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A Chemical Study of Legumes and Other Forage Crops of Western Oregon

By

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A Chemical Study of Legumes and Other Forage Crops of Western Oregon

By J. S. JONES and D. E. BULLIS

The growing of legumes is fundamental to a thoroughly well-developed agriculture in Western Oregon. However widely this fact is known and acted upon it cannot be over-emphasized by repetition. It is common farm experience that no procedure is more generally applicable for the rejuvenation of soils too long given over to the continuous growth of small grains and for stimulating the latent fertility of newly cleared lands than the systematic and persistent growth of the clovers, vetches, and other adaptable legumes. When, in addition to the value directly of legumes as rejuvenators of poorly conditioned soils, mention is made of their enormous feeding value and their indirect value as soil builders in the shape of barnyard manures, no argument is necessary in support of the fundamental relationship the legume crops bear to agriculture in Western Oregon. There are no crops here of greater importance, for they make the growing of other crops permanently possible and profitable.

Closely associated with legume crops are other forage crops, which, although not in any sense fundamental to the general agriculture of Western Oregon, are of vast importance economically, because of their extensive use in the feeding of dairy and other livestock. It is the sole purpose of this publication, one of a series dealing with some chemical phase of forage crop production and utilization, to carry over to farmers of Western Oregon some specific information regarding the chemical nature of these crops which so vitally affect their own immediate interests and the permanent general welfare of Western Oregon. In this instance information gained from rather extensive laboratory investigations harmonizes with and supplements that secured by farm experience. It is usable in that it makes for a better understanding of the requirements of forage crops for growth, their peculiar and relative values for the feeding of livestock, and the invigorating effect of the legumes on poorly conditioned and "run down" soils.

THE COMMONLY GROWN LEGUMES

ADAPTABILITY

Conditions of soil and climate which make of alfalfa the forage crop of first importance in irrigated sections of Eastern Oregon somewhat restrict its growth in Western Oregon, particularly in Willamette Valley and Coast counties. There is, however, a rather extensive acreage of river bottom lands in the Valley counties on which alfalfa is known to thrive excellently and on which its growth might be greatly expanded with benefit to the soil and the production of a greater tonnage of hay of a kind that is always in demand by feeders of dairy stock.

The clovers—red and alsike—adapt themselves to a wide range of conditions with respect to soil type and climate. They are extensively grown in Valley and Coast counties where the reaction of the soil is not too

strongly acid. Red clover is given the preference on the higher lying and well drained lands. Alsike, because of its adaptability to soil conditions incident to poor natural drainage, is confined almost exclusively to areas of that kind. The clovers are prominent among the legumes of Western Oregon.

The ability of common vetch to thrive on close-textured and somewhat acid soils gains for it, too, a peculiar significance for the agriculture of Western Oregon. It is thrifty and hardy under a wide range of soil conditions. Its ability to secure nitrogen under conditions that are adverse to other legumes and to store it as finished protein (muscle-building material) for the use of dairy and other livestock is an exceedingly valuable characteristic and one that might possibly by selection and breeding be made even more pronounced.

Other legumes, hairy vetch, field peas, and beans, are less widely grown, but each possesses some peculiar characteristic that makes it valuable for certain localities. No section of Western Oregon is without some legume that makes excellent growth and lends itself to soil-improvement programs and the feeding of livestock.

THE LEGUMES AS SOIL REJUVENATORS

It is common observance that newly cleared lands all too frequently are lacking in something that imparts "tone" and vigor to cultivated crops. Farm experience, too, teaches that soils, no matter how excellent the original condition of tilth, when continuously cropped with small grains or with small grains rotated only with non-leguminous forage crops, or even when "clean cultivated" for too long a time, as in orchard practice, invariably come into a condition of poor tilth and a lessened capacity for production. It is the peculiar function of legumes to overcome these conditions.

Soils fail to impart "tone" and vigor to growing crops largely because of an insufficient supply of nitrogen, one of the elements absolutely essential for the growth of all plants. Soils reach a "run-down" physical condition through failure to maintain in them a liberal supply of actively decaying organic matter. Nitrogen can be purchased in the form of commercial fertilizers, and sometimes such purchase is practicable. Barnyard manures will carry into the soil active forms of organic matter. But all too frequently commercial forms of nitrogen are too expensive for general use and barnyard manure is sufficient for a small fraction only of the soil that would be stimulated to greater production by its application. Just here the legumes can be made to save the situation.

The deep-rooted ones, like alfalfa and the clovers, enrich the soil enormously with sod-like masses of quickly decaying roots when the ground is broken for the succeeding crop. Such crops having brought up, too, from soil depths not ordinarily reached by fibrous-rooted plants, supplies of lime, potash, and phosphorus for their own nourishment, the succeeding crop has placed within its reach as the sod rots a supply of mineral plant food that would not otherwise become available to it. But these legumes, when vigorously inoculated with nitrogen-gathering bacteria, accomplish even more in the matter of placing necessary plant food at the disposal of the succeeding crop. Because of the activity of the bacteria which grow on them, the root masses are rich in a form of nitrogen that readily becomes available for the succeeding crop as the sod decays, and, best of all it has been taken largely from the unlimited supply of the soil air.

Unquestionably, these deep-rooted legumes are deservedly popular as rejuvenators of run-down lands wherever soil conditions permit of thorough inoculation and vigorous growth.

The annual legumes—vetches, beans, and field peas—when thoroughly inoculated with vigorously active nitrogen-gathering bacteria, likewise leave in their roots at harvest time a supply of nitrogen taken from the soil air which readily becomes available for the succeeding crop at no expense to the soil itself. The less extensive root systems of the annual legumes, however, put them at a disadvantage in comparison with alfalfa and the clovers in the matter of soil enrichment with active organic matter. The disadvantage is partly offset by the possibility of a more frequent appearance of these annual legumes in crop rotations and their less exacting requirements for growth. Whenever heroic treatment is necessary for the rejuvenation of soils in especially poor condition of tilth the annual legumes are readily available as cover crops. They have a well-established place in the agriculture of Western Oregon from the standpoint of soil fertility alone.

USING LEGUME CROPS

Alfalfa, red and alsike clover are most commonly cut for hay. The vetches and field peas are most frequently grown with wheat, oats, or barley and harvested for hay or silage. However harvested, the legumes figure prominently in the winter rations of sheep and cattle and are given first place among all forage crops because of their relatively large content of protein.

THE NON-LEGUMES

Of the non-legumes, some, as timothy, redtop, orchard grass, and rye grass are widely known and appreciated. Others, like marshland grass and canary grass, are localized crops whose utility is correspondingly restricted. Corn and sunflowers may very properly be mentioned in this connection as crops are more frequently harvested in Western Oregon for forage than grain. The non-legumes are less sensitive than legumes to soil reactions and are not likely to fail in any community because of acid-reacting soils.

The non-legumes, however, are soil exhausters. They have a place in rotations with small grains but like them they leave no accumulation of nitrogen in the soil in exchange for other plant foods taken. No one should think of growing timothy and orchard grass for reasons that make alfalfa, clover, and vetch so widely grown. In the form of hay the non-legume grasses bring into the ration a necessary roughage that is more palatable than the straws, comparatively cheap carbohydrates (energy-releasing and fat-producing compounds), and liberal amounts of mineral matter. Sunflower and corn silages impart to the winter ration of sheep and cattle the necessary succulence and are valued highly by feeders of dairy and other livestock for that reason alone.

COMPOSITION OF FORAGE CROPS

There are some analytical data available for practically all kinds of forage crops grown in Western Oregon. Clovers and alfalfa especially have been very frequently the objects of chemical investigations elsewhere and something is known of their response in composition to changes of environment. The data for two or three of the legumes which figure prominently in the agriculture of Western Oregon are, however, rather

meagre, and it is doubtful whether any are as strictly applicable to prevailing conditions as one might wish. This situation is remedied by the analytical data presented here. They bear strictly upon forage crops grown in Western Oregon.

ORIGIN OF SAMPLES

Samples from which analyses were made represent crops of 1919 and 1921. They were obtained through the cooperation of county agricultural agents and from the superintendents of the branch experiment stations in Jackson and Clatsop counties. All samples represent crops matured for hay or silage. Since they were hand-picked and very carefully handled in drying to prevent shattering of leaves and small stems, they probably more nearly represent the crops as grown than would samples secured behind mower and rake. The analyses were made on air-dry samples finely ground.

ANALYTICAL DATA

Although the analytical data are tabulated by sections, it must not be assumed that rigid comparisons, whereby the superiority of one section over another for the growing of any one crop might appear to be established, are thereby intended or invited. So many factors are concerned in the final make-up of plant substance that one is not justified in attempting such comparisons here as the three divisions of tabulated data naturally suggest. The more or less natural geographic divisions of Western Oregon were used in the tabulation of analytical data entirely as a matter of convenience for reference and comment. It is to be noted that the greatest range of forage crops prevails in the Valley counties.

The analytical data are presented in detail in tables I, II, and IV. It would be presumptuous to undertake interpretation of or to comment on the data from the various possible standpoints of interested readers. It would be equally presumptuous to leave to the reader all possible interpretations. The data will be viewed most naturally from the standpoint of the feeder of livestock, but they have a certain value agronomically from the standpoint of soil fertility. Comment here has been restricted to these two points of view, and for the benefit of those who might best appreciate a condensed expression of results, certain calculations have been made from the original data and summarized in tables III, V, and VI. The reader may therefore study the data from his own particular standpoint, or he may quickly secure the essential points applicable directly in calculating rations for livestock and for calculating the fertilizer requirements of the more prominent of these crops.

