Kansas State Agricultural College

EXPERIMENT STATION—Bulletin 175

ED. H. WEBSTER, *Director*

FARM BULLETIN

FIG. 1.—Samples of grass taken from variety plots on May 18, 1904, showing relative growth. Numbering from left to right, the names of the samples are: 1. Alsike clover. 2. Medium Red clover. 3. Medium Red clover with *Bromus inermis*. 4. *Bromus inermis*. 5. Timothy. 6. Redtop. 7. Meadow Fescue. 8. Orchard-grass. 9. Italian Rye-grass. All of these grasses were seeded in the spring of 1903.

Department of Agronomy

W. M JARDINE, *Agronomist in Charge*

Grasses

BY A. M. TEN EYCK,

Superintendent of Fort Hays Branch Agricultural Experiment Station

MANHATTAN, KANSAS

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Kansas State Agricultural College

EXPERIMENT STATION

The Department of Agronomy

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Changes in the Personnel of the Department

On July 1, 1910, Prof. A. M. TenEyck, Agronomist in Charge of the Department of Agronomy, was transferred to the Fort Hays Branch Agricultural Experiment Station as superintendent, and in August, Prof. W. M. Jardine, formerly of the United States Department of Agriculture, was elected agronomist to fill the vacancy thus created. Mr. E. G. Schafer was elected as Assistant in Crops. Mr. J. G. Lill succeeded Mr. Chas. J. T. Doryland as Assistant in Soils, Mr. Doryland having resigned to take graduate work in the Agricultural College of New Jersey. Mr. C. F. Chase was elected Assistant in Farm Mechanics, and Mr. Bruce Wilson succeeded Mr. Floyd Howard as Farm Foreman. This bulletin was prepared by Professor TenEyck when he was the Professor of Agronomy in this College but it was not fully completed until after these changes had taken place.

Other Departments of the Agricultural Experiment Station

ANIMAL HUSBANDRY	H. J. WATERS in charge
BOTANY	HERBERT F. ROBERTS in charge
BACTERIOLOGY	F. H. SLACK in charge
CHEMISTRY	J. T. WILLARD in charge
DAIRY HUSBANDRY	O. E. REED in charge
ENTOMOLOGY	THOMAS J. HEADLEE in charge
HORTICULTURE	ALBERT DICKENS in charge
VETERINARY SCIENCE	FRANCIS S. SCHOENLEBER in charge

Grasses

The Value of Grasses

Grass is the fundamental crop. Before the time of man, it covered the surface of the earth with its mantle of green and filled the soil with its thick, fibrous root-growth. Grass thus protected the land from the destructive influences of wind and water, and became also the primary food-supply for a large part of the animal creation. According to the government reports, corn holds the first place among the wealth-producing crops of this country, and grass (hay) takes second rank. It is safe to say, however, that grass is really greater than corn as a wealth producer. The government reports fail to take into account the great wealth produced from grass as pasture; its great value as a soil-protector and soil-renewer; and its power to increase the yield of other crops when used in rotation. Although the native wild grasses grow without the aid of man, it is only when certain species ate domesticated and cultivated that the greatest production of hay and pasture is secured.

True Grasses

The grass family (*gramineæ*) includes a number of the most important common farm crops not usually classed as grasses by the agriculturist. The cereal grains, including corn, wheat, oats, barley, rye, etc.; the saccharine and non-saccharine sorghums, including the sorgo (sweet sorghum), Kafir, milo, durra, etc.; and the millets of all varieties, are, botanically speaking, grasses. These crops are grown largely for their grain, but they may be used for hay or pasture. They are then properly classed as forage crops. The true grasses are used principally for meadow and pasture. They are mostly perennial, but include a few annuals also. In this bulletin, the commom clovers, though belonging to another family *(Leguminæ*), will be given some attention, mainly in their relation to grasses in combination meadows and pastures.

Grasses Worthy of Cultivation

It is a surprising fact that, of the thousands of varieties of grasses known to botanists, only a small number are valuable for cultivation. Prof. Thomas Shaw, in his book on "Grasses," names twenty-six varieties which he considers worthy of cultivation, and only nine of these are of major importance as farm crops. These nine grasses are named, in the order of their importance, as follows:

1. Timothy. *Phleum pratense*
2. Kentucky blue-grass. *Poa pratensis*
3. Bermuda grass. *Cynodon dactylon*
4. Orchard-grass. *Dactylis glomerata*
5. Redtop. *Agrostis vulgaris*
6. Russian brome. *Bromus inermis*
7. Meadow fescue. *Festuca pratensis*
8. Tall meadow oat-grass. *Arrhenatherum avenaceum*
9. Meadow-foxtail. *Alopecurus pratensis*

Six minor grasses which have a more or less local adaptation and use are:

1. Quack-grass. *Agropyrum repens*
2. Johnson grass. *Sorghum Halepense*
3. Crab-grass. *Syntherisma Sanguinalis*
4. Western rye-grass. *Agropyron tenerum*
5. Perennial rye-grass. *Lolium perenne*
6. Italian rye-grass. *Lolium Italicum*

Other less important grasses are:

1. Wire-grass. *Carex vulpinoidea*
2. Texas blue-grass. *Poa arachnifera*
3. Rough-stalked meadow-grass. *Poa trivialis*
4. Fowl meadow-grass. *Poa serotina*
5. Rescue-grass. *Bromus unioloides*
6. Sheep's fescue. *Festuca ovina*
7. Carpet-grass. *Paspalum compressum*
8. Velvet-grass. *Holcus lanatus*
9. Australian salt bush. *Atriplex Semibaccata*

Bluejoint *(Calamagrostis Canadensis)* and Blue grama *(Bouteloua oligostachya)* are two promising wild grasses not yet under cultivation.

To the above, the writer would add the following promising Kansas grasses, not yet under cultivation:

3. Big bluestem. *Andropogon furcatus*
4. Little bluestem. *Andropogon scoparius*
5. Buffalo-grass. *Bulbilis dactyloides*
6. Gama-grass. *Tripsacum dactyloides*
7. Indian grass. *Sorghastrum avenaceum*
8. Switch-grass. *Panicum virgatum*
9. Prairie oats. *Atheropogon curtipendulus*
10. Prairie grass. *Koeleria cristata* and *Eatonia obtusata*
11. Short gama. *Bouteloua hirsuta*

Classification According To Use

Meadow Grasses

Grasses may be classed as tall and short. The tall grasses, as the name implies, are those of taller growth, forming sufficient foliage to be mowed for hay. Among the more prominent hay or meadow grasses are timothy, redtop, meadow fescue, Russian brome-grass, meadow-foxtail, Johnson grass, and the several rye and wheat grasses. Western prairie hay is made up largely of such tall-growing wild grasses as big bluestem, little bluestem, Indian grass and the several *Panicums,* such as switch-grass, panic-grass, etc. Various species of *Spartina,* or marsh-grass, gama-grass, and bluejoint, make much of the coarser slough hay of the Middle and Eastern States.

Pasture Grasses

Grasses were first used for grazing. Certain grasses are much more valuable than others for this purpose. According to their habits of growth, grasses may be divided into two general groups: those species or varieties which spread by creeping stems, either above or below ground; and those which grow in tufts or bunches, and which do not spread except by starting new plants from the seed. The creeping grasses are by far the more valuable pasture grasses, since they do not readily run out, but are rapidly renewed and tend to thicken, covering the ground with a firm, thick sod. Of the bunch-grasses, those that produce leaves largely from the roots or crown are the more valuable for pasture; while the grasses which have a large proportion of leaves on the culm, or stem, are the more valuable for hay or meadow.

While several of the meadow grasses are valuable for pasture, the three distinctively pasture grasses are the Kentucky blue-grass of the Middle and Eastern States, with its Canadian variety in the North; the Bermuda grass of the South; and the buffalo-grasses of the Western Plains, of which there are several important varieties. These grasses are about equally valuable in their respective regions.

Lawn Grasses

Singularly the three great pasture-grasses are also the best lawn grasses in their respective regions. The characteristics of a good lawn grass are the same as those of a good pasture grass. Good lawn grasses should form a beautiful, even green-sward and

a firm, thick sod. Lawn grass should not be inclined to produce large stems, but should grow many leaves which lie close to the ground so that it may bear close and frequent clipping. None of the better meadow or hay-producing grasses are suitable for the lawn, because they make a stemmy growth and do not endure close and frequent clipping.

There is no virtue in the peculiar and complex lawn-grass mixtures often recommended by seedsmen, except that Kentucky bluegrass requires the presence of white clover both in lawn and in pasture in order that it may remain permanent and vigorous in growth.

Soil-Binding Grasses

All perennial grasses are soil-binding, even though they do not form a perfect sod, since the soil particles are held in the embrace of the extensive fibrous root system characteristic of all perennial grasses. However, the creeping grasses are the better soil-binders. They hold the soil with their roots, and also form a complete surface-cover which acts as a protection, shielding the soil from the destructive influence of wind and water. The three pasture and lawn grasses named are the great soil-binding grasses. Certain other meadow and pasture grasses, such as *Bromus inermis* and quack-grass, are well adapted for this use, as are also a number of the wild, or native, prairie grasses.

Grasses for Wet Land

The wild marsh-grasses can scarcely be improved upon in the slough and in poorly drained areas. Consequently the breaking of wet land is often a doubtful investment unless such land can be well drained and reclaimed from its swampy condition. However, there is much low land now in cultivation which is not swampy, but which is often too wet to till because it is frequently flooded by heavy rains or by the overflow of streams. Such land may well be seeded in grass and profitably kept either for pasture or for meadow. Grasses are great lovers of moisture, and all the more valuable domestic grasses thrive best on well-watered land. Certain varieties are better adapted than others to wet lands. Chief among these is common redtop, which is valuable both for meadow and for pasture. Timothy and redtop are usually sown together for meadow; and for pasture, other grasses may well be included– meadow fescue, orchard-grass, and Kentucky bluegrass. Alsike clover is better adapted to wet lands than are other

clovers. When possible, Alsike should be sown with redtop to improve the quality of the foliage and to increase the permanency and productiveness of the pasture or meadow.

Grasses for Dry Land

There are no dry-land domestic grasses which equal in hardiness the native wild prairie grasses of the western prairies. It is strange that certain of these hardy grasses which are so valuable, even in their wild state, have never been domesticated and improved. None of the domesticated grasses thrive under the more severe dry-land conditions. Certain varieties are much more hardy and productive than others. First among these may be mentioned the *Agropyrons,* or wheat grasses, of which the western rye-grass is the common cultivated variety. The wheat grasses are native of the northwestern states and are well adapted to the warmer climate of Kansas and Oklahoma. Other drouth-resisting grasses are Bermuda grass, tall oat-grass, and *Bromus inermis. Bromus inermis* is perhaps best adapted to conditions in western Kansas. Bermuda grass is scarcely hardy in this State, except perhaps in the southern counties. Farther south it becomes one of the most valuable grasses and may thrive even on the dry lands of western Texas and of western Oklahoma.

The farmers of the West have a difficult problem to reclaim for profitable grass production large areas of the drier western lands which have been cropped too long with wheat and other grains. None of the domestic grasses fulfill the conditions. It seems to the writer that the solution of this problem lies in the development of our native grasses. In fact, it has been demonstrated already that buffalo-grass may be successfully reestablished on old, cultivated fields within two or three years, by simply planting pieces of the sod. It is probable that if this grass and other western grasses were grown and bred under favorable cultural conditions for a few years, valuable strains might be secured and propagated.

Experiments With Grasses

For several years a field-test of a number of standard grasses has been carried on at this Station. The first Seedings were made in the spring of 1903, and later seedings, both in the spring and in the fall, have been made since that date. However, the results published in Table I are mainly the yields from the original plots seeded in 1903. The trials have been made on the average upland

soil of the Experiment Station farm, which, at the beginning of the experiment, was rather lacking in fertility. During the five years, the grass-plots have been given two light dressings of well-rotted barnyard manure, about twelve loads an acre. The manure was applied during the winter and was spread evenly. The land is now much improved in fertility, as shown by the increased yields of hay and by the rank growth of other crops planted on some of the plots after breaking, in 1907 and 1908. The grasses and clovers, and combinations seeded and tested in these experiments, are named in Table I, which gives the date of the first cutting and the annual, and average yield of hay for the several years.

The plots used in this experiment were each one fourth acre in area. The quantity of seed of each grass or combination sown was as nearly as possible the regular amount given in this bulletin. The number of cuttings for hay varied with the grass and with the season. Medium clover made two good cuttings; the second cuttings of mammoth red clover and Alsike were usually light, these varieties tending to head only once. Common alfalfa, Turkestan alfalfa, and sand lucerne yielded regularly four cuttings each per season. In favorable seasons the grasses produced a heavy aftermath, which was cut and cured. The weight of this aftermath added to the crop yield. Usually the second cutting did not amount to much, but in some seasons the yield was considerable. In 1908 the yield amounted to over a ton of cured hay per acre for *Bromus inermis,* and nearly one and one half tons for orchard-grass and for meadow fescue. Most of the grasses head only once in a season and produce regularly one good cutting. Timothy may produce heads twice in the wettest seasons, yielding two good cuttings. A heavy yield of timothy was grown in 1908, the second cutting yielding one and one half tons of good hay per acre.

The yields as given in Table I are comparable for four seasons, 1904-1907, being those of the original plots seeded in 1903, clovers excepted. In 1907, several of the plots were plowed, and the yields for 1908 were in several cases from other plots and from newer seedings.

The yields of hay in 1907 and 1908 were determined as follows: The field-cured hay was weighed as hauled from the field and samples were taken for moisture determination; the yields as reported are fork air-dry hay containing fifteen per cent of moisture. In 1904, 1905, and 1906, few moisture determinations were made and the yields given are for field-cured hay, but especial care was taken to have the hay well cured before stacking. However, the moisture-content of hay as stacked often varies greatly, different

TABLE I.—Results of Experiments with Grasses—Comparative Yields of Hay.

NAME OF CROP.	Av. date of 1st cuttin g.	Average yield per acre in pounds.							
		1904.	1905.	1906.	1907.	1908.	2 yrs., '04-'05.	4 yrs., '04-'07.	4 yrs., '05-'08.
Common alfalfa	June	4488	9720	8380	5900	9704	7104	7122	8426
Turkestan alfalfa	June	3520	8860	6840	5100	6692	6190	6080	6875
Sand lucerne	June 7	seeded	5880	5960	5280	8515	.....	.....	6434
Medium red clover	June 18	9420	5740	plowed	3440[3]	winter killed	7580	.....	.....
Alsike clover	June 18	2880	3340	4340	plowed	.....	3110	.....	.....
Mammoth red clover	July 5	4840	4072	plowed	3760[3]	winter killed	4456	.....	.....
Bromus inermis[1]	June 15	4840	2840	2240	1720	5232[7]	3840	2910	3008
Meadow fescue[1]	June 18	3680	1724	1630	620	4645[7]	2702	1913	2155
Orchard-grass[1]	June 11	590[2]	1621	1385	1144	7087[7]	1105	1185	2809
Timothy	July 5	4530	4901	5393	4293[4]	7526[8]	4715	4779	5528
Redtop	July 5	3982	2690	1570	plowed	.....	3339	.....	.....
Tall meadow oat-grass	June 13	1815	1785	1430	1785	4811	1800	1704	2453
Western rye-grass	July 9	2378	.....[5]	.....[5]	plowed	.....	.....	.....	.....
Perennial rye-grass	June 21	760	1340	plowed	.....	.....	1050	.....	.....
Italian rye-grass	June 21	883	3799	plowed	.....	.....	2341	.....	.....
Bromus erectus	June 10	1844	1720	plowed	.....	.....	1782	.....	.....
Kentucky blue-grass	May 29	seeded	.....	2500	1360	plowed	.....	.....	.....
Bromus inermis and medium red clover	June 14	5580	5740	2780	1480	plowed	5660	3895	.....
Bromus inermis and alfalfa[1]	June 7	5410	6100	6030	4280	9895	5755	5455	6576
Bromus inermis, orchard-grass, and medium red clover	June 13	5920	4960	2060	2360	plowed	5440	3825	.....
Bromus inermis, timothy, and medium red clover	June 13	5020	5000	2200	2020	plowed	5010	3560	.....
Timothy and medium red clover	July 4	6360	3664	4100	4293[4]	7373[5]	5012	4604	4857
Meadow fescue and medium red clover	June 13	6312	4040	1740	plowed	.....	5176	.....	.....
Meadow fescue, orchard-grass, and medium red clover	June 13	6208	4000	1880	840	plowed	5104	3252	.....
Timothy and redtop	July 5	2178	4356	4074	4293[6]	.....[6]	3267	3725	.....

[1] After 1904, average of two plots, one seeded in the spring of 1903 and one in the fall of 1903.
[2] Not comparable with other grass plots on account of poorer soil.
[3] Second seeding on another plot.
[4] Hay from these plots was weighed together, by error, and this is the average yield.
[5] Some foliage, but little stem growth; not cut for hay.
[6] Practically pure timothy in all plots; clover ran out in two years, and redtop does not show.
[7] Newer seedings, except *Bromus inermis*; increased yields due to manuring and favorable season.

samples from different cuttings showing a variation in moisture-content of from fourteen to thirty-six per cent. From the data secured, it appears that well-cured grass hay when stacked usually contains from eighteen to twenty-four per cent of water, while the moisture in alfalfa and clover hay may run a little higher. On the other hand, perfectly air-dry hay may contain as little as ten to twelve per cent of moisture, as shown by actual determinations.

The date of the first cutting varies with the several grasses and with the seasons. With alfalfa, the extremes in first-cutting dates were May 30 in 1903 and June 21 in 1904, a variation of twenty-two days. *Bromus inermis* comes next with a range of twenty days in the dates of maturing. The later-maturing grasses vary least, timothy showing a difference during the five years of only seven days in dates of cutting the first crops. Of the grasses

named, orchard-grass matures earliest; *Bromus inermis* is a close second; meadow fescue ranks third; and timothy, fourth. The medium red and Alsike clovers mature for hay with brome-grass and meadow fescue, while mammoth clover and timothy cut well together. Medium red clover matures too quickly to cut well with timothy, but the clover has this advantage, that it makes a rapid second growth after the first cutting. Thus it may produce two good crops of hay in a season, or the second crop may be harvested for seed. In earliness and rankness of growth, *Bromus inermis* ranks first (See Fig. 1 on title-page).

This early starting characteristic, with its spreading habit, makes *Bromus inermis* especially valuable for pasture.

In the average yield for the four years, 1904 to 1907, alfalfa easily ranks first; the combination crop of alfalfa and *Bromus inermis* ranks second; and timothy ranks third. Combinations of grasses with clover, except the combination of clover and timothy, have produced larger yields than has grass alone. The fact that timothy has yielded so well is rather remarkable, but it should be explained that timothy and combinations with timothy were given somewhat the advantage by being planted on the lower and doubtless on the better-watered and more fertile part of the field. The result is valuable, however, although the conditions of growth were more favorable to the timothy, since it proves that timothy will make excellent meadow in central Kansas when grown under favorable conditions.

It will also be observed that timothy is more permanent than the other grasses. The high average yield of timothy continued for each of the five years, while the yields of clover and of all other grasses except alfalfa decreased, usually after the second year. This deterioration is due to various causes: the clovers die in two or three years, meadow fescue gets thinner, and *Bromus inermis* becomes too thick and sod-bound. Orchard-grass, under favorable conditions, may maintain its productiveness for many years and may even improve in stand and increase in yield for three or four years.

It is also worthy of note that, as an average for the first two seasons after seeding, red clover produced a greater yield of hay than did alfalfa. This was due in part to a very favorable year for the clover in 1904, and also to the fact that alfalfa does not reach its maximum production until about the third year after seeding. Medium red clover has yielded better than mammoth red clover or Alsike, largely because of its strong second-crop habit. The other varieties fail to make a second growth in a hot, dry summer.

For the first two crops, the advantage of seeding clover with grasses is very apparent, as shown by the increased yields from all of the combination plots, the *Bromus* with clover proving to be one of the best hay-producing combinations. While the *Bromus*-alfalfa meadow outyields the *Bromus*- clover combination, there are objections to the *Bromus*- alfalfa combination because this crop requires four cuttings the same as alfalfa; also, the last three cuttings are largely alfalfa. The particular value of the *Bromus*-alfalfa combination is for pasture, while for meadow, especially in eastern Kansas, the clover with *Bromus* is preferable. That the newer seedings often have the advantage of older seedings, is shown by comparing the yields from several plots as given in Table II.

TABLE II.—Comparison of Old and New Seedings.

NAME OF GRASS.	Plot No.	Date seeded.	Yield of cured hay, per acre—lbs.				
			1904.	1905.	1906.	1907.	1908.
Bromus inermis	9	1903	4840	2160	1760	1400	Plowed
Bromus inermis	2	1904	.....	3460	3200	1040	Plowed
Meadow fescue	3	1903	3680	1880	1900	620	Plowed
Meadow fescue	28	1904	.....	4300	1360	400	Plowed
Meadow fescue	21	1906	.....	.....	.....	3800	4645
Orchard-grass	30	1903	590	952	1043	249	Plowed
Orchard-grass	29	1904	.....	2290	1728	2040	Plowed
Orchard-grass	20	1906	.....	.....	.....	4000	8884

There should have been no marked difference in the fertility of the plots seeded in 1903 and 1904, but plots 20 and 21 seeded in 1906 had previously grown alfalfa for three years. The yields indicate, also, that orchard-grass may not reach its maximum production until the third or fourth year after seeding.

Adaptation to Soil and Climate

In the study of grasses, their adaptation to soil and climate is often one of the most important factors. Of the first fifteen varieties of cultivated grasses named above, not more than three or four thrive well in any one locality. It is important, therefore, to select and to grow only those varieties of grasses which are best adapted to a certain locality. Whether a grass is well adapted to any locality or not can only be ascertained by an actual trial in the growing of the grass in that locality. Little authentic experimental work has been done along this line in Kansas, with the exception of the recent experiments at this Station, as reported in this bulletin. From these experiments and from the general ex-

perience of farmers, we have learned that timothy makes a good hay crop when grown under favorable conditions in the eastern counties of the State; and that south-central and eastern Kansas are especially adapted to the growing of meadow fescue, or English blue-grass, while *Bromus inermis* thrives best in the north-central portion of the State. Clover grows successfully in the eastern counties, while alfalfa is best adapted to the great central portion of the State. The following grasses and combinations of grasses and legumes may be recommended as suitable for meadow and pasture in the several divisions of the State named:

Grasses and Combinations for Meadow

Eastern Kansas

The figures indicate the number of pounds of seed per acre.

1. Timothy (10) and mammoth clover or Alsike clover (6) or medium red clover (8).
2. Orchard-grass (25) and medium red clover (8).
3. *Bromus inermis* (12) and medium red clover (8).
4. Meadow fescue (20) and medium red clover (8).
5. *Bromus inermis* (8), orchard-grass (12), and common red clover (6).
6. Redtop (6), timothy (8), and Alsike clover (4) (for the wetter lands).

Central Kansas

Nos. 2, 3, and 5 above, also Nos. 1 and 4, under the more favorable conditions.

7. *Bromus inermis* (14) and alfalfa (6).

NOTE.—Nos. 1, 2, and 4 are preferable in the south-central part of the State.

Western Kansas

No. 7 as named above.

8. *Bromus inermis* (10), tall meadow oat-grass (12), and alfalfa (6).
9. *Bromus inermis* (18).
10. Tall meadow oat-grass (24).

Combinations of Grasses for Pasture

Eastern Kansas

1. Meadow fescue (10), orchard-grass (10), *Bromus inermis* (8), and medium red clover (6) or Alsike clover (4).

2. Meadow fescue (10), timothy (6), redtop (6), and Alsike clover (4), especially on the wetter lands.

3. *Bromus inermis* (14) and clover (6) or alfalfa (6).

4. Kentucky blue-grass (24) and white clover (4).

Central Kansas

5. *Bromus inermis* (10), orchard-grass (12), western rye-grass (8), and common red clover (6), or alfalfa (6).

6. *Bromus inermis* (16) and alfalfa (6).

7. *Bromus inermis* (20). (*Bromus inermis* cannot be recommended for general planting in southern Kansas.)

