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Grasses and Clovers: Effect of Ripeness on Yield and Composition.

Experiment No. 50.

The yield and the utility in feeding determine chiefly the value of such crops as grasses and clovers; account must also be taken of some other things, such as cost and certainty of growing, and the risks and expense of harvesting. These last items are also not to be overlooked in an inquiry as to the stage of ripeness at which it is most profitable to cut any variety of grass or clover. The expense and risk in securing timothy, for example, may both be greater, if it be cut early when it will require much handling and long exposure in curing, than if cut late when with a little tending it will dry quickly. But in such an inquiry the main question is, To what extent are the yield and the feeding value of the hay affected by the ripeness of the crop when cut? The food value of hay depends upon its composition, its digestibility by the animal eating it, and the readiness and relish with which it is eaten. The investigations reported in this bulletin were undertaken to ascertain the effect of cutting certain grasses and clovers at different periods of growth upon the yield of hay and its composition. The results obtained by several others who have made investigations on the same lines are also given, and the whole is believed to be a fairly comprehensive summary of the data so far accumulated upon this subject in this country.

The digestibility of the crops harvested was not investigated; but the conclusions reached by men who have pursued this branch of the inquiry have been used—preference being given to experiments made in America.

EXPLANATION OF TERMS.

The treatment of the subject is necessarily technical to some extent, and an explanation of some of the terms used may help the general reader.

Fresh substance--Water—Water-free substance. Air-dry products, such as hay and well dried corn, contain some water, which is driven off when they are heated to the boiling point of water. Accurately speaking, therefore, hay is not a dry substance. To avoid confusion, the sample of hay taken to the chemist in its usual condition is called *fresh substance.* When the water has been driven off, that which is left is termed *water-free substance.*

Crude ash. When the chemist has burned his sample of hay, etc., he has left the mineral constituents, a part of them in the form of carbonates, and some sand. To this residue the term *crude ash* is applied.

Crude protein—True protein. Some of the group of nutrients distinguished by containing nitrogen (the gluten of wheat, white of eggs, and the lean of meat belong to this group) go to build up flesh and muscle. The term *true protein* is applied to such nitrogenous compounds, and the nitrogen in them is called *albuminoid nitrogen.* Other compounds containing nitrogen do not produce muscle. When these two classes are spoken of collectively, the term applied to them is *crude protein.*

Crude fat. This comprises the substances soluble in ether, such as the fat, wax, and the green coloring matter of plants (chlorophyll).

Crude fibre. This is the woody part of the plants.

Nitrogen-free extract. To what is left in the chemical analysis after the crude ash, the nitrogenous compounds, the crude fat, and the crude fibre, have been removed the term *nitrogen-free extract* is applied.

Co-efficient of digestion. The term *co-efficient of digestion* denotes the number of parts in a hundred of any given nutriment which are digested by the animal eating it. This co-efficient is determined by comparing the known quantity of the several nutrients in the amount of food fed to an animal in a given time with the amount of each found in the solid excrements for the same time. When the co-efficients of a particular food have not been ascertained, they are assumed to be the same as the known co-efficients of some closely similar food. The co-efficients vary with the class of animals fed. In this bulletin the co-efficients for cattle are used.

The pounds per acre of a crop being known, and its composition, the number of pounds of each nutritive constituent may be computed. The number of each thus found gives, when multiplied by its co-efficient of digestion the amount of each nutrient digested, and the sum of these several amounts is the total of digestible substance in the crop.

For example, take the first cutting of timothy reported in table 2: The yield per acre of hay was 4480 lbs. After driving out the water by heating, the dry substance left was 3287 lbs. This gives:

	Parts in 100.	Lb. per acre.	Digestion co-efficients.	Lb. per acre digestible.
Crude ash	6.81	224	—	—
Crude fat	5.	165	.49	81
Crude protein	7.33	240	.49	118
Crude fibre	32.11	1056	.5	528
Nitrogen-free extract	48.75	1602	.63	1009
Total	100	3287		1736

With our present knowledge we must hold such results not as conclusive, but rather as tentative and suggestive. They will, however, be of value to such as will use them with discretion.

Nutritive ratio. The relation between the digestible nitrogenous substances of a food, and the sum of its digestible, non-nitrogenous organic substances, is termed the *nutritive ratio.* In making up the sum of the non-nitrogenous substances, two and one-half times the amount of fat given by the analysis is taken; for the fat in burning produces two and one-half times as much heat as the starch, etc., and, hence, is assumed to have two and one-half times as much food value. The nutritive ratio of the sample of timothy considered above is thus formed:

$$\left((81 \times 2.5 = 202.5) + 528 + 1009 = 1739.5\right) \div 118 = 14.8.$$

The best nutritive ratio may be determined, approximately, for each class of stock; but, in general, a large proportion of nitrogenous substance, which makes the nutritive ratio small, is held to show a high food value, for this substance is the most useful food nutrient.

General Statement.

Four grasses, timothy, Kentucky blue grass, orchard grass, and meadow fescue, and two clovers, medium red and mammoth red, were used in the investigation. Incidentally there was some comparison of the varieties.

Tracts were selected which promised an even and a full yield. They were divided into plats each one rod square.

Two or more plats of each species were cut at each time of cutting, so that accidental variations might be in a measure overcome.

The grass, or clover, was shaken out after cutting, and turned once or twice. If left out over night, it was shocked. The weather was usually favorable, and the hay was mostly of good quality. When dry enough for storage the hay was weighed, chopped in a feed cutter, carefully mixed, and samples were analyzed by the Station chemists, Dr. Manns, B. Tatarian, and H. S. Grindley.

Timothy *(Phleum pratense).*

The timothy, which was substantially pure, was cut at four dates, June 25th, July 2d, 11th, and 23d, four plats at each date. The plats, numbered 27–42, were in a row; and to eliminate, as far as possible, any variations in land or yield from the averages of the cuttings, plats 27, 31,

35, and 39 were cut the first time; the second time, plats 28, 32, 36, and 40, etc. [*Diagram (e), p. 153.*]

June 25th, the timothy had been in full bloom two days—a few heads a little longer. July 2d, it had shed its pollen and half its anthers. July 11th, the seeds were in the dough and either the whole or the tips of the lower leaves were brown.

The hay from the first cutting was but moderately well cured. Plats 27 and 31 were cut between 11 o'clock a. m. and noon; plats 35 and 39, between 1 and 2 o'clock p. m. The hay from the plats first cut contained, when weighed, 24.6 per cent. of water; that from the plats cut later in the day, 28.46 per cent. of water. The hay from plats cut at the subsequent dates was excellently well cured.

Composition [*Table 1*]. The first cutting, which was not thoroughly cured, being left out, twelve lots of thoroughly field-cured hay, cut at three dates, contained an average of 21.93 per cent. of water. The average per cent. of air-dry timothy hay is put at 10.21 in No. 39; but probably samples dried in the laboratory were included. Atwater makes 12.5 per cent. or one-eighth of the whole, a fair average of water in timothy hay in barns in New England. If we accept this average for timothy hay in the barn, the loss on hay put into the mow in condition as above would be 215 pounds in the ton after storage.

In general, as the timothy ripened there was a decrease in the per cent. of crude ash, crude fat, and crude protein, and an increase of crude fibre and nitrogen-free extract. The exceptions were that the per cent. of ash was greater in the third than in the second cutting; that the per cent. of crude protein was greater in the fourth than in the third cutting; that the per cent. of crude fibre was greater in the third than in the fourth cutting; and that the percentage of nitrogen-free extract was greater in the first than in the second cutting. Jordan found a larger per cent. of crude fibre in timothy when nearly ripe than when in full bloom; while Ladd found a larger per cent. of nitrogen-free extract at full bloom. Atwater, whose percentage of fat was small, found an increase of fat and a decrease of nitrogen-free extract in timothy nearly ripe. Richardson's analyses are marked by a large percentage of crude protein and a small percentage of crude fibre. Otherwise, the results correspond in general with those of the Station.

Yield. Table 2 shows an increase of field-cured hay during the first two periods between cuttings, and a slight decrease in the third. There was a constant increase of water-free substance from the first to the last cutting. The average yield of the first two cuttings was two and one-fifth tons of field-cured hay per acre; of the last two, two and three-fifths tons. Similar averages of water-free substance were one and two-thirds and two tons, respectively. The largest increase in yield was between the second and third cuttings. There was a greater average yield of all the nutrients, fat excepted, at the last two cuttings than at the first two. The increase was mostly in crude fibre, 273 pounds, and nitrogen-free extract,

376 pounds. Jordan found a decrease in the crude protein and an increase in the crude fat, while Atwater found a decrease of crude protein and ash at the last two cuttings, on an average.

