesting and storage process is emphasized by this study.

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