FROM THE STANDPOINT OF NUTRITION

The Proteins. In Table I the analytical data are presented in a form that is perfectly familiar to those most likely to use them. The significance of each group of compounds in feeding operations is well understood, but this with reference to the proteins must be said: The proteins of seeds—corn, wheat, oats—because of fundamental differences in molecular structure, differ very markedly in their ability to meet the varied wants of the animal body. It is probable that the proteins of the stalks and leafy portions of the same plants also differ in feeding value for similar reasons. Actual feeding experiments are now considered necessary to establish fully

the relative feeding values of protein mixtures from various sources. The "crude protein" determinations, however, still serve as a rough measure of relative values in so far as the nitrogen-containing compounds are concerned and are presented here with that idea only.

It appears from Table I that of the commonly grown legumes, common vetch and field peas stand out most prominently in ability to elaborate protein compounds. If, pound for pound, the proteins of these crops should prove to be the equal in feeding value to those of red clover and alfalfa, it would seem to be perfectly proper to encourage their more extended growth and to capitalize for the Valley and Coast counties especially this ability to gather and utilize nitrogen under conditions that are somewhat adverse to the most thrifty possible growth of the clovers and alfalfa.

Table III summarizes the average composition of those crops that are most commonly used in feeding cattle and sheep. In Table V, column 3, there is a statement of pounds of crop required to equal the protein in 100 pounds of milk. Since a fraction only of the protein consumed is digested (roughly 63 to 70 percent for the hays and silage and 70 to 75 percent for the grains) and since there are body wastes to make good as well as milk to secrete, it is obviously impossible for the dairy cow to secure from the richest of legume roughage an amount of protein sufficient to meet her requirements in reasonably heavy milk production. The non-legumes are wholly inadequate, hence the importance of the concentrates (by-products of various kinds rich in protein, as bran, shorts, linseed meal) for this particular kind of feeding.

Carbohydrates Other than Crude Fiber. It has been the custom in the analysis of plant substances intended for feeding purposes to determine "crude fiber" and to report all other carbohydrates under the term "nitrogen free extract." That custom was followed in the compilation of Table I. "Nitrogen free extract," however, like the term "crude protein," is one that covers over a great deal of information that might possibly be made use of by feeders of livestock were it readily available. In Table II are summarized for the legumes the analytical data resulting from the determination of the more prominent components of a group of constituents common to all feeding stuffs that are usually lumped together under a heading that leaves much to be desired in the way of specific information. It is to be noted that sugars, starch, and pentosans make up a large part of the "nitrogen free extract." Total sugar is the sum of "reducing sugars," calculated as dextrose, and sucrose or cane sugar. When the sweetness of the blossoms and their attractiveness to honey-bees and other insects are recalled, one would expect to find in this class of feed stuffs rather large amounts of these carbohydrates. The pentosans are carbohydrates that yield in processes of digestion sugars called pentoses. Galactans are closely associated with the gums and mucilage-like compounds of plant structure. In processes of digestion they probably also yield a sugar called galactose. The sugars and starch vary rather widely in amount among individual samples of any one kind of legumes; the pentosans and galactans are fairly constant in amount.

It is commonly assumed that the several carbohydrates of plants have practically the same value as fat-producing and energy-releasing substances. It is possible, however, that with this group, as was the case with the proteins, the utilization of each individual carbohydrate by the animal body in metabolic processes might repay more extended experimentation than

has heretofore been given it. Different legumes, either alone or in mixtures with non-legumes, are not siloed with the same degree of success. Alfalfa is probably as difficult and field peas as easy as any legume to silo successfully. The presence of liberal amounts of fermentable sugars is believed to make for success in the siloing of forage crops. The data on the sugars in Table II tend in a general way to support that view.

Fatty Substances and Crude Fiber. Fat-like compounds of the forage crops are even smaller in amount than the data in the column headed "ether extract" indicate, for other substances than fats and oils are extracted with that solvent. In the grains the amount is appreciable and is to be reckoned with in compounding rations. On the other hand "crude fiber" or the fibrous portion of stalk and leaf, is large in all forage plants and low in the grains. In compounding rations the digestible portion is rated as carbohydrate and given the same value as an energy-releasing and fat-producing substance. There is a fairly wide range in the crude fiber content of samples representing any one kind of forage crop, but in all forage crops the crude fiber content is large.

Ash or Mineral Content. In Table I, under the heading "ash," is indicated the total mineral matter these forage crops contain. Animal life is practically dependent upon plant life for the mineral or inorganic portion of its make-up. Forage crops carry to dairy stock especially a large part of the mineral elements required for growth and milk production. They are for this class of livestock especially important from the standpoint of mineral nutrition.

Of the ash constituents of feedstuffs, phosphates, lime, magnesia, potash, and sulfur, give most concern, furnishing as they do the phosphorus, calcium, magnesium, potassium, and sulfur which enter into the make-up of bones, flesh, blood, milk and other body secretions. The percentages of these elements in forage crops, calculated on the air-dry plant substance, on the plant substance with all water removed (oven-dried), and on the crude ash are given in detail in Table IV. In view of the great diversity of soil types and climatic conditions that prevail within any one of the three sections under which the data have been tabulated the wide range in the percentages found for each of the several mineral elements in each of the forage crops is not surprising. From these data, however, one can calculate approximately the amount of the several mineral elements the forage crops offer to the animal body when they become a part of the daily ration.

MINERALS IN FORAGE CROPS ARE POSSIBLY LOW

There appears to be a fairly well established conviction among feeders of dairy stock in Western Oregon that Valley- and Coast-grown forage crops mature with smaller percentages of the mineral elements than the same crops east of the Cascades and in the prairie states. In the breeding of herds for heavy milk production it is believed by some at least, that real difficulty here and there is being experienced in providing rations sufficiently high in the several mineral elements to meet fully the animal's requirements. At any rate there is in the Valley all too frequently an actual physical breaking down of animals in heavy milk production and other disturbances—even diseases—not confined alone to dairy stock that serve to center inquiry around questions relating to the possible deficiency of mineral substances in available rations. The analytical data produced here cannot be made to answer positively any of these questions. It is

only from analytical work on specific rations fed for specific purposes that one can arrive at definite conclusions as to the adequacy or inadequacy of their mineral content. The present work emphasizes the necessity for just that kind of investigation. In the meantime, in the compounding of rations for milk production it might be worth while, as in the case of the proteins, to note the calculations on the mineral elements recorded in Table V.

The dairy cow, for example, puts as much phosphorus into 100 pounds of milk as there is in 65 pounds of red clover hay, 47 pounds of alfalfa hay, 44 pounds of vetch hay, 30 pounds of oats, or 31 pounds of barley; as much calcium as there is in 11 pounds of alfalfa hay, 13 pounds of red clover hay, 17 pounds of vetch hay, 516 pounds of oats, or 716 pounds of barley. She puts as much potassium into 100 pounds of milk as she consumes with 8 pounds of red clover hay, 9 pounds of vetch hay, 8 pounds of alfalfa hay, 32 pounds of oats, or 34 pounds of barley; and as much sulfur as she gets in eating 7 pounds of alfalfa hay, 13 pounds of red clover hay, 12 pounds of vetch hay, 9 pounds of oats, or 11 pounds of barley.

Since, like protein and other organic nutrients, a part only of the mineral portion of feedstuffs is retained by the animal body in processes of digestion, and since again there are needs for the mineral elements for purposes aside from milk secretion, it seems reasonable to question whether the heavy producer of milk can really secure from these forage crops enough, especially of calcium and phosphorus, to meet her requirements. Feedstuffs are readily available at all points in Western Oregon in the form of various concentrates for use in balancing rations from the protein-carbohydrate standpoint. There will be greater difficulty in making good any deficiency in the mineral elements of standard rations that may be established.

FORAGE CROPS IN RELATION TO SOIL FERTILITY

In the opening paragraphs of this discussion of the forage crops of Western Oregon, emphasis was placed on the peculiar and outstanding value of the legume crops when used primarily for giving "tone" to newly cleared lands and for rejuvenating others that for some reason are in a run-down condition. It is explained that the value of the legume over the non-legume for soil improvement purposes was traceable to an association of bacterial activity and the legume root system from which the legume profited by securing the nitrogen it requires for growth, not from the soil but from the soil air. When working at its best this association not only relieves the soil from the necessity of furnishing nitrogen for the growth of the legume but accomplishes an addition of organic nitrogen to the soil in amount equal to that built into the legume root system. This of course is then available for the succeeding crop and the tendency for nitrogen to become the limiting factor in crop growth is to that extent overcome. It was further explained that deep-rooting legumes like the clovers and alfalfa not only produce a heavy sod but secure during growth from soil depths far beyond the feeding range of fibrous-rooted plants large amounts of potash, lime, and phosphates, which are left in the surface soil in easily available condition for the succeeding crop as the sod decays. For all other essential elements of growth the legumes are as dependent upon the soil in which they grow as the non legumes.

FURTHER USE OF TABLE IV

The analytical data in Table IV can be used to show not only how much of the mineral elements the forage crops carry in rations made up for dairy and other livestock, but, approximately at least, the demand they make on the soil during growth for the various essential elements.