If we assume equal digestibility for the hay secured at the several dates, there was, using Jordan's co-efficients of digestibility [*Table 3*], an average of 1,773 pounds of digestible organic substance per acre at the first two cuttings, and 2,148 at the last two, or fifty-three per cent. of the water-free substance. In like manner Jordan found 1,404 pounds and 1,684 pounds; and Atwater, 1,647 pounds at first two cuttings, and 1,845 pounds at last two.

The nutritive ratio increased from the first to the third cutting, and slightly decreased from the third to the fourth. Jordan and Atwater both found a larger nutritive ratio than was found here.

These experiments, while conflicting in some points, indicate in general that although the quality of the hay may be better from grass cut at full bloom than from the late cut grass, the yield of timothy is greater when late cut. According to the test here, there was no considerable increase in yield from the time the seed was in the dough until the grass was nearly ripe. Atwater, however, found a considerable increase during that period.

Kentucky Blue Grass (*Poa pratensis*).

Eight plats [*Diagram* (*a*), *p. 153*] of Kentucky blue grass were cut at two stages of ripeness—Nos. 1, 3, 5, and 7, June 14th, seeds in the milk; Nos. 2 and 6, June 21st, Nos. 4 and 8, June 22d, seeds ripe. From 80 to 90 per cent. of the crop was blue grass; the rest was mostly timothy. One would have pronounced it almost pure blue grass on a casual glance, and it was as nearly pure as is usually found. The hay of the first cutting was well cured; that of the second was not. A heavy rain, which fell on plats 2 and 6 five hours after they were cut, bleached the hay somewhat.

The investigation of blue grass was extended to take in plats of pasture land. The grass on these plats had been cut with a machine July 1st and after that date was left to grow until cut for this experiment. The grass on 16 plats was cut on as many different days from July 30th to September 10th. The weather was hot and dry, and the grass was growing slowly. Equal quantities of water-free substance of each cutting were mixed and the sample thus obtained was analyzed February 9th, the grass (aftermath or fog) was cut with a sickle on a square rod of the same pasture, and the grass weighed and sampled. The growth since July 1st had been from 4 to 8 inches, averaging about 6 inches. There was a little live grass which was about 4 inches high.

Composition [*Table 1*]. At the first cutting the seeds of the blue grass were in the milk; at the second cutting, a week later, they were ripe. During th s time the percentage of crude fibre and of nitrogen-free extract increased slightly; that of the crude ash, crude fat, and crude protein increased. Scovell found similar changes, but much more

marked, except in the crude fibre, from the time the grass was well headed until it had been ripe two weeks. Richardson found variations in the crude fat; Scovell found a much larger per cent. of crude protein, and a smaller per cent. of crude fibre in pasture grass than was found here. The grass from the winter pasture contained much less crude protein and more nitrogen-free extract than the summer pasture. Otherwise, the results of analyses made elsewhere are in general similar to those obtained here.

Yield [*Table 2*]. The average yield of field-cured hay at the first cutting was one and two-thirds tons; at the second, two tons, and of water-free substance, 2,508 pounds at the first, and 2,907 at the second. There was an increase in all the nutrients during the ripening. This may have been due, in part, to the timothy, of which, it will be remembered, there was a small percentage mixed with the blue grass; for the timothy was heading at the first cutting, and developed rapidly during the week before the second cutting.

The average yield per acre of fresh blue grass pasture, cut at 16 dates from July 30th to September 10th, was rather less than two tons. The plat cut in February yielded at the rate of two and a half tons per acre. The yield of water-free substance from the summer pasture, was at the rate of 1,991 pounds per acre; from the winter pasture, 2,813, an increase of over 800 pounds in all, which consisted of crude ash, crude fibre, and nearly 600 pounds of nitrogen-free extract. These somewhat phenomenal results need a word of explanation. The pasture had not been grazed in the spring and was mown with an ordinary machine July 1st. The cutting with the sickle, four to ten weeks later, was made close to the ground, and thus much grass was secured which the machine had missed.

Table 3 shows for the blue grass hay an increase of 200 pounds of digestible organic substance per acre, and a slight increase of all the nutrients from the time the seeds were in the milk until they were ripe. The yield of digestible substance on the summer pasture was about as great as on the meadow that was mowed; and was greater in mid-winter on a pasture that had not been grazed or cut since July 1st. These results come from assuming a much higher digestibility for the grass than for the hay [See DESCRIPTION OF TABLES, *Table 3, p. 153*], and they need to be verified before they are used as the basis for any general conclusions.

ORCHARD GRASS *(Dactylis glomerata)*.

Six plats [*Diagram (b), p. 153*] of orchard grass were cut at two periods of growth—Nos. 9, 12, and 14, June 14th, when in full bloom; No. 11, June 21st, and Nos. 10 and 13, June 22d, when the seeds were in the milk. The panicles were green, tinged with purple. About three-fourths of the grass was orchard grass; the rest was mostly blue grass. The hay of the first cutting was well cured, but not of the second. That from plat 11 was bleached by rain.

Composition [*Table 1*]. The well cured hay contained a little more than one-fourth of its weight of water. The late cut hay was not well cured and contained over one-third its weight of water.

The average per cent. of crude ash and of nitrogen-free extract increased, and that of crude fat, protein, and fibre decreased between the first and second cuttings. Goessmann found an increase during the same period in the per cent. of nitrogen-free extract, it being from 1,090 to 1,446 pounds.

According to the digestion co-efficients, as determined by Jordan and Ladd [*Table 3*], 1,371 pounds of organic substance in the first cutting, and 1,655 pounds in the second were digestible. There was an increase in the nutritive ratio and an increase in the amount digestible of each nutrient from the time of full bloom until the seeds were in the milk.

Meadow Fescue *(Festuca pratensis)*.

A tract two rods square, of pure meadow fescue, the third year from seed, was divided into plats one rod square, Nos. 15–18 [*Diagram, (c), p. 153*]. The stand was thin. Plats 16 and 17 were cut June 14th, when about one-half the heads had seeds in the milk, and the other half were in blossom. Plats 15 and 18 were cut one week later, when the seeds varied from the milk to the dough stage. The spikelets were yellowish and the seeds shelled off easily.

Composition [*Table 1*]. The hay of the first cutting was well cured and contained nearly 29 per cent. of water. That of the second cutting was only fairly cured and contained 32 per cent. of water.

The percentage of crude ash and of nitrogen-free extract increased, and of crude protein and of crude fibre decreased during ripening. The average per cent. of crude fat remained the same. The analyses of the first cutting here compared with Ladd's analyses, show a larger per cent. of crude ash, fat, and fibre, and a smaller per cent. of crude protein and of nitrogen-free extract. Richardson's analysis is marked by a large per cent. of crude protein, and a small per cent. of crude fibre. Goessmann found in meadow fescue hay in seed a very small per cent. of crude fat.

Yield. The field-cured hay averaged one ton per acre at the first cutting; at the second, a little more than one and one-fifth tons [*Table 2*]. Of water-free substance there were 1,424 pounds at the first cutting; at the second, 1,954. There was an increase in yield in all nutrients during ripening [*Table 3*].

Medium Red Clover *(Trifolium pratense)*.

Eight plats [*Diagram (d), p. 153*] were cut at two stages of ripeness—plats 19–22 June 14th, when the clover was in full bloom, one head in five being considerably brown; plats 23 and 24, June 21st, when three-fourths of the heads were dead and a few of the leaves were brown. Before any cutting was done, plats 23 to 26 seemed to have more clover than the other plats. At the first cutting the leaves were well cured while the stems

were still green in color and texture. At the second cutting the clover was cured in the barn after plats 23 and 24 had received a heavy rain which bleached the leaves.

Composition [*Table 1*]. The per cent. of crude ash, fat, and protein decreased, and of crude fibre and nitrogen-free extract increased during ripening. Jordan found similar variations, except that nitrogen-free extract decreased on the whole. He found a greater increase in the crude fibre than was found here. Atwater found an increase in crude fat after the plant was nearly out of bloom. Richardson found a large per cent. of crude protein and a small per cent. of crude fibre. In aftermath the per cent. of crude fat increased during ripening, and in samples taken in New Hampshire the per cent. of crude ash increased. In general, however, there was a decrease in the per cent. of crude ash, fat, and protein, and an increase in the per cent. of crude fibre and nitrogen-free extract. Although there were exceptions, Voelcker also found a decrease in the per cent. of crude ash and nitrogenous matter, and an increase in the non-nitrogenous matter during the growth and maturing of the plant.

Yield [*Table 2*]. It was said above, that the plats which were cut last seemed to have a larger growth of clover; but those first cut gave the larger yield both of field-cured hay and of water-free substance. There was a slight increase of crude fibre, but a decrease in all the other nutrients from the time of full bloom until three-fourths of the heads were brown.

Atwater found an increase in yield until the clover was nearly out of bloom, and thereafter a decrease. Voelcker found a rapid increase in yield from April 15th to May 26th, a gradual increase from May 26th to June 16th, and, with slight exception, a gradual decrease from that date.