8. Meadow fescue (15), orchard-grass (15), and clover (6), or alfalfa (6) (southern Kansas, well watered lands).

Western Kansas

No. 7 as named above.

9. Native prairie grasses.

10. *Bromus inermis* (14), western rye-grass (8), and alfalfa (6).

11. *Bromus inermis* (14) and tall meadow oat-grass (12). (Tall meadow oat-grass is recommended for dry climate and light soil.)

Bermuda grass is not considered fully hardy in Kansas, but it is now being grown successfully in a small way in the southern counties of the State. It is recommended for further trial, especially if the roots for propagation are secured from Kansas fields.

Advantage in Combinations of Grasses

Combinations of grasses and perennial legumes are usually to be preferred to any single grass, both for pasture and for hay. They are especially desirable for pasture, giving more continuous grazing, a greater product, greater variety, and perhaps a better-balanced food ration. In choosing grasses for pasture, the object should be to select such varieties that the deficiencies of one variety may be balanced by the good qualities of another. Another object should be to select those that are different in their periods of growth and in their dates of maturing, so that by lengthening the

grazing period, continuous grazing may result. Combinations of grasses may be made which may produce a more perfect sod and a more permanent pasture than is possible for any one grass.

To illustrate, take a combination of orchard-grass, meadow fescue, and *Bromus inermis*. Orchard-grass starts very early in the spring, makes a rapid growth, and matures early in the summer. It produces little during the dry summer months; also, it grows in bunches and does not form a perfect sod. Meadow fescue, on the other hand, starts late in the spring, makes a slow growth in the early part of the season, and matures several weeks later than orchard-grass. Meadow fescue renews its growth in the latter part of the season, making excellent pasture until late in the fall. Like the orchard-grass, it also grows in tufts, but is not quite so bunchy in its manner of growing, so that it forms a much better sod when combined with orchard-grass than does orchard-grass alone. The *Bromus inermis* is quite different in character from either of the other grasses. It starts very early in the spring and usually continues to grow throughout the season. Being a vigorous, deep-rooting grass, it withstands drouth well, and so produces pasture during the dry periods when orchard-grass and meadow fescue practically cease growing. *Bromus inermis* grows until late in the fall, also. It has a habit of spreading by underground root-stalks, and thus fills up the spaces left between the tufts of orchard-grass and meadow fescue, forming a perfect sod. In the region where each of these grasses thrives, the combination of the three should make a better pasture than any one of them alone.

As a rule, a little clover or alfalfa should be seeded with every combination of grasses, whether for meadow or for pasture. The true grasses, so far as science has discovered, take all of their plant-food from the soil, but the legumes, such as clover and alfalfa, utilize the free nitrogen of the air, aided by the bacteria which grow on their roots. Instead of exhausting the nitrogen of the soil, the legumes tend to increase the supply, and act as "feeders" to the nitrogen-exhausting grasses. It is very important, therefore, that every pasture or meadow should contain some perennial legume, because the presence of these nitrogen gatherers not only causes a greater yield of the other grasses, but also makes the soil more fertile for the growing of the other crops. It should be noted here that when combinations of grasses are seeded for meadow, care should be taken that only those varieties are sown together which mature at about the same date, otherwise it will not be possible to produce the largest

yield of hay of the best quality. It will be observed that exactly the reverse is true when grasses are combined for the purpose of producing pasture.

FIG. 2.—A combination crop of Medium Red clover and *Bromus inermis*, June 23, 1904, just before cutting for hay. Seeded in the spring of 1903.

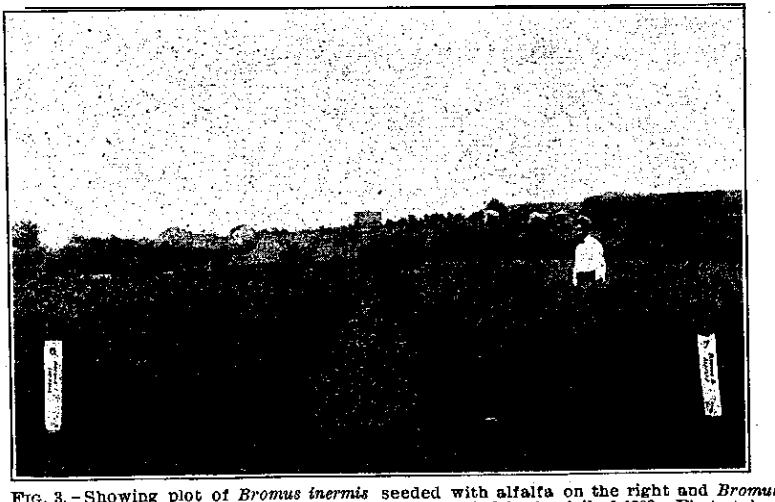

FIG. 3.—Showing plot of *Bromus inermis* seeded with alfalfa on the right and *Bromus inermis* seeded alone on the left. These plots were seeded in the fall of 1903. Photo taken June 7, 1908, just before the grass was cut for hay. Observe the ranker growth of the combination crop and the lesser growth and sod-bound condition of the grass on the plot seeded with *Bromus inermis* alone.

Seeding Grasses

The writer desires to repeat that with good seed, a proper seed-bed, and land adapted for growing alfalfa or grasses adapted to the soil and climate, a careful farmer should be almost as sure of a successful stand of grasses as the average farmer is of securing a successful stand of wheat or oats. Some may not agree with this statement, since many farmers have failed to get a good stand of grasses in a like experiment. Such failures are often due either to poor seed or carelessness in preparing proper seed-bed.

Good Seed

In order to grow any crop successfully, it is necessary to plant good seed, and this is especially true of grasses, clover and alfalfa. Grass seed is perhaps more apt to be poor in quality and low in vitality and more mixed with impurities than the seeds of any other crop. It seems hardly necessary to discuss this point, since every farmer knows that he must sow viable seed if he would get a "catch" of grass. But many farmers are careless; much poor seed is sold and sown; and costly failures result. Sometimes it is not possible to purchase first-quality seed of some kinds of grasses, but usually reliable seedsmen sell different grades of grass, alfalfa, or clover seeds, making a lower price for an inferior grade.

Two samples of red clover seed, one purchased at $3.50 and another at $5.50 per bushel, contained, respectively, 27.7 pounds and 55.8 pounds of germinative seed per bushel. The actual cost for good seed was $7.56 and $5.88 per bushel, respectively. The seed offered at the lower price was really much the costlier seed.[1]

In order to save a few dollars, the farmer often purchases the poorer quality of seed, with the result that he may lose money not only by investing in poor seed, but also by planting seed which will be a complete loss. Do not sow poor alfalfa, clover, or grass seed, but purchase the very best grade which the seedsmen have for sale, and test the germination of the seed before planting. It is usually better to delay sowing a year rather than to run the risk of loss by sowing an inferior grade of seed. Several states have passed laws regulating the sale of seeds and requiring a specific guarantee of purity and quality. Until such a law is enacted in this State, the farmers of Kansas must carefully inspect and test the seed as suggested above. If there is any question as

[1] Farmers Bulletin No.. 111, United States Department of Agriculture.

to purity, a sample may be sent to the Department of Botany of the State Experiment Station for analysis, and a report secured without charge.

Germination Test

It is often difficult to judge grass seed as to its vitality. Bright, clean, heavy seed, as a rule, may be safely sown; but the only reliable way to determine its vitality is to test its germination. This can be done by planting the seed out of doors, or in a small box indoors. If the seed is planted indoors, place several folds of wet paper in the bottom of the box, sprinkle the seed over it, and cover it with several folds of wet paper. Close the box and set it in a moderately warm place. Examine the seed at intervals of about three days, and re-moisten the paper if necessary. At the end of seven to fourteen days, the viable seeds will have germinated, and the percentage of germination may be calculated.

A large percentage of germination during the first five to seven days indicates a strong, vigorous seed; while a slow, weak germination indicates seed low in vitality, which may not germinate when planted, except under the most favorable soil conditions. A low percentage of germination, but fairly quick and strong germination, indicates a mixture of good and poor seed; and such seed may be sown, but more seed will be required per acre to insure a stand.

Adulterants and Weed Seed

Grass seed, alfalfa seed, and clover seed should be carefully examined for impurities, and if weed seeds are present, they should be removed before seeding. Cheat or chess, well known as a common grass or weed which grows in wheat fields, is a common adulterant of meadow fescue and *Bromus inermis*. The seed of cheat is larger than meadow fescue seed and smaller than *Bromus inermis* seed, but heavier than either. It usually has short beards or awns at the tip of the seed. Clover and alfalfa seed often contain dodder, which is usually smaller than clover or alfalfa seed and may often be removed by a twenty-mesh sieve. On account of the danger of dodder infection, however, it is usually safest to reject such seed. Other noxious weed seeds common in clover are the narrow-leafed, or "Buckhorn," plantain, and the curled, or sour, dock. Buckhorn seed is boat-shaped, and light brown in color, while dock seed is triangular in shape and reddish brown in color. Both have a smooth, shiny surface.

Timothy seed is usually pure, but old seed may often be mixed with new seed. Orchard-grass seed is sometimes badly adulterated with meadow fescue seed, which is a cheaper seed. Kentucky blue-grass seed is often very weak in vitality, due, in part, to improper methods of harvesting and storing. It is usually pure, but may be mixed with seed of Canadian blue-grass, a similar grass, but much less valuable than Kentucky blue-grass. The extent to which the seeds of these grasses are mixed can be determined only by an expert.[1]

Time of Seeding

Grasses and alfalfa may be seeded either in the spring or in the early fall. Clover should be seeded only in the spring or in the early summer, as fall-seeded clover is very apt to winter-kill. As a general rule, spring seeding for both grass and clover is the safer, although fall seeding has its advantages. If foul land is seeded in the spring, the weeds are apt to grow in such abundance as to smother out the young grass. If such land is sown in the fall the weeds may do little injury, merely serving as a cover during the winter. If the grass makes a good stand, the crop readily outgrows the weeds the next spring. Again, by spring seeding, practically a season is lost, no crop being produced by the land. If a successful "catch" is secured in the fall, a good crop of hay may be harvested the succeeding year. As a rule, fall seeding of grasses can not be recommended for western Kansas, on account of the prevailing dry winters and windy springs.

Spring seeding is preferable to fall seeding, as it offers more favorable conditions for starting the young plants. Sow all grass and clover seed as early in the spring as the ground can be put in good condition. The common grasses are usually not injured by frost, so that the earlier the seed is sown, the more likely the grass is to start and to make a good stand. In the early seeding of clover and alfalfa, there is some danger of destruction by frost, but, as a rule, the writer prefers to take this chance, rather than that of destruction by hard rains, or by dry or hot weather, to which later seeding is liable. An exception to this general statement may be made for western Kansas and for certain soils or localities, where later seeding may be preferred after the rains come, or when danger of soil blowing is past. In fact, a good general rule to follow in the seeding of grasses or alfalfa, either in the fall or in the spring, is, to prepare the seed-bed early and sow

[1] For further information on impurities and adulterants in grass seeds, see Bulletins 133 and 141 of this Station.

only when the soil is in a favorable condition to germinate the seed. Seeding in dry soil, or in a poorly prepared seed-bed, is very apt to result in failure.

Factors Which Determine Seed Germination and Plant Growth

With viable seed planted in the soil, a few simple factors largely determine the strength of germination, the stand, and the yield of the crop. These factors are *moisture, heat,* and *air.* Every farmer knows that a seed will not germinate while it is dry. No matter how favorable other conditions may be, before the processes are begun which produce growth, the seed must absorb moisture. Also, every seed requires a favorable degree of heat before it will germinate, and the presence of air is necessary in order to supply the life-giving oxygen. A seed placed in a vacuum with proper heat and moisture will not germinate. The same results often occur when seeds are planted in a very-wet or water-logged soil, because such soil largely excludes the air from the seed.

Understanding the necessary conditions to germinate seed, the farmer may prepare a suitable seed-bed almost any season. Although the methods to be employed for securing an ideal seed-bed may vary with different farmers in different localities, soils, and climates, and no exact rules will apply to all conditions, yet such a seed-bed may be readily described.

The Seed-Bed

Next to good seed, the seed-bed is the most important factor in establishing a good stand of grasses. We have learned that an ideal seed-bed must be warm and moist, and must have the presence of free air in the soil to supply oxygen to the germinating seed and to the roots of the growing plants. It is evident, also, that productive soils supply the necessary amounts of plant-food elements, other than water, which give a balanced food ration to the plant. All fertile soils contain a sufficient supply of the plant-foods– nitrogen, potassium, and phosphorus-but the compounds in which these elements exist are usually in an insoluble condition in the soil– a provision which nature makes to prevent the wasting of plant-food elements and to make possible the fertility and productiveness of the soil for ages.

The plant-food of the soil is gradually made available by the action of weathering agents, which decompose and disintegrate

the rock fragments, and by the action of the soil bacteria, which assist in the processes of decay. Chemical changes thus take place by which much of the insoluble and unavailable plant-food of the soil is gradually changed into soluble compounds. In this condition, the plant-foods become available as nutrients to the plant. This change of the plant-food in the soil is favored by the same conditions which are essential for the germination of seeds and the growth of plants; viz., the soil must be warm, moist, and well aerated.

An ideal seed-bed for grasses should not be loosened too deeply. The soil should be mellow; but finely pulverized only about as deep as the seed is sown. Below the seed, the soil should be firm, yet not too hard and compact, making good connection with the deeper subsoil. This offers the most favorable conditions for the germination of the seed and for the growth of the young grass-plants. The firm soil below the seed allows the capillary moisture to be drawn up to the seed, while the mellow soil above acts as a blanket to keep the moisture from escaping, and also allows heat and air to penetrate to the seed. Again, the mulch of mellow soil over the seed not only conserves the soil moisture, but at the same time gives the most favorable conditions for the delicate little plant to push upward into the air and sunshine, while the firm sub-surface soil gives the proper root-hold.

With a deep, loose seed-bed, the conditions for seed germination are less favorable than in the "ideal" seed-bed described. The loose soil may be warm enough and well aerated–perhaps too well aerated, causing the soil to dry out. With the deeply loosened seed-bed, the moisture in the subsoil is not available for the use of the germinating seeds, because the rise of the capillary water is checked at the bottom of the loosened soil. Such a seed-bed is almost wholly dependent upon rain for sufficient moisture to germinate the seed and to start the young plants. In such seed-bed, the crop is not only apt to "burn out" in summer, but it is also more apt to "freeze out" in the winter than is a crop grown in the "ideal" seed-bed.

Preparing the Seed-bed

It is unwise to seed grass of any kind upon weedy land. Preferably, grasses should follow inter-tiled crops which have been kept well cultivated and clear of weeds, or they may be seeded upon summer fallowed land which has been cultivated for the whole, or for a part of the season, so as to sprout and to destroy the weed seed in the surface of the soil. Land from which wheat,

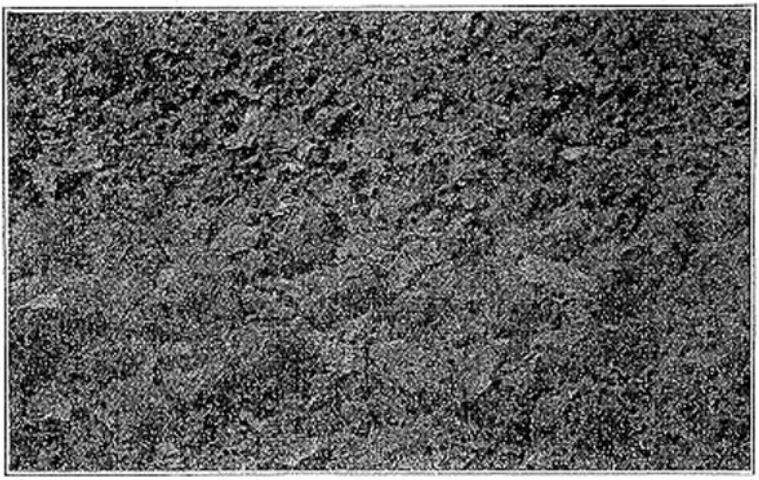

FIG. 4.—Soil in bad physical condition for a seed-bed. This field was plowed late in the spring, when the ground was hard and dry. The field has been disced and harrowed with little effect. It will be impossible to put this seed-bed into good condition until after the lumps have been softened by rain. Photo taken May 7, 1909, Field R., Experiment Station farm.

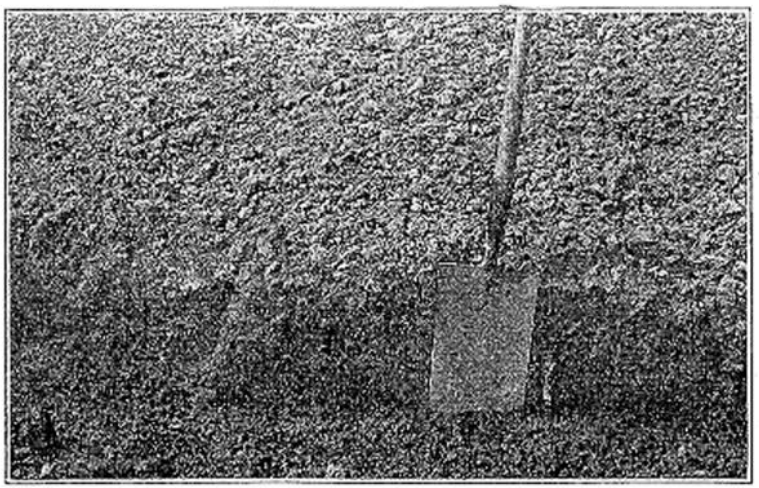

FIG. 5.—A well-prepared seed-bed. This field was plowed early in the spring and well cultivated with the harrow and Acme harrow. Observe the well-settled and well-pulverized condition of the soil and good union between the furrow slice and the subsoil. Photo taken May 7, 1909, Field T, Experiment Station farm.

barley, or oats has been cut, if plowed immediately after harvest, may make a good seed-bed for grass seed, if the soil is kept well cultivated with a harrow or Acme harrow until the weeds have been thoroughly killed and the sub-surface soil has become moist and well settled.

In seeding grasses following cultivated crops which have been kept free from weeds, it is best not to plow in preparing the seed-bed. The weeds have been killed in the surface of the soil, but if the land be plowed, the deeper soil which is brought to the sur-

FIG. 6.—Samples of soil taken from Fields T and R, described in Figures 4 and 5. Sample from Field T on the left, showing good texture; sample from Field R on the right, showing cloddy character of seed-bed. Samples taken to the depth of furrow slice, about 5 or 6 inches.

face will be likely to abound in weed seeds, unless previous careful cultivation has cleared this lower soil of weed seeds. Such land well disked and finely harrowed will give a better seed-bed than can be secured by plowing.

Deep plowing should never immediately precede the sowing of grasses. If the soil needs deep loosening it is well to plow a year or so previous to the seeding, because it is essential that the ground be well settled, and that good capillary connection be established between the furrow-slice and the sub-soil in order to insure the proper germination of the seed and the vigorous growth of the young grass plants.

When a seed-bed for grasses is prepared by plowing, the land should be plowed several weeks or months before seeding time and should be cultivated at intervals to clear it of weeds, to conserve the soil moisture, and to put the soil in the best possible condition. The seed-bed should be finished with a level, mellow surface, but with a rather compact sub-surface, in order that the seed may be evenly covered and brought into close contact with the moist soil. If it is necessary to plow shortly before seeding, the ground should be made firm by the use of a sub-surface packer, or a heavy, pulverizing roller. The disc-harrow may be made to

do the work of the sub-surface packer in part by setting the discs rather straight and by weighting the harrow. The packing and pulverizing of the furrow-slice is especially necessary when the soil is plowed dry or when stubble, trash, or manure are plowed under. If the furrow-slice is left loose and unpulverized, the capillary connection of the soil with the sub-soil is largely broken, and the soil water will not rise into the surface soil to supply the germinating seed and to feed the roots of the young plants. As a result, the seed fails to germinate well or the plant is often stunted in growth. In such a seed-bed the crop is apt to "freeze out" or to "burn out."

It is not best to plow under coarse manure or a heavy growth of weeds or stubble in preparing a seed-bed for grasses. If the soil is in good physical condition, a good seed-bed may be prepared by plowing immediately before seeding, provided the soil is re-packed and well pulverized as described above; but this is often a more expensive method than the discing or early plowing methods. It is often a good plan to disc the ground previous to plowing. If plowed immediately after discing, the loosened surface is in better condition to reunite readily with the subsoil when the furrow-slice is inverted. If the plowing is delayed, the ground should remain in good condition for plowing for a longer period during dry weather than land which has received no cultivation. Also, the disced surface receives and retains moisture. Hence, it may often be advisable to practice early discing of large areas when early plowing cannot be accomplished.

Seeding

Always have the seed-bed fully prepared before sowing the grass so that little work will have to be done on the ground after seeding. If the seed is sown broadcast, one light harrowing after seeding is usually sufficient to cover the seed properly, and is preferable to several harrowings or to any deep working of the soil after seeding. The harrowing should follow the seeding at once because, under favorable conditions, grass seed germinates very quickly, and a harrowing after germination has begun is apt to destroy many seeds.

Those who are practiced in this art seed successfully almost any grass by hand. When combinations of grasses are seeded, a much more even distribution of seed may be secured by the use of a wheelbarrow seeder, several makes of which are sold on the market. Many kinds of grass seeds may be properly sown by

means of the grass-seeder attachments which are usually provided on grain drills and seeders. The revolving broadcast-sower is also quite extensively employed. Often the ordinary grain drill is used in the seeding of meadow fescue and may be used also for seeding other grasses, clover, and alfalfa.

At this Station, we usually have good success with the broadcast method of seeding grasses and alfalfa, using the little wheelbarrow seeder. Grass seed sown early in the spring will often start best when it is barely covered with soil. When seeded with the drill, grass seed or clover seed should not usually be covered with more than one inch of mellow soil: and if the soil is pressed over the seed, a covering of one half inch should be sufficient. Grass or alfalfa seed may be drilled a little deeper in the fall, especially if the seed-bed is rather loose or dry at the surface.

Amount of Seed to Sow

The amount of seed to sow per acre varies with the different grasses and with the purpose for which the crop is to be used, whether to produce seed, pasture, or hay. For the production of seed, it is desirable to have strong, fully-developed plants; hence a smaller quantity of seed should be sown than would ordinarily be sown if the purpose were to produce a meadow. If the purpose is to produce a pasture for immediate use, a larger amount of seed is required than for the production of a meadow. For seed production, some recommend that as little as twelve to fifteen pounds of meadow fescue per acre be sown. The usual amount recommended for seeding is twenty-five pounds an acre. Combinations of grasses should not be sown if the purpose is seed production, as it is usually not easy to separate grass seeds, even if the two or more varieties that are planted together should mature and ripen at the same time.

A good old Scotch neighbor and relative who resided near my boyhood home in Wisconsin, when asked how much clover seed to sow for a good stand, answered, “Weel, in a gude season a very leetle will do, and in a bad season it don't make much difference.” But it is the judgment and experience of the writer that, by sowing an average amount of good seed at the right time, in a properly prepared seed-bed, it is possible to secure a successful stand of alfalfa, clover, or almost any other kind of common domestic grass, even in a season unfavorable to these crops.

The following amounts of seed of the several common grasses

that may be grown in this State are recommended for seeding when the purpose is the production of a meadow.

Table III.– Giving the Weight per Bushel and the Amount of seed to sow.

Variety of Grass.	Weight per bushel—pounds.	Amt. clean seed to sow per acre—pounds.
Timothy	45	12
Kentucky blue-grass	14	24
Orchard-grass	14	32
Meadow fescue	24	34
Redtop	14	16
Bromus inermis	14	18
Tall meadow oat-grass	14	24
Johnson grass	25	25
Western rye-grass	20	15
Perennial rye-grass	20	30
Italian rye-grass	20	30
Common red clover	60	12
Mammoth red clover	60	12
Alsike clover	60	10
Alfalfa	60	15
Bokhara, or sweet clover	60	20

When two or more varieties are seeded together, it is usual to seed at a slightly increased rate per acre. The amount of legume seed sown should be greater in proportion to that of the grasses. Thus in the following combination, these amounts may be sown: Orchard-grass, twelve pounds; meadow fescue, ten pounds; *Bromus inermis*, eight pounds; and red clover, six pounds an acre respectively. In such a combination, the clover is really an extra, since it dies out in two or three years, and its place must be taken by the grasses, if a good stand is to be maintained for several years. When combinations of grasses are seeded, it is usually advisable not to mix the seeds of different weight and size, but to sow each kind separately.