It is plain that the tax of the legumes on the soil is heaviest for calcium and potassium. The non-legumes—timothy and orchard grass—call for approximately as much potassium as do the legumes but for far less calcium. The soils of Western Oregon appear to be perfectly able to meet the heavy demands on them for potassium, but there are some whose content of lime in available condition is too small to meet the exacting requirements of legume crops for calcium. Additions of limestone in fertilizer form not only give to those soils a needed element of plant food but stimulate the associated nitrogen-gathering bacteria to greater activity by at least a partial neutralization of soil acids. The nitrogen-gathering bacteria which associate themselves with legumes of different kinds are not equally sensitive to the presence of soil acids but there is a limit in the intensity of acidity beyond which even the most resistant will not grow. Limestone then has a double function in the soils of Western Oregon in the growing of legumes. When soil conditions are such that the nitrogen-gathering bacteria cannot grow, then legume crops fail of their purpose in "toning" up new soils and rejuvenating old ones and become as truly exhaustive of soil nitrogen as are the non-legumes.

Sulfur is required by the legumes and other forage crops in smaller amounts than any other essential element listed in Table IV. For some reason, however, not perfectly understood but primarily because of the rather small amounts of sulfur in some soils, sulfur-carrying fertilizers have stimulated them to a remarkable increase in yields of clover and alfalfa. On this account largely sulfur is listed in Oregon among other commercial fertilizers.

Table VI was calculated from the original analytical data of Table IV. It brings out sharply a fact that is sometimes lost sight of. A given weight of any crop represents a perfectly definite draft upon the soil for just those elements of fertility that give it value. In good farm practice the net value of that draft is reduced appreciably by the careful conservation and return of all barnyard manure and litter resulting from feeding operations. Conversion of the data into cash values may be accomplished by simple multiplication when the price per pound of the various fertilizing materials mentioned is known.

In compiling Table VI there were assumed commercial fertilizers of a degree of purity readily obtainable from the fertilizer trade—92 percent sodium nitrate, superphosphate carrying 17 percent P_2O_5, 90 percent limestone, sulfate of potash carrying 48 percent K_2O, muriate of potash carrying 50 percent K_2O, and 95 percent land-plaster. The legumes, of course, for reasons already stated, should be charged only for the mineral elements used.

TABLE I. PERCENTAGE COMPOSITION OF LEGUMES AND OTHER FORAGE CROPS.

Crop	Where grown County	Calculations on air-dry basis						Calculations on oven-dry basis				
		Water	Ash	Crude protein N x 6¼	Ether extract	Carbohydrates: Crude fiber	Carbohydrates: Nitrogen-free extract	Ash	Crude protein N x 6¼	Ether extract	Carbohydrates: Crude fiber	Carbohydrates: Nitrogen-free extract
		Valley Section										
Alfalfa	Columbia	5.88	6.00	9.00	1.30	35.83	42.00	6.40	9.56	1.38	38.07	44.59
	Columbia	8.06	5.53	9.69	.79	31.23	44.70	6.02	10.58	.86	33.98	48.60
	Benton	6.96	6.67	10.58	1.17	32.38	42.24	7.15	11.37	1.26	34.78	45.44
	Benton	7.96	8.81	17.78	1.18	26.92	37.35	9.76	19.26	1.28	29.20	40.50
	Benton	7.62	6.94	13.38	1.38	28.28	42.40	7.50	14.50	1.49	30.60	45.91
	Benton	11.32	7.83	15.50	.70	29.95	34.70	8.83	17.49	.79	33.75	39.14
	Benton	7.62	6.59	11.94	1.14	31.69	41.02	7.14	12.95	1.23	34.27	44.41
	Average	7.92	6.91	12.55	1.09	30.90	40.63	7.54	13.67	1.18	33.52	44.09
Clover red	Columbia	7.87	4.82	8.50	1.37	28.98	48.46	5.22	9.25	1.49	31.47	52.57
	Columbia	8.85	5.38	8.19	.98	32.02	44.58	5.90	8.98	1.07	35.15	48.90
	Washington	6.91	6.42	11.50	1.65	28.84	44.68	6.95	12.38	1.77	31.00	47.90
	Linn	7.62	5.65	10.19	1.51	23.57	51.40	6.19	11.00	1.63	25.70	55.48
	Linn	6.77	5.12	8.94	2.11	26.50	50.56	5.60	9.56	2.60	28.40	53.84
	Linn	7.63	5.56	11.13	1.80	29.62	44.25	6.02	12.07	1.96	32.07	47.88
	Linn	7.85	5.38	9.62	1.39	27.41	48.35	5.84	10.43	1.51	29.75	52.47
	Linn	8.15	5.70	9.69	1.31	27.75	47.40	6.20	10.54	1.43	30.22	51.61
	Linn	6.98	6.62	10.42	1.35	25.10	49.53	7.20	11.20	1.45	26.96	53.19
	Linn	8.56	6.78	9.80	1.59	29.21	44.06	7.42	10.72	1.74	31.97	48.15
	Linn	8.73	6.68	10.74	1.47	31.23	41.15	7.32	11.78	1.61	34.23	45.06
	Benton	9.71	5.47	11.12	1.43	21.02	51.25	6.05	12.31	1.58	23.25	56.81
	Benton	6.22	5.92	11.92	1.79	23.20	50.95	6.46	12.75	1.91	24.13	54.75
	Benton	8.19	6.44	11.20	1.71	23.07	49.39	7.00	12.19	1.86	25.12	53.83
	Benton	8.52	5.40	10.12	2.08	23.36	50.52	5.87	11.06	2.27	25.54	55.26
	Benton	7.48	6.71	10.39	1.22	23.02	51.18	7.18	11.18	1.32	24.87	55.45
	Benton	11.11	6.92	11.37	1.19	26.56	42.85	7.80	12.81	1.34	29.89	48.16
	Benton	7.36	6.29	10.25	1.45	28.68	45.97	6.78	11.06	1.57	30.95	49.64
	Benton	8.09	7.55	9.14	1.20	25.59	48.43	8.18	9.95	1.31	27.81	52.75
	Average	8.03	6.08	10.23	1.51	26.55	47.60	6.59	11.12	1.65	28.87	51.77

TABLE I (Continued). PERCENTAGE COMPOSITION OF LEGUMES AND OTHER FORAGE CROPS.

Crop	Where grown County	Calculations on air dry basis: Water	Ash	Crude protein N x 6¼	Ether extract	Carbohydrates: Crude fiber	Carbohydrates: Nitrogen-free extract	Calculations on oven-dry basis: Ash	Crude protein N x 6¼	Ether extract	Carbohydrates: Crude fiber	Carbohydrates: Nitrogen-free extract
Clover alsike	Columbia	6.09	6.92	8.94	1.67	29.72	46.66	7.38	9.50	1.78	31.60	49.74
	Columbia	13.32	8.42	10.33	.77	29.05	38.11	9.66	11.92	.90	33.50	44.02
	Washington	6.70	5.34	11.12	1.67	29.18	45.99	5.79	11.94	1.79	31.23	49.25
	Linn	9.62	7.71	7.45	1.12	37.55	36.55	8.54	8.26	1.24	41.52	40.44
	Linn	10.56	6.29	9.84	1.23	35.44	36.64	7.03	11.00	1.38	39.65	40.94
	Linn	7.69	6.41	9.42	1.28	32.23	42.97	6.95	10.21	1.39	34.92	46.53
	Benton	5.92	6.85	9.56	1.13	26.50	50.04	7.44	10.19	1.20	28.18	52.99
	Benton	5.70	7.24	7.63	1.18	25.34	52.91	7.68	8.19	1.27	27.23	55.63
	Average	8.21	6.90	9.28	1.26	30.62	43.73	7.58	10.15	1.37	33.47	47.43
Vetch common	Columbia	6.72	6.98	14.75	1.10	26.95	43.50	7.52	15.82	1.18	28.90	46.58
	Columbia	7.53	5.49	15.07	.44	26.40	45.07	5.93	16.30	.50	28.52	48.75
	Columbia	8.36	6.87	13.44	1.25	31.80	38.28	7.50	14.68	1.36	34.69	41.77
	Washington	7.85	5.40	13.26	1.10	26.25	46.14	5.87	14.40	1.20	28.52	50.09
	Washington	7.98	6.77	15.80	1.20	25.72	42.53	7.34	17.50	1.30	27.96	45.90
	Linn	9.21	5.55	14.07	.98	26.88	43.31	5.86	15.00	1.08	29.60	48.46
	Linn	8.04	5.11	10.25	.81	24.76	51.03	5.56	11.15	.88	26.94	55.47
	Linn	8.50	5.67	14.06	1.22	29.42	41.13	6.20	15.37	1.33	32.18	44.92
	Linn	8.02	6.34	11.88	.90	27.65	45.21	6.90	12.95	.98	30.04	49.13
	Linn	7.80	6.07	13.87	1.01	26.00	45.25	6.59	15.05	1.10	28.21	49.05
	Linn	7.14	7.98	15.75	.92	25.75	42.46	8.59	16.98	.99	27.73	45.71
	Linn	6.69	7.23	11.20	.94	32.42	41.52	7.75	12.00	1.01	34.73	44.52
	Linn	7.50	7.26	13.56	.56	26.32	44.80	7.84	14.66	.60	28.43	48.47
	Benton	10.63	5.47	11.62	1.10	23.31	47.87	6.06	12.88	1.23	26.10	53.73
	Benton	12.20	4.97	12.12	1.10	23.95	45.66	5.66	13.56	1.25	27.20	52.33
	Benton	10.87	5.80	12.88	1.15	23.61	45.69	6.50	13.31	1.29	26.16	52.74
	Benton	8.60	5.45	14.63	.85	23.42	47.05	5.95	16.00	.93	25.62	51.50
	Benton	9.62	6.48	13.62	1.15	23.57	45.56	7.16	15.07	1.27	26.05	50.45
	Benton	8.73	5.55	12.12	.80	26.97	45.83	6.09	12.94	.88	29.52	50.57
	Benton	7.61	6.67	13.06	1.12	22.24	49.30	7.14	14.00	1.22	24.05	53.59
	Benton	8.81	6.01	13.56	1.01	25.19	45.42	6.62	14.87	1.11	27.60	49.80
	Benton	9.84	5.57	14.25	.88	24.74	44.54	6.20	15.88	.98	27.42	49.51
	Benton	7.73	5.52	12.52	.90	23.97	49.36	6.10	14.20	.98	25.98	52.74