Table 3 shows that the total of digestible organic substance was, at full bloom, 1,445 pounds per acre, and when three-fourths of the heads were dead, 1,283 pounds. There was a less quantity of each of the nutrients at the later stage of growth. The nutritive ratio increased during the ripening.

Mammoth Red Clover *(Trifolium medium)*.

Ten plats [*Diagram* (*f*), *p. 153*] were cut at three periods of growth —Nos. 43, 47, 51, and 55 June 30th when the clover was just beginning to blossom, about one head in ten being in bloom; Nos. 45, 49, and 53 July 11th when about one-half the heads were in full bloom and some were turning brown, and when the stems were already lodged; Nos. 46, 50, and 54 July 23d, when three-fourths of the heads were brown (containing ripe seeds), and when the lower leaves were brown and dead. The hay from each cutting was well cured when weighed and sampled.

Composition [*Table 1*]. The per cent. of crude ash, fat, and protein decreased during ripening; though with some irregularity, the crude fibre and nitrogen-free extract increased. The exceptions were that the nitrogen-free extract decreased from the first to the second cutting, and the

crude fibre from the second to the third. The sum of these two nutrients increased during each period.

The percentage of water in the field-cured hay decreased with each cutting. At the last it contained 19.53 per cent. which was the least average per cent. of water in any of the field-cured hays of this experiment.

Yield. The average yield per acre of field-cured hay from the clover cut when just beginning to bloom, was a little over two tons; from the clover in full bloom, nearly two and three-fourths tons; and from that nearly out of bloom, about two tons. The yield per acre of water-free substance at the three cuttings was 3,196, 4,038, and 3,392 pounds, respectively. The yield of all the nutrients was largest in the hay from clover cut when in full bloom.

According to Table 3 there were 2,036 pounds of digestible organic substance at the first cutting, 2,299 at the second; and 1,806 at the third. Fat excepted, there was the largest digestible quantity of all the nutrients at full bloom. The rapid deterioration in composition and in yield of clovers during ripening is, in part at least, due to loss of the leaves and finer parts. On this account the value of a crop of clover hay depends much upon the skill with which it is harvested.

Weight of Green Substance.

The day when each grass or clover was cut, a sample of the green substance was taken and the percentage of water in it ascertained. This being known, the weight of green substance per acre was easily computed. As given in Table 6, there was from 53.31 to 67.25 per cent. of water in the grasses, and from 68.19 to 76.05 per cent. of water in the clovers. The clovers contained about ten per cent. more water than the grasses. The per cent. of water decreased in each instance with the growth of the plant. In every case the green plant contained over one-half its weight of water.

The yield per acre of green substance varied in the grasses from three and one-half to four and three-quarters tons, and in the clovers from four and two-fifths to seven and three-fourths tons. The grasses lost while curing, from one and three-fourths to two and three-fifths tons.

In General.

An analysis of the results embodied in the tables given shows that while there are marked exceptions, there is, in general, a decrease in the per cent. of water, crude ash, crude fat, and crude protein, and an increase in the per cent. of crude fibre, and nitrogen-free extract as the plant matures during that period within which it is at all practicable to harvest the crop for hay. The increase of the non-nitrogenous over the nitrogenous portions has such few exceptions that they may be attributed to accidental variations of sampling. The decrease in the per cent. of fat is quite general, but there are marked exceptions.

An increase in the per cent. of crude ash is often accompanied by a decrease in crude fibre. Unusual variations in the percentage of crude ash may occur through an accumulation of dirt from various causes on the exterior of the plants, and these will change the relative proportion of the other substances. The increase in the per cent. of nitrogen-free extract is fairly general. The decrease of the crude protein and the increase of the crude fibre is more rapid in the clovers than in the grasses.

The increase of yield of the grasses from the period of full bloom until seeds are formed is appreciable. There is an increase of all the food nutrients, but the increase is most marked in the crude fibre and nitrogen-free extract. With timothy, orchard grass, and meadow fescue, there was, according to the experiments at this Station, an increase of six hundred pounds of water-free substance, or an average increase of one-fourth their weight from the full bloom until seeds were formed. With the clovers there was a decrease of yield after the period of full bloom (when about one-half the heads are in full bloom). There was a decrease in all the nutrients, with the exception of crude fibre, in which there is sometimes an appreciable increase. Last season medium and mammoth red clovers decreased about 375 pounds, a decrease of one-ninth from the period of full bloom until three-fourths of the heads were dead, the greater decrease occurring in the mammoth clover. Since part, at least, of the decrease is due to the loss of the leaves and finer parts as the plant ripens and is handled in harvesting, the loss would be greater, probably, in ordinary practice than in this experiment, as the care taken in handling while harvesting is usually less than was taken here.

According to the digestion experiments of German investigators there is a rapid decrease in the digestibility of clover after full bloom, and this still further reduces the value.

Whether the decrease in the digestibility of the grasses after full bloom will offset the increase of yield has not yet been determined. Presumably, the decrease in digestibility is not so rapid with the grasses as with the clovers.

With an ordinary yield the loss of water while curing in the field may be from two to five tons per acre; the loss is larger in the clovers than in the grasses. The loss in weight by drying after storing may be from two to four hundred pounds per ton.

Comparison of Hays.

In comparing the composition, as shown in Table 4, of the different forage plants cut for hay in this experiment, the most noticeable difference is to be seen in the percentage of crude protein in the clovers as compared to the grasses. Medium red clover contained over twice as large a per cent. of this substance as did timothy. Mammoth red clover contained about 3 per cent. less than did medium red clover. Timothy is distinguished by containing the least percentage of crude ash, crude

fat, and crude protein, the largest percentage of nitrogen-free extract, and, with one exception, meadow fescue, the largest percentage of crude fibre of any of the species analyzed. Of the grasses, orchard grass contained the largest percentage of ash and crude protein, and Kentucky blue grass the largest percentage of fat.

The analyses of mammoth red clover [*Trifolium medium*] published in this bulletin are believed to be the first published American analyses of this plant. This species is less known than the medium red clover [*Trifolium pratense*].

It is distinguished, agriculturally, by its larger and coarser growth, later maturity, and by the fact that it usually yields but one crop in a season. It is more esteemed as a renovater of old and poor lands than the medium red clover, on account of its larger growth; but on rich lands its coarseness is considered by many an objection. Its ripening when timothy does is a point in its favor for sowing with that plant. Except for its larger growth and later ripening, it is not readily distinguished from medium red clover. The results obtained last year with the two clovers are comparable, the soil, cultivation, etc., being similar. Table 4 shows a larger percentage of crude fibre and a smaller percentage of crude protein, ash, and fat than in medium clover. In other words, the analyses indicated that the medium clover hay is the better food. The average of 33 American analyses, compiled by Jenkins, more nearly corresponds to those of the mammoth red clover than to those of the medium red clover as determined here.

Yield.—Table 4 gives yield of each kind of hay harvested. While the results are not strictly comparable on account of the varying location of the tracts from which they were harvested, the stage of ripeness when harvested, and other modifying influences, still the soil was not radically different, and the climatic influences of course were the same. In yield, both of field-cured hay and water-free substance, timothy leads the list, followed by mammoth red clover, orchard grass, Kentucky blue grass, medium red clover, and meadow fescue.

Of timothy there were about two and two-fifths tons, of mammoth red clover two and one-third tons, of orchard grass two and one-eighth tons, of Kentucky blue grass one and four-fifths tons, of medium red clover one and three-fourths tons, of meadow fescue one and one-fourth tons of field-cured hay per acre; of dry or water-free substance there were one and four-fifths, one and three-fourths, one and one-half, one and one-third, one and one-fourth tons, and four-fifths of a ton per acre, respectively. Mammoth red clover gave the largest yield of crude protein, nearly twice as much as timothy hay. Next to mammoth red clover in yield of this substance stands medium red clover, followed by orchard grass, timothy, Kentucky blue grass, and meadow fescue. In yield of crude fat they stand in the same order, except that timothy stands third instead of orchard grass. Timothy gives the largest yield of crude fibre, followed by mammoth red clover, orchard grass, Kentucky blue grass, medium red

clover, and meadow fescue. In yield of nitrogen-free extract the order is the same.

In computing the yield of digestible substance, as given in Table 4, the digestion co-efficients ascertained by several investigators have been used, as already explained in detail.

The most striking fact with reference to this part of table is the much larger proportion of digestible nitrogenous matter in orchard grass hay than in timothy hay, as shown by the nutritive ratios, that of orchard grass hay being 8.5, and that of timothy 16.6. This is in part due to the former's larger percentage of crude protein, and in part due to the larger percentage of digestible crude protein in orchard grass hay, as determined by Jordan and Ladd. [DESCRIPTION OF TABLES, *Table 3, p. 153.*]

While the yield of orchard grass was less than of timothy, the digestible organic substance being about three-fourths that of timothy, its composition and digestibility indicate a better quality of hay for milch cows and growing stock. Orchard grass does not seem difficult to grow successfully in this state. It ripens with medium red clover, which makes it desirable for mixing with that plant. Nevertheless, its cultivation is adopted slowly. It has generally been held to be less readily eaten by stock than timothy, and the cost of the seed probably retards its adoption and general culture for meadows. As a pasture grass it is conceded to be inferior to Kentucky blue grass for this state.