Nurse-Crop

In the above discussion, no reference has been made to the use of nurse-crops in seeding grasses. In the middle and eastern states, and even in eastern Kansas, it has been the practice to sow certain grasses and clover with different kinds of grain as nurse-crops. This may be a practical method in regions of plentiful rainfall, but generally throughout Kansas the surer method is to seed alone, or without a nurse-crop, not only alfalfa but also clover and the common grasses adapted for growing in this State. If a nurse-crop is used, the grain should be sown thinner than usual, thus reducing the risk of smothering the young grass or clover with a thick growth of grain.

It is often desirable, should drought prevail or should the grain lodge badly, to cut the nurse-crop as early as possible for hay,

rather than to let the grain mature and to run the risk of losing the new seeding. Of all the domestic grasses, perhaps timothy may most safely be seeded with a nurse-crop, either in the fall with wheat or rye, or in the spring with winter-wheat, oats, or barley. A good "catch" of clover may often be secured from early spring seeding of winter-wheat or from a thin seeding of oats.

Often a good "catch" of clover or grass, which has been secured with a nurse-crop, has been killed at harvest time. This may be due to the sudden exposure of the tender, young plants to the hot, bright sunshine. However, it is often possible to select a time for cutting the nurse-crop when the weather is more or less cloudy and the soil moist. Some mow the grain stubble, and young grass or clover, close to the ground immediately after harvest, claiming that the young grass or clover is injured by excessive heat due to the reflection of the sun's rays from the straw or stubble. If the mower follows the harvester, the young plants are protected by the covering of stubble and weeds; also the drying of the soil is prevented to some extent by this mulch. The writer has not performed experiments to test this point.

Treatment After Seeding

After seeding, little more can be done for the new crop the first season than to mow the weeds two or three times to keep them from smothering out the young grass plants. It is best, especially in the early part of the season, not to mow the weeds very closely; raise the sickle-bar from four to six inches high and cut the weeds, but leave the larger part of the foliage of the grass uncut. If the young clover, grass, or alfalfa plants are cut back closely in the early part of their growth, before they have become well rooted, many of the young plants may be injured or destroyed.

Making Hay[1]

It is important to know what grasses are best adapted to grow in a certain locality, and to understand the best method of seeding such crops. Also, the hay should be harvested and saved in such a manner as to secure the largest amount and the best quality of the product. The writer would especially urge the importance of quality in hay. Good quality, as indicated by the bright green

[1]For making alfalfa hay, see bulletin No. 155 this Station.

color of well-preserved hay, will readily add a dollar or two per ton to the selling price.

Cutting the Hay

The common hay grasses and legumes differ somewhat in the stage of maturity at which each should be cut to make the best quality of hay, and farmers and feeders are learning that this difference in quality means not only a difference in market value but also a difference in feeding value. The stage of maturity at which grass should be harvested, in order to make hay of the best quality, varies somewhat with the different grasses and the use to which the hay is put. A safe rule applicable to all common grasses is to cut the grass just as it is beginning to bloom or just after the bloom has fallen. For cattle and sheep, hay from the early cutting is best but for horses the later cutting is preferable. When cut in the early stage, grass is sure to make good, clean hay of prime quality, if the hay is cured well. Often a larger weight may be secured by cutting the grass after it becomes more mature, but the quality of the hay is not apt to be so good. If grass is cut when in full bloom the hay is sure to be more or less dusty. The over-mature hay is less palatable to stock and its feeding value per hundred pounds is usually less than the value of that cut at an early stage of maturity.

CLOVER

To make from clover the most palatable hay of the highest feeding value, clover should be cut just when it is in full bloom, with a few of the blossoms turning brown. If it is cut before this stage, the hay will be lighter and more "washy," especially if fed to horses; while if the crop is left until the clover is mature, many of the leaves will be shattered or lost in harvesting. This will be a great loss, for the leaves are the most nutritious part of the clover, as they contain nearly two thirds of the protein in the plant.

TIMOTHY

To make the most palatable hay, timothy should be cut just as it is coming into bloom. When timothy is grown in combination with common red clover, it is necessary to cut the crop early in order to secure the clover before it has become too ripe to make good hay. The hay cut at this stage is best for feeding cattle and sheep. Timothy should not be allowed to stand until in full bloom, since, if cut at this stage, the hay will be dusty and especially objectionable for feeding horses.

To make the best hay for horses, timothy should be cut at the

FIG. 7.—Variety plot of Medium Red clover in full bloom, ready to cut. Photo taken June 23, 1904. Clover seeded in the spring of 1903.

FIG. 8.—Mowing the Timothy plot, July 7, 1909. This Timothy was seeded in the spring of 1903.

stage called "second bloom," which is really just when the grass has about ceased blooming and most of the blossoms have fallen. When timothy is cut at this stage, the greatest weight of hay is secured, and probably the greatest amount of nutrients but the hay is more woody and less palatable than timothy cut earlier.

The maturer hay, however, is relished by horses, and horsemen consider it superior to the less mature hay because less "washy."

OTHER GRASSES

Orchard-grass, western rye-grass, perennial rye-grass, English blue-grass, and Johnson grass quickly lose in palatability when nearing maturity, and should be cut for hay before the blooming stage. Other grasses, such as *Bromus inermis,* redtop, and tall oat-grass, retain their good qualities longer and make good hay if cut when in full bloom or after the blossoming stage. The annual cereal grains, such as barley, oats, and emmer, sowed sorghum, and Kafir, make the best hay if cut when the grain is in the milk or at the soft-dough stage.

MILLET

It is best to cut millet for hay as soon as it is fully headed, before the bloom forms. Cut at this stage, the hay is certainly less woody and more palatable than is the hay made from the more mature millet. The poisonous principle in millet which causes it to be injurious to stock, especially to horses, does not seem to depend upon the condition of the millet with regard to its maturity and the time of cutting. While the less mature millet is better relished, it may seem to give injurious results more quickly.

ANNUAL LEGUMES

Cow-peas should be cut for hay when the first pods are beginning to turn yellow. Soy-beans must not be left so long, but are ready to cut for hay as soon as the pods are well filled. If they are left until too mature, the leaves drop or shatter in harvesting, thus decreasing the palatability and the feeding value of the hay. Field peas and vetches make hay of good quality if cut when the pods are almost fully formed and some of the seed is beginning to ripen.

Curing the Hay

EFFECT OF SUN AND WIND

The most important factor in making good hay is favorable weather. Hay exposed to excessive rains is greatly injured in quality and in feeding value. This is especially true of hay from leguminous plants, such as clover and alfalfa. Every farmer knows that hay is injured by rain and dew, which cause it to bleach and to mould, and which take from it the natural aroma and palatability essential in hay of good quality. Not all are

aware, however, that hay which is cured too much in the sun not only bleaches and loses leaves by becoming too dry but also becomes lighter in weight and less palatable.

When one cures hay of any kind, he should aim to expose it to the sun no more than is absolutely necessary. The best hay is therefore made by curing it largely in cocks rather than by leaving it spread over the ground in the swath or windrow. Hay in the swath and windrow is also more exposed to injury by rain and dew than is hay in the cock. Rain not only bleaches hay, thus lowering its market value, but the feeding value of the hay may

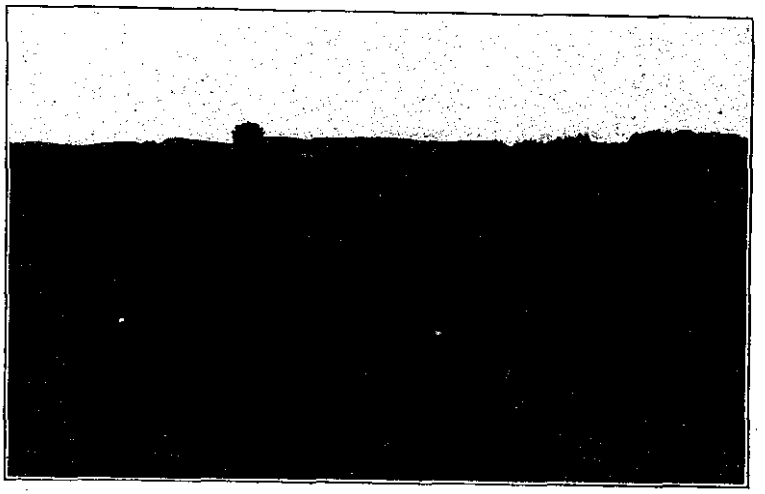

FIG. 9.—Curing alfalfa hay in the bunch. Part of a sixty-acre field on the Experiment Station farm. Second cutting. July 2, 1909.

also be very much decreased. Recent experiments have shown that when partially cured hay is exposed to heavy rain, a large percentage of the soluble substances, including a large part of the proteins, phosphoric acid, potash, and lime, was removed.[1]

BUNCHING AND COCKING

Hay cures more evenly in the cock than in the swath or the windrow. If left too long in the swath, the leaves become thoroughly dry, while the stems still retain a large amount of moisture. Such hay will not cure fully and evenly and is often put into the stack in a partly cured condition. If hay is raked before the leaves are dry and placed in cocks, the leaves continue to draw moisture out of the stems, thus allowing the hay to cure evenly.

[1]Paper read at the annual meeting of the Great Plains Coöperative Experiment Association, August 27, 1908, by J. F. Braezeak, of the United States Department of Agriculture.

Clover or alfalfa hay well cured in the cock in this way will keep perfectly in the stack or in the mow. When cured in the swath and windrow, the hay is often stacked in such condition that it may burn or spoil in the stack. Also, the greater breaking of the leaves which must take place in curing alfalfa or clover in the swath and windrow, makes the hay less palatable to stock, and less nutritious, than hay which has been properly cured.

WINDROW CURING

A large part of the hay made in the United States, however, is cured in the swath and windrow, or in shocks made by bunching the hay with the horse-rake. When a farmer has a large amount of hay to put up and little help with which to handle it, he is compelled to do the work in the most rapid and economical way. Putting up the hay directly from the windrow is not only a saving of labor, but it enables the hay-maker to do the work rapidly so that the danger of loss by exposure to the weather is lessened.

In the Central States it is common to cure timothy and clover hay in the swath and windrow, and to put it on the wagon by means of the hay-loader, which makes the work more rapid and does away with the hard labor of pitching hay. In the large alfalfa and prairie-grass fields of the Western States, the common method is to use sweep-rakes, by which the hay is taken directly from the windrow to the stacker. Where a large amount of hay is made, it is almost necessary to handle the crop by such a method. The method of curing hay in cocks is more applicable to the small farmer and to farmers who live where the market price of hay makes it profitable to handle it in this more expensive way.

Good Methods

The following general suggestions may be given with reference to making clover or alfalfa hay; as soon as the dew is off in the morning, start the mower; when the hay has wilted somewhat, run over it with a tedder if the crop is heavy and needs lifting; after an interval of a few hours, before the leaves have begun to get dry and brittle, rake the hay into windrows. Allow the hay to remain in this condition for a day or two, when it may be put into the stack or mow. If the plan of curing in cocks is followed, the hay should be placed in small cocks soon after raking. It will be necessary for it to remain in the field for from one to three days of drying weather before it is ready to be put into the stack.

It is possible to start the mower late in the afternoon, cutting until dark, raking the hay the next forenoon, and bunching or

cocking as described above. Good hay may be made in this way, since the dew does not blacken the green hay, and even a light rain during the night may not greatly damage it. There is some objection to this method, however, for making clover or alfalfa hay, in that the dew falling on the green hay in the swath seems to favor the development of white mold. Cutting only during the forenoon after the dew is off is perhaps the preferable method, provided the farmer can handle the crop rapidly enough in this way.

Hay is much more likely to be injured by the moisture *on* it than by the moisture *in* it. This should be an invariable rule: *Hay should not be raked or bunched or placed in the stack or mow when there is moisture on it either from dew or from rain.* Such hay is likely to mold in the cock or in the mow and is almost certain to heat, to blacken, or to "burn" in the stack.

Grasses cure much more quickly than do alfalfa and clover. The length of time required for curing grass hay will depend upon the kind of grass, upon the degree of maturity, and upon the weather conditions. In good weather most grass hays may be cut one day and stored the next. It is even possible to cut grass in the forenoon and to put it up in the afternoon.

Because hay requires rapid handling, it is not necessary to cure grass hay in the cock in good weather. In showery weather, however, it is a very good plan to rake the hay somewhat green, to cook it, and to allow it to cure. Grass hay will shed rain much better in the cock than will clover or alfalfa.

Storing Green Hay[1]

Although the methods described above are the safest and the most satisfactory, it is a very common practice to put clover hay into the mow in a partially cured condition, perhaps on the afternoon of the same day the hay is cut. Green or partly-cured clover put into a tight barn will become very hot, but it will not "burn." Such hay may come out in good condition for feeding, but with a brown color which injures the hay for selling on the market. It may be practicable, also, to store clover while green in raised-bottomed sheds, according to the plan which is now being used in this State for storing green alfalfa.

Hay Caps

It is now becoming a common practice in the more humid sections, where the method of farming is intensive rather than extensive, to protect the hay in the field by covering the cocks with canvas or with paper caps. There is little question regarding the

[1] See Kansas Experiment Station Bulletin No. 155, page 245.

practicability and economy of such a practice on small farms, and there is little question also but that the same method may be used profitably when alfalfa and clover are put up on a large scale. The canvas covers are doubtless to be preferred, since they are more durable and are more easily handled than are the paper caps.

Storing the Hay

Hay should be stored in sheds or in barns. Grass hay sheds the rain better than does clover or alfalfa, and may he stored out of doors with little loss, provided the stacks are well made and covered. However, a good hay-shed is a profitable investment on any farm. When hay is fed on the farm, the aim should be to store it in a convenient place so that it may be conveyed to the stock with the least amount of labor. If possible, the hay should be stored, and the live stock should be fed, under the same roof. This will avoid the expense of handling the hay a second time and the loss from the breaking of the leaves and heads.

METHODS

The most rapid way of putting up hay is by the use of sweep rakes and sweep-stackers, or swinging stackers. This necessitates stacking the hay in the field where it is cut. This method of putting up hay is best adapted to those regions where hay is made on a large scale. On the average farm, the practical method is to load the hay on wagons and to haul it to the stack or mow. The hay is rapidly removed from the load and dumped into the mow or stack by means of the hay-fork or the hay-sling. Slings are often preferable to hay-forks for unloading hay, on account of the cleaner and more rapid work which may be done by the use of the sling. For barn or shed storing, a carrier and track is usually most convenient. For field stacking, some form of hay-poles with the pulley and rope, either with or without the track, is in general use.

Hay should not be stacked on the ground, but on an elevated bottom made of poles and brush. If hay is green or unevenly cured, it is apt to "burn" or spoil when there is no ventilation beneath the stack. Great care should be taken to keep the middle of the stack full so that when the hay settles the stack will shed rain. There is no better grass-covering for stacks than marsh hay. When the stack is finished and topped out, one should not fail to bind on the cover with good hangers of wire attached to stones or heavy sticks of wood. As a rule, canvas or board stack-covers are troublesome and expensive and not to be recommended.

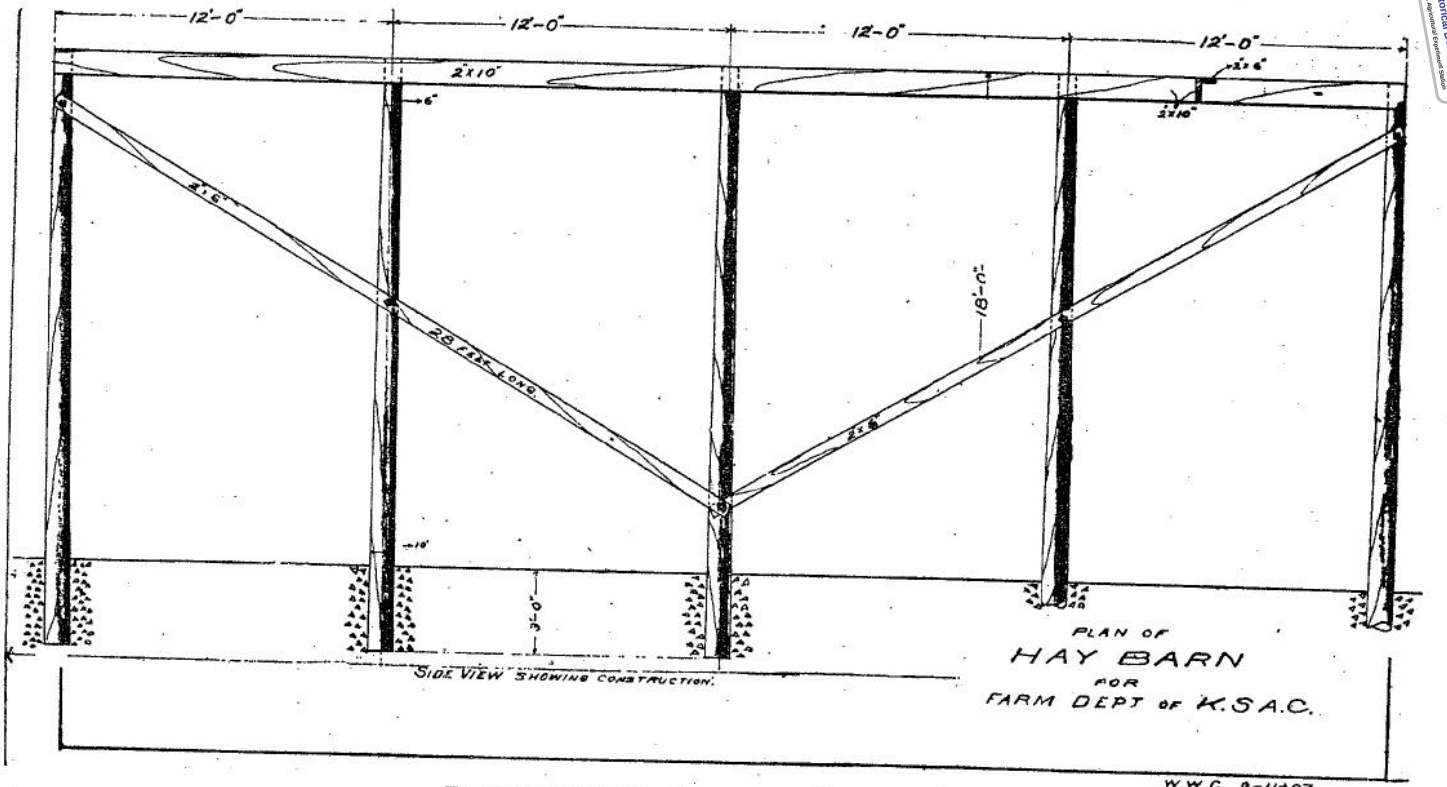

FIG. 10.—Side view of hay barn, showing method of bracing.

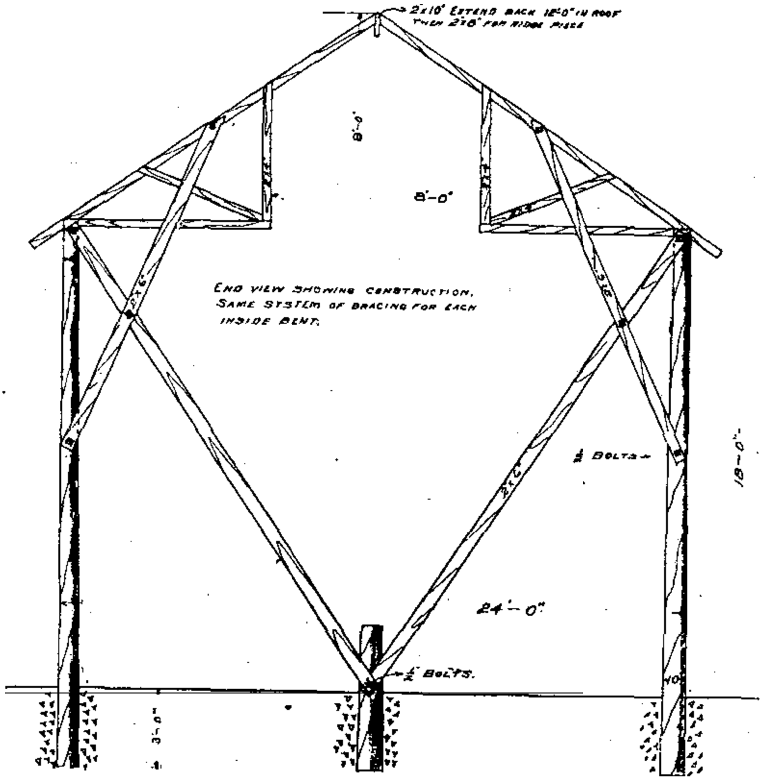

FIG. 11.—Cross-section of hay barn, showing method of bracing.

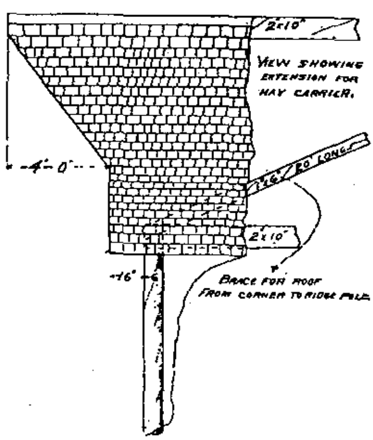

FIG. 12.—Section of roof of hay barn, showing extension for hay carrier track and plan for bracing roof.

A farmer might better build a good hay-shed than use such temporary means of protecting the stacks from rain. It is often advisable to have a canvas cover or two for temporary use when hay is stacked out of doors.

Salting or Liming Hay

It is a common practice in the middle and eastern states to salt the hay when it is put into the stack or mow. In Kansas this practice is not usually followed except by certain farmers who

FIG. 13.—Modern methods. Stacking hay with automobile, on farm of W. A. Van Dusen, near Manhattan, Kan.

stack alfalfa hay in a green or partially cured condition, and apply salt or lime for the purpose, as they claim, of preventing the hay from heating. There seem to be no sufficient data to prove that the application of lime or salt prevents hay from heating. No work along this line has been reported by experiment stations, and the reports of farmers vary. If the application of salt or lime prevents the heating of green or partially cured hay, this power is probably due to the influence which the salt or lime has in checking the growth of microbes or fungi which cause the fermentation that develops heat. In the same way, lime or salt may prevent the molding of hay.

There is little question but that the salted hay is relished better by stock. The fact that cattle eat the hay with greater relish may be the cause for the opinion among farmers that salting preserves the hay, or makes it keep better. The application of a small amount

of salt to the new hay in stacking may be recommended even when hay is well cured. The application of from two to four quarts of salt per ton is usually sufficient, but if the hay is green or only partially cured, more salt may be used. As far as the writer knows, there is no advantage in using lime to prevent the heating of hay, and salt should be preferred, since it adds palatability to the hay. So far as known, no injurious effects result from feeding the limed hay.

FIG. 14.—Breaking *Bromus inermis* sod on Experiment Station farm five years after seeding. Photograph taken April 3, 1908.

Baling Hay

It is necessary to bale all hay which is sold on the general market. The farmer may sell a little loose hay locally, but loose hay cannot be handled and hauled very far and sold with profit to the grower. Probably the best time to bale hay is in the fall or winter after cool weather has come and when other work is not pressing. Some farmers now bale their hay directly from the field. This is the best time to bale alfalfa, in order to retain the leaves. On the large prairie meadows of the West, this method of handling hay is practical and economical. As a rule, however, baling hay from the field is too slow a method of putting up hay.

As already explained, it is necessary to harvest hay at the right time and to store it rapidly, in order to secure the best quality. With prairie hay, this matter of time in cutting and making is not so essential as with other grass-hays, or with alfalfa and clover. Baling from the field usually necessitates slower harvesting of the crop, and the work is done at a time when labor is scarce and high-priced. Also, hay baled from the field is perhaps

more likely to spoil in the bale than if the hay were first stacked. The new circular power baler (Leubben), with a capacity of from five to ten tons per hour, may solve the question of successful field baling.