	Benton	7.05	6.45	11.13	1.25	24.19	49.93	6.83	11.75	1.34	26.00	54.08
	Benton	8.89	5.82	13.12	1.17	24.50	46.50	6.38	13.87	1.28	26.88	51.59
	Benton	8.65	6.18	14.50	1.14	24.33	45.20	6.78	15.26	1.25	26.60	50.11
	Benton	8.12	5.64	13.12	.78	23.95	48.39	6.01	14.00	.85	26.06	53.08
	Benton	8.33	5.99	13.12	1.13	26.43	45.00	6.50	14.25	1.23	28.89	49.15
	Benton	8.84	7.26	12.87	.73	25.08	45.22	7.96	14.10	.79	27.45	49.70
	Benton	8.08	5.68	10.43	.98	22.45	52.38	6.18	11.34	1.07	24.44	56.97
	Benton	6.93	5.47	11.44	.88	28.15	47.13	5.86	12.29	.95	30.24	50.66
	Benton	7.63	5.01	14.00	.87	25.15	47.34	5.48	15.15	.94	27.21	51.22
	Benton	7.70	6.70	15.50	1.08	26.65	42.37	7.26	16.80	1.17	28.87	45.90
	Benton	7.71	7.76	13.30	.63	29.14	41.46	8.41	14.43	.68	31.55	44.93
	Benton	8.81	5.40	14.12	.92	25.95	44.80	5.82	15.49	1.01	28.46	49.22
	Average	8.36	6.10	13.26	.97	25.80	45.51	6.64	14.38	1.06	28.14	49.78
Vetch												
Woolly Podded	Benton	7.06	6.12	12.31	.73	24.44	49.34	6.60	13.28	.79	26.29	53.04
(Hairy)	Benton	7.05	6.30	12.62	.83	25.88	47.32	6.78	13.58	.88	27.85	50.91
(Purple)	Benton	7.65	5.92	13.26	.71	25.39	47.97	5.45	14.37	.77	27.50	51.91
Hungarian	Benton	9.08	7.52	14.40	1.80	29.00	38.20	8.27	15.85	1.98	31.97	41.93
Peas												
Canada field	Columbia	7.27	7.17	13.90	1.85	22.30	47.51	7.78	14.94	1.99	24.04	51.25
	Benton	8.32	5.54	13.74	.90	18.48	53.02	6.01	15.00	.98	20.16	57.85
	Average	7.80	6.35	13.82	1.31	20.39	50.27	6.90	14.97	1.48	22.10	54.55
Peas												
Tangier	Benton	7.30	7.49	10.12	1.10	26.75	47.24	8.05	10.94	1.19	28.82	51.00
	Benton	7.52	7.09	11.80	1.02	27.76	44.81	7.65	12.76	1.10	29.97	48.52
	Average	7.41	7.29	10.96	1.06	27.25	46.03	7.85	11.85	1.14	29.40	49.76
White clover	Columbia	8.91	7.70	10.82	1.79	24.56	46.22	8.45	11.88	1.96	26.97	50.74
White clover	Benton	10.41	8.48	13.92	1.03	20.00	46.16	9.45	15.53	1.15	22.34	51.53
	Average	9.66	8.09	12.37	1.41	22.28	46.19	8.95	13.70	1.56	24.65	51.14
Sweet clover	Benton	8.17	5.30	7.75	1.10	32.65	45.03	5.77	8.45	1.20	35.55	49.03
Eureka	Benton	7.53	5.39	9.95	1.12	31.24	44.77	5.83	10.75	1.21	33.77	48.44

TABLE I (Continued). PERCENTAGE COMPOSITION OF LEGUMES AND OTHER FORAGE CROPS.

Crop	Where grown County	Calculations on air dry basis: Water	Ash	Crude protein N x 6¼	Ether extract	Carbohydrates: Crude fiber	Carbohydrates: Nitrogen-free extract	Calculations on oven-dry basis: Ash	Crude protein N x 6¼	Ether extract	Carbohydrates: Crude fiber	Carbohydrates: Nitrogen-free extract
Horse bean	Benton	8.54	5.49	13.42	.84	21.96	49.75	6.00	14.68	.92	24.03	54.37
Wild peas	Benton	7.29	4.46	15.74	1.35	35.50	35.66	4.82	16.98	1.46	38.34	38.40
Rye grass	Columbia	8.40	5.57	5.62	1.15	29.20	50.06	6.08	6.13	1.26	31.87	54.66
	Linn	8.37	6.80	3.21	1.16	32.36	48.10	7.43	4.00	1.26	35.22	52.09
	Benton	7.82	5.51	4.19	.75	30.05	51.68	5.97	4.55	.81	32.54	56.13
	Average	8.20	5.96	4.34	1.02	30.54	49.94	6.49	4.89	1.11	33.21	54.30
Mesquite	Columbia	7.71	4.87	6.16	1.64	32.22	47.40	5.28	6.69	1.78	34.92	51.33
	Linn	7.72	5.85	3.83	1.56	30.52	50.52	6.35	4.15	1.69	33.08	54.73
	Benton	8.37	6.62	7.25	1.34	32.41	44.01	7.22	7.90	1.46	35.39	48.03
	Average	7.93	5.78	5.75	1.51	31.72	47.31	6.28	6.24	1.64	34.46	51.38
Timothy	Columbia	7.32	4.59	6.29	1.30	34.20	46.30	4.95	6.78	1.40	36.93	49.94
	Benton	7.08	4.09	4.87	1.01	34.42	48.53	4.41	5.19	1.09	37.04	52.27
	Benton	6.73	4.57	6.06	1.67	35.95	45.02	4.91	6.50	1.79	38.50	48.30
	Average	7.04	4.42	5.74	1.33	34.86	46.61	4.76	6.15	1.43	37.49	50.17
Orchard grass	Columbia	6.95	5.02	5.29	1.02	37.28	44.44	5.39	5.68	1.09	39.00	48.84
Orchard grass	Benton	7.91	4.41	3.85	.94	34.69	48.20	4.79	4.18	1.02	37.67	52.34
	Average	7.43	4.71	4.57	.98	35.98	46.33	5.09	4.93	1.05	38.34	50.59
Brome grass	Columbia	8.14	3.84	5.81	.85	31.06	50.30	4.18	6.33	.92	33.83	54.74
Millet	Columbia	8.21	8.42	9.89	1.06	29.82	42.60	9.18	10.77	1.15	32.51	46.39
Soft chess	Columbia	7.76	3.57	5.94	.91	33.11	48.71	3.87	6.44	.99	35.90	52.80

