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BUFFALO GRASS

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BUFFALO GRASS[1]

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INTRODUCTION

Buffalo grass is one of the important crops of Kansas and of the Central Great Plains states. Its value in soil conservation and in the production of meat, milk, wool, and leather has long been recognized. Unfortunately, too many acres of the native prairie were plowed up for the production of other crops before its true value to the agriculture of the area was fully appreciated. The need for practical methods of re-establishing this grass has been growing with the years. In the absence of seed, methods of resodding were developed, but owing to excessive labor costs, the resodding practice was accepted only for establishing lawns and other small areas. During the last two years, however, seed has become available on the market and methods of inducing high germination have been developed. It is now practical to re-establish buffalo grass with consistent success.

Buffalo grass has no superior as a productive source of livestock feed on at least a part of the rolling, erosive and unproductive areas in the Central Plains. It likewise is well adapted as a protective turf on newly-developed air-fields, cantonments, ordinance plants, and other units in the region where the control of dust and erosion is essential. For these purposes, particularly on the heavier soils in the drier section of the Central Plains where Bermuda grass is not sufficiently winterhardy, buffalo grass has no superior.

Buffalo grass has been given little intensive study in the past. Published information is limited and fragmentary. The subject is treated herein rather fully. A detailed index will permit ready usage.

DESCRIPTION OF BUFFALO GRASS

BOTANICAL CHARACTERISTICS

Buffalo grass, *Buchloe dactyloides* (Nutt.) Engelm., is a low-growing, long-lived, drought-resistant perennial grass which spreads vegetatively by numerous surface runners. Profuse branching of the runners enables this grass to form a dense sod which is capable of withstanding considerable trampling. The short, dense, flat leaves of buffalo grass are covered with fine hairs which give the leaf surface a gray-green color instead of a bright green such as some grasses possess. The normal color gives way each fall to a purplish-red hue as cool nights begin. After several freezes, they

1. Contribution No. 40 from the Fort Hays Branch Experiment Station, in coöperation with the Division of Forage Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, United States Department of Agriculture.

2. Forage Crops Specialist, Fort Hays Branch Experiment Station, and Agent, United States Department of Agriculture, in charge of forage investigations.

become curly at the ends and take on a light-brown color until spring.

The reproductive organs, or flowers, are not commonly unisexual and are found on different plants, but are, in a small percentage of the cases, found on the same plant. Plants that have both male and female flowers are referred to as *monoecious,* while those having flowers of only one sex are referred to as *dioecious.* The male, or

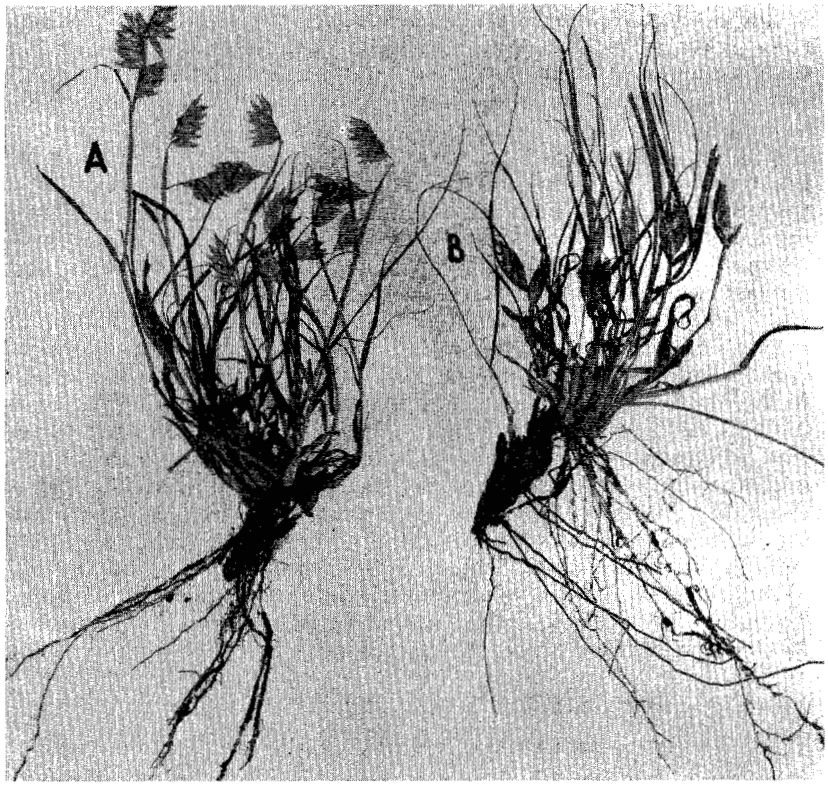

FIG. 1.—A. Male or staminate plant of buffalo grass showing the taller-growing, pollen-producing flowers.
B. Female or pistillate plant of buffalo grass showing how the burs or seeds are produced down among the leaves.

staminate plant, bears only pollen, whereas the female or pistillate plant bears only seed. (Fig. 1.) Frequently the staminate inflorescence is mistaken for the seed.

Male plants are distinguishable by the staminate inflorescences which protrude an inch or two above the leaves. Pollen is produced in two- or three-flowered spikelets contained in the two or three short spikes at the apex of slender culms. The female plants bear their pistillate inflorescences, consisting of from two to five ex-

tremely short spikes, commonly referred to as burs, down among the leaves where they are revealed only by close examination. These burs are produced on culms varying in height from ground level to several inches high, depending somewhat upon height and density of the leaves. The kernel or caryopsis is produced within the single-flowered spikelets of the bur and each bur may contain from three to 17 spikelets.

From counts of large populations, it has been determined that approximately 45 percent of the plants are male or staminate plants; 45 percent are female or pistillate plants; and the remaining 10 percent usually have flowers of both sexes. The sex behavior of this grass does not seem to be perfectly stable as various types of inflorescence variations have frequently been noted (18).[3] These variations throw some light on the historical botany of this grass but are of little practical value.

GROWTH HABITS

Buffalo grass is definitely a warm-season grass. Germination will not take place, regardless of when the seed is planted, until the days become warm in the spring. First seedling emergence usually coincides with the last killing frost in the spring. On established plantings, new growth in the spring begins two to three weeks earlier than the seed can be expected to germinate, but the rate of growth does not become vigorous until a few weeks later. In the latitude of Hays this is about the first of May. The first scattered flowers appear about May 10 and with normal seasonal conditions the height of the flowering period is reached during the last of May. Favorable rainfall during the month of May is essential to the setting of a heavy seed crop. Continued, favorable rainfall during June is necessary for the growth and development of this crop which usually ripens between July 15 and July 20.

The usual summer drought periods, accompanied by high summer temperatures, cause buffalo grass to dry up temporarily. If these periods are not too frequent or too prolonged, the grass generally shows no ill effect and will green up with the coming of the first good rain. During years when rains are timely and well distributed the grass remains green all season.

Vegetative growth slows up with the advent of shorter days and cooler nights in the fall and practically ceases by the time of the first killing frost. The foliage may not be completely killed back, however, until temperatures considerably below freezing result. Frequently in areas supporting a heavy growth of grass, the undergrowth remains green well into the winter.

Buffalo grass is famous for its palatability and nutritional qualities, especially in respect to winter utilization. Seasonal conditions, however, play an important part in determining the quality of forage whether it is utilized either in summer or in winter. Years with

3. Numbers in parentheses refer to literature cited, p. 78.

abnormally heavy spring and summer rainfall generally produce an abundance of forage but too frequently such forage lacks in feeding quality. Stockmen say such grass lacks "strength" or is "washy." This type of growth does not make desirable summer or winter pasture. Years with unseasonably wet periods in the fall may result in a late rank growth which, if frozen down, is lower in quality than usual. Similarly, wet periods occurring late in the fall after the forage has already cured, cause leaching and will rot the forage, resulting in a serious lowering of its nutritional qualities.