DESCRIPTION OF TABLES.

Table 1. In this table may be found the proximate composition of the hay from each plat, and the average composition of the hay from so many of the plats bearing the same variety of grass or clover as were cut at one time. Analyses are also given of the Kentucky blue grass, secured from the pasture in August and February in the way already described, p. 145. To these results, obtained at this Station, are added analyses by W. H. Jordan, of timothy, medium red clover [*Pa. State Coll. Rep't 1886, p. 271*], and orchard grass [*Me. Exp't Sta., Bull. No. 26, p. 7*]; by E. F. Ladd, of timothy, meadow fescue [*Sixth Rep't N. Y. Exp't Sta., p. 407*], timothy, Kentucky blue grass, orchard grass, and medium red clover [*N. Y. Exp't Sta., Bull. No. 14, New Series, p. 80*]; by W. O. Atwater, of timothy and medium red clover [*Rep't Conn. B'd of Agri. and Exp't Sta., 1878–9, p. 322*]; by Clifford Richardson, of the four grasses and medium red clover [*Rep't U. S. Dep't Agri., 1880, p. 151; 1881–2, p. 551; 1883, p. 231*]; by M. A. Scovell, of Kentucky blue grass [*Ky. Agri. Exp't Sta., Bull. No. 5, p. 23*]; by C. A. Goessmann, of orchard grass and meadow fescue [*Fifth Rep't Mass. State Agri. Exp't Sta., 1887, p. 125*]; by Wm. Frear, of medium red clover [*Rep't Pa. State Coll., 1887, Pt. 2, p. 112*], an average of 55 American analyses of timothy and an average of 33 American analyses of medium red clover, both compiled by E. H. Jenkins [*Rep't Conn. Exp't Sta. 1888, p. 90*].

Table 2. This table gives for each plat the yield per acre of field-cured hay, of water-free substance, and of each of its constituents; and the average of these is given for each set of plats bearing the same variety of grass or clover which were cut at the same time. The yields are also given for the blue grass pasture. To this are added yields per acre, as ascertained by W. H. Jordan, for timothy and medium red clover [*Pa. State Coll. Rep't 1886, p. 271*]; by W. O. Atwater, for timothy and medium red

clover [*Rep't Conn. B'd Agri. and Exp't Sta., 1878–9, p. 322*]; by A. Voelcker, for medium red clover [*Jour. Royal Agri. Soc., 1867, p. 41*]. In Nos. 11–13 the weight of fresh substance was taken after five months drying; and in samples (a)–(l), the weight is calculated on the basis of the fresh substance containing 16.7 per cent. of water.

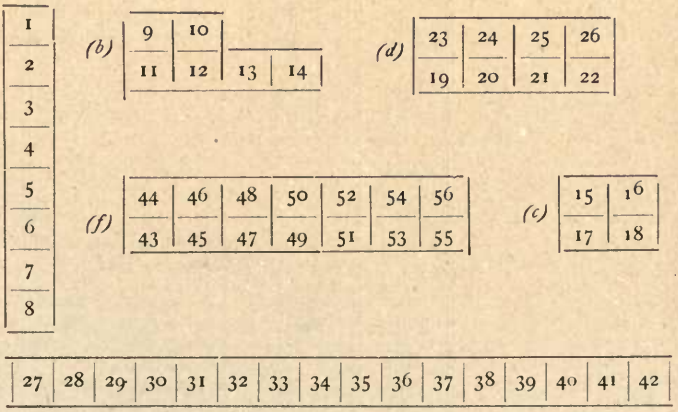
Table 3. This table gives the yield of digestible substance calculated from the data given in Table 2, using for timothy, Kentucky blue grass hay, and meadow fescue, the co-efficients of digestion of timothy as determined by W. H. Jordan in four trials: Crude protein, .49; crude fat, .49; crude fibre, .50; nitrogen-free extract, .63 [*Me. Exp't Sta., Bull. No. 26, p. 11*]; for the blue grass from the pasture, the co-efficients of pasture as given by Julius Kuhn: Crude protein, .75; crude fat, .66; crude fibre, .73; nitrogen-free extract, .79 [*Armsby's Manual Cattle Feeding, p. 487*]; for orchard grass, the average of the co-efficients of digestion, as determined by E. F. Ladd [*Proceedings Ann. Meet. Soc. for Promotion Agri. Science, 1888, p. 96*] and W. H. Jordan [*Me. Exp't Sta. Bull. No. 26, p. 11*]: Crude protein, .59; crude fat, .54; crude fibre, .60; nitrogen-free extract, .55; for medium red clover and mammoth red clover, co-efficients of digestion determined by Julius Kuhn [*Armsby's Manual Cattle Feeding, p. 487*], for Nos. 1–8, 12, and 5–7: Crude protein, .67; crude fat, .63; crude fibre, .48; nitrogen-free extract, .70; for Nos. 11, 13, and 8–10: Crude protein, .59; crude fat, .45; crude fibre, .39; nitrogen-free extract, .71; for Nos. 1–4: Crude protein, .74; crude fat, .71; crude fibre, .56; nitrogen-free extract, .77. To this are added yields of timothy as ascertained by Jordan [*Pa. State Coll., Rep't 1886, pp. 271–3*], and by Atwater [*Rep't Conn. B'd Agri. and Exp't Sta., 1878–9, p. 322.*]

Table 4. In Table 6 are brought together, for purposes of comparison, the facts as to composition, yield per acre of field-cured hay, and yield of digestible substance, developed in the experiment conducted here with the four grasses and two clovers named.

Table 5. This table gives the proximate composition, as determined by A. Voelcker [*Jour. Royal Agri. Soc. 1867, p. 41*], of fresh medium red clover cut at twelve dates, from April 15th to July 28th. Voelcker's report gives nothing in regard to the maturity of the plant at the different cuttings. Evidently the cutting was begun soon after the clover started in the spring, and it must have been entirely ripe at the last cutting.

Table 6. See Weight of Green Substance, p. 149.

DIAGRAMS OF PLATS.



(a) Kentucky blue grass.
(b) Orchard grass.
(c) Meadow fescue.
(d) Medium red clover.
(e) Timothy.
(f) Mammoth red clover.

TABLE 1. PROXIMATE COMPOSITION OF HAYS FROM GRASSES AND CLOVERS; STAGE OF GROWTH WHEN CUT; DATE OF CUTTING; PERCENTAGE OF WATER; COMPOSITION OF WATER-FREE SUBSTANCE; NITROGEN.