BALE CURED HAY ONLY

It has been shown from the experiments conducted at this Station that it is not advisable to bale alfalfa except when the hay is well cured and dry enough to stack. All hay which was baled green or in a partially cured condition spoiled in the bale. Similar experiments in baling clover hay from the field have given similar results. Only well-cured hay may be safely baled[1].

Marketing the Hay

The most profitable way for the farmer to market hay is in the form of horses, beef, pork, mutton, or dairy products. Such products are easily taken to market; and the by-product from feeding the live stock, the manure which may be returned to the soil, may be almost equal in value to the hay itself. Yet some hay must be sold in order to supply the demand for this product.

There is always some local demand for hay. This demand may be supplied by those farmers who produce only a little more hay than is required for feeding on their farms. The farmer who grows hay in larger quantities must seek a market farther from home, and this requires that the hay be baled and shipped to the central markets in the large cities. It is not easy to decide as to just which is the best time to sell hay. Often the price of hay is higher in the latter part of the winter than during the previous months or than it is immediately after the farmer turns the stock out to pasture. In February and March there is likely to be a shortage in the supply of hay. At that time the large grower may often take advantage of the advanced price to gain an additional profit in the sale of his crop. However, the factor which largely determines the price is the quality of the hay. Good hay will always command a fair price, and it has been the aim of the writer in this discussion to call the attention of haymakers to some of the essential factors in the production of good hay.

Shrinkage of Hay

An experiment to determine the shrinkage of hay in the mow was conducted at the Kansas Experiment Station in 1888 by Professors G. H. Failyer and J. T. Willard[2].

[1] See Bulletin No. 123 of this Station.

[2] See the First Annual Report of the Kansas Experiment Station.

The plan was to fill canvas sacks with several kinds of hay and to bury the sacks in the mow. The weights of the sacks of hay were taken before the hay was stored. The hay of the several kinds was harvested and put into the mow in June, July, and August. On December fifteenth of the same year the sacks were taken out of the mow and the loss in weight determined. Also, moisture determinations were made of samples of hay, both at the time of stacking and when the final weights were taken. The results of the trial are given in table IV:

TABLE IV.—Percentage of Moisture in Samples and Loss in the Mow.

KIND OF HAY.	Per cent. moisture when stored.	Per cent. moisture when taken from mow, Dec. 15.	Per cent. loss in weight.
Orchard-grass, blue-grass, and clover	15.65	10.54	5.71
Blue-grass	19.59	10.60	10.05
Orchard-grass and clover	19.75	11.80	9.01
Millet	21.86	8.89	14.25
Clover	9.08	11.87	3.17[1]
Prairie hay	14.00	10.61	3.39

[1]Gain.

From this experiment, it would appear that the loss in the weight of well-cured hay of the several common grasses, after the hay has been in the mow several months, may vary from three to ten per cent. In the above experiment, it appears that clover actually gained in weight, which must be unusual, since clover is often stacked rather green.

During the season of 1905, the Agronomy Department of this Station made a determination of the moisture in samples of hay of various kinds when the hay was stacked. The samples were from the first cutting, which was harvested in June and July. All of the hay was well cured and stacked in good condition. The moisture in the several samples as determined is given in table V.

TABLE V. – Percentage of Moisture in Well-Cured Hay when Stacked.

KIND OF HAY.	Per cent. moisture when stacked.	KIND OF HAY.	Per cent. moisture when stacked.
Bromus inermis	17.45	Alfalfa	17.3
Meadow fescue	15.09	Medium red clover	14.90
Orchard-grass	15.41	Alsike clover	16.41
Tall meadow oat-grass	13.95	White Bokhara clover	17.73
Italian rye-grass	17.30		

It would appear, from the results of the experiment conducted by Professors Failyer and Willard, that all kinds of hay contain about the same amount of moisture when the hay becomes fully cured in the mow. The average moisture in the mow-dried hay in

that experiment, not including the millet, was 11.08 per cent. If this per cent. (11.08) be subtracted from the percentage of moisture found in the hay of various kinds as shown by the 1905 test, it would allow a shrinkage varying from three to six and one half per cent., provided there was no shrinkage other than that due to the loss of moisture.

The testing of the moisture content of the samples of hay when the hay was stacked, was continued by the Agronomy Department in 1908 and 1909. The percentages of moisture found in various kinds of grass hay when stacked are given in table VI. The determinations for 1905 are included.

TABLE VI.—A Comparison of Moisture in Hay as Stacked.

KIND OF HAY.	Percentage of Moisture[1].		
	1905	1908	1909
Timothy		26.52	22.00
Bromus inermis	17.45	31.99	38.24
Meadow fescue	15.09	28.13	27.86
Orchard-grass	15.41	32.20	36.07
Tall meadow oat-grass	13.95	31.45	23.92
Average	15.45	30.06	29.62

[1]The percentage given in each case is the average for several determinations.

It is evident that the hay stored in 1908 and 1909 was not fully cured, yet this hay was cured enough to keep when stored in the stack or mow. Hay stored in this condition may readily lose fifteen to twenty per cent. in weight after being put in the mow or stack, due to loss of moisture alone.

The percentage of moisture in alfalfa as stacked, as determined by the Agronomy Department, crop of 1909, is given in table VII.

TABLE VII.– Moisture in Alfalfa when Stacked.

DATE OF CUTTING.	Number of determinations.	
First, June 5	32	30.0
Second, July 3	32	33.5
Third, August 6	32	28.5
Fourth[1], September 30	28	24.0
Average	124	29.0

[1] Crop of 1908.

A number of the samples were fully air-dried in the laboratory before the total moisture was determined. The moisture in the air-dried samples varied from nine to twelve per cent. If this hay became perfectly air-dry in the mow or stack, it would lose from seventeen to twenty per cent. in weight as an average for the

four cuttings. Green alfalfa when cut has shown, on an average, about eighty per cent. of moisture at the first cutting and seventy per cent. of moisture at the second cutting.

Men experienced in handling hay usually figure on about twenty per cent loss in the weight of the hay after it is put into the mow. The statement is made, also, that after baling the hay, each bale will shrink from two to five per cent. in weight. As hay is ordinarily stacked on a farm, there is often considerable loss from damage by rains, so that the actual amount of hay taken from a stack may often show a loss considerably greater than that due to the shrinkage in the weight of the hay by loss of moisture. It appears that the amount of moisture retained in cured hay when stacked varies with different kinds of hay and with different conditions of curing. Ordinarily, the loss in weight of hay stacked when well cured and protected from loss other than that which may occur by natural shrinkage, should not be greater than ten to fifteen per cent.

Seed Production

The production of certain grass seeds is confined to limited areas. This is due in part to the fact that grasses do not produce seed equally well everywhere, and also to the special development of the industry in certain localities. A large part of the Kentucky blue-grass seed sold on the market comes from certain counties in Kentucky, Iowa, and Missouri. Meadow fescue seed is produced largely in eastern Kansas, and more extensively in Johnson county than in any other county in the State. Orchard-grass seed is produced largely new Louisville, Ky. The seed of *Bromus inermis* is still largely imported from Hungary and Russia, but this seed is harvested also in northern Nebraska, in North Dakota and in South Dakota. Timothy is grown for seed over a larger area than that of any of the other grasses, but its production on a large scale for market is confined to certain counties in northern and southern Iowa.

Timothy

Timothy will produce good seed in eastern and central Kansas. It is preferable to save and to plant the home-grown seed rather than to sow seed produced in other states, on account of the better adaptation of the crop produced from the acclimated seed. For this reason Kansas-grown seed should be preferred in the culture of other domestic grasses in this State. The slow adaptation of several domestic grasses in this State is due in part

to the fact that the new seedings are usually made with imported seed, hence the grass has no chance to become adapted to our different climatic and soil conditions.

Timothy should be cut for seed as soon as the heads turn brown. It is usually harvested with the binder and bound in medium-sized bundles and shocked at once. It should be threshed from the field as soon as the grass is well cured, or it should be stacked and threshed later as may be desired. If timothy is left standing long in the shock, there will be a considerable loss of seed in hauling it. Four bushels per acre is an average yield of timothy seed. Well-saved timothy straw makes fair roughage for horses and mules, but is not relished by other stock.

Meadow Fescue

Meadow fescue ripens quickly after it comes into flower and should be harvested as soon as the heads turn brown. The crop may be harvested with the grain binder and handled in a manner similar to that already described for timothy. A good yield of meadow fescue seed is two hundred to three hundred pounds per acre. The first two or three crops are the most productive for seed. The usual practice is to break up the old sod the third or fourth year and to seed other fields.

Orchard-Grass

Orchard-grass is one of the earliest grasses to bloom and to ripen. Care should be taken not to leave the crop too long before harvesting. When this grass is over-ripe, much seed is lost in handling. The crop may be harvested with the binder and handled as directed for timothy and meadow fescue. Care should be taken in threshing to adjust the fan, since the seed is very light and chaffy and easily lost. It is better to save the seed with a great deal of chaff and to separate it later with the fanning-mill. If stored in large bulk immediately after threshing, orchard-grass seed is apt to heat. The seed should be spread and dried before it is stored in large bulk, or it may be stored safely in sacks. One hundred fifty pounds of orchard-grass seed per acre is a good yield.

Bromus Inermis

Bromus inermis is ready to harvest for seed when the heads assume a deep purplish shade. If left until the heads are brown there will be considerable loss of seed in harvesting. *Bromus inermis* may be cut with a binder and handled in much the same manner as the other grasses named. It is a common practice,

however, to cut it high and to bind the stems into sheaves. The seed crop is shocked or removed from the field. The undergrowth is mowed for hay. The crop may also be harvested for seed by mowing and handling loose the same as hay. To avoid shelling the seed, the hay should not be handled during the hot, dry portion of the day. Under favorable conditions, three or four hundred pounds of *Bromus inermis* seed per acre is a good crop. The largest yields of seed are secured the first and second years after seeding. This grass does not produce so much or so good a quality of seed in Kansas as it does farther north. The production of seed in this State, however, should be urged in order to secure seed which is better adapted to our climatic conditions than is the northern-grown seed.

Care must be taken in threshing *Bromus inermis* to adjust the fan, since the seed is large and light and easily blown over the sieves. It is better to secure the seed with a large proportion of chaff, which may be readily removed with the fanning-mill. In threshing *Bromus inermis,* use the oat-sieves.

Kentucky Blue-Grass

Kentucky blue-grass is harvested with a stripper. This is simply a box on wheels, with a revolving cylinder in front. The surface of the cylinder is covered with steel spikes. This cylinder revolves rapidly and throws the seed with pieces of the heads into the box. The seed is ready for harvest as soon as the heads turn brown.

Great care must be taken in curing blue-grass seed, since it heats very quickly. This seed must be spread thinly, two to three inches deep, on a drying floor, within a few hours after it is gathered. New seed should be stirred at intervals until it is nearly dry. Then it should be shoveled together into heaps eighteen to twenty inches deep, or it should be stored in sacks. The germinating power of the seed is quickly destroyed by heating. By the ordinary methods of handling, the seed is usually injured in vitality. Ninety-five per cent. of newly harvested seed germinates. Seed purchased in the market is considered good if fifty per cent. of it germinates.

The gathering of Kentucky blue-grass seed in this State can scarcely be recommended as an industry, yet it is advisable for farmers to gather enough seed for their own fields. A farmer may seed a field by mowing blue-grass when it is mature and by spreading the heads and hay over the field. Then the field should be disced to cover the seed. Seed gathered with the stripper

may be similarly planted on new fields. The advantages gained by the latter method of seeding are two: The seed planted is of strong vitality; and such seed is best adapted to the soil and climate. This method of seeding may be used also in securing a stand of native bluestem or of other wild prairie grasses.

Clovers

Clovers are more uncertain seed-producing crops than grasses, yet by proper management and under favorable conditions very large yields of clover seed may be secured. Yields of from eight to ten bushels an acre have been reported, but three to four bushels an acre is a good crop. Even two bushels an acre, with clover seed at ordinary prices, will pay for the harvesting and threshing, and will return a fair rental on the land.

The production of clover seed is largely dependent upon the presence of bumblebees or of other bees or insects which have proboscides long enough to reach the nectar in the flower-cups. These insects are largely the agents through which the pollination of the blossoms is effected. It is claimed that the ordinary honey-bee may cause the fertilization of Alsike clover and white clover, but not of red Clover and mammoth clover, since the proboscis of the honey-bee is not long enough to reach the nectar in the flowers of the red and of the mammoth clover. Since it may be fertilized by honey-bees, Alsike clover is a greater seed-producer and a more certain crop than red or mammoth clover. The greater seed-producing quality of Alsike clover may also be in part due to a larger number of heads on the plant.

The first crop of Alsike clover or of mammoth clover produces seed. The second growth, if there is any, seldom matures seed. to insure a good seed-crop from Alsike or from mammoth clover, the rankness of growth should usually be reduced somewhat by pasturing it in the spring or by mowing it when the clover has reached a height of from four to eight inches. The grazing or mowing makes the clover mature a little later, and allows for greater fertilization by bees. Even when clover is pastured in the spring, it is advisable to mow it when the grazing ceases, to make it grow more evenly and to kill the weeds. The second crop of medium red clover is much the better seed producer. The first cutting produces little or no seed on account of the absence of the bumble-bees. Under favorable conditions, it is possible to harvest two crops of white clover seed in a season.

Cut clover for seed before it becomes too ripe, when most of the bloom has fallen and when the heads are turning brown.

Alsike clover should be out when it is a little less mature than medium red clover or than mammoth clover, since Alsike breaks up badly when the heads are fully ripe. The crop is usually harvested with a self-rake reaper or by means of a mower with a buncher, or windrow, attachment. Great loss of seed may result if the mower is run over the cut clover; also, if the clover is raked into windrows with the horse-rake. If clover must be harvested by means of the ordinary mower and horse-rake, mow and rake the clover when the dew is on, or after a light rain.

The best plan is to hull the clover as soon as it is dry, threshing it from the field. It is advisable to turn the gavels or windrows the second or third day after cutting, also after rain, in order to cause the clover to dry and to cure evenly and quickly. The clover huller is much better than the ordinary separator for threshing clover. Some grain separators are equipped with huller attachments which do fairly good work.

It is often desirable to stack clover or to place it in sheds soon after cutting, and to thresh it at a more convenient time. The stack or shed should have a tight floor in order to save the seed, which will usually shell out badly. In loading and stacking clover, much care should be taken to catch the hulled seed. The wagons should have tight-bottomed racks, and a canvas should be spread under the wagon at the stack or shed.

Clover seed should always be carefully fanned and graded for market, since such extra labor and care is amply repaid by an advance in the selling price. Also, care should be taken to keep clover seed pure and free from weed seed. In order to insure clean seed, it is usually necessary to go over the field a few weeks before cutting the clover and to clip off or to dig up the tall weeds. Mowing early in the season tends to destroy weeds, and prevents the grasses growing with the clover from maturing seed. "Saving Alfalfa Seed" is fully discussed in Bulletin No. 155 of this Station.

The Pasture

According to the nature of the plants used, pastures may be divided into annual, temporary, and permanent. Annual pastures must be seeded anew each year and must include such crops as the cereal grains, millet, the sorghums, rape, field peas, vetches, cow-peas, and soy-beans. For hogs, they may also include kale, artichokes, and root-crops. These crops and their use for pasture and forage will be discussed in a separate bulletin on annual forage crops. Temporary pastures are those produced by seeding

some of the perennial grasses or combinations of these with clover or alfalfa, with the purpose of using the grass as a crop in rotation with other farm crops. Often the meadow and pasture is combined in one, the grasses being used for hay production for a year or two after seeding, then for pasture. However, since different combinations of grasses are desirable to make the best meadow or the most useful pasture, it is often well to seed separate fields for each purpose.

Permanent pasture is one in which the land is seeded permanently in grass to be used continuously for grazing. This seldom occurs except with native grass lands which are too rough or too stony to be plowed or tilled. The term, "permanent pasture," often refers to the profitable use of pastures for a long period.

When land may be tilled profitably, the temporary pasture is greatly to be preferred to permanent grass land in the West and Middle West, because of the beneficial effect which grasses and legumes have in improving the fertility of the soil. Most of the tame grasses valuable for pasture or meadow are not well suited for permanent pasture, but should be used for temporary pasture or for meadow in rotation with small grains, corn, and other crops.

Experiments with Pasture Grasses

In the spring of 1903, a series of combinations of grasses with clover were seeded in field B on the Experiment Station farm. The field was laid off in six parallel strips, each one hundred feet wide and one hundred sixteen rods long. These strips extended north and south and contained approximately 4.35 acres each. The field had grown cow-peas and soy-beans and corn in 1902. The grass plots crossed the plots of the previous year.

The seed-bed was prepared by discing, "Acmeing," and harrowing, early in the spring. The seeding was accomplished with the Thompson wheelbarrow seeder, between the dates of March 28 and April 6. The brome-grass hopper was used to seed the *Bromus inermis*. The seed was covered by a light harrowing, with the smoothing harrow following the seeder. The seed-bed was in good condition and the weather was exceptionally favorable for seeding and for sprouting the seed. All of the grasses started well, and the clover made a good stand on all plots. The plots were seeded as follows, plot 1 lying on the west side of the field on the highest ground (See table VIII):

Table VIII.—Plan of Seeding Pasture Grasses and Clover in Combination.

Plot no.	Grasses seeded.	Amount of seed sown per acre, pounds.
1	Orchard-grass	18.16
	Meadow fescue	16.10
	Medium red clover	4.50
2	Orchard-grass	18.40
	Medium red clover	10.80
3	*Bromus inermis*	18.30
	Meadow fescue	14.00
	Medium red clover	3.50
4	Orchard-grass	19.70
	Bromus inermis	14.60
	Medium red clover	3.70
5	Timothy	8.60
	Bromus inermis	15.00
	Medium red clover	2.80
6	*Bromus inermis*	15.00
	Medium red clover	4.50

This work was started in coöperation with the Animal Husbandry Department of this Station. The purpose was to undertake pasturing experiments in order to compare the productiveness and relative grazing qualities of the several grasses and combinations. However, no definite pasturing experiments have been undertaken. The whole field has been pastured alike with cattle, horses, and sheep, the sheep grazing only during the past two seasons. At times the grass has been very closely cropped; and the pasture has been grazed continuously from early spring until late in the fall. The author has from time to time taken observation notes.

The field was not grazed the first season. The weeds were clipped three or four inches high on June 29, and the grasses and weeds were mowed again late in August, a little clover hay being secured.

The grasses and clover made a good start in the spring of 1904, covering the ground fairly well. The pasture was grazed with cattle and horses early and regularly, but not very closely, during the season of 1904. It was observed that the stock allowed the orchard-grass to form seed-heads, but the plots of *Bromus inermis* were kept closely grazed.

The clover had largely disappeared in the season of 1905, and it did not re-appear to any great extent. Close grazing allowed no seed-heads to form and there was no re-seeding of the clover. The author observed that the orchard-grass was becoming thicker, that the *Bromus inermis* made an excellent sod, while timothy and meadow fescue did not make a good showing. It was evident that the *Bromus inermis* and the orchard-grass were taking the place of the other grasses.

This pasture was given a heavy surface dressing of barnyard manure during the seasons of 1905, 1906, and 1907. The grasses

continued to thrive even better than formerly, in 1908 and 1909. On June 11, 1910, a careful observation was made of this field as to the stand and condition of the grasses in the several plots. During that season the pasture was grazed by sheep, cattle, and horses. It was observed that all the plots were well covered with a thick turf except in the gumbo spots. No clover appeared in any of the plots. The percentage of stand of each of the other grasses in each or the plots was estimated as follows (See table IX):

TABLE IX.– Giving Percentage of Stand of Grasses in the Several Plots.

PLOT No.	Name of Grasses.	Percentage of Stand.
1.....	Meadow fescue	10
	Orchard-grass	90
2.....	Orchard-grass	100
3.....	Meadow fescue	15
	Bromus inermis	85
4.....	Orchard-grass	50
	Bromus inermis	50
5.....	*Bromus inermis*	100
6.....	*Bromus inermis*	100

It was observed that while all of the plots were closely grazed, plots 3, 5, and 6, containing mostly *Bromus inermis,* were more closely grazed than plots 1, 2, and 4, which were largely orchard-grass. Sheep seemed to graze about equally well on orchard-grass and *Bromus inermis,* and the combination of the two grasses on plot 4 was the best stand of grass and the best pasture. The orchard-grass appeared to stand better on the gumbo spots than did *Bromus inermis.* The combination of orchard-grass and Bro*mus inermis* is preferable to either alone. These grasses seem to be about equally persistent, and when combined, are apparently relished more by stock than the orchard-grass alone, are not so closely grazed as the *Bromus inermis* alone, and furnish more grazing in a season. Meadow fescue and timothy seem to be no more productive and much less persistent than orchard-grass and *Bromus inermis.* Meadow fescue and timothy, however, have little value in a combination pasture. This pasture could have been improved by an occasional re-seeding of clover. In this field is a strip of native prairie grass. Observation from year to year indicates that the stock graze less on the native grasses than on the tame grasses. Sheep, especially, preferred the tame grasses and allowed the native prairie grass to make a rank growth in the fall of 1909, while they kept the tame grasses c1osely cropped. Sheep also graze well on orchard-grass, while cattle and horses relish it much less than they do *Bromus inermis.*

Care and Management of Grass Lands

Renewing the Growth of Grasses in Permanent Meadows and Pastures

The writer recommends the use of the grasses as temporary meadows and pastures in rotation with other crops. When the meadow or pasture decreases in productiveness, the plan should be to break the sod and to grow other crops for a few years before again seeding the field to grass. By this method, larger yields both of grass and of grain crops may be secured apparently without greater exhaustion of soil fertility than may result from continual cropping with grain. In fact, the usual result is that the soil remains more fertile by such a system of rotation. This is due to the protection which the land receives while in grass, to the improvement in soil texture, to the accumulation of humus, and to the extra fertilization by the manuring which occurs from pasturing stock on the grass land. Occasionally, however, it is advisable to keep a field in grass as long as it may be profitably used for this purpose. Low, wet lands, rough or stony lands, and sloping, washy lands are often better adapted to grasses and legumes than to grain crops, hence it is desirable to keep grass growing on such land for long periods.

As meadows and pastures grow old, they become sod-bound and less productive. The available fertility of the soil becomes largely exhausted, and much of it is locked up in the immense root-system which has been developed by the thick growth of the grass. If the field is one which can be used profitably in growing other crops, the best plan is to break the sod and seed new fields to grass. If, however, it is desired to continue the use of the meadow or pasture, a new growth may be secured by partially breaking or by thoroughly discing and harrowing the sod in the spring. This will have the effect of destroying some of the grass roots, which soon decay, furnishing plant-food for the new growth of the grass. Discing also loosens and aerates the soil. This mulch of mellow soil conserves the soil moisture, thus favoring the growth of the grass. Grasses which spread from the root are most successfully renewed in this way.

Manuring and Fertilizing

There is no better fertilizer for grass than farmyard manure. A top dressing applied during the fall or early winter will serve during the winter as a cover to protect the grass roots from the

extremes of temperature. As spring opens, the rain carries the nutriment from the manure to the roots of the grass, stimulating an early spring growth, which may continue throughout the season. During the summer, the manure acts as a mulch to keep the moisture in the soil, thus protecting the plants more or less from the influence of drouth.

There is no more convenient place to haul the manure than to the grass land, and there is no crop which responds more readily than grass to the application of manure. It is not necessary to wait until the pasture or meadow is old and worn out before making liberal applications of manure. When the purpose is to plow the sod, the manure should be applied a year previous to the breaking. This will produce larger crops of grass during the season following the application of the manure, and by increasing the root-growth, will add to the humus of the soil, leaving the land more fertile for succeeding crops. Thus the manuring of grass land results in a double benefit, as compared with the manuring of corn or other grain land.

Grazing Meadows

Many farmers turn the live stock into the meadow after harvesting the hay crop, and depend upon the meadow to furnish the late summer or early fall grazing. When there is a vigorous aftermath, and a second crop of hay is not desired, no harm may result from such pasturing. In fact, the grazing may be beneficial, since a heavy mulch of dead grass tends to smother the meadow during the winter or to retard the early growth of grass the next spring. It is not desirable to burn the heavy grass-growth in the spring because burning wastes the nitrogen and exhausts the soil humus. However, it is almost necessary to burn a heavy covering of dead grass because, if left on the ground, it not only checks the new growth, but it interferes with the mowing, and injures the quality of the hay. The meadow should not be grazed too closely or too late in the fall, since late, close grazing will leave the grass with little winter protection and may result in weakening the plants so as greatly to retard their growth the next spring.