Redtop	Linn	7.53	6.40	3.12	1.08	37.81	44.06	6.93	3.37	1.17	40.94	47.59
	Linn	8.65	8.40	5.06	1.24	31.37	45.28	9.20	5.55	1.36	34.39	49.50
	Average	8.09	7.40	4.09	1.16	34.59	44.67	8.06	4.47	1.26	37.67	48.54
Fescue meadow	Benton	7.24	4.15	4.72	.90	31.41	51.58	4.48	5.10	.97	33.91	55.54
Oat grass												
Tall	Columbia	7.66	4.53	4.89	1.04	37.00	44.88	4.91	5.30	1.13	40.05	48.61
	Benton	7.31	4.99	4.66	1.35	32.52	49.17	5.38	5.03	1.46	35.13	53.00
	Average	7.49	4.76	4.78	1.19	34.76	47.02	5.15	5.16	1.30	37.59	50.80
Cheat	Benton	8.65	6.40	5.19	1.33	36.66	41.77	7.00	5.68	1.46	40.15	45.71
Meadow Fox Tail	Benton	7.62	7.72	5.72	1.75	29.34	47.85	8.36	6.20	1.89	31.73	51.82
Harding Grass	Benton	6.79	6.78	6.56	1.58	32.79	45.50	7.28	7.05	1.69	35.16	48.82
Beardless Rye	Benton	6.10	3.89	4.17	1.38	31.85	52.61	4.15	4.45	1.47	33.97	55.96
Vicia	Benton	7.98	7.51	19.64	1.38	25.91	37.58	8.15	21.24	1.50	28.21	40.90
Creeping Bent	Benton	6.38	5.76	6.05	1.87	28.02	51.92	6.15	6.47	2.00	29.91	55.47
Reed Canary	Benton	7.12	4.79	4.85	1.06	27.20	54.98	5.16	5.22	1.14	29.27	59.21
Reed Fescue	Benton	7.20	6.63	5.81	1.22	38.85	40.29	7.15	6.27	1.31	41.88	43.39
Lotus												
Crassifolius	Benton	8.43	8.05	18.94	1.54	22.64	40.40	8.78	20.68	1.68	24.73	44.13
Sunflowers	Columbia	9.16	10.17	9.89	2.68	25.34	42.76	11.20	10.89	2.96	27.89	47.06
Corn	Benton	9.44	5.47	9.80	1.39	23.16	50.74	6.04	10.73	1.53	25.59	56.11
Silages												
Corn	Benton	76.38	1.30	1.89	.42	6.08	13.93	5.52	8.01	1.76	25.72	58.99
	Benton	74.75	1.54	2.59	.69	4.73	15.70	6.09	10.28	2.73	18.75	62.15
	Benton	81.83	2.01	1.10	.26	5.23	9.57	11.06	6.08	1.45	28.78	52.63
	Benton	73.00	1.39	2.64	.97	4.45	17.55	5.14	9.78	3.58	16.48	65.02
	Benton	89.92	.59	1.06	.30	2.18	5.95	5.89	10.51	3.04	21.63	58.93
	Average	79.18	1.37	1.85	.53	4.53	12.54	6.74	8.93	2.51	22.27	59.55
Sunflowers	Benton	81.34	2.15	1.87	1.35	5.58	7.71	11.53	10.10	7.22	29.92	41.23
	Benton	77.20	2.52	2.42	.55	5.63	11.68	11.04	10.59	2.40	24.70	51.27
	Benton	84.80	1.59	1.83	.62	3.71	7.45	10.45	12.06	4.11	24.40	48.98
	Benton	81.25	1.65	1.36	.92	5.22	9.60	8.78	7.26	4.91	27.86	51.19
	Benton	77.62	1.55	2.24	.85	6.22	11.52	6.93	10.00	3.80	27.80	51.47
	Benton	86.70	2.04	2.12	.31	4.07	4.76	15.37	15.92	2.26	30.57	35.88
	Average	81.48	1.92	1.97	.77	5.07	8.79	10.68	10.99	4.12	27.54	46.67

TABLE I (Continued). PERCENTAGE COMPOSITION OF LEGUMES AND OTHER FORAGE CROPS.

Crop	Where grown County	Calculations on air dry basis						Calculations on oven-dry basis				
		Water	Ash	Crude protein N x 6¼	Ether extract	Carbohydrates: Crude fiber	Carbohydrates: Nitrogen-free extract	Ash	Crude protein N x 6¼	Ether extract	Carbohydrates: Crude fiber	Carbohydrates: Nitrogen-free extract
Oats and vetch	Benton	70.29	2.20	2.09	.52	9.70	15.20	7.41	7.05	1.76	32.61	51.17
	Benton	76.87	1.64	2.20	.68	7.99	10.62	7.08	9.50	2.94	34.61	45.87
	Average	73.58	1.92	2.14	.60	8.85	12.91	7.24	8.28	2.35	33.61	48.52
Horse beans	Benton	77.45	1.39	3.41	.67	6.25	10.83	6.15	15.13	2.95	27.73	48.04
	Benton	74.58	1.50	4.26	.34	7.20	12.12	5.92	16.74	1.33	28.38	47.63
	Average	76.02	1.44	3.84	.50	6.73	11.47	6.03	15.94	2.14	28.05	47.84
Barley and Vetch	Benton	70.15	1.96	2.97	.64	10.42	13.86	6.58	9.96	2.13	35.22	46.11
Corn and Clover straw	Benton	71.00	2.18	2.36	.55	8.80	15.11	7.52	8.15	1.88	30.38	52.07
Corn and Alfalfa	Benton	74.55	2.14	2.66	.68	4.56	15.41	8.41	10.44	2.67	17.90	60.58
Wheat	Benton	69.03	2.15	1.67	.69	10.87	15.59	6.96	5.38	2.23	35.08	50.34
Alfalfa	Benton	74.59	2.07	3.93	.96	8.47	9.98	8.14	15.47	3.79	33.35	39.25
Tangier peas	Benton	78.40	1.65	2.50	.53	7.51	7.41	7.62	11.56	2.43	34.77	43.62
Sweet Clover	Benton	70.45	1.79	2.70	.52	12.61	11.93	6.07	9.14	1.77	42.64	40.38
The Grains												
Wheat												
Huston	Benton	10.67	2.01	10.57	1.62	3.20	71 93	2.25	11.83	1.81	3.58	80.53
Marquis	Jackson	9.50	1.88	11.00	1.86	3.17	72.59	2.08	12.16	2.05	3.50	80.21
Baart	Jackson	10.16	1.89	11.52	1.26	2.81	72.36	2.11	12.84	1.40	3.13	80.52
	Average	10.11	1.93	11.03	1.58	3.06	72.29	2.15	12.28	1.75	3.40	80.42
Barley												
Fall	Linn	10.02	2.86	10.68	1.47	4.73	70.24	3.18	11.77	1.63	5.36	78.06
Bald	Benton	9.83	2.04	13.44	1.48	2.41	70.80	2.26	14.90	1.64	2.67	78.53
Hannchen	Benton	11.17	2.23	9.60	1.53	4.27	71.20	2.51	10.81	1.72	4.81	80.15
	Average	10.34	2.38	11.24	1.50	3.80	70.75	2.65	12.49	1.66	4.28	78.92

Oats												
Fall or Grey	Linn	9.38	3.58	9.95	5.28	9.97	61.84	3.95	10.98	5.82	11.00	68.25
White	Linn	9.58	3.31	10.32	3.80	13.05	59.94	3.67	11.47	4.22	14.44	66.21
Senator	Benton	9.22	3.46	9.69	4.11	12.47	61.05	3.82	10.66	4.53	13.73	67.26
Senator	Columbia	8.94	3.12	12.98	2.74	17.01	55.21	3.42	14.25	3.00	18.69	60.64
Black Victor	Lane	8.25	3.79	11.35	5.25	11.50	59.86	4.13	12.37	5.72	12.52	65.26
	Average	9.07	3.45	10.86	4.24	12.80	59.58	3.80	11.95	4.66	14.07	65.52
Miscellaneous												
Cheat seed	Benton	12.24	4.28	7.05	1.20	8.32	66.91	4.87	8.03	1.37	9.48	76.25
Sunflower seed	Benton	4.78	2.61	15.41	28.66	30.74	17.80	2.74	16.19	30.09	32.28	18.70
					Southern Oregon Section							
Alfalfa												
	Josephine	7.22	7.70	15.30	1.30	30.15	38.33	8.39	16.50	1.40	32.50	41.21
	Jackson	6.62	6.43	14.06	1.58	27.22	44.09	6.88	15.07	1.69	29.13	47.23
	Jackson	6.34	5.21	13.86	1.52	37.33	35.74	5.56	14.82	1.62	39.84	38.16
	Jackson	6.22	9.48	12.62	1.37	31.39	38.92	10.06	13.44	1.46	33.46	41.58
	Jackson	6.94	8.52	15.00	.87	32.34	36.33	9.15	16.13	.94	34.74	39.04
	Average	6.67	7.47	14.17	1.33	31.68	38.68	8.01	15.20	1.42	33.93	41.44
Clover, red												
	Josephine	7.90	6.76	12.89	2.03	25.89	44.53	7.35	14.00	2.20	28.12	48.33
	Jackson	7.00	5.94	12.82	2.38	25.22	46.64	6.37	13.75	2.56	27.12	50.20
	Jackson	6.98	6.94	12.68	1.90	27.52	43.97	7.41	13.63	2.04	29.85	47.07
	Average	7.29	6.55	12.79	2.10	26.21	45.06	7.04	13.79	2.27	28.37	48.53
Clover, alsike	Jackson	6.24	6.17	10.06	1.80	29.21	46.52	6.61	10.75	1.92	31.16	49.56
					Coast Section							
Clover, red												
	Tillamook	6.64	7.37	12.25	1.76	30.04	41.94	7.85	13.13	1.88	32.18	44.96
	Tillamook	6.27	8.32	12.37	1.69	30.76	40.59	8.94	13.19	1.80	32.80	43.27
	Average	6.46	7.84	12.31	1.73	30.40	41.26	8.39	13.16	1.84	32.49	44.12
Clover, alsike												
	Clatsop	6.21	6.46	13.50	1.56	27.39	44.88	6.89	14.37	1.66	29.20	47.88
	Clatsop	7.70	6.28	13.61	1.25	27.58	43.58	6.75	14.75	1.35	29.88	47.27
	Tillamook	6.78	7.16	9.50	1.16	33.54	41.86	7.55	10.19	1.24	35.97	45.05
	Tillamook	7.24	9.60	10.62	1.52	33.81	37.21	10.35	11.44	1.64	36.44	40.13
	Average	6.99	7.36	11.82	1.37	30.58	41.88	7.89	12.69	1.47	32.87	45.08

TABLE I (Continued). PERCENTAGE COMPOSITION OF LEGUMES AND OTHER FORAGE CROPS.