No.	Plat No.	Lab. No.	Stage of growth.	Date of cutting.	Percentage of water.	Water-free substance.					Nitrogen	
						Crude ash.	Crude fat.	Crude protein.	Crude fibre.	Nitrogen-free extract.	Total.	Albuminoid.
			Timothy.									
1	27	51			23.61	6.99	5.07	7	31.1	49.84	1.12	.98
2	31	52	Full bloom. Has been	June 25	25.58	6.84	4.59	7.43	32.37	48.77	1.19	.98
3	35	53	in full bloom 2 days.		28.03	6.14	4.77	7	33.91	48.18	1.12	.98
4	39	54			28.88	7.27	5.58	7.87	31.08	48.2	1.26	.91
			Av. 1st cutting. ...		26.53	6.81	5	7.33	32.11	48.75	1.17	.96
5	28	61			20.86	6.79	4.59	6.56	35.21	46.85	1.05	1.02
6	32	62	One-half anthers shed.	July 2	21.59	6.49	4.28	7	35 07	47.16	1.12	1.05
7	36	63			20.03	6.79	4.37	6.56	32.31	49.97	1.05	1.02
8	40	64	Pollen shed.		20.53	6.54	4.58	6.12	32.37	50.39	.98	.98
			Av. 2d cutting.....		20.75	6.65	4.46	6.56	33.74	48.59	1.05	1.02
9	29	72			23.32	6.14	3 44	5.25	33.66	51.51	.84	.84
10	33	73	Seed in dough,	July 11	23.9	8.19	4.15	6.56	33.1	48	1.05	.98
11	37	74	lower leaves partly		23.17	5.79	4.07	6.12	33.48	50.54	.98	.98
12	41	75	brown.		23.24	6.79	3.61	6.56	37.55	45.49	1.05	.98
			Av. 3d cutting.....		23.41	6.73	3.81	6.12	34.45	48.89	.98	.95
13	30	85			22.72	6.19	3.36	6.12	32.08	52.25	.98	.98
14	34	86	Seeds in ½ to ⅔ of	July 23	22.48	5.69	3.36	6.12	34.19	50.64	.98	.84
15	39	87	the heads ripe.		22.72	5.84	3.58	6.56	34.89	49.13	1.05	.91
16	42	88	¼ leaves brown.		18.63	5.89	3.21	6.12	34.1	50.68	.98	.91
			Av. 4th cutting....		21.64	5.9	3.38	6.23	33.82	50.67	1	.91
			W. H. Jordan.									
17			Av. 4 Anal., in bloom.	1881–2	12.5	4.06	2.38	6.51	38.54	48.51	1.04	
18			Av. 4 Anal., nearly ripe.	1881–2	12.5	3.6	2.49	5.38	35.8	52.73	.86	
			W. O. Atwater.			* Pure ash.						
19			Well headed out.	1876	12.5	*4.69	1.95	9.57	33.03	50.74	1.53	
20			In full bloom.	1876	12.5	*4.35	1.96	7.12	33.28	53.29	1.14	
21			Out of bloom.	1876	12.5	*4.15	1.75	7.06	33.78	53.26	1.13	
22			Nearly ripe.	1876	12.5	*3.65	1.97	6.81	35.43	52.14	1.09	
			E. F. Ladd.									
23			Av. 3 Anal., full bloom.	1887	15.35	5.14	2.95	7.98	31.64	52.29	1.27	
24			Av. 3 Anal., late cut.	1887	15.35	4.32	2.8	6.31	35.03	51.54	1.01	
25			Av. 21 Anal., full bloom	....	15.35	4.91	3.18	7.79	31.75	52.37	1.25	
			Clifford Richardson.	1880,								
26			Spike invisible.	June 1	7.85	8.68	4.56	12.54	19.91	54.31	2.01	1.31
27			Spike visible.	June 1	8.8	6.41	3.4	11.9	21.03	57.26	1.86	1.31
28			Before bloom.	June 23	6.8	9.82	3.63	10.33	22.03	54.19	1.65	1.29
29			Early bloom.	June 23	5.6	6.04	3.85	10.2	22.7	57.21	1.63	1.33
30			Full bloom.	June 18	6.3	5.66	3.58	9.9	21.93	58.93	1.58	1.2
31			Early seed.	June 18	5.95	10.53	3.4	12.1	22.9	50.07	1.93	1.42
32			In bloom.	June 4	7.05	6.56	3.95	8.48	23.53	57.48	1.36	1.06
33			Full bloom.	July 1	6.1	5.64	2.98	7.46	22.84	61.08	1.19	.83
34			Spike invisible.	1881	7.5	5.19	4.6	9.66	23.46	57.09	1.55	1.25
35			Spike visible.	1881	7	4.73	4.22	9.61	25.34	56.1	1.54	1.09
36			In bloom.	1881	6	4.57	4.2	5.79	28.28	57.16	.93	.83
37			After bloom.	1881	7.1	3.88	3.23	5.25	29.92	58.72	.84	.69
38			Early seed.	1881	6.5	3.02	2.7	5.41	26.03	62.05	.87	.69
			E. H. Jenkins.									
39			Av 55 Am. Anal.	....	10.21	4.67	2.36	6 85	33.8	52.32	1.1	

TABLE I. CONTINUED.

No.	Plat No.	Lab. No.	Stage of growth.	Date of cutting.	Percentage of water.	Water-free substance.					Nitrogen	
						Crude ash.	Crude fat.	Crude protein.	Crude fibre.	Nitrogen-free extract.	Total.	Albuminoid.
			Kentucky blue grass.									
40	1	22	Seeds in milk.		22.46	9.5	4.38	8.31	32.14	45.67	1.33	1.26
41	3	23		June 14	23.43	9.9	4.58	7.87	32.04	45.61	1.26	1.26
42	5	24			26.47	7.85	5.53	8.31	32.49	45.82	1.33	1.26
43	7	25			25.07	9.8	4.54	8.85	32.61	44.2	1.4	1.19
			Av. 1st cutting.....		24.36	9.26	4.76	8.33	32.32	45.33	1.33	1.24
44	2	40	Head yellowish.	June 21	23.69	10.17	4.13	7.87	33.72	44.11	1.26	1.12
45	4	42	Seeds ripe.	June 22	25.36	9.6	4.49	8.75	32.77	44.39	1.4	1.12
46	6	43	Some timothy in	June 21	32.82	7.54	4.21	7.87	30.41	49.97	1.26	1.12
47	8	46	bloom.	June 22	29.32	8.09	3.91	7.87	35.16	44.97	1.26	1.12
			Av. 2d cutting.....		27.8	8.85	4.18	8.09	33.02	45.86	1.29	1.12
48		113	Summer pasture.	July 30 Sept. 10	47.05	8.49	4.74	15.55	28.95	42.27	2.48	2.17
49		128	Winter pasture.	F'b 9,'89	44.18	10.34	3.11	10.7	25.06	50.79	1.71	1.58
			E. F. Ladd.									
50			Hay.		15.35	4.91	3.58	7.72	32.24	51.55	1.24	
			M. A. Scovell.									
51			About 5 inches high.		11.07	9.12	5.78	26.29	21.61	37.2	4.21	
52			Headed, not in blos'm.		8.78	9.12	4.01	17.88	31.89	37.1	2.86	
53			Ripe about 2 weeks.		16.09	5.59	2.4	8.42	31.9	51.69	1.35	
			Clifford Richardson.	1880.								
54			Panicle just visible.	April 23	6.65	8.07	4.88	19.88	18.43	48.74	3.18	2.7
55			Panicle spreading.	May 1	7.15	5.57	4.07	16.21	22.83	51.32	2.68	2 38
56			Full bloom.	May 21	6.98	8.3	3.9	12.61	23.76	51.43	2.01	1.99
57			In seed.	June 5	7.55	6.38	4.25	12.49	24.34	52.54	2	1.63
58			Panicle closed.	April 27	6.95	6.61	3.92	12.23	21.92	55.32	1.96	1.84
59			In full bloom.	May 8	6	7.02	2.85	7.82	25.49	56.85	1.28	1.18
60			After bloom, brown.	June 1	7.35	7.23	3.92	8.88	23.85	56.12	1.42	1.17
61			Full bloom.	May 19	6.15	7.73	3.41	10.44	23.1	55.32	1.67	1.53
62			In seed, brown.	June 8	7.45	6.21	3.51	7.36	24.34	58.58	1.18	1.03
63			Before bloom.	May 10	6.15	8.42	4.99	19.38	21.87	45.34	3.1	2.47
64			In bloom.	May 17	5.95	7.82	3.77	15.09	24.93	48.39	2.41	1.9
65			After bloom.	May 27	5.15	9.07	3.3	12.36	22.75	52.51	1.97	1.62
			Orchard grass.									
66	9	26	In full bloom.		26.2	9.85	4.68	10.06	32.86	42.55	1.61	1.4
67	12	27		June 14	28.21	9.5	4.84	10.93	33.48	41.25	1.75	1.68
68	14	28			24.81	8.85	4.51	10.5	36.56	39.58	1.68	1.61
			Av. 1st cutting.....		26.41	9.4	4.68	10.49	34.3	41.13	1.68	1.56
69	11	45	Seeds in milk.	June 21	35.49	10.64	3.65	9.62	35.45	40.64	1.54	1.26
70	10	41	Heads green in color.	June 22	33.69	10.72	4.75	8.75	31.78	44	1.4	1.4
71	13	44	Tinged with purple.	June 22	31.62	9.49	4.03	9.62	26.24	50.62	1.54	1.26
			Av. 2d cutting.....		33.6	10.28	4.14	9.33	31.16	45.09	1.49	1.31
			C. A. Goessmann.	1880.								
72			In bloom, 2 Anal.	June 4	9.13	8.28	2.4	10.12	34.13	45.07	1.62	
73			In seed, 2 Anal.		8.55	5.82	3.41	7.86	35.63	47.28	1.26	

TABLE I. CONTINUED.