Timothy is easily killed by too close grazing, but this is not equally true of all grasses. Permanent pasture grasses, such as Kentucky blue-grass and the wild prairie grasses, may be pastured late in the fall without injury, provided the grass has been allowed to make a vigorous growth in the late summer and early fall. This may often be accomplished on a well-managed farm, by using the

meadow aftermath for pasture, as described above, allowing the grass in the regular pasture to make a rank growth during the early fall.

Care of Pastures

The productiveness of any pasture grass will be very much reduced by continued close grazing, for the leaves are the lungs and the stomach of the plant. In the leaves; carbon and water from the air, and mineral plant-food elements from the soil, are brought together and, in the presence of sunshine, chlorophyll, and life-giving oxygen, the complex products are made which sustain the life of the plant and cause growth. The bad results of close grazing are especially noticeable in a dry season, but too close grazing at any time weakens the vitality of the plants so that they may not start quickly and vigorously in the spring. Grass should not, as a rule, be pastured the season it is sown. If the season has been very favorable, and if the grass has grown luxuriantly, it may be pastured lightly in the autumn. Close or late grazing should be carefully avoided, because the young plants need their green leaves in order to produce a vigorous root-growth.

Grass becomes less palatable to stock as it matures and forms seed. In order to maintain a fresh, vigorous growth, tame-grass pastures should be mowed before the seed-heads mature. It is advisable also to mow permanent pastures once or twice a year to prevent the seeding of weeds, and to destroy buck brush or other plants that are likely to start in places where the grass has become thin. Grasses in permanent pastures or meadows require more care than those that are grown in rotation with other crops. It is advisable to re-seed permanent pastures occasionally. They must also be fertilized with manure or chemical fertilizers in order to maintain their productiveness. Occasionally, it is advisable to cultivate such grass lands by discing and harrowing early in the spring. The reseeding and manuring should come preferably at the time of cultivation.

BURNING OFF PASTURES

It is a very common practice in Kansas to burn off the prairie pasture in the spring. In the judgment of the writer this is a useless practice, for by dividing the range and by careful management as suggested above, it is possible to keep the pastures grazed down sufficiently so that they will not require burning. While a heavy growth of dead grass in a pasture is objectionable, a mixture of old and new grass may be preferable to new grass alone for early spring pasture. When cattle are changed abruptly

from dry feed to young, green grass, the too-great laxative often causes scouring and the cattle frequently lose in weight for a few weeks. This check in growth may be largely avoided by a judicious mixing of dry feed and green feed, such as may occur if a short growth of dead grass remains in the pasture. It is not advisable to burn a part of the pasture and to leave a part unburned, since the stock will then feed mainly on the burned portion, grazing the young grass very closely. This may result in permanent injury to the pasture, or at least may result in decreasing the amount of grazing for the single season.

RE-ESTABLISHING AN OLD BLUE-GRASS PASTURE

In answer to the question from a farmer in eastern Kansas, "How shall I re-establish an old Kentucky blue-grass pasture?" the author made this answer:

"If you wish to continue the blue-grass pasture as a permanent pasture, I would advise you to re-seed the pasture to Kentucky blue-grass and white clover, with a little Alsike clover. Perhaps the best plan for you to pursue in re-establishing the grass in this old pasture is to disc and harrow the pasture early in the spring, and to plant ten pounds of Kentucky blue-grass seed, two pounds of white clover seed, and four pounds of Alsike clover seed an acre. I would advise you to double-disc the field, cross-discing the second time, then to sow the seed and to barrow twice, so as to level the ground and to cover the seed.

"In order to insure a catch of grass and clover, it may be necessary to keep the stock from this pasture for at least a part of the first season after seeding. I would not advise you to pasture it until the latter part of the summer or early fall. Even then the young grass and clover should not be pastured closely. The cattle should be taken off early in the fall in order that the grass may make a good growth before winter begins. Possibly it is advisable to allow the cattle to run on this pasture early in the season immediately after seeding, in order to firm the soil and to give the seed better opportunities to germinate. Or better still, I would roll the field after seeding, if it seems necessary. However, it may not be necessary to use a roller, since the disc and harrow may put the ground in good seed-bed condition. The soil should not be left too loose and open.

"It would aid in getting a start of new grass on this pasture if you should manure the field during the winter previous to re-seeding. Preferably, give a light dressing of well-rotted manure, ten to twelve tons per acre, evenly spread and mixed with the surface soil by discing and harrowing, as described above.

"If it is not possible for you to secure manure, it may pay to apply commercial fertilizers previous to re-seeding the pasture in the spring. Some of the slaughter-house fertilizers which are rich in nitrogen and phosphoric acid should be preferred. If the land is weedy and a great growth of weeds starts, these should be cut at intervals during the season, to prevent them from seeding, also to prevent injury to the young grass. Bear in mind that it is necessary to give this land a rest from pasturing for a year, or for a part of a year, in order to renew the growth of grass and to make a productive pasture.

"If there is a very poor stand of grass on this old pasture and the land is badly infected with weeds, I would advise you to break up the pasture, provided the field can be plowed and tilled. Crop it a few years, preferably with inter-tilled crops, and then re-seed to grass. If this plan is adopted it will he advisable to sow other grasses with the Kentucky blue-grass and clover. For your section of the State, I would recommend a combination of *Bromus inermis,* orchard-grass, meadow fescue, Kentucky blue-grass, Alsike clover, and white clover. Plant about eight pounds of each kind of grass seed with four or five pounds of Alsike clover seed and a pound or two of white clover seed per acre. The other grasses named in the combination are not so valuable for permanent pasture as Kentucky blue-grass, but they grow much more rapidly at first and so furnish much more grazing for the first two or three years. They will gradually die out and be replaced by the Kentucky blue-grass and white clover. In starting a Kentucky blue-grass pasture, it is often advisable to sow small amounts of other grasses in this way in order to secure an abundance of pasture the first two or three seasons. It will not be advisable, however, to attempt to re-seed the old pasture with the tame grasses named above without breaking up the pasture, since the domesticated grasses will not start well on the sod land. It will not be advisable to plow this pasture with the purpose of re-seeding it the present season."

A similar method may be employed for re-establishing old pastures of native prairie-grasses in central and western Kansas, without breaking the sod. Experiments have shown that old prairie pastures may be renewed simply by manuring, discing, and giving the pasture a year's rest from grazing. In parts of the State, sweet clover *(Melilotis alba)* and Japan clover *(Sespedeza striata)* are being used to renew the fertility and productiveness of old, worn-out prairie pastures. (See the discussion of these clovers.)

Breaking and Cropping Grass Lands

Perhaps the best time to break prairie land, or old, tough sod is late in the spring, in May or June. In the spring, the grass roots are more tender and cut more easily than in the late summer or fall. The soil, too, is usually in good physical condition in the spring, containing sufficient moisture to plow well. If the sod is broken quite late in the spring or early in the summer after the grass is well started, the grass is apt to be killed out better than by fall breaking or by early spring breaking. This more complete killing of the grass by the later breaking is partly due to the hot, dry weather which is likely to occur at that season of the year.

In breaking the prairies of the West, the usual plan is to break late in the spring, and rather shallow– two to four inches deep. After the sod has lain for two or three months, it is back-set or re-plowed a little deeper than the breaking. This turns the tough, partially-rotted sod under and brings to the surface two or three inches of mellow earth in which to plant the seed grain. When this method of breaking is followed, winter-wheat is usually the first crop planted on the new land, and this planting does not take place until several months after the first breaking. This gives time for the decay of the sod, the storing of moisture in the sub-soil, and the preparation of some available plant-food with which to start the new crop.

Some farmers practice breaking a little earlier in the spring, plowing a little deeper and planting at once some late crop, such as millet, Kafir, or cane, perhaps without any preparation of the seed-bed other than plowing or disc-harrowing. Other farmers break the sod in the fall, and, usually without re-plowing, plant early spring crops. Frequently this method of deep breaking and immediate cropping gives unfavorable results. Farmers complain that new land treated in this way, though it may produce a good sod crop, may not produce so well at the second cropping, and occasionally this apparent lack of fertility may continue for several seasons. It is a general opinion among farmers that late fall or early spring breaking injures new land. The writer has carried out experiments in breaking and cropping sod land both at the Kansas Experiment Station and at the North Dakota Experiment Station, the results of which, in part at least, agree with this general experience of the farmers: that the injurious effects on the land are not due to the time or method of breaking, but rather to the immediate cropping of the new land.

The starting of a new crop at once on breaking gives no time

for the proper decay of the sod. The moisture in the soil and the rains which fall are largely used by the growing crop, and the sod does not rot; hence there is no accumulation of available plant-food, and the soil remains in bad physical condition. The writer carried on the following interesting experiment at the North Dakota Experiment Station. The sod of a field that had grown a crop of flax was observed to be in dry, hard chunks when it was plowed in the fall after spring breaking. The adjacent plot, broken at the same date but fallowed and cultivated during the summer, was in excellent physical condition when plowed in the fall. The summer-fallowed field gave a much larger yield of wheat.

In my judgment, no injury need come to land from early spring or early fall breaking, or even from very late fall or winter breaking, provided the sod is allowed to decay and to accumulate moisture, so that it may be put into good seed-bed condition by cultivation before a crop is planted. It is often more convenient and more economical for the farmer to break sod in the fall or winter, and if this is done, such land should be disced and harrowed early in the spring, or back-set to prepare a good seed-bed for planting some late crop.

Crops to Follow Grass

It is proper to sow legumes and grasses with crops which thrive in soils well supplied with humus and available nitrogen, such as Indian corn, Kafir, potatoes, and rank-growing forage crops like millet and sorghum. It is not advisable to follow clover, alfalfa, or combinations of legumes and grasses immediately with small grains, since, with an excessive supply of nitrogen, these crops will produce too great growth of straw, and lodge, and fail to fill well.

With favoring climatic conditions, flax is an excellent crop to grow on old, tough sod, such as native prairie-grass sod, old brome-grass sod, or blue-grass sod. Certain annual legumes, such as field peas, vetches, and cow-peas, may also be advantageously grown on old sod-land to aid in subduing the sod. These crops often produce well on new land, and they are excellent crops to hasten the decay of sod and to prepare the new land for its second crop. Oats is a strong "feeder" and may produce better on grass-sod land than do other small grains. It is not a safe crop to follow clover or alfalfa, on account of the tendency of the grain to grow too rank and to lodge. When the sod is not so tough but that it may be readily cultivated, an inter-tied crop, on the

breaking, should be preferred to a sowed crop, since by careful cultivation the grass is more completely killed, and the sod is rotted better. Certain grasses, such as Johnson grass, quack-grass, and Bermuda grass, seem to thrive by cultivation and may be an exception to this rule. Such grasses are more readily held in check by smothering-crops, such as millet, cane, and Kafir.

FIG. 15.—First crop on *Bromus inermis* sod which was broken in the fall of 1903. This corn produced over 15 tons of green forage per acre, which was put into the silo. Ordinary land adjacent yielded 8 tons per acre.

Experiments in Breaking and Cropping Prairie Sod

An experiment was carried on at this Station in 1904-1905 to compare spring and fall breaking of native prairie sod, to determine what crops produce well on sod land, and to observe the effect such crops may have on succeeding crops. Twenty-one plots, each twenty-five rods long and two rods wide, and each containing an area of twenty-four hundredths of an acre, were laid off in the summer of 1904 on a piece of high upland prairie pasture on the College farm. The soil in this field was rather shallow and underlaid with limestine at a depth of from three to five feet; hence the field was not very productive, especially in an unfavorable season. The Plan of the experiment is briefly given in table X. The sod was plowed at three different times: early in the fall, August 27 to September 3; late in the fall, November 16 and 17; and early in the spring, March 15 to 18. There was no late spring breaking. The breaking was from two and one half inches to five inches deep. One Plot of the early fall breaking was back-set late

in the fall; other plots received no re-plowing before the planting of the sod crops.

Several plots of flax and a number of other standard crops were planted on this new breaking in the spring of 1905. Four plots were left fallow. Two of these were cultivated to keep down the weeds and on two the weeds were cut once or twice during the season to prevent them from seeding. In the fall of 1905, this series of plots was divided into three equal divisions running crosswise of all the plot series. On the west third of each of the several plots winter-wheat was planted, on November 2, 1905. On the middle third flax was planted, in the spring of 1906; and in the east division corn was planted.

The seed-bed for the 1906 wheat was prepared on all plots by discing and harrowing after the removal of the sod crops as named in the table. The division in which flax seed was planted was plowed in the spring while preparing the seed-bed. In the east third corn was planted with the lister without previous cultivation.

The very late seeding of the wheat, and the thin soil, resulted in a low yield from all plots. Flax did comparatively better than wheat, being a fair crop, but the corn was an inferior crop on all of the plots, and no yield test was recorded. Some of the data on this experiment are tabulated in table X.

From the data in table X it appears that the forage crops and the inter-tilled crops, millet, cane, corn, and Kafir, were the better yielding first crops on sod. Of the small grains, oats and emmer were much superior to barley and spring-wheat in yield. Flax averaged a fair crop, giving rather larger yields from shallow late fall breaking. The "back-setting" and the early fall breaking had a decided effect in reducing the flax yield on plot 11, which gave thirty-eight per cent. less yield than plot 10, adjacent to it, which was not replowed.

The second year's crops, both of flax and of wheat, were noticeably greater on the summer-fallowed plots and after cow-peas. Flax gave larger yields, also, after small grains, millet, corn, and Kafir, than after flax; and the yield of flax after cane was relatively light. Wheat made a relatively good yield after corn, fair yields after Kafir and flax, and very low yields after the small grains, millet, and cane. The writer is well aware that this is not a very satisfactory experiment on account of the light yields, and the results are not conclusive but suggestive of facts as previously discussed in this bulletin and as experienced by many farmers.

TABLE NO. X.—A Summary of Results of Experiments in Breaking and Cropping Sod Land.

Plot No.	Date plowed.	Depth plowed, inches.	Crop of 1905. Kind.	Crop of 1905. Yield, per acre.	Crop of 1906. Wheat, bu. per acre.	Crop of 1906. Flax, bu. per acre.	Crop of 1906. Corn, bu. per acre.
	1905.						
1.....	Early spring..	5	flax.....	7.96 bu	8.91	4.66	Poor crop on all plots—little difference observable—no yields taken.
2.....	.....	2½	fallow cultivated	.....	14.30	11.55	
3.....	.....	2½	fallow not cultivated.	.....	14.84	11.79	
4.....	.....	2½	flax.....	9.08 bu.....	10.90	8.12	
	1904.						
5.....	Early fall	2½	flax.....	9.07 bu.....	9.13	8.23	
6.....	.....	2½	fallow cultivated ...	.....	14.11	9.56	
7.....	.....	2½	fallow not cultivated.	.....	12.86	11.45	
8.....	.....	5	flax.....	7.50 bu	8.09	9.12	
	1904.						
9.....	Late fall	5	flax.....	6.03 bu	8.09	10.45	
10.....	.....	5	flax.....	9.21 bu	6.95	9.56	
11.....	.....[1]	5	flax.....	5.88 bu	6.43	9.34	
12.....	.....	5	spring wheat....	14.72 bu.....	3.32	8.78	
13.....	.....	5	oats.....	30.97 bu.....	5.08	11.56	
14.....	.....	5	barley	11.10 bu.....	3.84	11.01	
15.....	.....	5	emmer	30.10 bu.....	3.53	10.01	
16.....	.....	5	millet	4333 lbs	4.87	10.56	
17.....	.....	5	cane[2].....	14579 lbs.....	6.12	9.12	
18.....	.....	5	cow-peas[2]	4.10 bu.....	14.21	12.45	
19.....	.....	5	corn[2]	32.72 bu.....	10.79	11.12	
20.....	.....	5	Kafir[2]	13911 lbs. green wt.	9.23	10.34	
21.....	.....	5	flax.....	.....	8.92	.....	

[1]Back-set December 22nd, 7 inches deep.
[2]Cane sowed in close drills; cow-peas, corn, and Kafir planted in rows and cultivated.

Grass as a Soil Improver

Formerly the chief crop of the western plains was grass, and grass is still one of the most important crops of the West. On the hills and uplands, where nothing else will grow, buffalo-grass thrives, furnishing pasture for great herds of cattle. In the valleys and more favored locations, bluestem and other native prairie-grasses grow readily, producing thousands of tons of prairie hay annually. The Kansas crop alone averages from five to six million tons a year. For persistency in resisting drouth and unfavorable conditions, no other crop can compare with the native grasses of the western prairies. However, one of the great problems to be solved by western agriculturists is how to handle these grasses so that they may be successfully and economically propagated.

Grass is a soil-protector, a soil-renewer, and a soil-builder. Covering the land with grass is nature's way of restoring fertility to old, worn-out soil. True grasses do not add nitrogen to the soil as do clover and alfalfa, yet they are nitrogen-gatherers. They

collect the nitrogen of the soil and store it up in their roots and by the decay of these roots, humus is formed. Thus grasses prevent the waste of nitrogen and other plant-food elements, protect the soil, and maintain its fertility and tilth. By their extensive and penetrating root-systems may grasses tend to break up and to deepen the soil, thus improving its texture and increasing its moisture-holding capacity. The roots gather the mineral plant-food in the deeper subsoil and store it, in part, in the great fibrous root-growth nearer the surface. This causes an increase in the supply of available plant-food in the soil for the use of more shallow-rooting crops.

When the prairie is first broken, the soil is mellow, moist, and rich, producing abundant crops. After a few years of continuous cultivation, the physical condition of the soil changes; the soil becomes finer grained, more compact, and heavier to handle. It dries out more quickly than sod that is newly broken, and often turns over in hard clods when plowed. This is due to the decay of the grass roots, and to the exhaustion of the soil humus. The grass roots, which separated the soil particles and yet held them together, have decayed, and as a result, the soil tends to run together and become very sticky when wet. When such soil dries, the adhesive character disappears almost entirely, and when loosened by the plow or harrow, it easily drifts or blows away.

The perfect tilth and freedom from clods so characteristic of virgin soils is more or less completely restored whenever land has been sown to grass for a sufficient length of time. After the ground is covered with sod, washing and puddling of the soil by rain is prevented. As the roots grow, the soil particles are wedged apart and rearranged, and thus the mellow, open character of virgin soil is restored. At the same time, through the great growth of the roots, which form humus and accumulate mineral plant-food, the soil is made more fertile for succeeding crops.

The leguminous crops, such as clover and alfalfa, are not equal to grasses as soil protectors, but are superior to grasses as soil fertilizers, since they increase the total available supply of nitrogen in the soil. This is due to the action of bacteria which are found on the roots of leguminous plants, and which take free nitrogen from the air in the soil and make it available for the use of plants. Moreover, perennial legumes, such as clover and alfalfa, arm very deep feeders, and take a part of the mineral elements of their food from the soil below the depth of the feeding ground of ordinary crops. Because of their large root-growth in the surface

soil, they accumulate a supply of mineral elements of plant-food, which gradually becomes available, as the roots decay, for crops which follow the leguminous crops.

FIG. 16.—Timothy.

Rotation of Crops with Grasses

In order to maintain soil fertility, and at the same time to secure the greatest profit in farming, a practical and scientific rotation of crops should include the following:

1. Grasses and perennial legumes.
2. Pasture, with the addition of manure for one or two years previous to breaking the sod.
3. Inter-tilled crops.
4. Small grain crops, plus green-manuring crops planted in the stubble after harvest.

Small grain crops must be grown on every farm. Often they are the greatest money-making crops; hence they must be given a prominent place in the general crop-rotation system. Inter-tilled crops, also, are often the money-making crops of the farm, and are necessary in every rotation plan, in order that the land may be cleared of weeds. Especially is this true in localities where small grains form the main crop, for by continuous grain-growing, the land becomes foul and weedy. Cultivation conserves

the soil moisture and develops the fertility of the soil. It increases the supply of available plant-food by producing those conditions which favor chemical change, the growth of soil bacteria, and the decay of vegetable matter. In a sense, "tillage is manure."

Grasses and legumes maintain the supply of soil nitrogen and restore the proper soil texture. Besides, they are profitable crops, and are absolutely necessary on every farm upon which live stock is kept. Every farm must have its pasture. The pasture should be made a part of the regular crop rotation. Many soils become too light and mellow by continuous cropping and need the trampling of stock to restore their firmness. Much more grass can be produced when pastures are kept fresh and new, and the consequent increase in fertility and improvement of soil texture result in larger crops of corn, or grain, when the meadow is again under cultivation.

If manure is applied for about a year before the meadow is broken, it will stimulate the growth of grass, causing a greater production of hay, or furnishing better grazing, while the soil is being enriched by an increased root-growth which results in a larger supply of humus. Soils in which organic matter and humus are deficient may be improved in fertility and in texture by green-manuring. A cheap and practical method of green-manuring is to plant a crop adapted to this purpose in the grain stubble immediately after harvest, as suggested in the general plan for crop rotation.

It is necessary in carrying out permanent systems of crop rotation to have fields of nearly equal area, in order to grow about the same acreage of the several crops each year. In this way it is possible to keep a definite amount of live stock and to have regularity and uniformity in farming from year to year.

A practical system of crop rotation for a farm of 160 acres, divided into eight equal fields, is as follows:

ROTATION NO. 1

The Farm Plan, Showing Crops on All Fields for One Year.

Legumes and forage.	Wheat.
Wheat.	Wheat.
Wheat plus legumes.	Pasture (manured).
Spring grains (seed to grass).	Clover and grasses.

Rotation Plan, or Order of Crops on Each Field.

1st year—Grass and clover.
2nd year—*Pasture* (manured).
3rd year—Wheat.
4th year—Wheat.
5th year—Legumes and forage.
6th year—Wheat.
7th year—Wheat plus legumes.
8th year—Spring grains (seed to grass).

It will be observed that the crops growing on the eight fields each year are the same as those named in the order of crops on each field in eight years. By following this plan of rotation, the farmer will raise each year eighty acres of wheat; forty acres of grass, twenty acres of which may be used for pasture; twenty acres of small grains other than wheat; and twenty acres of forage crops, a part, at least, of which consists of annual legume crops. Each year twenty acres of grass land is given a dressing of manure; and a twenty-acre field of wheat is renewed in fertility by a crop of cow-peas, or by some other green-manuring crop. In the course of eight years the whole farm will have been seeded to grass and clover, and each field will have remained in grass for two years.

ROTATION NO. 2

If this system of rotation does not leave the land in grass and clover long enough, a sixteen-year rotation may be preferred.

The Farm Plan, Showing Crops on All Fields for One Year.

Forage crops.	Wheat.
Small grains plus legumes.	Wheat.
Corn.	Pasture (manured).
Small grains (seed to grass).	Clover and grasses.

Rotation Plan, or Order of Crops on Each Field.

1st year—Grass and clover.
2nd year—Grass and clover.
3rd year—Pasture (manured).
4th year—Pasture.
5th year—Wheat.
6th year—Wheat.
7th year—Wheat.
8th year—Wheat plus legumes.
9th year—Forage crops.
10th year—Corn.
11th year—Small grains.
12th year—Small grains plus legumes.
13th year—Forage crops.
14th year—Corn.
15th year—Small grains plus legumes.
16th year—Small grains (seed to grass).

By following this system of rotation, the 160-acre farm will raise each year forty acres of wheat, forty acres of small grains, twenty acres of corn, twenty acres of forage crops, twenty acres of grass for meadow, and twenty acres of grass for pasture. If corn is preferred, it may be grown in place of wheat, By this sixteen-year rotation, there are always two fields planted to grass, each for a period of four years. This requires that one field be seeded to grass every two years, and that one grass-field be plowed up every two years and planted again in wheat, or to other crops. Thus it requires sixteen years for the whole farm to receive a rotation of grass and clover.