Crop	Where grown County	Calculations on air dry basis						Calculations on oven-dry basis				
		Water	Ash	Crude protein N x 6¼	Ether extract	Carbohydrates		Ash	Crude protein N x 6¼	Ether extract	Carbohydrates	
						Crude fiber	Nitrogen-free extract				Crude fiber	Nitrogen-free extract
Vetch												
common	Tillamook	7.36	6.98	14.07	.72	33.00	37.87	7.54	15.18	.78	35.62	40.88
Peas												
Canada field	Tillamook	9.49	4.81	13.98	1.08	23.64	47.00	5.14	16.38	1.19	26.13	51.16
Miscellaneous												
Yellow clover	Tillamook	8.50	5.24	10.82	1.61	31.69	42.14	5.73	12.50	1.76	34.64	45.37
Marsh land clover	Coos	9.97	9.00	14.41	1.91	26.65	38.06	10.00	16.01	2.12	29.60	42.27
Marsh land grass	Coos	6.78	4.87	4.60	.93	45.37	37.45	5.23	4.94	1.00	48.54	40.29
Canary grass	Coos	6.61	5.79	5.80	.85	31.95	49.00	6.20	6.21	.90	34.06	52.63
Sweet vernal grass	Coos	7.85	2.78	2.86	.79	34.00	51.02	3.02	3.10	.85	36.92	56.11
Salt grass	Coos	7.39	10.68	10.38	1.87	28.67	41.01	11.52	11.21	2.02	30.96	44.29
Redtop	Coos	8.13	5.73	7.62	2.12	26.94	49.46	6.24	8.29	2.31	29.33	53.83
Silages												
Corn*	Coos	72.64	1.81	4.57	.32	9.24	11.48	6.62	16.48	1.17	33.75	41.98
Sunflowers	Clatsop	83.38	1.58	1.95	.47	4.61	8.01	9.53	11.72	2.81	27.77	48.17
Horse beans	Clatsop	84.25	1.29	2.15	.61	3.80	7.90	8.18	13.65	3.86	24.13	50.18
Sunflowers and Pole Bean	Clatsop	82.38	1.57	1.83	.47	4.46	9.29	8.92	10.40	2.64	25.33	52.71
Oats and Peas	Clatsop	62.42	3.44	3.30	1.35	10.21	19.28	8.92	8.77	3.59	27.15	51.57

*Frosted.

TABLE II. THE CARBOHYDRATE FRACTION OF LEGUMES, FURTHER SEPARATION OF THE "NITROGEN-FREE EXTRACT." PERCENTAGE AVERAGES ON OVEN-DRY BASIS.

Legumes and number of determinations	Where grown	Crude fiber	Reducing sugars	Sucrose	Starch	Pentosans	Galactans	Not determined
Alfalfa (4)	Valley section	33.15	1.73	3.99	2.33	15.85	2.68	17.53
Alfalfa (5)	So. Oregon	33.83	1.14	4.48	3.26	15.35	2.17	15.04
Clover, red (9)	Valley section	26.65	5.14	6.22	2.25	14.11	2.22	24.07
Clover, red (2)	Coast section	32.49	2.91	1.58	1.40	14.75	2.64	20.84
Clover, red (3)	So. Oregon	27.93	3.20	4.07	2.42	13.83	2.96	22.05
Clover, alsike (3)	Valley section	30.02	4.33	3.87	3.58	14.73	2.98	22.05
Clover, alsike (4)	Coast section	32 87	2.64	2.26	3.25	15.78	4.47	16.68
Clover, alsike (1)	So. Oregon	31.16	3.17	3.08	1.13	15.85	2.60	23.73
Clover, yellow (1)	Coast section	34.64	5.46	.55	3.22	15.36	1.88	18.90
Vetch, common (15)	Valley section	27.08	3.31	6.29	6.35	15.33	1.67	18.04
Vetch, common (1)	Coast section	35.62	4.08	3.50	3.01	14.04	2.52	14.73
Peas, Canada field (2)	Valley section	22.10	1.06	4.70	11.53	12.30	1.61	23.33
Peas, Canada field (1)	Coast section	26.13	9.45	4.98	7.20	12.08	2.13	15.32
Peas, Tangier (1)	Valley section	28.82	2.38	5.51	7.25	15.58	2.21	20.07

TABLE III. AVERAGE WEIGHT IN POUNDS OF NUTRIENTS IN 100 POUNDS OF CROP AS ORDINARILY FED. CONDENSED FROM TABLE I.

Crop	Section	No. of analysis averaged	Water	Crude ash or mineral matter	Crude Protein N x 6¼	Ether extract "fat"	Carbohydrates	
							Crude fiber	N-free extract
Legumes								
Alfalfa	Valley	7	7.92	6.91	12.55	1.09	30.90	40.63
Alfalfa	Southern Oregon	5	6.67	7.47	14.17	1.33	31.68	38.68
Clover, red	Valley	19	8.03	6.08	10.23	1.51	26.55	47.60
Clover, red	Southern Oregon	3	7.29	6.55	12.79	2.10	26.21	45.06
Clover, red	Coast	2	6.46	7.84	12.31	1.73	30.40	41.26
Clover, alsike	Valley	8	8.21	6.90	9.28	1.26	30.62	43.73
Clover, alsike	Southern Oregon	1	6.24	6.17	10.06	1.80	29.21	46.52
Clover, alsike	Coast	4	6.99	7.36	11.82	1.37	30.58	41.88
Clover, white	Valley	2	9.66	8.09	12.37	1.41	22.28	46.19
Vetch common	Valley	35	8.36	6.10	13.26	.97	25.80	45.51
Vetch common	Coast	1	7.36	6.98	14.07	.72	33.00	37.87
Vetch, hairy	Valley	1	7.05	6.30	12.62	.83	25.88	47.32
Vetch Hungarian	Valley	1	9.08	7.52	14.40	1.80	29.00	38.20
Peas, Canada field	Valley	2	7.80	6.35	13.82	1.31	20.39	50.27
Peas, Canada field	Coast	1	9.49	4.81	13.98	1.08	23.64	47.00
Peas, Tangier	Valley	2	7.41	7.29	10.96	1.06	27.25	46.03
Peas, Wild	Valley	1	7.29	4.46	15.74	1.35	35.50	35.66
Non-Legumes								
Rye Grass	Valley	3	8.20	5.96	4.34	1.02	30.54	49.94
Mesquite	Valley	3	7.93	5.78	5.75	1.51	31.72	47.31
Timothy	Valley	3	7.04	4.42	5.74	1.33	34.86	46.61
Orchard grass	Valley	2	7.43	4.71	4.57	.98	35.98	46.33
Redtop	Valley	2	8.09	7.40	4.09	1.16	34.59	44.67
Redtop	Coast	1	8.13	5.73	7.62	2.12	26.94	49.46
Oat grass, tall	Valley	2	7.49	4.76	4.78	1.19	34.76	47.02
Corn, whole plant	Valley	1	9.44	5.47	9.80	1.39	23.16	50.74
Silages								
Corn	Valley	5	79.18	1.37	1.85	.53	4.53	12.54
Corn*	Coast	1	72.64	1.81	4.57	.32	9.24	11.48
Sunflower	Valley	5	81.52	1.87	1.99	.65	4.97	9.00
Sunflower	Coast	1	83.38	1.58	1.95	.47	4.61	8.01
Oats and Vetch	Valley	2	73.58	1.92	2.14	.60	8.85	12.91
Barley and Vetch	Valley	1	70.15	1.96	2.97	.64	10.42	13.86
Oats & peas	Coast	1	62.42	3.44	3.30	1.35	10.21	19.28
Horse Beans	Valley	2	76.02	1.44	3.84	.50	6.73	11.47
Horse Beans	Coast	1	84.25	1.29	2.15	.61	3.80	7.90
Grains								
Wheat	Valley	3	10.11	1.93	11.03	1.58	3.06	72.29
Oats	Valley	5	9.07	3.45	10.86	4.24	12.80	59.58
Barley	Valley	3	10.34	2.38	11.24	1.50	3.80	70.75

* Frosted.

TABLE IV. THE MINERAL CONSTITUENTS OF LEGUMES AND OTHER FORAGE CROPS OF WESTERN OREGON. FIGURES INDICATE PERCENT.