No.	Plat No.	Lab. No.	Stage of growth.	Date of cutting.	Percentage of water.	Water-free substance. Crude ash.	Crude fat.	Crude protein.	Crude fibre.	Nitrogen-free extract.	Nitrogen Total.	Albuminoid.
			Orchard grass.—	*Cont'd.*								
			Clifford Richardson.	1880.								
74			Panicle not out.	April 23	5.75	10.29	4.12	15.97	18.76	50.86	2.49	1.48
75			Panicle closed.	May 4	7.35	8.26	3.13	10.39	23.18	55.04	1.63	1.63
76			Full bloom.	May 13	6.4	8.07	3.24	9.53	25.4	53.76	1.53	1.37
77			After bloom.	June 1	8.84	9.01	2.83	8.25	27.26	52.65	1.32	.99
78			In bloom. Late growth.	June 18	6.25	8.64	3.98	12.51	24.67	50.2	1.99	1.22
79			Late bloom.	June 23	6.65	6	3.62	8.62	24.42	57.34	1.38	.96
80			Seed nearly ripe.	July 1	6.4	6.73	3.34	7.3	25.09	57.54	1.16	.71
81			Early bl'm, Av. 2 Anal.			8.77	3.83	11.4	24.82	51.18	1.8	1.1
82			Full bloom, Av. 6 Anal.			7.38	3.33	8.91	25.19	55.17	1.43	1.07
			W. H. Jordan.									
83			7-10 days past bloom.		10.95	7.02	3.4	8.42	37.08	44.08	1.35	
			E. F. Ladd.									
84			6 Analyses.		15.35	7.24	4.17	9.58	36.79	42.09	1.53	
			Meadow fescue.									
85	16	33	½ in bloom.	June 14	29.5	9.35	4.04	7.87	38.34	40.4	1.26	1.19
86	17	34	½ in milk.		28.18	7.65	4.34	8.31	32.79	46.91	1.33	1.19
			Av. 1st cutting.....		28.84	8.5	4.19	8.09	35.56	43.65	1.29	1.19
87	15	39	Seeds, milk to dough	June 21	31.73	9.94	4.06	6.56	33.25	46.19	1.05	1.05
88	18	38	state. Spikelets y'llow		32.53	11.39	4.32	8.75	31.55	43.99	1.4	1.12
			Av. 2d cutting.....		32.13	10.66	4.19	7.65	32.4	45.09	1.22	1.08
			E. F. Ladd.									
89			Full bloom.	1886	15.35	6.29	3.63	7.81	34.93	47.34	1.09	
90			Full bloom.	1887	15.35	8.84	3.92	11.13	33.28	42.83	1.78	
			Clifford Richardson.	1880.								
91			After bloom.	June 1	7.6	7.16	3.3	11.37	27.63	50.54	1.82	1.03
			C. A. Goessmann.	1886.								
92			In seed, fertilized.	June 28	7.4	7.17	2.17	7.02	34.46	49.18	1.12	
93			In seed, unfertilized.	June 28	8.03	8.18	1.78	7.27	34.61	48.16	1.16	
			Medium red clover									
94	19	32			31.27	9.5	8.7	15.75	26.51	39.54	2.52	2.17
95	20	30	Full bloom. 1 head in	Juue 14	28.67	8.45	7.38	15.75	25.4	43.02	2.52	2.24
96	21	29	5 brown.		29.12	7.95	7.96	16.18	27.19	40.72	2.59	2.38
97	22	31			29.77	8.25	7.03	15.75	25.45	43.52	2.52	2.17
			Av. 1st cutting.....		29.71	8.54	7.77	15.85	26.14	41.7	2.54	2.24
98	23	47			30.4	8.24	5.65	15.31	29.96	40.84	2.45	2.1
99	24	48	¾ heads dead. Few	June 21	22.31	7.94	6.31	15.75	27.21	42.79	2.52	2.1
100	25	49	lower leaves brown.	June 22	22.83	8.29	5.79	15.75	25.57	44.6	2.52	2.1
101	26	50			25.86	7.89	7.87	15.75	27.61	40.88	2.52	1.96
			Av. 2d cutting.....		25.35	8.09	6.4	15 64	27.59	42.28	2.5.	2.06

TABLE I. CONTINUED.

No.	Plat No.	Lab. No.	Stage of growth.	Date of cutting.	Percentage of water.	Water-free substance.					Nitrogen	
						Crude ash.	Crude fat.	Crude protein.	Crude fibre.	Nitrogen-free extract.	Total.	Albuminoid.
			Medium red clover.	*Cont'd.*								
			W. H. Jordan	1882.								
102			Heads forming.	May 24	11	8.42	4.52	23.31	17.53	46.22	3.73	
103			Heads formed.	June 5	9.73	7.73	3.58	18.36	23.37	46.96	2.94	
104			Full bloom.	June 22	9.82	7.07	3.16	14.66	28.06	47.05	2.35	
105			Some heads dead.	July 3	9.05	6.6	3.08	13.69	36.4	40.23	2.19	
106			Heads all dead.	July 19	10.13	6.19	2.78	12.52	37.5	41.01	2	
			W. O. Atwater.									
107			Just before bloom.	1875	14.3	8.34	1.71	14.27	27.75	47.93		
108			Full bloom.		14.3	7.65	2.38	13.48	27.79	48.7		
109			Nearly out of bloom.		14.3	7.36	1.8	13.13	29.87	47.86		
110			Nearly ripe.		14.3	6.5	2.4	10.37	31.75	49		
			Clifford Richardson.	1880.								
111			Head invisible.	April 19	7.68	9 29	7.62	26.54	10.99	45.56	4.25	3.43
112			Head well formed.	May 4	9 45	8.89	5.8	25.51	13.09	46.71	4.08	2.94
113			Full bloom.	May 10	8.55	8.31	4.79	19.14	15.91	51:85	3.07	1.93
114			After bloom.	June 1	8.36	7.25	4.62	18.09	19.91	50.13	2.72	2.51
115			In seed.	June 8	8.15	7.35	3.97	15.24	19.11	54.33	2.44	1.83
116			Head invisible.	June 23	6	11.22	3.96	26.44	13.93	44.45	4.23	2.78
117			Head well formed.	June 27	7.35	8.9	3.33	20.02	17.16	50.59	3.21	2.23
118			Full bloom.	July 1	7.4	8.91	3.89	20.79	15.82	50.59	3.33	2.19
119			After bloom.	July 10	7.2	7.43	4.72	16.22	15.41	56.22	2.59	2.23
120			In seed, brown.	July 15	7.3	6.69	4.72	15.1	17.86	55.63	2.42	1.75
121			Full bloom.	1881	7.4	7.45	7.58	16.8	18.68	49.49	2.69	2.05
122			After bloom.	1881	5.8	8.17	4.23	14.33	19 88	53.39	2.39	1.94
			Wm. Frear.									
123			Full bloom.	1881	71.27	7.24	3.73	12.03	29.08	47.92	1.93	1.54
			E. F. Ladd.									
124			Full bloom, 21 Anal.		15.35	6.5	4.11	14.24	30.7	44.45	2.28	
			E. H. Jenkins.									
125			33 American Anal.		11.38	7.03	2.75	14.16	30.3	45 76	2.27	
			Mammoth red clo	**ver.**								
126	43	56	About 1 head in 10	June 30	23.72	7.49	6.98	13.56	31.3	40.67	2.17	1.82
127	47	57	in bloom. Others		29.44	8.19	6.65	14	30.63	40.53	2.24	1.82
128	51	58	small and green.		24.12	7.89	6.68	14	30.32	41.11	2.24	1.82
129	55	59			27.96	7.99	6.31	13.75	29.05	42.9	2.2	2.03
			Av. 1st cutting....		26.31	7.89	6.65	13.84	30.32	41.3	2.21	1.87
130	45	76	½ heads in full bloom	July 11	26.7	7.09	6.22	13.12	34.21	39.36	2.1	1.82
131	49	77	Some turning brown,		24.08	6.54	6.75	13.12	35.89	37.7	2.1	1.82
132	53	78	lodged.		26.6	6.09	4.49	12.25	34.14	43.03	1.96	1.82
			Av. 2d cutting.....		25.79	6.57	5.82	12.83	34 75	40.03	2.05	1.82
133	46	89	¾ to 4-5 of heads	July 23	19.62	6.04	5.18	11.37	32.36	45.05	1.82	1 75
134	50	90	brown. Seeds ripe;		18.34	6.99	4 82	11.37	29.37	47.45	1.82	1.75
135	54	91	lower leaves dead.		20.63	6 29	5.33	11.37	37.02	39.99	1.82	1.75
			Av. 3d cutting.....		19 53	6.44	5.11	11.37	32.92	44.16	1 82	1.75

TABLE 2. YIELD PER ACRE OF HAYS FROM GRASSES AND CLOVERS—POUNDS OF FRESH SUBSTANCE; OF DRY SUBSTANCE, AND ITS COMPONENTS.