ROTATION NO. 3

On a farm which has permanent pasture, it is not so necessary to use grasses in rotation, for the same results are secured by the use of clover and alfalfa. Clover is necessarily used in short rotations, since it produces profitable crops but two years in

succession. Alfalfa, however, may be used in longer rotations. Probably four years is as long as alfalfa may be used profitably as a fertilizer. The following is a sixteen-year rotation with alfalfa, adapted to a farm with four fields of about equal area:

A Sixteen-Year Rotation with Alfalfa, Small Grains, and Corn on Four Fields.

Year.	Field A.	Field B.	Field C.	Field D.
1910[1]	Small grain (S).	Corn (M).	Corn.	Corn
1911.	Alfalfa (M).	Small grain (CC)	Corn	Corn
1912.	Alfalfa	Corn (M)	Small grain (CC)	Corn
1913	Alfalfa	Corn.	Corn (M).	Small grain (CC)
1914.	Alfalfa (B).	Small grain (S).	Corn.	Corn (M)
1915.	Corn.	Alfalfa (M).	Small grain (CC)	Corn
1916.	Corn.	Alfalfa.	Corn (M).	Small grain (CC)
1917.	Small grain (CC)	Alfalfa.	Corn.	Corn (M).
1918.	Corn (M).	Alfalfa (B).	Small grain (S).	Corn.
1919.	Corn.	Corn.	Alfalfa (M).	Small grain (CC)
1920.	Small grain (CC)	Corn.	Alfalfa.	Corn (M).
1921.	Corn (M).	Small grain (CC)	Alfalfa.	Corn.
1922.	Corn.	Corn (M).	Alfalfa (B).	Small grain (S).
1923.	Small grain (CC)	Corn.	Corn.	Alfalfa (M).
1924.	Corn (M).	Small grain (CC)	Corn.	Alfalfa.
1925	Corn.	Corn (M).	Small grain (CC)	Alfalfa.
1926.	Small grain (S).	Corn.	Corn.	Alfalfa (B)
1927[2]	Alfalfa (M).	Small grain (CC)	Corn.	Corn.

[1]It is assumed that this farm has been cropped largely with corn and small grains and has received little rotation of crops. No alfalfa is growing on the farm in 1910, when field "A" is seeded. The rotation really begins in 1911.

[2]Observe that. this is a repetition of 1911 crops viz., this rotation is repeated every sixteen years. each of the four fields having received a rotation of four years in alfalfa.

(S)– Seed to alfalfa in fall. (B)– Break alfalfa sod. (This should properly be done in the spring when the new catch of alfalfa by fall seeding is assured.) (CC)– Catch crop or green-manuring crop, planted in the stubble after the small grain is harvested. (M)– A dressing of barnyard manure applied in the fall and winter as a surface dressing on the alfalfa field or spread on corn stubble land and plowed under previous to planting the following crop of corn.

This plan of rotation is really a three-year rotation on three fields, one of the four fields being kept in alfalfa as shown in the plan. The order of the rotation on each field is corn, followed by corn, followed by small grain; thus, two fields of corn, one of small grain, and one of alfalfa, are grown on the farm each year. At the end of four years, the field of alfalfa, which has not been included in the three-year rotation, is plowed and planted to corn the succeeding season. One of the three fields which has been in the regular rotation is seeded to alfalfa and comes out of the regular three-year rotation plan, remaining in alfalfa for four years. Then this field is plowed and planted to corn and becomes one of the fields in the three-year rotation series, while another field which has been seeded to alfalfa comes out of the regular three-year rotation.

It will be observed that such a plan may be followed with five, six, or more fields. With four fields by the method described, one fourth of the farm is kept continually in alfalfa, the alfalfa fields changing every four years. This requires sixteen years for all the fields to be rotated with alfalfa. With five fields, one fifth of the farm will be in alfalfa each year, and it would require twenty-five years for the rotation to be carried out on all the fields.

ROTATION NO. 4

The Farm Plan Showing Crops on all Fields for One Year.

Clover.	Corn and legumes.
Clover.	Small grains.
Corn.	Wheat (seed to grass).

Rotation Plan or Order of Crops on Each Field.

1st year—Clover.
2nd year—Clover.
3rd year—Corn.
4th year—Corn and legumes.
5th year—Small grain.
6th year—Wheat (seed to grass).

The above is a six-year rotation with clover, adapted to a farm with six fields.

Rotation No. 5 is well adapted to a farm which carries a large amount of live stock where pasture as well as alfalfa is required in rotation with small grain and corn. This is a sixteen-year rotation plan adapted to a farm with eight fields. It will be observed that four fields, or one half of the farm, is always in alfalfa or in grass, but occasionally there may be only one field in alfalfa and three in grass, or vice versa (see plan). This is the result of the arrangement by which the seeding and the breaking of grass and alfalfa sod is made to come on alternate years in order to distribute the work evenly from year to year. The plan could readily be changed so that the crops would be regular, with two fields of alfalfa and two fields of grass each year, but this would require breaking two fields every other year, one of alfalfa and one of grass. This farm would always have two fields of corn and two fields of small grain. If it were preferable, corn or some other crop instead of small grain might be grown on one of these fields each year previous to the year in which the land is seeded to grass or alfalfa.

If this plan of rotation is successfully carried out, each of the eight fields in the farm will have been in alfalfa four years and in grass four years at the end of sixteen years of cropping. During this period the whole farm will have been manured twice. Meanwhile, four fields will have produced each year crops of corn and grain, and there is little question but that a farm thus managed and properly stocked may be even more fertile at the end of sixteen years than it was at the beginning. It is the judgment of the writer that a farm upon which crops are thus carefully rotated will produce more bushels of grain in a series of years at a less cost per bushel than may be secured if practically all of the land on the farm is kept continually in grain crops. The alfalfa, grass, and other soil-maintaining crops on the farm will yield an additional income. With the live stock which may be produced on the farm

ROTATION NO. 5

A Rotation on Eight Fields with Alfalfa, Grass, Corn, and Small Grain.

YEARS.	Field 1.	Field 2.	Field 3.	Field 4.	Field 5.	Field 6.	Field 7.	Field 8.
1910....	Small grain(SA).	Corn (M).....	Corn.....	Corn	Small grain.... (SG)	Corn (M).....	Corn.....	Corn.
1911....	Alfalfa.....	Small grain	Corn.....	Corn.....	Grass meadow.	Small grain.... (SG)	Corn (M).....	Corn (M).
1912....	Alfalfa.....	Small grain (SA)	Corn (M).....	Corn (M).....	Grass meadow. (M)	Grass meadow.	Small grain....	Corn.
1913....	Alfalfa (M).....	Alfalfa.....	Small grains.....	Corn.....	Meadow or pasture.. (B)	Grass meadow.	Small grain.... (SG)	.....
1914....	Alfalfa (B)	Alfalfa.....	Small grain(SA).	Corn (M).....	Corn.....	Meadow or pasture.. (M)	Grass meadow.	Small grain.
1915....	Corn	Alfalfa (M)	Alfalfa.....	Small grain....	Corn (M).....	Meadow or pasture.. (B)	Grass meadow.	Small grain.
1916....	Corn (M).....	Alfalfa (B)	Alfalfa.....	Small grain.... (SA)	Small gran	Corn.....	Meadow or pasture.. (M)	Grass meadow.
1917....	Small grain	Corn.....	Alfalfa (M)	Alfalfa.....	Small grain.... (SA)	Corn (M).....	Meadow or pasture.. (B)	Grass meadow.
1918....	Small grain(SG).	Corn (M).....	Alfalfa (B).....	Alfalfa.....	Alfalfa.....	Small grain	Corn.....	Meadow or pasture (M)
1919....	Grass meadow...	Small grain	Corn.....	Alfalfa (M)....	Alfalfa.....	Small grain .... (SA)	Corn (M).....	Meadow or pasture (B)
1920....	Grass meadow...	Small grain (SG).	Corn (M).....	Alfalfa (B)	Alfalfa (M)....	Alfalfa.....	Small grain	Corn.
1921....	Meadow or pasture (M).	Grass meadow...	Small grain.....	Corn.....	Alfalfa (B).....	Alfalfa.....	Small grain .... (SA)	Corn (M).
1922....	Meadow or pasture (B).	Grass meadow...	Small grain(SG).	Corn (M).....	Corn.....	Alfalfa (M)	Alfalfa.....	Small grain.
1923....	Corn.....	Meadow or pasture(M).	Grass meadow...	Small grain....	Corn (M).....	Alfalfa (B)	Alfalfa.....	Small grain (SA)
1924....	Corn (M).....	Meadow or pasture(B).	Grass meadow...	Small grain.... (SG)	Small grain....	Corn.....	Alfalfa (M)....	Alfalfa.
1925....	Small grain	Corn.....	Meadow or pasture(M).	Grass meadow.	Small grain.... (SG)	Corn (M).....	Alfalfa (B)	Alfalfa.
1926....	Small grain(SA).	Corn (M).....	Meadow or pasture (B).	Grass meadow.	Meadow grass.	Small grain....	Corn.....	Alfalfa (M).
1927....	Alfalfa.....	Small grain.....	Corn.....	Meadow or pasture .. (M)	Grass meadow.	Small grain.... (SG)	Corn (M).....	Alfalfa (B).
1928....	Alfalfa.	Small grain S(SA).	Corn (M).....	Meadow or pasture.. (B)	Meadow or pasture.. (M)	Grass meadow.	Small grain....	Corn.

(M)—Manured. (B)—Break sod either in fall or spring. (SA)—Seed to alfalfa; this may be done in the fall and a catch of alfalfa secured without losing a crop. (SG)—Seed to grass, which may also be done in the fall in the West and South, and in the spring with grain, in the Central and Eastern states.

an additional profit may accrue to the farming business. Meanwhile by such a system of farming, the soil of this farm may become more fertile and more capable of producing large crops of corn and grain; while by the continuous cropping system, it would become largely depleted in fertility.

Improvement of Grasses

Up to the present time very little has been done in the way of breeding or of improving grasses. The native grasses of the West thrive there by Nature's breeding and selection and not by the hand of man. The testing of varieties of grasses to determine their adaptation to soil and to climatic conditions is the first step toward the improvement of the grasses in any locality. The improvement work with other crops, such as wheat and corn, has shown that even the varieties which are hardiest and best adapted to a given soil and climate, may be still further improved in yield and in hardiness by a method of selection and testing which discovers the superior individuals which may be made the foundation stock for new strains or improved varieties. This work has been just begun with the cereal grains, but with remarkable results, and there is no reason why similar improvement may not be made with grasses by similar methods of selection and breeding.

Each kind of grass as ordinarily sown by the farmer consists in reality of a number of more or less distinct varieties mixed together. With the usual methods of securing grass-seed, there is no opportunity to separate these varieties; but if the seed from different heads or from different plants is planted in separate rows or plots, then pure and superior strains may be propagated. In fact, enough work along this line has already been accomplished to show valuable results. Dr. A. D. Hopkins, at the West Virginia Experiment Station, has produced a number of different varietal types of timothy by this method of head-row breeding. In a similar manner, Professor Leckenby, of the Eastern Oregon Experiment Station, has isolated twenty-two different varieties of *Bromus inermis* as distinct in their agricultural characteristics as are the ordinary varieties of wheat. At the Kansas Station, work of this character is being undertaken with *Bromus inermis* and timothy. It is probable that each of the valuable standard grasses may be separated into varieties, some of which will show a marked improvement over the ordinary mixture of varietal types.

This breeding work requires technical knowledge and much time and patience in order to establish the new strains and vari-

eta1 types. The work really belongs to the specialist and to the experiment stations, but the farmer may assist greatly in an important phase of the grass-improvement work by bringing under cultivation some of the more valuable wild grasses. If farmers in different portions of the State would persistently gather the seed, and plant and cultivate these wild grasses, the result would shortly be the development of improved domesticated varieties. The mere growing of these wild plants under more favorable cultural conditions should cause a general improvement of the grass and may develop individual plants, which, if observed, separated, and propagated, might become the founders of a new and better variety.

Characteristics of Some Important Grasses

In this discussion of several important grasses, mention will be made mainly of the special characteristics, culture, and uses of the grasses discussed.

Timothy

Timothy *(Phleum pratense),* also called Herd's Grass, is a native of America, indigenous to the New England states. It is said to have been discovered and brought to notice in the middle of the eighteenth century by one Timothy Herd, of New Hampshire; hence, the name. It is a perennial grass which grows in stools, or tillers, and does not spread from the root, but readily thickens by re-seeding under favorable conditions, forming a nearly perfect sod. The stems are upright with few leaves and, unless thickly sown, the grass forms coarse, stemmy hay. It grows to a height of from two to four feet, according to conditions, and is surmounted by a spike two to ten inches long. When in full bloom a field of timothy is an attractive sight.

The root-growth of timothy is both bulbous and fibrous. The fibrous character is relatively greater in moist, sandy soils. As shown in the sample (see Fig. 8), the roots may reach to a depth of several feet, though the grass is generally considered a surface feeder. (Perhaps this grass roots more deeply in Kansas soil– see Fig. 18.)

ADAPTATION AND USES

Timothy easily ranks first as the great standard hay-grass of America. Its general use and extensive cultivation arises in part from the wide range of its adaptation, but more from its many good qualities. It is easily grown, cured, and transported; it

seeds abundantly, and the seed is easily saved. Timothy hay has an attractive appearance and is highly palatable and very nutritious. It has been found to be especially adapted to the needs of horses. For cattle and sheep, a combination of timothy and clover is preferable to timothy alone.

Timothy requires a temperate climate and a moist, fertile soil. It is well suited to river-bottom lands rich in humus, and thrives well in prairie loam and even in stiff clay soils which are well watered. Dry, sandy soils and soils low in fertility are poorly adapted to the growing of timothy. Timothy succeeds well in eastern and southeastern Kansas, and in portions of central and south-central Kansas it may be recommended under favorable conditions. While timothy is essentially a hay grass, it may be used for pasture. It is easily injured by the trampling of cattle and by close grazing, and hence is not considered one of the best pasture grasses. However, for pasture, it is often advisable to seed it in combination of other grasses and clover.

Timothy is preferably sown with clover for meadow, the Alsike, mammoth clover or medium red clover being preferred according to soil conditions, to the use which is to he made of the hay, and to the preference of the grower. Alsike clover and timothy should be preferred on wet land; also, to produce a fine quality of hay for feeding sheep or young stock. Mammoth clover and timothy mature at about the same time and are well suited for growing together where each thrives well, but the combination makes a rather coarse, unpalatable hay. Medium red clover is more often seeded with timothy than are the other clovers. This combination makes an excellent crop even though the medium red clover does mature a little earlier than the timothy. The writer would usually recommend to seed medium red clover with timothy in central and in southern Kansas, since, in a favorable season, timothy may make two cuttings the same as medium red clover. A good second cutting from Alsike or from mammoth clover is seldom secured.

Timothy may be sown either early in the spring or early in the fall. Prefer to seed clover and timothy in the spring and do not seed with a nurse-crop in the fall. If the grass is sown alone in August or in early September and starts well, it should produce a fair crop of hay the following season.

FIG. 17.—Timothy roots. Sample taken July 2, 1909, six years after seeding.

FIG. 18.—Orchard-grass.

A field of timothy may be maintained for ten years or more and return profitable yields by growing it with clover or by manuring and fertilizing the field. If the grass becomes thin or weedy, add at intervals, preferably early in the spring, a little seed both of timothy and of clover. Usually, enough seed of both clover and timothy will shell out to maintain the stand, especially if an occasional crop is harvested for seed. Timothy does not form a very tough sod. The sod may be broken readily either in late summer or in early spring and the land planted with wheat, corn, or other grain-crops. Care should be taken to disc and to harrow the sod well in order to put it in a well-pulverized condition before planting.

Orchard-Grass

Orchard-grass (*Dactylis glomerata*) is a native of Europe, but has become very widely distributed and is now grown throughout the countries of Europe, Western Asia, Northern Africa, and in many parts of North America. It is successfully grown in the eastern half of this State, but is not adapted to dry-land conditions. It is a hardy perennial grass, but not so good a cold or drought resister as *Bromus inermis*, though it is grown successfully farther south.

FIG. 19.—Cutting the Orchard-grass for hay, June 15, 1909. This plot was seeded in the spring of 1908.

Orchard-grass is essentially a moist-climate grass, but it will stand more drought than will meadow fescue or Kentucky blue-grass.

Next to brome-grass, it is one of the earliest grasses to start in the spring and grows very rapidly. It reaches maturity in May or in early June, even earlier than Kentucky blue-grass. Its habit is to grow in bunches or tufts unless sown thickly. However, this grass will soon thicken up in a pasture by self-seeding. In the course of three or four years, it will form a dense growth and a very thick sod. If allowed to seed occasionally, it will even thicken up in a meadow in the same way. Due to its self-seeding habit, orchard-grass is a more nearly permanent grass than is meadow fescue, and it often continues to improve in stand and in productiveness for several years after seeding. It is a very hardy grass under favorable conditions; meadows have been reported as producing good crops for a dozen years.

Orchard-grass is particularly well adapted to grow in the shade, and is often grown in orchards. It is an excellent pasture grass when rightly managed. It ranks high in nutritive value, but is not relished by live stock so well as Kentucky blue-grass or *Bromus inermis.* It grows large stems very quickly and becomes tough and unpalatable, hence requires mowing to start a new growth. It makes good hay when cut early, but, owing to the

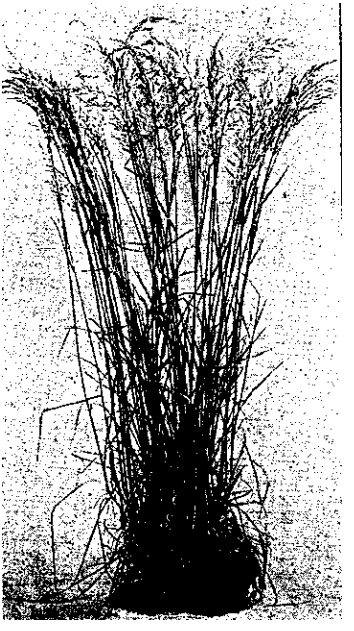

FIG.20. – Meadow Fescue

quickness with which it matures, it is apt to become too mature before cutting, when it makes a coarse, bulky, and unpalatable hay. For these reasons it has never become very popular as a hay grass.

Meadow Fescue

Meadow fescue (*Festuca pratensis*), usually known as "English blue-grass"[1] in Kansas, is indigenous to Europe and Western Asia. It is much grown in Great Britain and in Northern Europe, and is a hardy perennial grass, well adapted to endure low

[1] There is no good reason for this name, other than that the grass is grown largely in England for pasture and for meadow. It seems desirable, therefore, to call the grass by its proper name, "meadow fescue."

temperatures. It may also endure warm climates, as shown by its successful culture in the South, where it is especially valuable for winter pasture. It is a moisture-loving grass and is not well adapted to dry climates.

Meadow fescue is grown successfully in the area south of the Kansas river and extending west from the Missouri line about

FIG.21 – Meadow Fescue roots. Sample taken June 24, 1909, three years after seeding

FIG.23 – Bromus inermis

one hundred miles. It thrives best on the fertile and heavier soils, although it is grown largely on the slopes and uplands. In eastern Kansas it will grow well on any good corn land.

Meadow fescue is a tufted grass more spreading in habit than orchard-grass but not so rank nor so rapid a grower. It obtains its best development the second or third year after seeding. In some of its features it resembles the Kentucky blue-grass. The leaves have a bluish tint and the stems are rather stiff and wiry, but the panicle of the head is narrower and less open than that of the Kentucky blue-grass. Meadow fescue blooms later than the

blue-grass, but the blades start early in the spring. The quantity of forage is not great, but the grass is rich in nutrients and well liked by stock both as pasture and as hay. The hay, unless cut early, is apt to be a little tough or woody. This grass usually produces stems only once in a season, but produces a great aftermath of foliage in favorable seasons, which remains green late into the fall and winter, furnishing excellent pasture.

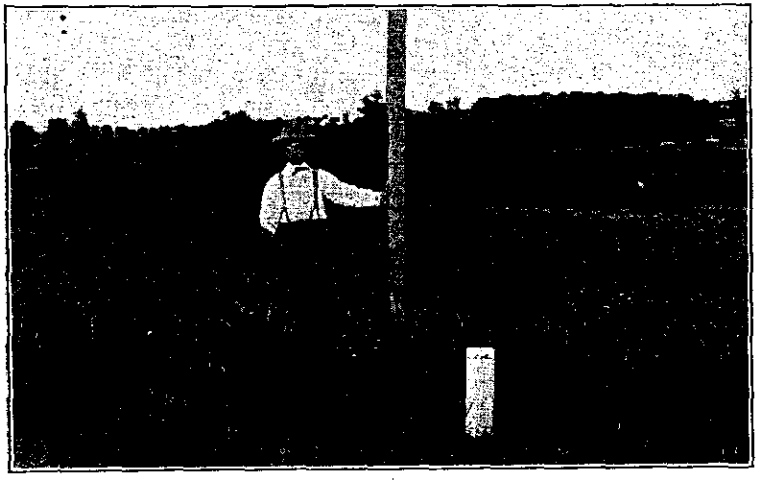

FIG.22. – Variety plot of Meadow Fescue. June, 1904, just before cutting for hay. Grass was seeded in the spring of 1903.

In Kansas the grass is grown especially for its seed, Kansas supplying about seventy-five per cent. of the total amount of seed produced in the United States. Johnson county, Kansas, leads in the production of meadow fescue seed. This seed finds a ready sale in European countries, where it is sown for meadow and for pasture. The price is regulated by the supply and the foreign demand, and has ranged from two to ten cents per pound. The largest seed crop produced in Kansas was harvested in 1896 and was estimated at 3,360,000 pounds. The yield of seed for the first three or four years after planting averages from six to twelve bushels per acre (twenty-four pounds per bushel), although yields of from fifteen to twenty bushels have been reported. In from three to five years the grass makes a less vigorous growth and the yield of seed decreases. The practice is to plow the sod at the end of the fourth year and to rotate with corn or other crops for a few years before the field is again seeded to grass.

The fact that meadew fescue has proven to be a profitable crop

when grown for seed, has perhaps caused it to be valued more highly for pasture and as a hay grass than it really deserves. It appears that meadow fescue is not so extensively adapted to conditions in this State as are orchard-grass and *Bromus inermis*. It is less permanent, and less valuable for pasture, than either of these grasses, while timothy exceeds it as a hay grass in that section of the state where meadow fescue grows best.

Russian Brome-Grass

Russian brome-grass (*Bromus inermis*), also known as Australian or Hungarian brome and as smooth, or awnless, brome, is a native of Asia and of Europe, where it has been cultivated for more than a century. Introduced into the United States in the early eighties, it has become widely distributed throughout the northern and western part of our country, thriving well in the northern states and succeeding well in the West under dry farming conditions. It is a very hardy grass, resisting both cold and drought but it will grow well and produce good crops only in fertile soil and with a moderate supply of moisture. It does not succeed well in a hot climate, central Kansas being about the southern limit for the profitable growing of *Bromus*.

Bromus inermis is a perennial grass spreading by underground root-stems which produce numerous shoots and a very dense fibrous growth of roots that often fill the soil completely to a depth of five or six feet. It thickens very rapidly, even though the stand may be thin at first, and soon forms a very tough, thick sod. The stems are numerous, reaching a height of from three to four feet under favorable conditions, but often the growth in height is much less. The leaves are numerous and large, furnishing a dense mass of foliage which completely covers and shades the ground. These large leaves add greatly to its value for hay and for pasture. The fully developed head is a spreading, open panicle averaging from four to six inches in length, though the head may be longer or entirely wanting when the grass is old and very thick. Brome-grass makes good hay, but it is essentially a pasture grass. Live stock of all kinds are fond of it and, under favorable conditions, it will furnish continuous grazing from early spring until late in the autumn. In this respect, when *Bromus inermis* is in its prime, it exceeds all other grasses. Its fault is that it thickens rapidly, becoming sod-bound to such an extent that its growth is checked in from three to five years.