NORMAL VARIATIONS

Buffalo grass as it occurs in nature is highly variable. Individual plants growing side by side in the same environment may differ in respect to number, length and width of leaves; height and amount of seed production; size and quality of seed; extent and rapidity of spread; susceptibility to certain diseases, as well as to many other characters. For pasture these variations may seem to be of little importance but actually they affect not only the yield but the quality of the forage as well. Where the grass is used for seed production, these variations are of more significance.

ADAPTATION

DISTRIBUTION

Buffalo grass occurs naturally throughout the Great Plains region from the Canadian line to the Rio Grande river (5, 11).[4] It is of greatest importance in the Central Plains area where it and blue grama *(Bouteloua gracilis* Lag.) compose more than 90 percent of the native vegetation on the non-sandy soils. This area of major importance embraces approximately 190,000 square miles and includes south-central and the extreme western half of Nebraska, the western half of Kansas, the eastern fourth of Colorado, the western third of Oklahoma and northwest Texas. (Fig. 2.)

Although buffalo grass is best adapted to this area, it occurs in pure stands only in pastures (a) that have been continuously overgrazed for some time, (b) in pastures that were so severely dusted during the "major drought" that only the buffalo grass has been able to make a comeback and (c) in naturally revegetated areas that were once under cultivation. It normally occurs in mixtures and should be reseeded in mixtures with other short grasses of which blue grama is by far the most important.

Blue grama grass, although often mistaken for buffalo grass, is readily distinguishable from the latter. It is a typical bunch grass and does not spread by surface runners as does buffalo grass. Its leaves are more narrow and erect, and the seed is produced in flag-

4. The writer is under obligation to the following men for supplying information relative to the adaptation and distribution of buffalo grass: K. L. Anderson, B. F. Barnes, H. M. Benedict, L. A. Clark, C. E. Fisher, C. J. Franzke, R. L. Hensel, B. F. Kiltz, Leroy Moomaw, E. W. Nelson, L. A. Newell, G. A. Rogler, H. W. Staten, A. D. Stoesz, and S. E. Wolff.

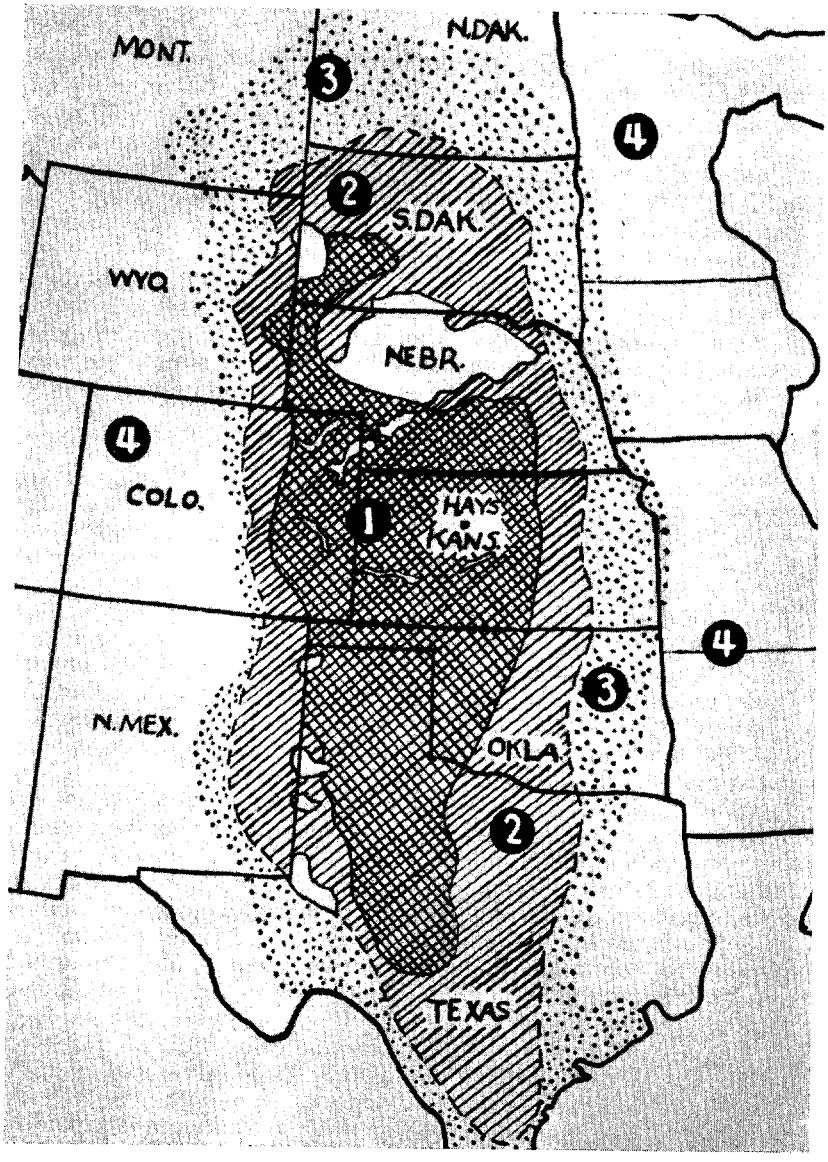

FIG. 2.—Regional distribution and importance of buffalo grass as indications of its value for revegetating cultivated land.

1. Area of major distribution and importance. With blue grama constitutes better than 90 percent of the native vegetation on the nonsandy soils. Should be of primary consideration when regrassing cultivated land.

2. Area of secondary distribution and importance. Of greatest value on the heavier soils under heavy grazing systems. One of several grasses to consider in revegetating cultivated land.

3. Area of minor importance. Indicates outlying distribution where it occurs generally as single plants or on small localized areas. Should be considered for revegetation purposes only on heavy soils where it has proved by trial to have definite value.

4. With the exception of the Black Hills area in western South Dakota which also contains no buffalo grass, the light areas indicate sandy soils containing little or no buffalo grass.

like heads at the top of stems which average nearly 18 inches in height.

In an area surrounding the region of major importance, particularly to the north and south, buffalo grass is of at least secondary importance. In this territory it occurs in varying degrees of abundance dependent primarily upon soil type and closeness of grazing. This area is large, comprising 234,000 square miles, but throughout its extent, from southwestern North Dakota and southeastern Montana to southern Texas, buffalo grass is a desirable component of the grass mixture, especially for heavier-type soils.

Small areas of buffalo grass may be found outside of this region of secondary importance, but in these areas there are other grasses which do as well or better. This third area is outlined in Figure 2 primarily to show the approximate outer limits of buffalo grass and not to recommend its use except where it has been proved of value.

CLIMATE AND ITS EFFECT

Buffalo grass normally thrives best in the Great Plains territory having a rainfall range of from 12 to 25 inches. The severe drought of the Thirties and the transition in farming systems, which have resulted in more intensive use of pastures, have pushed it eastward to the 28-inch rainfall belt. This is especially true in Kansas and In the states to the south but is not true to the same degree in the North Plains territory where buffalo grass is not so well suited to the low temperatures as some of the native and cultivated grasses. This situation in Kansas, according to early observers (3, 4, and 15), represents more closely the condition existing before the country was settled when prairie fires and heavy grazing by buffaloes discouraged the taller grasses.

Although pastures of nearly pure buffalo grass may be found east of Abilene, Marion, and El Dorado, Kansas, it cannot be expected that this grass will continue to thrive there. Wet seasons such as 1941 and 1942 create conditions more favorable for the bluestem grasses than for buffalo grass, and when they gain sufficient foothold they will crowd out the latter grass. Over a period of years the eastern boundary of the buffalo grass region will be found to occupy a shifting position, retreating westward in wet periods and advancing eastward in dry periods.