No	Stage of growth.	Fresh substance.	Water-free substance.	Crude protein.	Crude fat.	Crude fibre.	Nitrogen-free extract	Crude ash.
	Timothy.							
1		4320	3300	231	167	1026	1645	231
2	Full bloom.	4000	2977	221	137	964	1451	204
3		4960	3570	250	170	1210	1721	219
4		4640	3300	260	184	1025	1591	240
	Av. 1st cutting.....	4480	3287	240	165	1056	1602	224
5		4400	3482	228	160	1226	1632	236
6	Pollen and ½ anthers	4320	3387	237	145	1188	1597	220
7	shed.	4160	3327	219	145	1075	1662	226
8		4400	3497	214	160	1131	1763	229
	Av. 2d cutting.....	4320	3423	225	152	1155	1663	228
9		4960	3803	200	130	1280	1959	234
10	Seed in dough.	6080	4627	303	192	1532	2221	379
11		4960	3811	233	155	1276	1926	221
12		4960	3807	250	137	1430	1732	258
	Av. 3d cutting.....	5240	4012	246	153	1380	1960	273
13		4320	3338	204	112	1071	1744	207
14	Seed nearly ripe.	6000	4651	284	156	1590	2356	265
15		4800	3709	243	133	1294	1823	216
16		5600	4557	279	146	1554	2310	268
	Av. 4th cutting.....	5180	4064	253	137	1377	2058	239
	W. H. Jordan.							
17	Av. 4 cutti's in bloom.	2955.5	2586.5	168.4	62.4	996.4	1254.4	104.9
18	Av. 4 cutti's ner'y ripe	3501.5	3063.4	164.9	76.3	1096 9	1615	110.3
	W. O. Atwater.							
19	Well headed out.	3120	2749	263	54	908	1395	129
20	In full bloom.	3760	3301	235	65	1099	1759	143
21	When out of bloom.	3600	3117	220	55	1053	1660	129
22	Nearly ripe.	4200	3616	246	71	1281	1886	132
	Kentucky blue grass							
40		3360	2605	216	114	837	1190	248
41	Seeds in milk.	2720	2083	164	96	667	950	206
42		3520	2588	215	143	841	1186	203
43		3680	2757	244	125	899	1219	270
	Av. 1st cutting.....	3320	2508	210	119	811	1136	232
44		3520	2686	211	111	906	1185	273
45	Seeds ripe.	3840	2866	251	129	939	1272	275
46		4080	2741	216	115	834	1379	207
47		4720	3336	263	130	1173	1501	269
	Av. 2d cutting.....	4040	2907	235	121	963	1334	256
48	Pasture, summer.	3760	1991	310	94	576	842	169
49	Pasture, winter.	5040	2813	301	87	705	1429	291

TABLE 2. CONTINUED.

No	Stage of growth.	Fresh substance.	Water-free substance.	Crude protein.	Crude fat.	Crude fibre.	Nitrogen-free extract	Crude ash.
	Orchard grass.							
66		3760	2775	280	130	912	1180	273
67	Full bloom.	4160	2987	326	145	1000	1232	284
68		2880	2166	228	98	792	857	191
	Av. 1st cutting.....	3600	2642	278	124	901	1090	249
69		5680	3664	353	133	1299	1489	390
70	Seeds in milk.	4640	3077	269	146	978	1354	330
71		4320	2954	284	119	775	1495	281
	Av. 2d cutting.....	4880	3232	302	133	1017	1446	334
	Meadow fescue.							
85	Full bloom.	1920	1354	107	55	519	547	126
86		2080	1494	124	65	490	701	114
	Av. 1st cutting.....	2000	1424	116	60	504	624	120
87	Passed bloom.	2560	1748	115	71	581	807	174
88		3200	2159	189	93	681	950	246
	Av. 2d cutting.....	2880	1954	152	82	631	879	210
	Medium red clover.							
94		4400	3024	477	263	802	1195	287
95	Full bloom.	3440	2454	387	181	623	1056	207
96		2880	2041	330	163	555	831	162
97		3680	2584	407	182	658	1124	213
	Av. 1st cutting.....	3600	2526	400	197	660	1052	217
98		3600	2506	383	141	751	1024	207
99	¾ heads dead.	3360	2610	411	165	710	1117	207
100		2720	2099	331	121	537	936	174
101		3360	2491	392	196	688	1018	197
	Av. 2d cutting.....	3260	2427	379	156	672	1024	196
	W. H. Jordan.							
104	Heads in bloom.	4210	3680	539.5	116.3	1032.6	1731.4	260.2
105	Some heads dead.	4141	3428	469.3	105.6	1247.8	1379.1	226.2
106	Heads all dead.	3915	3361	420.7	93.7	1260.3	1378.3	208
	W. O. Atwater.							
107	Just before bloom.	1618	1385	198	24	384	664	115
108	Full bloom.	1641	1401	189	33	390	682	107
109	Nearly out of bloom.	2054	1750	230	31	523	837	129
110	Nearly ripe.	1802	1523	158	36	484	746	99
	Augustus Voelcker.							
(a)	April 15	970	808	120		595.2		92.8
(b)	April 28.	2028	1689.6	249.6		1273.6		166 4
(c)	May 12.	3517	2931.2	449.6		2233.6		248
(d)	May 26.	5357	4464	470.4		3603.2		390.4
(e)	June 2.	5372	4476.8	430.4		3704		342.4
(f)	June 9.	6947	5788.8	510.4		4841.6		436 8
(g)	June 16.	7557	6297.6	710.4		5131.2		456
(h)	June 23.	7233	6027.2	560		5001.6		465.6
(i)	June 30.	7215	6012.8	489.6		5102.4		420.8
(j)	July 7.	6611	5508.8	430.4		4691 2		387.2
(k)	July 18.	6843	5702 4	369.6		4920		412 8
(l)	July 28.	5950	4958.4	299.2		4364.8		294.4

TABLE 2. CONTINUED.

No.	Stage of growth.	Fresh substance.	Water-free substance.	Crude protein.	Crude fat.	Crude fibre.	Nitrogen-free extract	Crude ash.
	Mammoth red clover							
126		3440	2624	356	183	822	1067	196
127	Beginning to bloom.	5040	3556	498	234	1089	1444	291
128		5440	4128	578	275	1254	1696	325
129		3440	2478	341	156	720	1063	198
	Av. 1st cutting.....	4340	3196	443	212	971	1317	252
130		5600	4105	538	255	1404	1617	291
131	Full bloom.	5600	4252	558	287	1526	1603	278
132		5120	3758	460	169	1283	1617	229
	Av. 2d cutting.....	5440	4038	519	237	1404	1612	266
133		4560	3665	417	190	1186	1651	221
134	Nearly out of bloom.	4240	3462	393	167	1017	1643	242
135		3840	3048	347	162	1128	1219	192
	Av. 3d cutting.....	4213	3392	386	173	1110	1504	218

TABLE 3. YIELD PER ACRE OF HAYS FROM GRASSES AND CLOVERS—POUNDS OF DIGESTIBLE SUBSTANCE, AND ITS COMPONENTS; NUTRITIVE RATIO; PERCENTAGE OF DIGESTIBLE DRY SUBSTANCE.

No	Stage of growth.	Organic substance.	Crude protein.	Crude fat.	Crude fibre.	Nitrogen-free extract.	Nutritive ratio	Pr. ct. dry substance digestible
	Timothy.							
1		1744	113	82	513	1036	15.5	53
2	Full bloom.	1571	108	67	482	914	14.4	53
3		1895	123	83	605	1084	15.5	53
4		1732	127	90	513	1002	13.6	53
	Av. 1st cutting.....	1736	118	81	528	1009	14.8	53
5		1831	112	78	613	1028	16.4	53
6	Pollen and ½ anthers shed.	1787	116	71	594	1006	15.3	53
7		1760	107	71	535	1047	16.4	53
8		1860	105	78	566	1111	17.9	53
	Av. 2d cutting.....	1810	110	74	578	1048	16.5	53
9		2036	98	64	640	1234	20.7	54
10	Seed in dough.	2408	149	94	766	1399	16.2	52
11		2041	114	76	638	1213	17 9	54
12		1996	123	67	715	1091	16.1	52
	Av. 3d cutting.....	2120	121	75	690	1234	17.6	53
13		1789	100	55	535	1099	17.7	54
14	Seed nearly ripe.	2495	139	77	795	1484	17.6	54
15		1980	119	65	647	1149	16.5	53
16		2441	137	72	777	1455	17.6	54
	Av. 4th cutting.....	2176	124	67	688	1297	17.4	54
	W. H. Jordan.							
17	Av. 4 cuttings in bloom.	1404	83	31	498	792	16.6	54
18	Av. 4 cuttings nearly ripe.	1684	81	37	549	1017	20.8	55
	W. O. Atwater.							
19	Well headed out.	1488	129	26	454	879	10.9	54
20	Full bloom.	1805	115	32	550	1108	15.1	55
21	Out of bloom.	1707	108	27	526	1046	15.2	55
22	Nearly ripe.	1984	121	35	640	1188	15.9	55
	Kentucky blue grass.							
40		1330	106	56	418	750	12.4	51
41	Seeds in milk.	1060	80	47	334	599	13.1	51
42		1343	105	70	421	747	12.7	52
43		1398	120	61	449	768	11.5	51
	Av. 1st cutting.....	1282	103	58	405	716	12.4	51
44		1357	103	54	453	747	12.9	51
45	Seeds ripe.	1457	123	63	470	801	11.6	51
46		1448	106	56	417	869	13.5	52
47		1725	129	64	586	946	13.1	52
	Av. 2d cutting.....	1496	115	59	481	841	12.8	51.5
48	Pasture, summer.	1380	233	62	420	665	5.3	69.3
49	Pasture, winter.	1027	226	57	515	1129	7.9	68.5

TABLE 3. CONTINUED.