Crop	County	Water	Ash		Phosphorus			Calcium			Magnesium			Potassium			Sulfur	
			Air dry	Oven dry	Air dry	Oven dry	Ash	Air dry	Oven dry	Ash	Air dry	Oven dry	Ash	Air dry	Oven dry	Ash	Air dry	Oven dry
Valley Section																		
Alfalfa	Linn	6.70	6.67	7.15	.183	.197	3.02	1.47	1.59	22.08	.289	.309	4.33	1.09	1.16	16.30	.102	.109
	Benton	9.73	8.81	9.76	.279	.309	3.16	1.43	1.59	16.28	.176	.194	1.99	2.33	2.51	26.45	.303	.336
	Linn	7.62	6.94	7.50	.231	.260	3.33	1.06	1.15	15.30	.279	.302	4.03	1.75	1.89	25.22	.137	.148
	Columbia	6.25	6.00	6.40	.292	.311	4.87	.786	.819	12.82	.150	.160	2.50	1.80	1.92	30.06	.148	.158
	Linn	11.32	7.65	8.53	.230	.259	3.00	.920	1.04	12.02	.168	.189	2.19	2.15	2.42	28.10	.133	.150
	Linn	7.62	7.88	8.53	.162	.175	2.06	1.62	1.75	20.55	.197	.214	2.50	1.42	1.54	18.02	.126	.137
	Columbia	8.06	5.45	5.93	.173	.188	3.18	.800	.870	14.67	.074	.081	1.48	1.49	1.62	27.36	.077	.084
	Average	8.19	7.06	7.69	.221	.243	3.23	1.15	1.26	16.25	.190	.207	2.72	1.72	1.87	24.70	.147	.160
Clover, red	Benton	9.71	5.47	6.05	.131	.145	2.39	.868	.962	15.88	.236	.261	4.32	No determination			.098	.109
	Benton	8.38	5.92	6.46	.140	.152	2.36	1.44	1.57	24.13	.432	.472	7.30	1.15	1.26	19.44	.099	.108
	Linn	8.71	5.65	6.19	.170	.186	3.03	.878	.962	15.67	.257	.281	4.50	1.51	1.65	26.92	.103	.112
	Benton	7.97	6.44	7.00	.170	.184	2.63	.990	1.07	15.39	.215	.233	3.34	1.87	2.04	29.14	.126	.136
	Benton	8.02	5.40	5.87	.162	.176	2.99	.862	.937	15.95	.246	.258	4.56	1.47	1.60	27.30	.095	.104
	Linn	8.60	5.12	5.60	.138	.151	2.70	1.08	1.18	21.09	.337	.368	6.58	1.15	1.26	22.45	.068	.075
	Washington	7.56	6.42	6.95	.214	.232	3.34	.892	.965	13.90	.203	.220	3.17	2.03	2.19	31.50	.121	.131
	Benton	6.61	6.71	7.18	.143	.153	2.13	.892	.955	13.29	.211	.226	3.15	1.96	2.10	29.20	.089	.095
	Columbia	7.55	4.82	5.22	.115	.124	2.38	.984	1.06	20.41	.196	.212	4.08	1.36	1.47	28.14	.068	.074
	Benton	11.11	6.94	7.80	.195	.219	2.81	1.02	1.14	14.67	.148	.167	2.14	1.75	1.97	25.80	.085	.095
	Linn	7.85	6.37	6.91	.153	.166	2.52	1.21	1.31	19.00	.167	.181	2.62	1.19	1.29	18.70	.051	.055
	Benton	7.34	6.40	6.90	.161	.174	2.52	.780	.842	12.20	.139	.150	2.34	1.94	2.09	30.28	.067	.072
	Linn	6.98	6.32	6.79	.156	.168	2.47	1.08	1.16	17.10	.224	.240	3.54	1.29	1.39	20.40	.063	.068
	Benton	8.09	7.37	8.02	.166	.181	2.26	1.00	1.09	13.57	.165	.180	2.25	1.92	2.09	26.06	.085	.093
	Linn	8.56	6.36	6.96	.196	.214	3.08	1.00	1.10	15.80	.185	.202	2.91	1.57	1.72	24.68	.084	.092
	Columbia	8.85	5.75	6.31	.123	.135	2.14	.688	.755	11.97	.126	.138	2.19	1.75	1.92	30.50	.057	.063
	Average	8.24	6.09	6.64	.158	.173	2.61	.979	1.07	16.25	.218	.237	3.69	1.59	1.74	26.03	.085	.093
Clover, alsike	Benton	7.91	6.85	7.44	.150	.163	2.19	.996	1.08	14.53	.232	.252	3.39	1.99	2.16	29.00	.110	.120
	Washington	7.77	5.34	5.79	.233	.253	4.37	.752	.816	14.09	.234	.254	4.38	1.52	1.65	28.55	.143	.155
	Columbia	6.16	6.93	7.38	.196	.209	2.83	.804	.857	11.60	.207	.221	2.99	2.15	2.29	30.95	.090	.096
	Linn	10.56	6.42	7.18	.248	.277	3.86	.944	1.05	14.70	.170	.190	2.65	1.42	1.58	22.07	.102	.114
	Columbia	13.32	8.59	9.91	.188	.216	2.18	.610	.703	7.10	.116	.133	1.35	3.14	3.62	36.58	.073	.084
	Average	9.14	6.83	7.54	.203	.224	3.09	.821	.901	12.40	.192	.210	2.95	2.04	2.26	29.43	.104	.114

Vetch	Benton	9.83	5.47	6.06	.219	.243	4.00	.780	.865	14.25	.169	.187	3.08	1.39	1.55	25.48	.061	.067
	Benton	10.82	5.80	6.50	.184	.206	3.17	.952	1.07	16.38	.288	.323	4.96	1.08	1.21	18.60	.096	.108
	Benton	10.26	5.45	6.08	.210	.234	3.85	.868	.967	15.92	.216	.241	3.96	1.35	1.52	24.70	.098	.109
	Benton	6.58	6.67	7.14	.167	.179	2.51	.892	.955	13.40	.184	.197	2.77	1.89	2.03	28.40	.098	.105
	Benton	10.59	6.01	6.72	.266	.298	4.43	.832	.930	13.87	.240	.269	4.01	1.42	1.58	23.60	.091	.102
	Benton	10.22	5.57	6.20	.211	.237	3.79	.736	.819	13.20	.173	.192	3.10	1.43	1.60	25.72	.076	.085
	Benton	11.12	5.42	6.10	.187	.210	3.45	.700	.787	12.90	.230	.259	4.24	1.15	1.29	21.20	.110	.125
	Benton	5.42	6.45	6.83	.215	.227	3.33	.932	.986	14.45	.166	.175	2.57	1.69	1.79	26.28	.088	.093
	Linn	6.44	4.55	4.86	.131	.140	2.89	.548	.585	12.04	.126	.134	2.76	1.30	1.39	28.60	.062	.066
	Benton	6.11	5.64	6.01	.133	.142	2.36	.694	.738	12.30	.167	.178	2.96	1.50	1.60	26.60	.080	.086
	Benton	7.90	5.99	6.50	.309	.335	5.16	.690	.749	11.52	.190	.206	3.17	1.69	1.84	28.28	.089	.096
	Washington	6.26	5.40	5.76	.245	.261	4.54	.556	.593	10.30	.128	.136	2.36	1.78	1.90	32.95	.075	.080
	Washington	8.59	6.71	7.34	.310	.340	4.63	.564	.613	8.41	.187	.204	2.79	2.35	2.57	35.00	.128	.140
	Columbia	7.18	6.98	7.52	.281	.313	4.17	.812	.875	11.64	.176	.190	2.53	2.01	2.17	28.92	.089	.096
	Benton	8.84	7.07	7.76	.238	.260	3.36	.686	.753	9.70	.145	.159	2.05	1.78	1.95	25.20	.158	.173
	Benton	7.63	6.05	6.55	.136	.148	2.24	1.02	1.10	16.80	.216	.228	3.48	.958	1.04	15.83	.094	.102
	Linn	8.04	5.63	6.12	.245	.267	4.37	.668	.726	11.87	.158	.172	2.81	.743	.808	13.21	.080	.087
	Linn	8.50	6.90	7.56	.330	.360	4.68	.663	.725	9.61	.093	.102	1.36	1.39	1.52	20.13	.071	.078
	Linn	7.14	7.78	8.38	.273	.294	3.51	.832	.895	10.63	.097	.105	1.25	1.86	2.00	23.90	.069	.074
	Linn	7.50	7.26	7.85	.272	.294	3.75	.668	.721	10.88	.068	.074	1.06	1.68	1.81	23.12	.060	.065
	Linn	8.81	5.35	5.87	.262	.288	4.90	.538	.590	10.05	.109	.120	2.04	1.40	1.53	26.08	.042	.046
	Columbia	8.36	7.48	8.16	.257	.281	3.44	.532	.581	7.10	.128	.140	1.71	2.74	2.99	36.65	.105	.115
	Average	8.23	6.16	6.72	.231	.253	3.75	.735	.801	12.15	.166	.181	2.78	1.57	1.71	25.38	.087	.095
Peas	Benton	7.92	5.54	6.01	.236	.257	4.27	1.04	1.12	18.70	.207	.225	3.74	1.08	1.17	19.44	.081	.088
	Benton	7.52	7.05	7.62	.249	.270	3.54	.972	1.05	13.79	.150	.162	2.30	1.31	1.42	18.58	.101	.109
	Columbia	7.80	7.17	7.78	.243	.263	3.38	.880	.995	12.27	.195	.212	2.72	2.26	2.45	31.54	.102	.111
	Average	7.75	6.59	7.14	.243	.263	3.73	.964	1.04	14.92	.184	.200	2.92	1.55	1.68	23.19	.095	.103
Timothy	Benton	7.09	4.22	4.54	.104	.112	2.46	.074	.080	1.76	.033	.038	.828	.738	.795	17.50	.063	.068
	Benton	6.73	4.63	4.97	.155	.166	3.36	.076	.081	1.64	.033	.035	.708	1.37	1.47	29.55	.074	.079
	Columbia	7.32	4.65	5.02	.236	.254	5.07	.064	.069	1.38	.031	.034	.676	1.49	1.61	32.14	.072	.078
	Average	7.05	4.50	4.84	.165	.177	3.63	.071	.077	1.59	.033	.036	.737	1.20	1.29	26.40	.070	.075
Orchard grass	Benton	7.91	5.05	5.48	.141	.153	2.79	.076	.082	1.50	.048	.052	.950	1.72	1.86	33.05	.044	.048
Sunflowers	Columbia	9.16	9.76	10.66	.193	.213	1.98	.784	.863	8.04	.188	.207	1.93	3.70	4.07	37.90	.115	.127
Sunflower seed	Benton	4.78	2.57	2.70	.437	.459	17.00	.029	.030	1.12	.102	.107	3.82	.693	.728	25.96	.155	.162
Wheat	Benton	10.67	1.85	2.07	.342	.382	18.48	.0044	.0049	.238	.037	.042	2.03	.475	.532	25.68	.108	.121
Oats	Linn	9.38	3.60	3.97	.365	.403	10.15	.016	.0176	.445	.024	.027	.679	.434	.479	12.04	.113	.125
	Benton	9.22	3.49	3.84	.361	.398	10.34	.030	.033	.860	.034	.037	.975	.455	.500	13.00	.125	.137
	Columbia	8.94	3.07	3.30	.303	.333	9.88	.031	.034	1.02	.024	.027	.795	.463	.509	15.10	.166	.183

TABLE IV. (Continued). THE MINERAL CONSTITUENTS OF LEGUME AND OTHER FORAGE CROPS OF WESTERN OREGON.