As a hay grass, *Bromus* is equal to timothy in feeding value, but

timothy exceeds it in commercial value. Also, timothy exceeds it in yield and in permanence in localities to which the two grasses are equally well adapted. Bromus exceeds timothy in hardiness and in drought resistance, and it may be grown successfully on the Western Plains where the annual rainfall does not exceed twelve to fifteen inches. Under such conditions, however, it is much less productive. It lives under dry conditions that would destroy many other grasses, and when the rains come it will start again vigorously. Its great drought resistance is doubtless due in part to its extensive and deep root growth. (See Fig. 25)

Compared with other important grasses, *Bromus inermis* succeeds well on the lighter, sandier soils and drier lands; but, like other grasses, it grows better on deep, rich, fertile loam well supplied with moisture. The grass may be sown either early in the fall or early in the spring, preferably with alfalfa or with clover. It is somewhat difficult to sow on account of the large size and light weight of the seed. It is usual to sow *Bromus inermis* broadcast, by hand, since the seed is very light and is sown with difficulty with the drill or grass seeder. Certain of the wheelbarrow seeders, however, have a special box attachment for seeding *Bromus inermis.* It is possible also to sow *Bromus inermis* with a common grain drill. To do this it is necessary to place a shaker in the bottom of the seed box. The shaker is made in this manner: Nail together two narrow strips of inch board in the bottom of the seed box, splicing them in the center; drive two ten-penny nails through this board into each seed cup; attach to the middle of the board a handle which reaches to the top of the box. Put only a small amount of seed into the box at one time. With a boy working this handle to prevent the seed from clogging the drill, it is possible to do a fairly even job of seeding.

Another method of seeding is to mix the *Bromus inermis* seed with oats so as to soap about one bushel of oats per acre with the required amount of *Bromus inermis* seed. On light soils which are inclined to drift with the wind, oats serves to protect the soil from the force of the wind. The oats should be cut early for hay in order that the young grass plants may not be destroyed by drought or by shading. The method of drilling in the seed is often preferred in light soil and in a dry climate. As a rule, the seed should not be covered over one half of an inch to one inch deep. If the ground is dry when the Seed is sown, rolling may be beneficial, but the harrow should follow the roller.

It is very important to test *Bromus inermis* seed and to be sure that it will germinate. Much impure and poor *Bromus inermis*

seed has been sown. With good seed and under reasonably favorable conditions, *Bromus inermis* is not an especially hard grass to start. When once established, it is very hardy and, as stated, it tends to become thicker from year to year.

Bromus inermis should not be considered as a permanent pasture grass or as meadow grass. It is rather a grass to be used

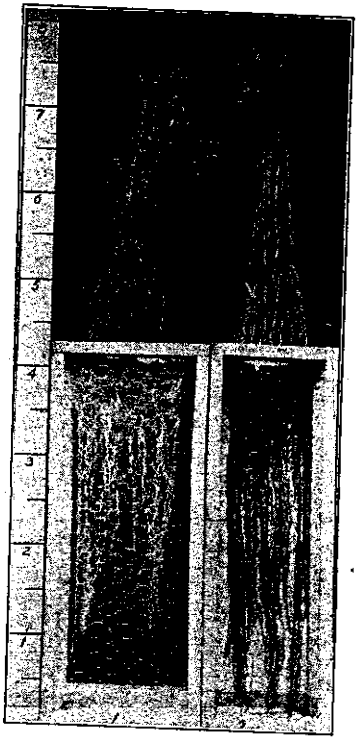

FIG.24– *Bromus inermis* roots on the right. Sample taken June 30, 1903, showing root development three years after seeding. Orchard-grass roots on the left. Sample taken June 27, 1903, showing development of roots from the one plant or stool two or three years after seeding.

in rotation with other crops. It is usually preferable to re-seed new fields every three or four years, plowing the old fields and planting them to corn or to other crops. It is possible to renew the growth of *Bromus inermis* after it has become old and sod-bound by partially breaking the sod and by discing thoroughly to level the field. The writer has tried this method and has also tried very thorough discing of the sod, with fairly favorable results.

The grass was renewed in growth within a year or two, and produced fairly good yields again; but the renewing in this way took a longer time and proved to be more expensive than the new seeding of another field. Hence it is usually more desirable to seed other land rather than to attempt to renew an old meadow or pasture of Bromus inermis.

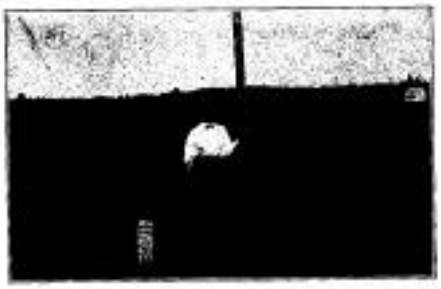

FIG.25 .— Variety plot of Bromus inermis June 28, 1904, just before the crop was cut for hay. Seeded in the spring of 1903.

Brome-grass is very persistent and somewhat difficult to destroy when it is once well established, but farmers need not fear it on this account since, by proper methods, it may be readily and fully eradicated. Prefer to break Brome-grass sod late in the summer or early in the fall. Plant this field with an inter-tilled crop the succeeding year. Give the new orop thorough cultivation. This method used at the Kansas Experiment Station has practically eradicated the grass in a single season.

Western Rye-Grass

Western rye-grass (*Agropyron tenerum*) is a Native American grass, the famous bunch-grass of the bunch-grass ranges of the Canadian northwest. It is one of the hardiest perennial grasses, and, according to Professor Shaw, none of the cultivated grasses excel it for growing under dry conditions, and no amount of cold seems to injure this grass. It is superior to *Bromus inermis* in this respect, but it is not well adapted to a hot climate, and does not thrive so well in western Kansas as it does in the states

farther north. This grass was first grown under cultivation and brought to public notice in the early eighties by Kenneth McIvor, Verben, Manitoba, Canada. It has been rapidly introduced as a cultivated grass throughout the northwest, and is considered one of the most valuable hay and pasture grasses in the drier, colder sections of the United States and Canada.

Western rye-grass resembles somewhat the rye plant, but it has a long, slender, smooth head more like that of wheat, and is known also as slender wheat-grass. It is the only grass among

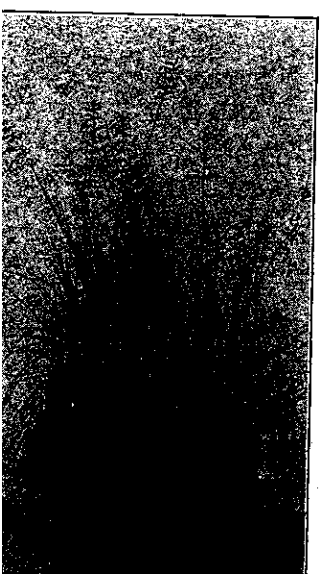

FIG.26 – Kentucky Blue-grass.

hundreds of species or varieties growing wild on the prairies of the West and Northwest which has as yet been domesticated. On the range, it grows in height from twelve to eighteen inches; but under cultivation, with favorable conditions, its height may reach three or four feet. Each stool, or tiller, produces many leaves and several stems. These grow erect and bear heads six inches or more in length. No study has been made of the roots of this grass at this Station, but the roots are fibrous in character, abundant, and extend deep into the soil.

Western rye-grass starts rather slowly in the spring and ceases growth early in the autumn; but it is a good late spring and summer grass for pasture. This grass makes good hay and outyields

Bromus inermis where the two are equally well adapted. The hay is easily handled, and it is readily eaten by stock if cut before it has become too mature. It is a great producer of seed, and the seed is easily sown. Western rye-grass may have considerable value in western Kansas in resetting the older tilled lands with grass to prevent soil-drifting and to restore the soil humus. It is doubtful, however, whether the grass is so hardy or so well adapted for growing in western Kansas as are the native prairie grasses, such as the buffalo-grass and bluestem. Other rye-grasses, such as perennial rye-grass *(Solium Perenne)* and Italian rye-grass *(Solium Italicum),* have little value in this State.

Kentucky Blue-Grass

Kentucky blue-grass *(Poa pratensis),* with two or three of its allied varieties, is the greatest American pasture grass, and it is grown extensively throughout a large part of the United States and Canada. Professor Shaw states that it is grown more or less in every state in the Union. From the Mississippi to the Atlantic it occupies more territory and has been found more useful for grazing than any other grass. It is also considered a valuable pasture grass for a considerable distance west of the Mississippi river. In the western part of the Great Plains region, conditions are too dry for the successful growing of Kentucky blue-grass except by irrigation.

Fifty years ago there was little or no Kentucky blue-grass in Kansas, but it has been gradually working west even without field seeding, until it is the common roadside grass of a large part of eastern Kansas, and furnishes the grazing in many of our pastures which were originally devoted to the wild prairie grasses. Kentucky blue-grass spreads by underground roots, hence it forms a perfect sod. It makes a very fibrous growth of roots near the surface, but is not a deep-rooting grass and does not stand drouth well. It starts very early in the spring and matures early, blooming in May or early in June. This grass makes little growth in the hot summer months, but with sufficient moisture it thrives again in the fall, supplying excellent grazing until freezing weather. It is one of the most palatable and most nutritious grasses for all kinds of stock, but has little value for hay. Kentucky blue-grass is not so productive as the other grasses used for hay, and the leaves form a mat so close to the ground that they can scarcely be cut with the mower. The grass is difficult to harvest so as to

make a good quality of hay, as the grass matures very rapidly, the stems soon becoming tough and wiry.

Kentucky blue-grass is also the great lawn grass of America, for which use it is particularly well adapted because of its abundant growth of reclining leaves which lie very close to the ground and which make a velvety sward which admits of frequent clippings without injuring the grass, provided the lawn is well watered and

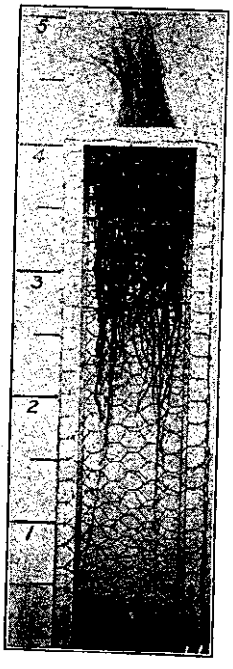

FIG. 27.—Kentucky Blue-grass roots. Sample taken September 4, 1903, from the Agricultural College campus. Age of grass not known; may be described as old Blue-grass sod.

FIG. 28.—Tall Meadow Oat-grass.

well fertilized. White clover should always be associated with Kentucky blue-grass both for pasture and for lawn, in order that the grass may remain permanent and productive.

Redtop

Redtop *(Agrostis vulgaris)* is the most commonly cultivated variety of the species of grasses indigenous to America, among the more common of which are redtop, Herd's grass, bent-grass, Borden's grass, dew grass, summer grass, finetop, and Rhode

Island bent-grass. Redtop is a perennial grass which grows from a few inches to three or four feet in height under varying conditions of soil and climate. The stems are erect, with slender, smooth, and rounded linear leaves. The panicle is oblong and spreading, and usually of a purple or reddish tint. The roots are more or less fibrous or creeping, hence the grass is particularly well adapted to low or wet lands. It starts later in the spring than Kentucky blue-grass, grows more slowly, and is later in maturing. It is not so valuable for pasture or for hay as timothy, being less palatable. Redtop hay is less suitable for marketing, though it is often grown with timothy for hay, and with timothy, meadow fescue, or orchard-grass and Alsike clover, for pasture. In wet lands it gradually supplants other grasses. Redtop does not have a wide adaptation or utility in Kansas, but for hardiness to thrive in poorly drained areas, the peculiar conditions for which it is suited, there is no other domesticated grass superior to it.

At this Station, on upland soil, redtop has not appeared to be as persistent as timothy, even though the grass was favored by being seeded in the lowest and best-favored portion of the field.

Tall Meadow Oat-Grass

Tall meadow oat-grass *(Arrhenatherum avenaceum)* is said to be the most valuable variety of the oat-grass family. This is a coarse, tall-growing perennial grass resembling the common oat, but more slender in every way. The grass grows in tufts, or bunches, commonly three or four feet high, but often reaching a height of five or six feet. Oat-grass does not make a sod, and should usually be sown in combination with other grasses. It is of considerable value for meadow and for pasture in Kansas and in the states farther south. Tall meadow oat-grass is even earlier in maturing than orchard-grass, being ready to cut for hay early in June. It springs up quickly after cutting, furnishing a good aftermath for pasture; or, under favorable conditions, two or three cuttings of hay in a season. In the southern states, this grass grows late in the fall and furnishes winter pasture. The grass seeds freely and the seed is strong in vitality. Oat-grass starts quickly and grows rapidly, usually yielding a hay crop from spring seeding the first season. The grass is deep rooting, resisting cold, drouth and heat, and may be recommended for seeding in western Kansas under the more favorable soil conditions. For pasture, it is preferable to sow it in combination with western rye-grass and *Bromus inermis.*

Farmers disagree as to the feeding value of tall meadow oat-grass. Some think oat-grass is of small feeding value and others speak very highly of it. Its feeding value is probably a little below the average of standard grasses. It makes a rather coarse, unpalatable hay unless great care is taken to harvest it before it matures, and it reaches maturity very quickly after heading. Also, its rapid, coarse growth and slightly bitter taste cause stock to prefer the other grasses for grazing. The main characteristics which recommend it are its hardiness and rapid, vigorous growth.

FIG. 29.—Variety plot of Tall Meadow Oat-grass. Photo taken in June, 1904, just before cutting for hay. Seeded in the spring of 1903.

Bluestem Grasses

There are two valuable species of this excellent hay and pasture grass which grow abundantly on the prairies of eastern and central Kansas. These are the big bluestem *(Andropogon furcatus)* and the little bluestem *(Andropogon scoparius)*, both of which are dry-land grasses. Little bluestem resists drouth better than big bluestem and is better adapted to the higher lands. The big bluestem luxuriates in the draws and on lower lands, where the soil is deeper and the supply of moisture is greater.

These grasses form a large part of the famous prairie hay of Kansas and Nebraska. They are probably not so well adapted for pasture as for meadow, since by close pasturing they are soon destroyed. This is due to their habit of growing in bunches or stools; to their method of propagation, which is by seed only; and to the fact that they are spare seeders, which is their greatest

fault. It is safe to affirm that the bluestem grasses would long since have been cultivated if an abundance of seed could have been secured. There is no question regarding their valuable qualities for meadow. Even in the wild state, their value as hay grasses on the Western Plains is not exceeded by that of any of the domesticated grasses. By scientific breeding and selection, doubtless

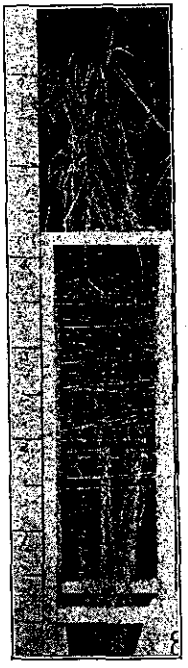

FIG. 30.—Big Bluestem (*Andropogon furcatus*) roots. Sample taken September 4, 1903, from an old prairie meadow on the Agricultural College farm. Observe the thick net work and fibrous growth of roots and the deep root system.

the bluestem grasses will become still more valuable and will help to solve the problem of returning to grass the western lands which have already been cropped too long with wheat and other grain.

In Fig. 30 is shown a sample of the big bluestem grass roots. The sample was taken from the Experiment Station pasture, and represents the full growth of the grass to August 2. This is an excellent specimen of grass roots, and is indeed a wonder when we consider the large number of roots and their great length. The roots were broken off four and a half feet from the surface,

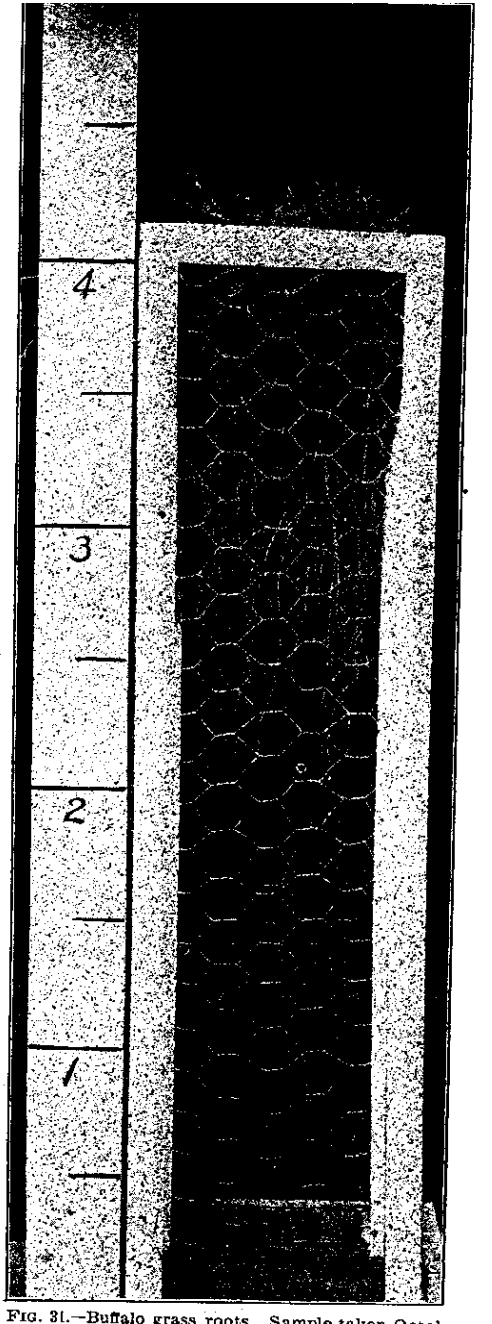

FIG. 31.—Buffalo grass roots. Sample taken October 20, 1903, from an upland prairie pasture near the Agricultural College farm.

but from their size they must have extended at least two feet deeper into the compact clay subsoil. This grass makes a deeper root growth than *Bromus inermis*, and the roots, though less numerous, are somewhat coarser, presenting a somewhat irregular and tangled growth. Big bluestem forms a dense, tough sod, from six to eight inches thick, and the subsoil is filled with a great mass of roots. After the sod is broken, the roots gradually decay, supplying nitrogen and humus to the soil.

Buffalo-Grass and Grama-Grass

No grass of the Western Plains is better known for its valuable qualities as a pasture grass than is the famous buffalo-grass *(Bulbiles dactyloides)*, a sample of which is shown in Fig. 32. Withstanding drouth, hot winds, and the persistent trampling of cattle, this grass thrives on the dry uplands of central and western Kansas, filling the soil with roots and covering the earth with a thick mantle of stems and leaves. Owing to the spring rains, it makes a good, early growth. As summer advances and dry weather begins, it ceases to grow, but does not die. The crop cures on the ground, furnishing grazing of the best quality. When the rains come in the fall, the grass again starts to grow, producing a second crop which cures on the ground, and continues to furnish grazing throughout the winter. Buffalo-grass spreads by means of runners which creep along the ground and root at intervals. The leaves are short and curly, and the plants form a mellow sod, covered with two or three inches of soft, cushion-like foliage. The seed-stems extend a few inches above the foliage, but they are not very numerous. The grass has practically no value for hay, since it produces very lightly and cannot be harvested readily.

As the sample shows, the roots are numerous, but do not penetrate deep into the soil. The first four inches of soil, however, are completely filled with roots, which form a fairly firm sod. The roots are thread-like, and almost white in color. On the whole, the feeding capacity of this grass is much less than that of *Bromus inermis* or big bluestem; hence it is less productive than either of these grasses. Although it is uninjured by drouth, it ceases growth sooner when a drouth approaches than do the deeper-rooting grasses mentioned.

Bermuda Grass

Bermuda grass *(Cynodon dactylon)* is a creeping perennial grass, the stems of which produce nodes, or joints, at short intervals, and each node is capable of producing a new plant. This grass spreads very rapidly under favorable conditions, roots at each joint, and produces numerous upright leaf-branches, from four to six inches in height. These branches bear the flowers and seed in from three to six Slender spikes. Each joint has from two to four leaves, which are flat, spread widely, and gradually taper to a

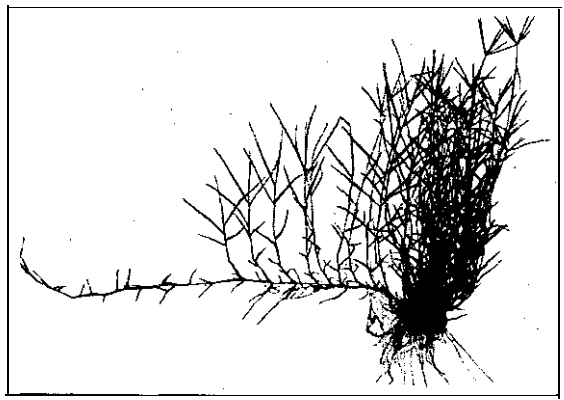

Fig. 32. – Bermuda Grass. (Courtesy of the Oklahoma Experiment Station.)

slender tip. The grass produces shallow, under-ground root-stalks, as well as surface runners, but the roots are mainly fibrous, and deep feeders.

Bermuda grass is the great pasture grass of the sub-tropical and warmer temperate regions throughout the world, and is probably a native of tropical Asia. It was introduced into Georgia during the War of 1812, and has been widely distributed throughout the South, where it is now considered the most valuable pasture grass, holding the place in those states that Kentucky blue-grass holds in the North. Like Kentucky blue-grass it is also the universal lawn grass in the section over which it has spread. Bermuda grass is distinctly a warm-weather grass; it will not grow in cold weather, and is not hardy where the temperature falls much below the zero point. At this Station it usually winter kills, but in the southern counties of the State it is comparatively hardy, and farmers there have reported that they have grown it successfully for periods of from four to eight years. This grass is grown successfully throughout the larger part of Oklahoma. The

Experiment Station of that state is breeding this grass and has developed a hardier variety. The hardy Bermuda is the variety recommended for planting in northern Oklahoma and southern Kansas.

FIG. 33.—Johnson grass. (Courtesy of the Tennessee Experiment Station.)

In its habits of growth, Bermuda grass is almost the reverse of Kentucky blue-grass. It starts to grow late in the spring, grows slowly at first, and thrives best in the hottest summer weather. With the earliest frosts, the grass is killed to the ground, remaining brown and dead during the winter and early spring. Like other grasses, it grows most luxuriantly in fertile soil, but it will also grow on poor, sandy, gullied, or worn soils. To these soils, Bermuda grass furnishes protection and supplies humus, but it will not yield much pasture. It is one of the best soil-binding grasses, and is very persistent, withstanding both heat and drouth; but it does not thrive in the driest lands of western Texas and Oklahoma, and it will not grow in the shade.

Bermuda grass is primarily a pasture grass and is relished by all kinds of stack. It will stand close grazing and much trampling. It also makes hay of excellent quality, but will not grow rank enough to mow and handle well, except on very fertile soil. Under the more favorable conditions, it furnishes two or three cuttings,

yielding in a season from two to four tons of hay per acre. Since it furnishes no late fall or early spring pasture, other grasses or annual pasture crops must be grown in order that the farmer may supply continuous grazing for his stock.

Bermuda grass may be propagated both from seed and from root cuttings. The seed is often low in vitality and sprouts so slowly that the young plants are apt to be crowded out by weeds; hence this method of starting Bermuda grass cannot be recommended, except where roots cannot be readily secured. In such cases, the planting should be on a small area to produce plants whose roots may be used for planting larger areas. The seed-bed should be clean, fertile, and well-pulverized. The seed must be sown late in the spring after the danger from freezing is past, and covered very lightly. One pound of seed is sufficient to plant from one fourth to one third of an acre. The seed is expensive, costing from fifty cents to a dollar a pound.

The grass may be propagated most readily and cheaply by transplanting pieces of the sod, about two inches square, at intervals of from one to two feet, in rows three feet apart. It may also be propagated from cuttings of the roots from two to three inches long, planted from six to twelve inches apart, in shallow furrows from three to four feet apart. The roots or the pieces of sod should-be covered to a depth of from two to four inches. The space between the rows may be cultivated for a time, or a light seeding of oats or other grain may be planted as a nurse-crop, to be cut for hay or pastured off with cattle. Horses or sheep should not be allowed to graze on the young grass, because they destroy many of the creeping stems and prevent the rapid spread of the grass. Planted as described above, under favorable conditions Bermuda grass will cover most of the intervening space by the close of the season. A similar method may be employed to start lawns, but the soil should receive more careful preparation and the cuttings or the pieces of sod should be planted at closer intervals to insure quick growth and a uniform cover.