The present boundary line between the short and tall grasses is approximately 75 miles east of where it would have been placed a generation ago. Because the bluestems were so extensively reduced during the severe drought, years and because of the present methods of pasture management, it appears that this boundary will continue to approximate its location. It is a common expression among farmers in the area that they would rather have the short grasses than the tall grasses because of their ability to withstand year-around grazing.

Along with drought resistance, buffalo grass is heat resistant and has a fairly high degree of cold tolerance. Except in the extreme

north, it is able to survive successfully the coldest winters. It also withstands the rather frequent severe droughts and periods of high wind that are common to the entire Plains area. Buffalo grass cannot, however, survive in dense shade, which limits its use for many landscape-planting purposes.

SOIL AND HABITAT REQUIREMENTS

Buffalo grass prefers the heavier soils but will grow on a fairly wide range of soil types. Although it is more productive on the rich heavy soils of the region, it also grows well on the poorer, badly eroded soils. It may even be found growing on rocky, calcareous slopes in mixtures with blue grama, side oats grama, sand dropseed, little bluestem and hairy grama. It prefers well-drained soils and, because more vigorous grasses offer it severe competition, it cannot survive on watercourses that carry frequent surges of silty flood waters.

Buffalo grass does not thrive on soils containing an excessive amount of sand. For this reason, it is not a common grass in the "sand-hill" areas of the region. In such areas it may occur sparingly on the flats and drainageways where the soil contains considerable silt, and flooding is not excessive.

In considering the revegetation of cultivated areas, soil type is of prime importance. Areas consisting of heavy to semi-heavy soils should be planted to mixtures containing a high percentage of buffalo grass. For special purposes, even pure stands can be established on such soils. As the soils become lighter, the proportion of buffalo grass should be decreased and supplemented by better-adapted species, such as blue grama, side oats grama, little bluestem, and sand dropseed and hairy grama. On the more sandy soils the use of buffalo grass in the mixture should be extremely light or omitted entirely.

RESPONSE TO CULTIVATION

Buffalo grass, although recognized and often praised as being palatable and nutritious, has many times been criticized for its relatively light production under range conditions. Dr. George Vasey of the United States Department of Agriculture, said in 1889: "It may be safely laid down as principle that no great improvement in this respect can be expected without cultivation of the soil. With this, even the buffalo and grama grasses may be expected to double their production" (15).

New seedings exhibit greater vigor and higher production than native pastures for three to six years after establishment and may continue to show some advantage for a longer period of time. Savage and Runyon (13) reported that abandoned fields fully covered with buffalo grass withstood the drought up to 1936 much better than adjacent virgin pastures. Instances are reported where seed yields from commercial harvests in 1941 and 1942 were many times greater on naturally-revegetated fields than from adjacent native

pastures. This was true, not only where the virgin pasture contained a considerable mixture of blue grama, but also where the native stands consisted largely of buffalo grass. Dickson and his associates (2) reported it a common observation to see newly-sodded lawns reach their peak of excellence a few years after transplanting and after a period of 8 to 10 years die out almost completely.

Several explanations for this favorable response have been suggested. One is that root competition in new plantings is not so serious as in older plantings. The better aeration of recently-cultivated soils may play some significant role. There is also the possibility that new plantings are continually tapping new stores of plant food and deep moisture as they develop. Another thought is that new roots and new plant systems are more efficient in their use of plant food and water. Possibly soil flora developing in old plantings and having a depressing effect upon the plant are destroyed by cultivation which gives the new stand a better opportunity.

Admittedly these explanations do not explain to a satisfactory degree the benificial effects that are apparent in revegetated areas, sometimes apparent over a long period of years. However, the condition exists and it is a means whereby the return in pasturage may be increased. Revegetation would seem to be highly practical through the use of medium-length rotations with cultivated crops. Such rotation systems would also aid materially in maintaining the soil fertility level and are entirely feasible now that practical methods of re-establishing this grass in a relatively short period of time have been perfected.

ESTABLISHING STANDS OF BUFFALO GRASS FOR PASTURE

Nearly every farm in the territory where buffalo grass is adapted has at least a small acreage of cultivated or waste land that is desired back in grass and, of course, a number of farms have large areas that should never have been plowed. There are at this time three general methods of obtaining buffalo grass on the areas that are suited to its production. These methods include *(a)* natural revegetation, *(b)* vegetative propagation, and *(c)* seeding. The following discussions of each practice will disclose their relative merits for any farm under consideration.

NATURAL REVEGETATION

Natural revegetation, as the name implies, simply means allowing the land to revegetate itself naturally any way it will. Although the method has been used quite extensively in the past, because of the absence of more practical methods, it requires so long and is such a wasteful system of management that its use is not generally to be recommended. Investigators who have studied the practice (13, 14) report that such land seldom becomes fully revegetated

with the more desirable grasses in less than 25 years and often more than 40 years are required.

These areas in passing through their various stages of reclamation, often leave their marks upon the agriculture of the region. The first few years after abandonment, annual weeds and annual grasses take over. During this stage, fields in the sections of lighter soils are likely to become bad "blow spots," in which case they may have a ruinous effect on the surrounding area. In the districts of heavier rainfall they are subject to severe erosion and much gullying is likely to result before the soil finally becomes stabilized. Following the annual weed stage are successive periods when mixed weeds and short-lived perennial grasses predominate. About this time, if the soil is suited to its growing, scattered plants of buffalo grass appear. These few plants grow and increase and in the final stages will gradually over-run the area until nearly a pure stand is obtained. Fortunately such stands, if the soil has not been depleted too seriously during the long interim of natural comeback, are often quite productive.

RESULTS WITH TRANSPLANTING VEGETATIVE MATERIAL

Because of its spreading habit of growth, buffalo grass lends itself to vegetative methods of propagation. At about the time the wheat market began to decline in the late Twenties and the need far regrassing the most unproductive cultivated areas became apparent, investigators looking for a way to re-establish this valuable grass turned to vegetative methods to determine their possibilities in the absence of seed supplies.

D. A. Savage, in charge of the forage crops work at the Fort Hays Branch Experiment Station from 1929 to 1936, inclusive, began a systematic study of resodding buffalo grass in 1929 and carried it on for five years (11). Since that time large field plantings have been made, to substantiate these earlier detailed studies and also to obtain information on actual labor and material requirements. These experiments provide a fund of information relative to many of the phases of sodding this grass.

Transplanting Runners.— Transplanting runners is dependable only where artificial watering can be employed. Under field conditions the method is very impractical for three reasons. First, in the region where buffalo grass is adapted, soil and climatic conditions are not favorable for spontaneous rooting of the nodes which is essential to success; second, the method is too laborious and consequently too expensive; and third, a suitable source of runners easily secured is often not available on the average farm.

Broadcasting Sod.— Another method consists of broadcasting pieces of sod with a manure spreader or some similar implement or broadcasting by hand on recently-cultivated land and packing or rolling the soil immediately afterward. This method is fairly successful but is yet a hazardous method under all but the most favorable moisture conditions. Besides requiring much labor to reduce

the turf to suitable pieces for spreading, this method also requires an enormous amount of sod to plant a given area. Savage (11) found that by cutting the sod in shallow strips and placing as large pieces as possible in the manure spreader, that the reel did a fairly good job of distribution. Furthermore, it seemed the soil was not shattered from the roots so badly as where the turf had been cut, previously into small pieces. The method, however, at its best gave no quicker coverage than where 4-inch cubes were transplanted three feet apart and the requirements for labor and especially sod were considerably less where sod cubes were used.