No	Stage of growth.	Organic substance.	Crude protein.	Crude fat.	Crude fibre.	Nitrogen-free extract.	Nutritive ratio	Pr. ct. dry substance digestible
	Orchard grass.							
66		1431	165	70	547	649	8.3	52
67	In full bloom.	1548	192	78	600	678	7.7	52
68		1134	135	53	475	471	8	52
	Av. 1st cutting.....	1371	164	67	541	599	8	52
69		1878	208	72	779	819	8.5	51
70	Seeds in milk.	1568	159	79	587	745	9.6	51
71		1519	168	64	465	822	8.6	51
	Av. 2d cutting.....	1655	178	72	610	795	8.9	51
	Meadow fescue.							
85	Full bloom.	684	52	27	260	345	12.8	50
86		779	61	32	245	441	12.6	52
	Av. 1st cutting.....	731	57	29	252	393	12.7	51
87	Passed bloom.	890	56	35	291	508	15.7	51
88		1077	93	46	340	598	11.4	50
	Av. 2d cutting.....	984	74	40	316	554	13.5	51
	Medium red clover.							
94		1707	320	166	385	836	5.1	56
95	Full bloom.	1412	259	114	299	740	5.1	58
96		1172	221	103	266	582	5	57
97		1490	273	114	316	787	5.1	58
	Av. 1st cutting.....	1445	268	124	317	736	5.1	57
98		1309	226	63	293	727	6.1	52
99	Heads dead.	1387	243	74	277	793	5.2	53
100		1124	195	55	209	665	5.2	54
101		1310	231	88	268	723	5.2	53
	Av. 2d cutting.....	1283	224	70	262	727	5.4	53
104	Heads in bloom.	2143	362	73	496	1212	5.2	58
105	Some heads dead.	1790	277	47	487	979	5.7	52
106	Heads all dead.	1760	248	42	491	979	6.4	52
	Mammoth red clover.							
126		1675	263	130	460	822	6.1	64
127	Beginning to bloom.	2256	369	166	610	1111	5.8	63
128		2631	428	195	702	1306	5.6	64
129		1585	252	111	403	819	5.9	64
	Av. 1st cutting.....	2036	328	150	544	1014	5.9	64
130		2327	360	161	674	1132	7	57
131	Full bloom.	2409	374	181	732	1122	6.2	57
132		2162	308	106	616	1132	6.5	58
	Av. 2d cutting.....	2299	348	149	674	1128	6.6	57
133		1966	246	85	463	1172	7.7	53
134	Nearly out of bloom.	1870	232	75	397	1166	7.5	54
135		1583	205	73	440	865	7.3	52
	Av. 3d cutting.....	1806	227	78	433	1068	7.5	53

TABLE 4. HAYS—COMPARISON OF VARIETIES.

Proximate Composition of Field-cured Hays.

Name of variety.	Stage of growth.	Water in fresh substance.	Water-free substance.				
			Crude ash.	Crude fat.	Crude protein.	Crude fibre	Nitrogen-free extract
Timothy	Full bloom	26.53	6.81	5	7.33	32.11	48.75
	½ anthers shed	20.75	6.65	4.46	6.56	33.74	48.59
	Seed in dough	23.41	6.73	3.81	6.12	34 45	48.89
	Seeds nearly ripe	21.64	5.90	3.38	6.23	33.82	50.67
	Average	23.68	6.52	4.16	6.56	33.53	49.23
Ky. blue grass	Seeds in milk	24.36	9.26	4.76	8.33	32.32	45.33
	Seeds ripe	27.80	8.85	4.18	8.09	33.02	45.86
	Average	26.08	9.05	4.47	8.21	32.67	45.60
Orchard grass	Full bloom	26.41	9.40	4.68	10.49	34.30	41.14
	Seeds in milk	33.60	10.28	4.14	9 33	31.16	45.09
	Average	30.00	9.84	4.41	9.91	32.73	43.11
Meadow fescue	Full bloom	28.84	8.50	4.19	8.09	35.56	43.65
	Seeds in milk	32.13	10.66	4.19	7.65	32.40	45.09
	Average	30.48	9.58	4.19	7.87	33.68	44.37
Med'm red clover	Full bloom	29.71	8.54	7.77	15.85	26.14	41.70
	¾ heads dead	25.35	8.09	6.40	15.64	27.59	42.28
	Average	27.53	8.31	7.08	15.75	26.87	41.99
Mammoth red clover	Beginning to bloom	26.31	7.89	6.65	13.84	30.32	41.30
	Full bloom	25.79	6.57	5.82	12.83	34.75	40.03
	Nearly out of bloom	19.53	6.44	5.11	11.37	32.92	44.16
	Average	23.88	6 97	5.86	12.68	32.66	41.83

Comparative Yields per Acre of Hays.

Name of variety.	Fresh substance.	Water-free substance.	Crude protein.	Crude fat.	Crude fibre.	Nitrogen-free extract	Ash.
Timothy	4805	3696	241	152	1242	1821	241
Kentucky blue grass	3680	2708	222	120	887	1235	244
Orchard grass	4240	2937	290	129	959	1268	291
Meadow fescue	2440	1689	134	71	568	751	165
Medium red clover	3430	2477	390	176	666	1038	207
Mammoth red clover	4632	3508	449	208	1143	1462	246

Comparative Yield per Acre of Digestible Substances of Hays.

Name of variety.	Total organic substance.	Crude portein.	Crude fat.	Crude fibre.	Nitrogen-free extract	Nutritive ratio.	Percentage total dry substance.
Timothy	1960	118	74	621	1147	16.6	53
Kentucky blue grass	1389	109	58	443	779	12.6	51
Orchard grass	1513	171	69	576	697	8.5	52
Meadow fescue	857	66	34	284	474	13.1	51
Medium red clover	1898	296	54	491	1057	5.8	54
Mammoth red clover	2047	301	126	550	1070	6.7	58

TABLE 5. [*See Table 1.*] PROXIMATE COMPOSITION FRESH MEDIUM RED CLOVER. [*A. Voelcker.*]

	Date of cutting.	Fresh substance.				Water-free substance.		
		Water.	Pure ash.	Nitrogenous matter.	Non-nitrogenous matter.	Pure ash.	Nitrogenous matter.	Non-nitrogenous matter.
(a)	April 15	82.25	2.07	2.68	13	11.61	15.12	73.27
(b)	April 28	80.8	1.91	2.88	14.41	9 94	14.93	73.13
(c)	May 12	81.31	1.59	2.87	14.24	8.5	15.37	76.13
(d)	May 26	78.7	1.81	2.25	17.24	8.5	10 56	80.94
(e)	June 2	78.8	1.63	2.06	17.51	7.68	9.69	82 68
(f)	June 9	73.2	2.03	2.97	21.8	7.57	8.81	83.62
(g)	June 16	74.1	1.88	2.94	21.08	7.25	11.31	81.44
(h)	June 23	72.5	2.13	2.56	22.81	7.74	9.31	82.95
(i)	June 30	65.2	2.44	2.87	29.49	7.01	8.25	84.74
(j)	July 7	68.7	2.21	2.5	26.59	7.06	7.94	85
(k)	July 18	64.01	2.61	2.37	31.01	7.25	6.62	86.13
(l)	July 28	50.8	2.93	3	43.27	5.95	6.06	87.99

TABLE 6. GRASSES AND CLOVERS—PERCENTAGE OF WATER IN GREEN SUBSTANCE; YIELD PER ACRE; LOSS OF WATER IN CURING.

Lab. No.	Name of variety.	Stage of growth.	Date cutting.	Pr ct. wat'r in green substance.	Calculated y'ld green substance.	Water lost in curing.
60	Timothy	Anthers ½ shed	July 3	64.14	9545	5225
67	"	Seed in dough	July 11	57.5	9440	4200
83	"	Seed nearly ripe	July 23	53.31	8704	3524
19	Kentucky blue grass	Seeds in milk	June 14	65.08	7182	3862
35	" " "	Seeds ripe	June 22	61.48	7545	3505
21	Orchard grass	Full bloom	June 14	67.25	8067	4467
36	" "	Seeds in milk	Jnne 22	65.21	9290	4410
20	Medium red clover	Full bloom	June 14	76.05	10547	6947
37	" "	Heads ¾ dead	June 22	72.4	8794	5534
66	Mammoth red clover	Full bloom	July 11	73.91	15477	10037
82	" "	Ne'ly out of bloom	July 23	68.19	10663	6450

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All communications intended for the Station should be addressed, not to any person, but to the

AGRICULTURAL EXPERIMENT STATION, CHAMPAIGN, ILLINOIS.

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SELIM H. PEABODY,
President Board of Direction.