Bermuda grass is very persistent and very difficult to eradicate from good soil when climatic conditions favor its growth. Usually, farmers who use it in rotation with other crops do not desire it completely eradicated, but depend upon its roots which are left in the soil to renew the stand of grass after other crops are removed. In Kansas and Oklahoma, Bermuda grass may be completely eradicated if proper methods are used and advantage is taken of the climate, soil, and season. Late fall or winter plowing, which exposes the tender roots to severe freezing, will largely destroy

it; or if plowing is done at the approach of a dry season and the roots are dragged to the surface with a harrow or weeder, the grass may be destroyed. If smother-crops are then planted or if the land is planted with inter-tilled crops and given thorough cultivation, very few plants will remain the second season, and these may be exterminated by carefully digging them out.

Bermuda grass seldom produces seed north of Florida and southern California, and where seed is not produced it does not readily spread to fields where it is not planted. In localities where it produces seed abundantly, it spreads everywhere and cannot be controlled.

When it is desired to keep Bermuda pasture more or less permanent, the grass requires renewing occasionally by re-plowing, or by fertilizing, or both. It usually becomes very thick and sod-bound and non-productive after four or five years. In such cases, the grass may be renewed by breaking the sod in the fall and planting winter grain, such as winter-wheat, barley, or oats. The next season, after such grain crop is removed, Bermuda grass will thicken up rapidly and furnish early summer and late fall grazing. The pasture should be fertilized occasionally with barnyard manure, or commercial fertilizers. It is also advisable to use cow-peas or clover in rotation, in order to maintain the supply of soil nitrogen.

Grasses of Doubtful Value, Which Are Often Noxious Weeds

There are four well-known grasses, or grass weeds, which ought to be mentioned under this head: Johnson grass; quack-grass; crab-grass; and chess, or cheat. All of these grasses are great pests under certain conditions; yet when properly managed, each of them often makes valuable pasture or hay.

Johnson Grass

Johnson grass *(Sorghum halepense)* is said to be the worst weed in the South; yet it will yield from two to five crops of good hay each year, averaging from one to three tons per acre each cutting. This hay is relatively high in feeding value and is relished by all kinds of stock. The only objection to the grass as a forage crop is the difficulty with which it is controlled or eradicated when once it has become established.

Johnson grass belongs to the sorghum family. It is a peren-

nial and, until the plants are a foot high, closely resembles young cane. It is well supplied with leaves, and often reaches a height of eight or ten feet, though the average height for this hay is from three to six feet. It has an open, branching head, from six to twelve inches long, which produces many seeds. The seed slightly resembles flax and has strong vitality. The plant is usually propagated from the seed, but it may be started by planting the roots. It fills the surface soil with numerous large, creeping root-stocks,

FIG. 34.—Chess (*Bromus secalinus*).

which are supplied with latent buds about an inch apart, each of which may produce a new plant.

Johnson grass is adapted only to a warm climate. It is a hot-weather plant which can stand much drouth, but produces large yields only with an ample supply of moisture. It starts to grow late in the spring and ceases at the approach of the first cool weather. In the summer it grows rapidly, and it may be cut as often as once a month while the weather remains warm. It is essentially a soiling grass, and does not endure close grazing. The trampling of the stock kills the roots and causes the grass to

become thin and patchy. When this grass is used for pasture, it is necessary to plow the pasture occasionally in order to renew the stand of grass.

Johnson grass is a native of Eastern Asia. It was introduced into the United States in 1835, by Governor Means, of South Carolina. A few years later, it was widely distributed throughout the South by William Johnson, of Alabama, from whom it takes its name. It is hardy only in the states south of the fortieth parallel. Even in the southern states the growth in the spring is relatively late and slow. It is not hardy where the frost penetrates the ground to the entire depth of the creeping root-stocks, since these roots are killed as deep as the frost penetrates. The grass usually winter-kills at the Kansas Experiment Station. Even in the southern counties of Kansas there is little fear that this grass may become a pest, since it will be destroyed by severe winters; and destruction may be readily accomplished almost any winter by deep plowing and dragging late in the fall, which exposes the root-stocks of the grass to the winter frosts. Farther south the eradication of the grass becomes a more difficult problem. Persistent destruction of the young grass by cultivation will largely eradicate Johnson grass from a field in a single season. Bulletins giving further information upon this subject may be secured from experiment stations in Oklahoma and in other southern states.

While the Kansas farmer need not fear this grass as a pest, he should exercise care to prevent it from spreading. Spreading may result from distribution of seed, or from the dragging of roots to a new locality. Johnson grass has become so much of a pest in some of the southern states that laws have been passed making the careless spreading of the grass a misdemeanor.

Quack-Grass

Quack-grass *(Agropyrum repens)*, also called couch-grass, witch-grass, twitch-grass, etc., is one of the perennial wheat-grasses, and is much more persistent than others of its kind. When once well-started under favorable conditions it spreads rapidly from bud-producing, creeping root-stocks, which branch out in every direction and crowd out all other plants. This grass also propagates freely from the seed.

Quack-grass is a native of Europe. It flourishes best in a moist, temperate climate, in a fertile clay-loam or in black-loam soil. The stems range in height from one to three feet, but the under-growth is thick and the sod formed is tough. The flowering

spikes are rather slender, resembling wheat heads. The leaves are of a dark-green shade and are coarse and tough. The stems become woody as the grass approaches maturity. However, when fresh and young, the grass is well-relished by stock and makes good pasture. Where it is not dangerous as a weed-pest, it makes an excellent soil binder for gulleys and embankments. In fertile soil, if renewed by re-plowing and cultivation, it produces large yields of good hay when it is cut in season.

Thus it has some good qualities, but since other more valuable grasses which are not dangerous weeds thrive under the condition favorable to the growth of quack-grass, the seeding of quack-grass on any farm cannot be recommended. If the grass is accidentally started in a field, the farmer should employ every available means to exterminate it at once. Culture-methods, by which quack-grass may be eradicated from cultivated fields in a year or two, have been discovered and are now in use among northern and eastern farmers. One of these methods is known as the "Crane System," and was discovered and practiced successfully by Mr. P. B. Crane, of Long Lake, Minn. He describes his method in a little book which he has published. [1]

While quack-grass is a dangerous pest in Canada and in the northern and eastern states, it is not very difficult to control in the West and South. However, there is a certain species of grass much like it, known as western wheat-grass *(Agropyron spicatum),* which is a native of the Western Plains. Western wheat-grass is a pest and is difficult to eradicate from fertile, moist soil in eastern and central Kansas. It is, nevertheless, of value for pasture and may be recommended for seeding in western Kansas, though at this time seed is difficult to obtain, since the grass has not been domesticated. Western wheat-grass is well worthy of cultivation and improvement.

Chess

Chess, or cheat *(Bromus secalinus)* is one of the brome-grasses; but instead of having great economic value, like *Bromus inermis,* it is a foul weed that is very troublesome in the winter-wheat growing states. This is the common cheat-of-wheat, so-called, perhaps, because it often deceives the farmer and cheats him out of a crop. It grows very much like winter wheat, growing from seed in the fall, living through the winter, starting again early in the spring, and maturing a little earlier than the wheat. The ripe seed

[1] Published by Webb Publishing Co., Minneapolis, Minn.

The Vermont Experiment Station has recently published Bulletin No. 149, "A Practical method ofKilling Quack-Grass."

shatters, thus re-seeding the ground for the next crop. If the wheat is checked or killed by winter freezing, chess may take its place and give the farmer a crop of cheat instead of wheat. So often has this occurred that, until recently, many farmers believed that wheat turned into cheat. Since this grass is a winter annual, growing each fall from seed matured that same season, it is readily controlled by a rotation of crops which includes corn or other inter-tied crops. Then if the seed-wheat, or other seed-grain is carefully graded, a chess-free crop may be secured.

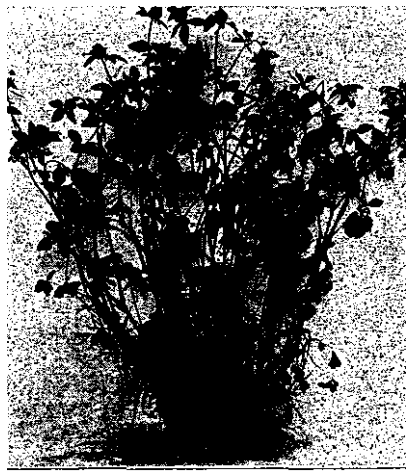

FIG. 35.—Medium Red clover.

This grass has some value for winter and early spring pasture, and may make fair hay if cut before it blooms. But other grasses are to be preferred for such use. As a matter of fact, chess is often found as an adulterant of orchard-grass, meadow fescue, and *Bromus inermis* seed. Its presence in grass seed is doubtless often an accident, due to the presence of the chess in the meadow, except the first year after seeding. It is readily destroyed by mowing before it seeds.

Crab-Grass

Crab-grass (*Panicum sanguinale*) is really a species of millet, belonging to the same genus as Japanese barn-yard grass *(Panicum crusgali).* It is an annual which grows best in the hottest weather. Its flowering spikelet bears some resemblance to the claw of a crab, hence the name. The grass spreads rapidly because the

stems partly recline and tend to root at each joint. It matures quickly and seeds abundantly. The seeds may retain vitality for several years when buried deep in the soil without favorable conditions for germination.

Crab-grass is a great pest in corn and in other inter-tilled crops, for the quick-rooting, intertwining stems make it difficult to destroy by cultivation. The fact, also, that the seed germinates late in the season, after the ordinary cultivation of corn ceases, makes it a very difficult weed to eradicate. If rains follow the harvest, this grass springs up quickly in grain-stubble fields and grows rapidly, maturing seed in a few weeks. In such cases, it may be cut for hay or used for pasture. It is best controlled by planting late smothering crops, such as sowed cane, or Kafir, or by rotation of such crops as will require late cultivation or a partial summer fallow. A season or two of thorough, late cultivation will clear the land of this pest.

Crab-grass has some value both for hay and for pasture, but it is seldom used for this purpose. Sometimes, if a crop of it is prodated, the farmer attempts to plow it under before it seeds and then it furnishes some green-manure. More often, the mature crab-grass is burned off in preparing the land for planting the next crop. While this grass may have some local economic value, it is a troublesome weed in Kansas and should be dealt with strenuous1y.

Clover

It is not the purpose in this bulletin to treat the subject of clover fully. The term "clover" includes a number of species of several genera of the *Leguminosæ* family, which, as a group, are excellent forage crops and unequaled as soil fertilizers. Botanically, the true clovers belong to the genus *Trifolium,* plants with leaves divided into three leaflets and flowers collected in cone-shaped spikes or rounded heads. Several valuable cultivated species are medium red clover *(Trifolium pratense),* mammoth clover *(Trifolium magnum),* Alsike clover *(Trifolium hybridum),* small white clover *(Trifolium repens),* and crimson clover (*Tribolium incarnatum).* Agriculturally, several other valuable leguminous plants are classed as clovers; one of the most valuable of these is alfalfa *(Medicago sativa).* Other species which have more or less value are Bokhara, or sweet, clover, (*Melilotus alba*), Japan clover *(Sespedeza striata),* and burr clover *(Medicago denticulata).*

All the plants of the clover family have the power to take from

the soil the nitrogen required for their growth. They do this by means of bacteria which live in little tubercles or nodules on the clover roots. Thus clover may not only produce large yields of valuable forage very rich in that most important food constituent, protein, without drawing on the nitrogen of the soil, but by its growth of roots and by the accumulation of nitrogen compounds in the tubercles and in the roots, clover actually increases the supply of available nitrogen in the soil, thus enriching the soil. However, the long and continuous growing of clover may largely exhaust the supply of mineral plant-food elements in the soil, causing the soil to become "clover sick" or unbalanced in plant-food supply and hence non-productive of all other crops as well as of clover.

The Common Field Clovers

Many of the general principles as related to seed-bed preparation, seeding beds, making hay, etc. that apply to grasses, apply equally well to clovers. There are, however, slight differences in the time and methods of seeding best adapted to certain varieties of clover, as compared with grasses. For instance, in this climate, medium red, mammoth, and Alsike clovers are not safely seeded in the fall, since the fall-seeded clover is very likely to winter-kill. Clover should be seeded early in the spring, or it may be fairly successful if planted in well-prepared soil in the late summer. In Kansas, it is the usual custom to seed clover early in the spring with a nurse-crop of small grain, as clover succeeds better, perhaps, than most grasses when sown with a nurse-crop. However, it will usually succeed best when sown alone. Clover should always be mowed or pastured in the fall of its first year. This is necessary in order to prevent it from seeding, since if the plants produce seed they are apt to die during the first winter, leaving a thin, patchy stand the next season when the largest crop should be produced. Of the common clovers, medium red, and mammoth are ordinarily biennials, the plants dying the second year, or after producing seed. White clover and Alsike are more nearly perennial, though the stand of Alsike clover gradually becomes thinner and is seldom thick enough to leave after the third year.

Unless grown for seed production, clover should be sown usually in combination with grasses both for pasture and for meadow. If the clover is not pastured too closely or cut too frequently, it will re-seed itself sufficiently to maintain a partial stand for a long period, or by scattering a little new seed occasion-

ally early in the spring, clover may be continued indefinitely. In fact, it is advisable, where clover succeeds, to scatter clover seed occasionally in permanent pastures, or in meadows where it will act as a fertilizer of the soil.

FIG. 36.—Alsike clover.

Fig. 37-- Common white clover.

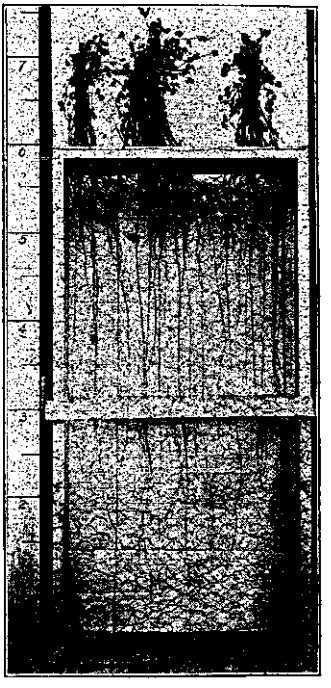

FIG. 38.—Medium Red clover roots. Sample taken August 19, 1904, being the second crop of clover for that season. This clover was seeded in the spring of 1903.

Common clovers are not so well adapted to Kansas conditions as is alfalfa, except perhaps in the eastern and southeastern part of the State. Clover cannot be recommended for seeding in middle and western Kansas except under special conditions, as on low, well-watered land or on land too wet to grow alfalfa.

Medium Red Clover

For producing valuable forage and enriching the soil, medium red clover exceeds the other varieties. It produces regularly two or more cuttings each season, while other varieties usually produce one cutting. It furnishes early and late pasture. It is a surer seed producer and is better adapted to ordinary conditions

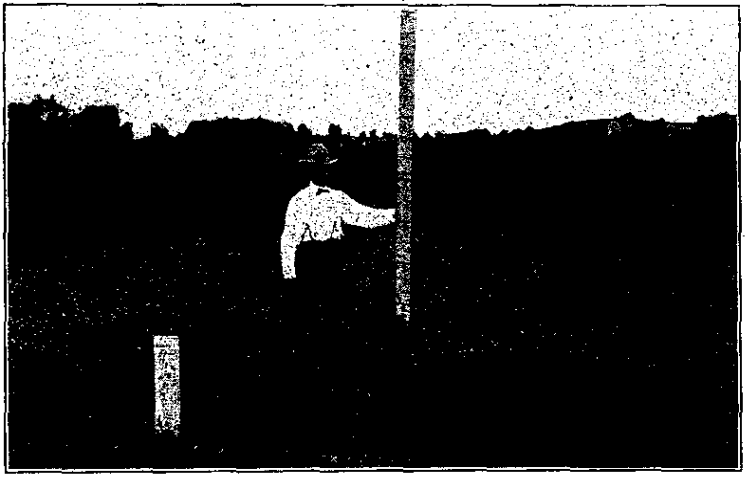

FIG. 39.—Variety plot of Alsike clover, June 23, 1904. Photo taken just before cutting for hay. Seeded in the spring of 1903.

FIG. 40.—A typical Kansas alfalfa field.

than either the Alsike or the mammoth varieties. As a soil improver it is rarely excelled by any other legume when used in regular rotation, except that alfalfa or mammoth clover may perhaps exceed it in certain soils and under certain climatic conditions.

ALSIKE CLOVER

Alsike clover is less coarse, more reclining in its habit of growth, and more leafy than medium clover. It is also more hardy and better adapted to wet or poorly drained land. Because of these characteristics it is preferred to the medium or mammoth clover for pasture. White clover is superior to Alsike as a permanent pasture plant.

MAMMOTH CLOVER

Mammoth clover is larger and coarser than medium red clover. Its roots are larger and extend deeper into the sub-soil. As a soil improver it may be somewhat superior to the other clovers, especially on heavy land with clay sub-soil. For hay it is inferior to Alsike or medium clover because of its coarse, stemmy character; and it is also less valuable for pasture, since it starts later in the spring and does not make so rapid a growth after cutting as do the other clovers.

WHITE CLOVER

White clover, the hardiest and most widely distributed of all clovers, is peculiarly valuable as a pasture plant when combined with Kentucky blue-grass. Its presence in Kentucky blue-grass pastures, while often decried by farmers, is really very necessary in order that the stand and productiveness of the blue-grass be maintained. It is somewhat objectionable for pasturing horses, causing slobbering; yet it really adds to the richness of the forage and its presence increases the amount and improves the quality of the grazing, due to its fertilizing effect on the soil. Where it thrives best, white clover is unexcelled as a honey producer, which is another reason for maintaining it in pastures and lawns.

Annual Clovers

CRIMSON CLOVER

Crimson clover is one of the more important annual clovers. It is adapted to a moist, mild climate. The usual practice is to seed it in the summer or early fall. It then grows late into the autumn furnishing fall and winter pasture. It starts early in the spring and may be used for pasture or soiling, cut for hay, or plowed under for green manure. Where it succeeds well, it is a valuable

soil fertilizer. It is better adapted to soils low in fertility than are most other legumes.

It is doubtful whether crimson clover may be profitably grown in Kansas, for it has not succeeded very well at the Kansas Experiment Station. Seeded in the spring, it makes little growth and it is not hardy when seeded in the fall. In the southern counties of the State it should give better results and may be recommended for trial by early fall seeding.

JAPAN CLOVER

Japan clover is one of the hardiest plants of the clover family for a warm climate. It is well adapted to conditions in the southern states, but it is not hardy in the colder climate of the northern states. In recent years, it has been introduced into parts of southern Kansas, where it appears to be quite hardy, growing and thriving in the native prairie pastures to such an extent that some farmers fear it will crowd out the grasses. However, Japan clover is more likely to invigorate the growth of the grass by increasing the fertility of the soil. It also adds to the amount and richness of the grazing.

Japan clover retains its hold on the soil by re-seeding itself each year. It starts very late in the spring and is checked by the first autumn frosts; yet, where the climate is warm enough, when once established it is very persistent, and its power of self-propagation in the South nearly equals that of white clover in the North.

Japan clover is usually seeded in the spring. It may be sown in the fall in the southern states; but in Kansas, late spring seeding is preferable on account of the tender nature of the young plants, which are likely to be destroyed by a late spring frost. Perhaps the only practical use for Japan clover in this State is for pasture. In seeding the pasture early spring discing previous to seeding and light harrowing after seeding will greatly assist in securing a good stand. When well started under conditions which allow its growth, it will continue to propagate itself unless grazed so closely as to prevent it from producing seed. Late fall or early spring discing and harrowing will favor the starting of the young clover and may also increase the growth of other grasses.

SWEET CLOVER

The value of sweet clover is variously estimated by different farmers in different parts of the country. By some it is considered an objectionable weed of no value, while others claim it is equal to alfalfa as a forage crop. This difference in opinion is

largely due to the different methods of handling the crop. If sweet clover is allowed to grow large and coarse, its natural condition as a roadside weed, it has little value. When seeded thickly in cultivated fields and pastured closely or mowed early, it makes good pasture or yields a fair quality of hay of high nutritive value. Its worst characteristic is its bitter taste, to which live stock must become accustomed before they will eat it readily. It appears, however, that stock learn to like sweet clover, and will thrive on it. Sweet clover is also valuable for bee pasture, producing much honey of excellent quality.

Perhaps it is most valuable as a soil fertilizer when grown in rotation with other crops. It is adapted to poor soil and is a good crop to precede alfalfa in order to put the soil in good tilth and to provide bacteria for starting the young alfalfa. Sweet clover bacteria will also live and thrive on alfalfa roots and insure the successful growing of alfalfa in soils which are lacking in alfalfa bacteria.

In the southern states, sweet clover should be seeded in the spring, but in Kansas and in states farther south, late summer or early fall seeding should be preferred. If sown too late in the fall the young plants are likely to winter-kill. When the plant produces seed it dies, but by pasturing or frequent cutting, sweet clover may be made to continue its growth during the summer. If allowed to mature seed it readily re-seeds itself and maintains its stand. As a weed, it is often so persistent that many farmers have supposed the plant to be perennial and difficult to eradicate; but this is not true. A single year's thorough cultivation of the soil will practically clear the land of sweet clover, and it may be largely destroyed by mowing when the plants are in full bloom.

Sweet clover may often be advantageously sown in old pastures and on roughland, where, when it becomes established, it will add much to the amount of grazing. By improving the fertility of the soil, it will cause a renewed growth of other grasses.

There are two common varieties, the white-flowered and the yellow-flowered. The white-flowered variety is a ranker, coarser grower and perhaps a better fertilizer, though it may have less value for hay or pasture, The yellow-flowered sweet clover is less coarse, more reclining in its habit of growth and more leafy than is the other variety. It would seem to be the better variety for pasture and perhaps for hay. It is not so widely distributed as the white-flowered variety and may not be so hardy. There seems

to be no record of comparative tests of these varieties to prove their relative value.

Burr Clover

Burr clover is not hardy in Kansas, but succeeds well farther south. It is a fall annual or biennial, starting early in the autumn and, in a mild climate, growing late in the winter. It matures its seed early the next spring, ripening in May. It has considerable value for winter pasture in the southwestern states, but its particular value lies in its adaptability as a catch-crop, or fertilizer.

Conclusion

In this bulletin I have presented certain experimental data which have been secured during the past eight years by myself and my assistants in the Department of Agronomy at the Kansas State Agricultural Experiment Station. I have also attempted to give to my fellow farmers the benefit of my observation, investigation, and experience along this line, carefully summarized in the general information and suggestions published in these pages. I hope and believe that this bulletin will do much good.

Few of us have even begun to appreciate the value of grass to permanent and successful agriculture. Without grass and its allies, clover and alfalfa, profitable agriculture would soon cease. As a modern agricultural writer puts it: "No grass, no cattle; no cattle, no manure: no manure, no grass," and we may truthfully add, "no crops." We have the saying, "more truth than poetry." This bulletin is not poetical, but there is poetry in grass and there is truth in poetry, and as a tribute to grass and also to one of Kansas' greatest sons, John J. Ingalls, I wish to conclude this bulletin by quoting Mr. Ingalls' magnificent prose-poem:

"Grass is the forgiveness of Nature– her constant benediction. Fields trampled with battle, saturated with blood, torn with the ruts of cannon, grow green again with grass, and carnage is forgotten. Streets abandoned by traffic become grass-grown like rural lanes, and obliterated. Forests decay, harvests perish, flowers vanish, but grass is immortal. Beleaguered by the seven hosts of winter, it withdraws into the impregnable fortresses of its subterranean vitality and emerges upon the first solicitation of spring. Sown by the winds, by the wandering birds; propagated by the subtle horticulture of the elements, which are its ministers and servants, it softens the nude outline of the world. Its tenacious fibers hold the earth in its place and prevent its soluble

components from washing into the wasting sea. It invades the solitudes of the deserts, climbs the inaccessible slopes and forbidden pinnacles of mountains, modifies climates, and determines the history, character, and destiny of nations. Unobtrusive and patient, it has immortal vigor and aggression. Banished from the thoroughfare and the field, it bides its time to return, and when vigilance is relaxed, or the dynasty has perished, it silently resumes the throne from which it has been expelled but which it never abdicates. It bears no blazonry of bloom to charm the senses with fragrance or splendor, but its homely hue is more enchanting than the lily or the rose. It yields no fruit in earth or air, and yet, should its harvest fail for a single year, famine would depopulate the world."

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