Dormant seed normally present in buffalo grass turf usually will provide a feeble source of planting material in event the vegetative material fails. Despite this assurance of an ultimate stand the method is not recommended generally.

Spot Sodding.— Probably the first demonstration of sodding native grass in Kansas was carried out by Sewell on the experiment station farm at Garden City in 1888 (16). Lyon and Hitchcock (7) in 1904 suggested establishing buffalo grass by transplanting small pieces of sod and pressing them into prepared soil. In 1912, two of the residence lawns on the Fort Hays Branch Experiment Station were successfully established by the sod method. Sodding thereafter became a more or less common practice of establishing lawns but was not used extensively for regrassing cultivated land. Although, as a result of the detailed studies inaugurated in 1929, highly successful methods of sodding were developed, the requirements for labor are so excessive as to limit their use to small areas or to the establishment of special increase areas for the growing of seed.

Time to Sod.— Although buffalo grass has been successfully sodded at Hays in almost every month of the year, the optimum transplanting season is in the spring months when evaporation is low and rains are more frequent. This is especially true on large cultivated areas where irrigation is not possible.

The months of April, May, and June are normally good months for sodding. Periods following a good rain are ideal when moist sod pieces handle easier and with less crumbling than dry sods. Likewise these moist sods, when transplanted into freshly-cultivated moist soil, suffer less setback than dry sods, which assures a better percentage of survival.

When buffalo grass is sodded during the winter months from October to March, water is almost always necessary to keep the sods from drying out as a result of winter winds and freezing. Although sodding at this time may be convenient for lawns and landscape areas it is not recommended generally as the watering encourages the growth of winter annual grasses and weeds. These pests, of which little barley and tansy mustard are the most common, grow until early in the summer, thereby weakening the buffalo grass. Plantings made during the recommended season tend to

escape these pests and will sod over in a much shorter period of time.

Preparation of Soil for Sodding.—Various implements may be used to prepare a seedbed satisfactory for transplanting buffalo grass sods. Since the most common methods of spot sodding require that the soil be thoroughly worked and loosened to a depth of about 4 inches, the one-way wheatland disc plow, tandem disc harrow, duckfoot field cultivator and springtooth harrow each has a place. The first two implements are better adapted to firm, trashy fields while the latter have advantages on fallow or recently-cultivated seedbeds.

Fallow and spring-grain land, on which the weeds have been controlled, usually make better seedbeds than sorghum, corn, or close-drilled feed land because of their advantages in moisture. These seedbeds, however, offer little resistance to blowing and thus are hazardous to use in sections where blowing is likely to be a problem.

Securing Sods.—Transplanting material should be obtained from areas containing practically pure stands of buffalo grass. Native pastures usually provide the best sources, although areas of relatively pure buffalo grass should be selected with care, as blue grama may compose a considerable portion of the sod. Blue grama is not objectionable in itself, but as it is a bunch grass, no spread can be expected from sods composed largely of grama.

Newly-established buffalo grass as a rule does not make a good source of sod because the soil is loose and crumbles easily. Sods secured from native pastures are more likely to be firm and will not crumble if the growth of grass is vigorous and the soil contains a reasonable supply of moisture.

A special sod cutter may be constructed by bolting a sharpened, U-shaped, flat, steel blade to a plank so that the cutting edge will cut about 4 inches below the surface into the soil. It is cheap, easy to construct, and more efficient in preparing usable sod pieces than is a plow or any other common implement, on the farm. A series of holes in the blade will permit adjusting the depth of cut. A more elaborate cutter may be made by bolting the U-shaped blade to a frame with handles similar to the frame of a walking plow and supporting this by adjustable wheels controlled by a lever for adjusting the cutter in and out of the ground. A piece of old, stalk-cutter-blade steel is ideal for making the cutting blade, which is usually bent to cut a strip of sod 12 inches wide. One or two rolling colters, as desired, may be attached to this machine to cut, the 12-inch strip of sod into 4- or 6-inch strips as the implement, is drawn through the field. These strips can then be cut with a spade to the desired size. Sods between 4 and 6 inches square and between 3 and 4 inches thick make desirable pieces for handling and are as satisfactory and efficient in establishing stands as larger pieces.

In obtaining the sods, it is a good practice to work on the contour and to leave intervals of uncut sod to provide a base from which grass can spread and revegetate the furrows. The uncut areas will

prevent erosion while the furrows are "healing over." This usually requires only a season.

Distributing Sods and Subsequent Treatment.—Two methods of distributing the sods on the seedbed are common. One consists of sliding the sod pieces down metal chutes from a truck or wagon as it is driven through the field. The other consists of dropping the sod pieces by hand into small furrows and later packing the soil around the sod with a heavy roller. (Fig. 3.)

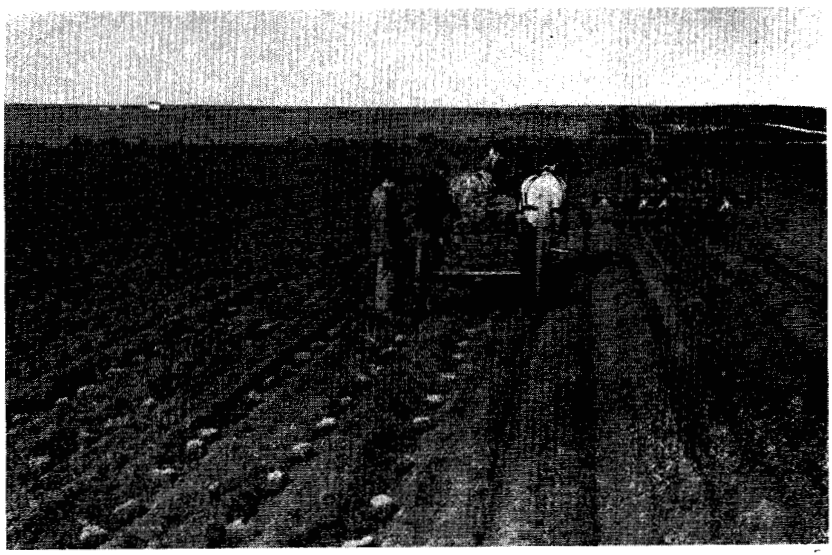

FIG. 3.—Spot sodding a cultivated field with buffalo grass. Despite the perfection and success of the method, it requires entirely too much labor to be practical except under very special conditions.

Sometimes in the first method the sods are directed just in front of the rear wheels of the truck which makes further packing unnecessary. The crushing effect of the truck or wagon wheels is rather severe, however, and some mortality usually can be expected. Some difficulty may be expected, too, in sliding the sods down the chutes. Frequently, they will not slide or if the chute is set at too steep an angle they tend to roll, generally landing on their sides or upside down. These difficulties require the careful attention of the operator at all times. Varying moisture conditions and size of sods determine largely how well the chutes work.

Furrows for the second method of planting can be conveniently constructed by the use of a duckfoot field cultivator using only those shovels that give the desired row spacings. After the rows are made, several rows can be planted at a time from the rear of a truck or wagon as it is driven through the field. To prevent excessive drying, rows should not be made far in advance of planting, and pack-

ing should be done immediately. The furrow method has an advantage in leaving the surface rough and receptive to moisture the first few months after planting. This is of special value on sloping land where it is always advisable to plant on the contour. Usually by the time the grass has grown together the surface has become leveled as a result of rains and grazing.

Coverage is obtained in direct proportion to the interval of spacing. Usually a well-established plant of buffalo grass under competition with weeds and with regulated grazing can be expected to make at least a foot of spread each season. Thus, it can be anticipated that sods spaced a foot apart will spread together the first year while those spaced five feet apart will require approximately five years to form a complete cover.