Crop	County	Water	Ash		Phosphorus			Calcium			Magnesium			Potassium			Sulfur	
			Air dry	Oven dry	Air dry	Oven dry	Ash	Air dry	Oven dry	Ash	Air dry	Oven dry	Ash	Air dry	Oven dry	Ash	Air dry	Oven dry
	Lane	8.25	3.64	3.96	.408	.445	11.22	.026	.028	.714	.021	.023	.587	.418	.456	11.50	.136	.148
	Lane	10.10	3.01	3.35	.324	.360	10.77	.020	.022	.665	.028	.031	.942	.389	.432	12.92	.097	.108
	Average	9.18	3.36	3.68	.352	.388	10.47	.023	.027	.741	.026	.029	.796	.432	.475	12.91	.127	.140
Barley	Benton	11.17	2.13	2.40	.325	.366	15.24	.024	.027	1.15	.031	.035	1.47	.428	.482	20.12	.101	.114
	Benton	12.32	2.37	2.70	.347	.396	14.63	.013	.015	.540	.037	.042	1.57	.388	.442	16.50	.105	.120
	Average	11.75	2.25	2.55	.336	.381	14.94	.018	.021	.85	.034	.038	1.52	.408	.462	18.31	.103	.117
Corn	Linn	10.23	1.39	1.55	.314	.350	22.64	.022	.024	1.58	.029	.032	2.07	.318	.355	22.90	.109	.121
								Coast Section										
Clover, red	Tillamook	6.15	7.37	7.85	.161	.172	2.19	.980	1.04	13.29	.250	.267	3.40	2.35	2.51	31.90	.068	.072
	Tillamook	6.95	8.32	8.94	.165	.177	1.98	1.37	1.47	16.48	.247	.256	2.97	2.13	2.29	25.60	.106	.114
	Average	6.55	7.85	8.40	.163	.175	2.08	1.18	1.26	14.89	.249	.262	3.19	2.24	2.40	28.75	.087	.093
Clover, alsike	Clatsop	6.20	6.46	6.89	.167	.178	2.59	.620	.661	9.59	.403	.431	6.18	2.80	2.98	43.26	.112	.119
	Clastop	6.85	6.28	6.75	.171	.183	2.17	.612	.657	9.73	.402	.432	6.40	2.11	2.26	33.54	.073	.078
	Tillamook	5.95	7.10	7.55	.153	.163	2.15	.819	.872	11.54	.182	.194	2.56	2.65	2.81	37.20	No Det'n	
	Tillamook	7.28	9.60	10.35	.246	.256	2.57	.530	.570	5.50	.204	.220	2.13	3.38	3.64	35.20	.123	.133
	Average	6.57	7.36	7.86	.184	.195	2.37	.645	.690	9.09	.298	.319	4.32	2.74	2.92	37.30	.103	.110
Peas	Tillamook	6.37	4.81	5.14	.201	.214	4.17	.644	.688	13.38	.173	.184	3.59	1.45	1.55	30.08	.130	.139
								Southern Oregon Section										
Alfalfa	Jackson	6.48	6.43	6.48	.199	.213	3.10	1.22	1.30	18.93	.200	.213	3.10	1.42	1.51	21.98	.126	.134
	Josephine	8.22	7.70	8.39	.165	.180	2.15	1.04	1.14	13.56	.211	.230	2.74	2.26	2.46	29.35	.166	.180
	Jackson	6.33	5.21	5.56	.237	.254	4.55	1.62	1.72	30.99	.370	.394	7.08	.65	.69	12.43	.175	.187
	Jackson	6.87	8.52	9.15	.231	.248	2.71	1.16	1.24	13.61	.232	.249	2.73	2.41	2.59	28.32	.212	.227
	Average	6.97	6.97	7.40	.208	.224	3.13	1.26	1.35	19.27	.253	.271	3.91	1.69	1.81	23.02	.170	.182

Clover, red	Josephine	8.04	6.76	7.35	.133	.145	1.96	1.05	1.14	15.45	.300	.326	4.43	1.83	1.99	27.12	.123	.134
	Jackson	6.81	5.94	6.37	.195	.209	3.28	1.27	1.37	21.46	.264	.283	4.44	1.36	1.46	22.85	.151	.162
	Jackson	6.42	6.94	7.41	.238	.254	3.43	1.16	1.23	16.64	.292	.312	4.21	1.78	1.90	25.60	.119	.127
	Average	7.09	6.55	7.04	.189	.203	2.89	1.16	1.25	17.85	.285	.307	4.36	1.66	1.78	25.19	.131	.141
Clover, alsike	Jackson	6.66	6.17	6.61	.172	.184	2.78	.730	.782	11.82	.225	.242	3.65	1.91	2.05	31.02	.126	.135
Wheat	Jackson	9.50	1.89	2.09	.393	.434	20.80	.0064	.0071	.338	.0407	.045	2.15	.412	.455	21.80	.114	.126
	Jackson	10.16	1.85	2.06	.334	.372	18.07	.0048	.0053	.260	.0323	.0359	1.75	.477	.531	25.80	.122	.136
	Average	9.83	1.87	2.08	.364	.403	19.44	.0056	.0062	.299	.0365	.0405	1.95	.445	.493	23.80	.118	.131
Barley	Jackson	9.97	2.28	2.53	.396	.440	17.37	.0236	.0262	1.035	.0279	.031	1.17	.492	.547	21.37	.113	.126
	Jackson	9.83	1.97	2.18	.417	.453	21.20	.0216	.0239	1.096	.0231	.0256	1.175	.603	.659	30.60	.084	.093
	Average	9.90	2.13	2.36	.407	.447	19.29	.0226	.0251	1.065	.0255	.0283	1.172	.548	.603	25.99	.099	.110

TABLE V. WEIGHT OF CROP IN POUNDS REQUIRED TO EQUAL IN PROTEIN AND THE MINERAL ELEMENTS AMOUNTS OF THE SAME SUBSTANCES IN 100 POUNDS OF MILK. CALCULATED FROM ANALYTICAL DATA IN TABLES I AND IV.

Crop	Section	For protein N	For phosphorus P	For calcium Ca	For magnesium Mg	For potassium K	For sulfur S
Legumes							
Alfalfa	Valley	30	47	11	5	9	7
Alfalfa	Southern Oregon	27	49	10	4	9	6
Clover, red	Valley	37	65	13	4	9	13
Clover, red	Southern Oregon	30	55	11	3	9	8
Clover, red	Coast	31	63	11	3	6	13
Clover, alsike	Valley	41	50	16	5	7	11
alsike	Southern Oregon	38	60	18	4	8	9
alsike	Coast	32	56	20	3	5	11
Vetch, common	Valley	29	44	18	5	9	13
Peas, field	Valley	27	42	13	5	10	12
Peas, field	Coast	27	51	20	5	10	9
Non-legumes							
Timothy	Valley	66	62	182	27	12	16
Orchard grass	Valley	83	72	170	19	9	25
Grains							
Oats	Valley	35	29	516	35	35	9
Barley	Valley	34	31	716	26	36	11

* Grain only.

TABLE VI. FERTILIZING MATERIALS IN POUNDS REQUIRED TO REPLACE IN THE SOIL NITROGEN AND OTHER ESSENTIAL ELEMENTS USED IN THE PRODUCTION OF ONE TON OF AIR-DRY LEGUME OR OTHER FORAGE CROP.

Crop	Section	Sodium nitrate for nitrogen	Super-phosphate for phosphorus	Limestone for calcium	Sulfate of potash for potassium	Muriate of potash for potassium	Land-plaster for sulfur
		N	P	Ca	K	K	S
Alfalfa	Valley	267	60	64	86	83	17
Alfalfa	Southern Oregon	302	56	70	85	81	19
Clover, red	Valley	218	43	54	80	77	10
Clover, red	Coast	263	44	66	112	108	10
Clover, red	Southern Oregon	273	51	64	83	80	15
Clover, alsike	Valley	197	55	46	102	98	12
Clover, alsike	Coast	252	50	36	137	132	12
Clover, alsike	Southern Oregon	215	46	41	96	92	14
Vetch, common	Valley	283	62	41	79	76	10
Peas, field	Valley	295	66	54	78	75	11
Peas, field	Coast	299	54	36	73	70	15
Timothy	Valley	123	45	4	60	58	8
Orchard grass	Valley	97	38	4	86	83	5
Sunflowers	Valley	211	52	44	185	178	13
Wheat *	Valley	235	93	.2	24	23	12
Wheat *	Southern Oregon	.....	98	.3	22	21	13
Oats *	Valley	232	95	2	21	20	14
Barley *	Valley	241	91	1	20	19	12
Barley *	Southern Oregon	221	110	1	27	26	11
Corn *	Valley	.....	85	1	16	15	12

*Grain only.