Weeds are always a troublesome factor until complete coverage is obtained. They may be controlled by mowing or by grazing intensively for short periods. Mowing should be done when the weeds become tall enough to shade the grass. Usually two or three clippings a season are sufficient to keep them under control. Cattle or sheep may be used to good advantage to remove the weeds if sufficient numbers can be placed on the area for short intervals before the weeds get too large and woody.

Labor Requirements for Sodding Large Areas.[5]—During the spring of 1940 a field of sufficient size was sodded to permit the securing of accurate records on labor and equipment requirements. Planting material was obtained from a near-by native pasture. The sods were cut with a sod cutter into 6-inch strips varying in length from 12 to 15 inches, a convenient size for handling, and were loaded on a low, flat-bed trailer pulled by a pickup truck and hauled to the edge of the field being sodded. Here the sods were cut again with corn knives into pieces between 4 and 5 inches long. Thus, they varied in sizes from 4 by 6 inches to 5 by 6 inches. As they were cut they were loaded again on a flat-bed wagon pulled by a team. The wagon was driven through the field and the sods dropped by hand at the desired intervals into furrows made with a duckfoot field cultivator. (Fig. 3.) A check on the time showed that only one-sixth of the total time was required for distributing the sods once they were prepared. Undercutting, loading, hauling, and recutting the sods required five-sixths of the total time.

This field was fallowed in 1939, was deeply cultivated with the duckfoot cultivator once prior to transplanting and just ahead of the sodding, and rows were made with the same duckfoot cultivator using only those shovels that gave the desired spacing. Immediately after distributing the sods, the team was unhitched from the wagon and hitched to a surface packer and the sodded area packed. Packing twice pushed much of the loose soil into the furrow and a good job of transplanting was effected with no hand work.

5. Information obtained from coöperative investigations conducted by the Soil Conservation Service and the Kansas Agricultural Experiment Station at the Fort Hays branch station.

The field was divided equally and two intervals of sod spacings used. Labor and equipment requirements per acre for the two intervals of spacing are presented in Table 1. Because of the excessive requirements for labor, it appears this method of re-establishing buffalo grass will be found practical only for small fields and for the establishment of seed fields where the crop must be propagated vegetatively to secure the desired results.

TABLE 1.—*Labor and equipment requirements in hours per acre for re-establishing buffalo grass by the spot sod method.*

ITEM OR EQUIPMENT.	27-inch sod spacing.	54-inch sod spacing.
	Hours	*Hours*
Tractor, 3-plow	1.0	1.1
Duckfoot cultivator, 14 foot	1.0	1.1
Farm wagon	12.0	3.2
Surface packer	1.5	1.6
Sod cutter	1.0	0.4
Pickup truck, ½ ton	13.7	4.7
Team (2 horses)	14.5	5.2
Man labor	65.4	23.1

PLANTING BUFFALO GRASS SEED

Until within the last few years planting buffalo grass by the seed method was impossible because there was no seed available. It was unavailable largely because the seed is produced so near the ground its harvest was considered impossible. Another factor partly responsible for the delay in the use of seed was the common idea that all seed was of low quality and would not grow successfully, even if it could be collected. The normal low yield of seed likewise provided no incentive for the perfection of machinery to accommodate its harvest. Today, however, buffalo grass seed is appearing on the market and successful methods of handling to insure good germination and successful establishment have been developed.

Although most of the buffalo grass seed available at this time is harvested from native pastures where low yields and unstable production prevent an adequate supply, the future is brightened by the fact that new methods of handling improved types give promise of high, consistent yields that will do much toward supplying normal demands.

These facts are of considerable importance to the agriculture of the region because they mean that buffalo grass may now be successfully and economically established on cultivated land within a short time where, heretofore, it required from three to five years by the best sodding method and from 25 to 40 years where the areas were allowed to revert naturally.

Treatment of Seed Usually Necessary.—Treatment of buffalo grass seed usually is necessary if the best results are to be expected. This is because dormancy is so pronounced that only a small percentage of the seed will grow the first year after planting. Before this fact was discovered the use of buffalo grass seed was regarded as impractical because it was thought the quality of most seed was so low that satisfactory stands could never be obtained. Finally, however, it was observed that, when fields planted with seed were left undisturbed for a period of years the grass eventually made a stand. Further study revealed that. final coverage was not entirely the result of the spread of the original stand, but was found to take place partly from the emergence of new seedlings which appeared in small numbers each succeeding spring. What was regarded for years as poor quality is now known to have been in reality the natural dormancy which is so pronounced in the seed of this species. This dormancy factor is responsible to a large degree for the recovery that has been and is being made in the drought-ridden pastures of the western part of the buffalo grass region.

Studies with well over one hundred strains and various lots of seed indicate that the extent of dormancy may vary considerably with the sample because of variations in strain and because of differences in methods of growing, harvesting, and handling. Usually, however, dormancy is so pronounced in all lots as to require treatment for maximum success. A preliminary germination test will be helpful in determining the need for treatment. Whenever a sample of good quality seed does not exhibit at least 40 percent immediate germination in the laboratory, it usually may be assumed that, dormancy is so pronounced as to require treatment.

Methods of Treating the Seed.—Many natural and artificial treatments have been studied in the search for practicable methods of inducing immediate germination in buffalo grass. In general the result's have been highly successful but the most effective procedures have by necessity become rather involved. The structure of the buffalo grass seed-unit (bur) itself has complicated this process. With the caryopsis or kernel enclosed within the tough bur-covering, there is little opportunity to reach the seed mechanically (such as is done in the scarification of other seed) without complete dehulling. In dehulling the protective value of the hull is lost. Thus, if the seed-bur is to be left intact, treatment must be accomplished in much the same indirect manner as weathering. Since this natural process is quite slow in bringing about an effective increase in the immediate germination, it has been studied, copied, and intensified with the result that highly successful treatments have been discovered.

To provide a rather complete understanding of the reaction of this grass to various treatments, brief discussions of most of the studies will be presented. These should be of value particularly to other students of the subject in that they should eliminate needless repetition and provide a basis for the development of quicker, easier and more economical methods of treatment.

Natural Processes. — Weathering, as observed in numerous instances and as pointed out by Pladeck (9), is a natural means of improving the germination of buffalo grass seed. The process, however, must extend through one or more winter seasons to be the most effective. Unfortunately, after weathering for this length of time, the seed all shatters to the ground where it may wash away, be eaten by insects and rodents, or become embedded in the soil. This means harvesting weathered seed is possible only by vacuum or wind-blast machines where, under the most favorable conditions, only a fraction of the seed may be retrieved. Thus, even though some improvement in germination may be obtained, the method is wasteful, costly, and not to be recommended generally. Very little seed of this type is to be found on the market.

Aging the seed through storage brings about a slow, gradual increase in germination. (Table 2.) However, the practice is slow, expensive, and involves the risks of insect damage and other storage troubles. Maximum germination can never be expected from this method because part of the viability is lost before all the dormancy is overcome. That some viability may be retained for a long period of time, however, may be indicated by the results of A. E. Lowe at the Garden City Branch Experiment Station in Kansas, who found that seed recovered from sod used to build a sod house still exhibited an average viability of 28 percent at the time the house was torn down 25 years later (6).

TABLE 2.—*The effect of various length water-soaking treatments on the germination of buffalo grass seed and the influence of storage on the germination of both treated and untreated seed as measured by laboratory tests.*[1]

Method, year and date of laboratory tests.	Percent germination (of burs containing seed).					
	Not soaked.	Soaked 24 hrs.	Soaked 48 hrs.	Soaked 72 hrs.	Soaked 96 hrs.	Average.
Germinated with water:						
April, 1940	8.6	47.1	61.5	62.8	54.2	46.8
June, 1941	17.1	47.6	73.0	76.5	63.8	55.6
April, 1942	30.5	66.5	75.0	83.5	75.0	66.1
Germinated with a 0.2 percent solution of potassium nitrate:						
April, 1940	33.0	77.4	66.3	88.0	85.6	70.1
June, 1941	50.9	77.8	84.5	72.2	64.1	69.9
April, 1942	65.5	80.5	84.0	76.0	84.0	78.0

1. The seed was harvested in July, 1938, thus, was two years old when treated in March, 1940. Results in 1941 and 1942 indicate how seed held up in viability during storage.

Germination tests were made by Miss Albina F. Musil in the laboratory of the Division of Forage Crops and Diseases. Water was used to moisten the substratum in part of the test and a 0.2 percent solution of potassium nitrate was used in the other. The value of potassium nitrate in increasing the germination suggested its use as a pretreating agent in later trials.

Attempts have been made to secure better germination of buffalo grass seed by harvesting the seed while it is yet slightly immature. A limited response has been obtained but the advantage in germination was many times offset by the lower quality and lower yield of seed. Quality is determined by the number of burs containing

viable seed and the number of viable caryopses per 100 burs. Seed gathered in the soft-dough stage, or approximately a month before the normal ripening date, usually contains less than half as many caryopses per 100 burs as seed that is permitted to mature fully.

Mechanical Treatments.— In the study of mechanical treatments of buffalo grass seed, a legume seed scarifier and an ordinary hammer mill were used to process the seed and determine the effects of treatment upon germination. The scarifier removed the prongs from the end of the bur effecting heavier test weight and better purity but had no effect on germination. The hammer mill gave various results depending upon size of screen used and speed at which the machine was operated. Operating at normal speed and using a medium-large screen, the seed was processed to practically the same extent as with the scarifier but many of the caryopses were threshed out. The seed left in the bur showed no improvement in germination but the caryopses germinated satisfactorily. The use of smaller screens effected almost complete removal of the caryopses from the hull but injured a high percentage of the naked seeds. G. L. Weber of North Dakota, reported similar results with a specially designed hammer mill in North Dakota, but stated the desired increase in germination could be obtained without serious injury to the exposed seed (17.)

Since mechanical treatments are generally effective only when they become severe enough to hull the seed, they cannot safely be recommended for increasing the germination. Hulled seed, though giving good germination in the laboratory, has not given consistent success in the field. Removing the hull seems to hinder the establishment of proper moisture relations between the seed and the soil. Hulled seed will begin to germinate almost immediately after coming in contact with moisture. Many failures follow seeding in moist soil during dry or windy atmospheric conditions. Invariably the soil dries out to a depth below the seed level and causes the insufficiently-rooted seedling to perish. In contrast, the thick, tough hull enclosing the seed requires considerable moisture to saturate it, and, therefore, germination usually does not start unless soil moisture and atmospheric conditions are sufficiently favorable to assure the seedling a reasonable opportunity to become established.

The use of hulled seed also presents some mechanical difficulties such as obtaining uniform coverage and avoiding the danger of covering too deep. Although these difficulties are mentioned, there is little doubt that special equipment could be constructed or secured that would overcome them. However, it does not seem necessary to give these problems further consideration because the use of unhulled seed offers no problem in drilling and better results usually can be expected. The use of hulled seed is not recommended.

Acid and Chemical Dust Treatments.— Sulphuric acid has been tried in attempts to increase the germination of buffalo grass seed. All treatments employed digested the hull of the bur to the extent that most of the caryopses were released. Although increas-

ing the germination to about the germination of mechanically hulled seed, the treatment did not prove practicable. Aside from its prohibitive cost, the use of acid is difficult and dangerous under most conditions.

Seed, both hulled and unhulled, was treated with New Improved Ceresan with varying results. Seed in the bur gave very little response in germination while hulled seed showed increases of from 10 to 30 percent. Since field planting of hulled seed is not recommended, dusting is practical only under special conditions. Ceresan

FIG. 4.—Results of planting treated and untreated buffalo grass seed in the field May 15, 1940. Row marked 72 was planted with 100 treated seeds and showed 59 percent germination as compared with 5 percent germination for the untreated row marked CK.

is often used to treat seed of selections and crosses which are started in the greenhouse where it has an additional value for controlling damping-off diseases.

Soaking and Chilling Treatments.— The prompt germination of buffalo grass seed has been most consistently and effectively improved by the use of various soaking and chilling treatments. The age of the seed and the extent of natural weathering are important factors in determining the nature of the treatment needed. In general, the newer the seed and the more optimum the conditions were under which it had been harvested, the lower its immediate germination and the more severe must the treatment be to overcome natural dormancy.

The choice of treatment or combmation of treatments will be governed by the age of the seed, the conditions of harvest, and the extent of natural weathering. Lacking this information, one can judge by the present germination and quality of seed what treatments to employ. Fortunately, in the absence of both records and germination tests, one can employ the recommended procedure for treating new seed, without fear of injuring the seed, since in all the trials employed, there has not been a single instance where severe treatment has not given a beneficial response in ermination.

The caryopsis or kernel of buffalo grass is small, amber-colored, hard, and vitreous. When normally matured, properly harvested, and correctly stored, from 80 to 98 percent of the caryopses will exhibit dormancy. They will absorb water and swell but will not germinate unless the seed coat is punctured, scratched, partially digested, or broken. As mentioned, it is impossible to do this mechanically without destroying the outside hull which is known to be of value in obtaining stands in the field. Thus it is necessary to overcome natural dormancy by use of a liquid carrier such as is accomplished in the natural weathering process.

Water was first used for soaking in an attempt to improve the germination of buffalo grass seed. A sample of unweathered seed harvested in 1938 was put to soak in March, 1940. The treatments consisted of soaking for from one to four days after which the seed was dried so it could be stored, handled, and planted by regular methods. The results of this study are presented in Tables 2 and 3, which present a comparison of the results obtained in the laboratory and in the field. It will be noticed that field germinations are much below those indicated in the laboratory and are more variable. This is a common observation not only with buffalo grass but with many seeds. A field germination of 25 percent is considered acceptable while a laboratory germination of 50 percent is considered of equal value. The field germination results for 1942 were very poor because of adverse conditions at planting time and do not accurately reflect the true effect of storage on the viability of water-treated seed. The laboratory results in Table 2 show not only that viability was retained, but that germination actually increased slightly after two years' storage.

In succeeding trials, partially presented in Tables 4 and 5, with various ages and types of seed, water and solutions of vitamin B, copper sulfate, potassium permanganate, gentian-violet and commercial borax all failed to induce satisfactory germination in new seed even when the soaking treatment was followed by a period of satisfactory chilling. Although these solutions were capable of inducing satisfactory germination in seed older than two years, where chilling followed soaking, the responses were not enough better than those obtained from water treatment to warrant the additional expense.

TABLE 3.—*The effect of various length water-soaking treatments on the germination of buffalo grass seed and the influence of storage and season on the germination of both treated and untreated seed when planted in the field.*[1]

YEAR AND DATE OF PLANTING.	Percentage bur germination.[2]					
	Not soaked.	Soaked 24 hrs.	Soaked 48 hrs.	Soaked 72 hrs.	Soaked 96 hrs.	Average.
April 13, 1940	13.0	24.4	32.4	33.6	29.3	26.5
April 29, 1940	15.4	27.3	34.4	31.3	37.0	29.1
May 15, 1940	7.0	30.7	44.4	46.6	39.7	33.7
Average of 1940 plantings	11.8	27.5	37.1	37.2	35.3	29.8
April 22, 1941	20.7	45.1	54.6	54.3	48.0	44.5
May 9, 1941	4.3	23.0	26.6	33.7	30.0	23.5
May 24, 1941	8.0	34.4	44.0	49.7	43.6	35.9
Average of 1941 plantings	11.0	34.2	41.7	45.9	40.5	34.7
May 4, 1942	3.7	7.1	8.3	9.7	10.1	7.8
May 18, 1942	4.9	8.0	14.6	12.1	12.1	10.3
June 4, 1942	5.7	14.9	21.1	24.4	22.7	17.8
Average of 1942 plantings	4.8	10.0	14.7	15.4	15.0	12.0

1. The seed used for this test was the same as used for the laboratory tests reported in Table 2.

2. Germination is most accurately expressed on the basis of burs which actually contain seed. As this determination is impossible in the field, it is of interest to know that 91.3 percent of the burs contained healthy seed as determined by dissecting a representative number.

Weak solutions of potassium nitrate, ammonium nitrate, common salt, Semesan, and ammonium sulfate were found to be superior to water in the treatment of new seed, especially where chilling followed soaking, but the advantages over water alone disappeared rapidly as the age of the seed increased past the second year. These same solutions were also superior to water in the treatment of seed older than two years, where soaking was the only treatment used. However, the response, where soaking was the only treatment, was never so great but that chilling always gave some additional stimulus. However, additional increase in germination from chilling, in the case of such seed, was seldom practicable because of the time and expense involved.

Of all solutions employed, those of potassium nitrate, or saltpeter, gave the most consistently successful results. The addition of gentian-violet (one part dye to 40,000 parts liquid solution) was effective in staining the seed a purplish-blue without interfering with the beneficial action of the treatment. This procedure provides a successful and satisfactory method of marking treated seed so that it can readily be identified, and is a process that cannot be duplicated easily for fraudulent purposes.

Studies of various chilling and freezing treatments where those practices were employed alone, in combination with various soaking treatments and where the seed was dried before being chilled, disclosed that to be effective the seed must be wet during the chilling process. (Table 5.) Where seed was pretreated by soaking in an

TABLE 4.—*The effect of various soaking and chilling treatments on the germination of three crops of Selection 1-i buffalo grass seed when tested immediately after treatment and following a year of storage.*[1]

Chilling treatment subsequent to soaking.	Year of seed harvest.	Percent germination (of burs containing seed).													
		Seed not soaked.		Where seed was soaked 24 hours in.[2]											
				Water.		0.2 percent KNO_3.		0.5 percent KNO_3.		1.0 percent KNO_3.		2.0 percent KNO_3.		5.0 percent KNO_3.	
		1942	1943	1942	1943	1942	1943	1942	1943	1942	1943	1942	1943	1942	1943
None.	1939.....	54	50	46	33	69	58	60	41	65	28	65	36	66	55
	1940.....	69	57	80	55	45	54	76	57	69	55	51	50	66	46
	1941.....	12	31	17	26	26	42	23	26	22	40	27	38	31	52
	Average,	45	46	48	38	47	51	53	41	52	41	48	41	54	51
Chilled 2 weeks 41°F.	1939.....	63	27	85	87	72	72	85	88	84	85	85	80	86	76
	1940.....	41	54	78	91	73	91	82	86	76	95	74	85	78	83
	1941.....	10	29	34	61	35	82	52	73	40	70	46	70	33	61
	Average,	38	37	66	80	60	82	73	82	67	83	68	78	66	73
Chilled 3 weeks 41°F.	1939.....	61	73	86	98	79	90	93	98	91	95	86	89	87	93
	1940.....	55	52	88	94	83	99	92	100	92	100	78	93	83	92
	1941.....	17	35	54	80	57	82	51	75	41	85	41	72	43	70
	Average,	44	53	76	91	73	90	79	91	75	93	68	85	71	85
Chilled 4 weeks 41°F.	1939.....	53	50	86	91	82	92	94	99	90	100	77	86	78	77
	1940.....	46	66	83	100	91	97	82	98	85	97	80	91	78	93
	1941.....	14	33	56	78	55	86	73	93	65	84	48	83	62	68
	Average,	38	50	75	90	76	92	83	97	80	94	68	87	73	79
Chilled 6 weeks 41°F.	1939.....	54	41	83	97	98	99	100	98	99	100	65	80	94	98
	1940.....	36	64	90	100	80	98	95	100	100	100	78	92	84	100
	1941.....	17	37	85	100	64	81	87	100	85	98	69	83	79	94
	Average,	36	47	86	99	81	93	94	99	95	99	71	85	86	97
Grand average.....		40	47	70	79	67	82	76	82	74	82	65	75	70	77

1. The seed used in this study was harvested in July of the years indicated, treated during December, 1941, and January, 1942, and germinated in March, 1942, and January, 1943, in the laboratory.

2. Soaked samples which were to be followed by chilling were maintained in a saturated condition throughout the entire chilling period, but were dried immediately following. Soaked samples not chilled were dried immediately after their 24-hour soaking treatment. The seed that was not soaked was germinated either without treatment or following chilling to compare with samples pretreated by soaking.

TABLE 5.—*The effect of different soaking and chilling treatments on the germination of a commercial source of buffalo grass seed when applied six months after harvest, when applied 19 months after harvest and when the early-treated seed was stored for a year before planting. Seed harvested in fall of 1941 before any natural weathering occurred.*

SOAKING TREATMENT PREVIOUS TO CHILLING.	Percent germination (of burs containing seed) from tests A, B, and C.[1]																	
	Not chilled.			Chilled at 41°F.												Strawhouse.		
				2 weeks (wet).			4 weeks (wet).			6 weeks (wet).			6 weeks (dry).[2]			6 weeks (wet).		
	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.
Seed not soaked	7	7	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	6	10	13	.....	.....	.....
24 hours in water	8	8	8	8	32	51	42	67	82	26	71	95	6	9	.....	63	83	74
24 hours in 0.2 percent potassium nitrate	8	13	22	20	35	59	60	69	88	53	78	87	7	16	.....	78	84	73
24 hours in 0.5 percent potassium nitrate	11	23	27	30	53	74	65	74	87	72	90	86	8	25	.....	75	82	77
24 hours in 1.0 percent potassium nitrate	12	24	36	26	63	70	74	81	89	83	86	95	14	21	.....	80	79	86
24 hours in 2.0 percent potassium nitrate	13	23	26	39	66	68	84	84	83	88	96	94	18	20	.....	72	67	79
24 hours in 0.2 percent ammonium nitrate	.....	.....	27	.....	.....	69	.....	.....	81	.....	.....	79	.....	.....	.....	.....	.....	80
24 hours in 0.5 percent ammonium nitrate	8	23	27	26	57	64	70	75	82	59	79	90	8	14	.....	72	78	83
24 hours in 1.0 percent ammonium nitrate	9	22	28	26	51	69	74	70	85	59	76	91	8	28	.....	55	64	81
24 hours in 2.0 percent ammonium nitrate	.....	.....	24	.....	.....	59	.....	.....	81	.....	.....	80	.....	.....	.....	.....	.....	76
24 hours in 0.1 percent common salt	.....	.....	24	.....	.....	45	.....	.....	80	.....	.....	85	.....	.....	.....	.....	.....	77
24 hours in 0.2 percent common salt	9	21	20	12	35	36	19	64	69	51	76	81	7	10	.....	81	84	79
24 hours in 0.5 percent common salt	8	13	25	10	27	50	39	71	83	39	61	89	8	19	.....	73	83	75
24 hours in 1.0 percent common salt	.....	.....	21	.....	.....	48	.....	.....	80	.....	.....	91	.....	.....	.....	.....	.....	84
24 hours in 0.2 percent ammonium sulfate	.....	.....	19	.....	.....	40	.....	.....	73	.....	.....	88	.....	.....	.....	.....	.....	75
24 hours in 0.5 percent ammonium sulfate	.....	.....	25	.....	.....	47	.....	.....	78	.....	.....	83	.....	.....	.....	.....	.....	78
24 hours in 1.0 percent ammonium sulfate	.....	.....	19	.....	.....	42	.....	.....	77	.....	.....	80	.....	.....	.....	.....	.....	82
24 hours in 2.0 percent ammonium sulfate	.....	.....	22	.....	.....	56	.....	.....	75	.....	.....	69	.....	.....	.....	.....	.....	63
24 hours in 0.0025 percent Gentian Violet	.....	.....	12	.....	.....	.....	.....	.....	.....	.....	.....	76	.....	.....	.....	.....	.....	60
24 hours in 0.0025 percent Gentian Violet and 0.5 percent potassium nitrate	.....	.....	21	.....	.....	.....	.....	.....	.....	.....	.....	92	.....	.....	.....	.....	.....	76

1. Test A—Seed treated during January and February, 1942, and tested in laboratory in April, 1942.
Test B—Seed treated during January and February, 1942, and tested in laboratory in January and February, 1943 (after a year's storage).
Test C—Seed held 19 months before treating. Treated February and March, 1943, and tested in laboratory in April, 1943.

2. Samples indicating a soaking treatment previous to chilling were dried before chilling.

acceptable manner, chilling was found to be more effective than freezing. In general, warmer chilling temperatures were more effective in overcoming dormancy than temperatures near freezing, but when temperatures were raised much above 41 degrees F., the risk of having the seed heat while in treatment was found to more than offset the greater effectiveness. Temperatures of —10 degrees F. for as long as 15 days did not injure seed viability but failed to give any beneficial response regardless of the pretreatment.

Variable temperatures such as were secured during January and February of 1942, and February and March of 1943, in an outside

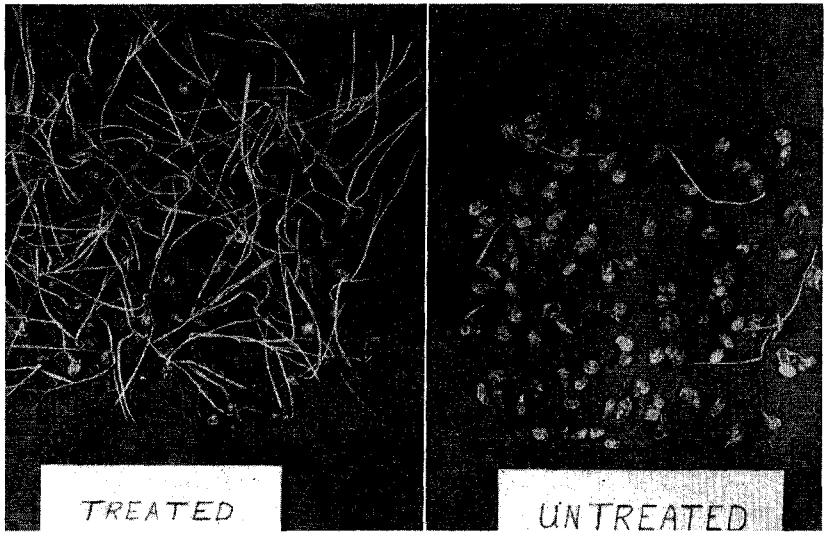

FIG. 5.—Results at the end of a 10-day laboratory germination test show the value of soaking buffalo grass seed in saltpeter and chilling it for six weeks. Along with higher germination, treated seed germinates more promptly and uniformly.

storehouse made of straw bales, gave practically as good results in overcoming dormancy as a uniform temperature of 41 degrees F. In fact, the fluctuating temperatures increased the effectiveness of water and common salt solutions in the 1942 tests. (Table 5.) Temperatures that year varied from 63 to —2 degrees F. with an average maximum of 46.5 and an average minimum of 23.1 degrees. Temperatures in 1943 varied from 78 to —12 degrees F. with an average maximum of 53.9 and an average minimum of 20.1. The average mean temperatures were 34.8 and 37 degrees, respectively. The results of these tests indicate that straw storage would be practicable over most of the region north of Oklahoma.

Data in Tables 4 and 5 demonstrate the effect of age of seed at treating time on ease of treatment as reflected in the response of different chilling periods. In general the older the seed and the

stronger the soaking solution, the shorter the chilling period needs to be.

The effect of seed treatment upon viability in storage is an important consideration. All results, Tables 2, 3, 4, and 5, indicate that treated seed may be stored for one or two years without any loss of viability. In fact, most treatments have given better germination a year after storage than they have immediately following treatment. (Table 5.) If, however, there is some question that seed will not be sold or used the first year following harvest, it will be advisable to delay treatment as long as possible, not because of any deterioration in the quality of treated seed, but because old seed is more easily, cheaply, and effectively treated than new seed. This is especially evident from a comparison of treatments B and C in Table 5.

Recommended Procedure for Treating Buffalo Grass Seed. — Immediate germination provides the most reliable basis for determining the need of treatment since records of the age of seed and the extent of natural weathering are not always available. When good quality seed is found to possess less than 40 percent germination, dormancy may be assumed to be so pronounced that the seed will benefit from treatment. Soaking such seed for 24 hours in a 0.5 percent solution of saltpeter and then chilling at 41 degrees F. for six weeks, will raise the immediate germination to at least 75 percent of its germinating capacity. Similar treatment with 0.2 percent solution of common salt will do nearly as well, especially if variable chilling temperatures are employed following soaking.

A 0.5 percent solution is prepared by dissolving one-half pound of the treating agent in 100 pounds of water. The seed should be maintained in a wet or saturated condition throughout the period of chilling even if this means resoaking for 3- or 4-hour periods once or twice during the period. Immediately following chilling, the seed should be dried at temperatures under 120 degrees F. When temperatures above 50 degrees are employed in drying, the process should be completed within a 24-hour period. Otherwise, germination may start.

Where facilities for chilling at 41 degrees are not available, satisfactory results may be expected from the use of the strawhouse. Such a storage structure can be constructed cheaply and effectively used north of Oklahoma during the winter months where outside temperatures rarely rise above 60 degrees. Temperatures inside the structure can be watched during cold and warm periods and regulated by opening the house during the day or night as the need may be to maintain a temperature of approximately 41 degrees.

Where the amount of seed to be treated does not justify the construction of a strawhouse and where facilities for chilling at 41 degrees F. are not available, temperatures down to 34 degrees will give satisfactory responses if saltpeter is used for soaking. A few dairy plants, meat markets, ice plants, locker plants, or similar establishments maintain chilling rooms with satisfactory tempera-

tures, and might be willing to make space available at a small charge for the purpose of treating relatively small amounts of seed. Very small samples may even be treated in home refrigerators when circumstances do not afford more convenient methods and treated seed cannot be purchased.

Seed is handled most conveniently in sacks during the soaking and chilling treatments. (Fig. 6.) Handling in this manner helps retard the rapid drying out of the seed while chilling and enables arrangements of the material so that the cold air can circulate and

FIG. 6.—Soaking buffalo grass seed in a solution of saltpeter followed by chilling at approximately 41° F., for six weeks in the recommended treatment. Seed is handled in sacks for convenience.

penetrate to all points. (Fig. 7.) Careless stacking of the sacks has been known to result in heating and partial germination where these precautions were not observed.

Seed known to be three years old or older or seed which indicates immediate germination of from 30 to 50 percent may usually be stimulated sufficiently by the soaking treatment alone. A trial test in this case requires only a short time and may be well worth the extra effort if it discloses chilling is unnecessary. If the trial test does not raise the germination to 75 percent (all burs containing apparently healthy seed are considered viable or as having potential germination), then a 2- or 3-week chilling period will be necessary

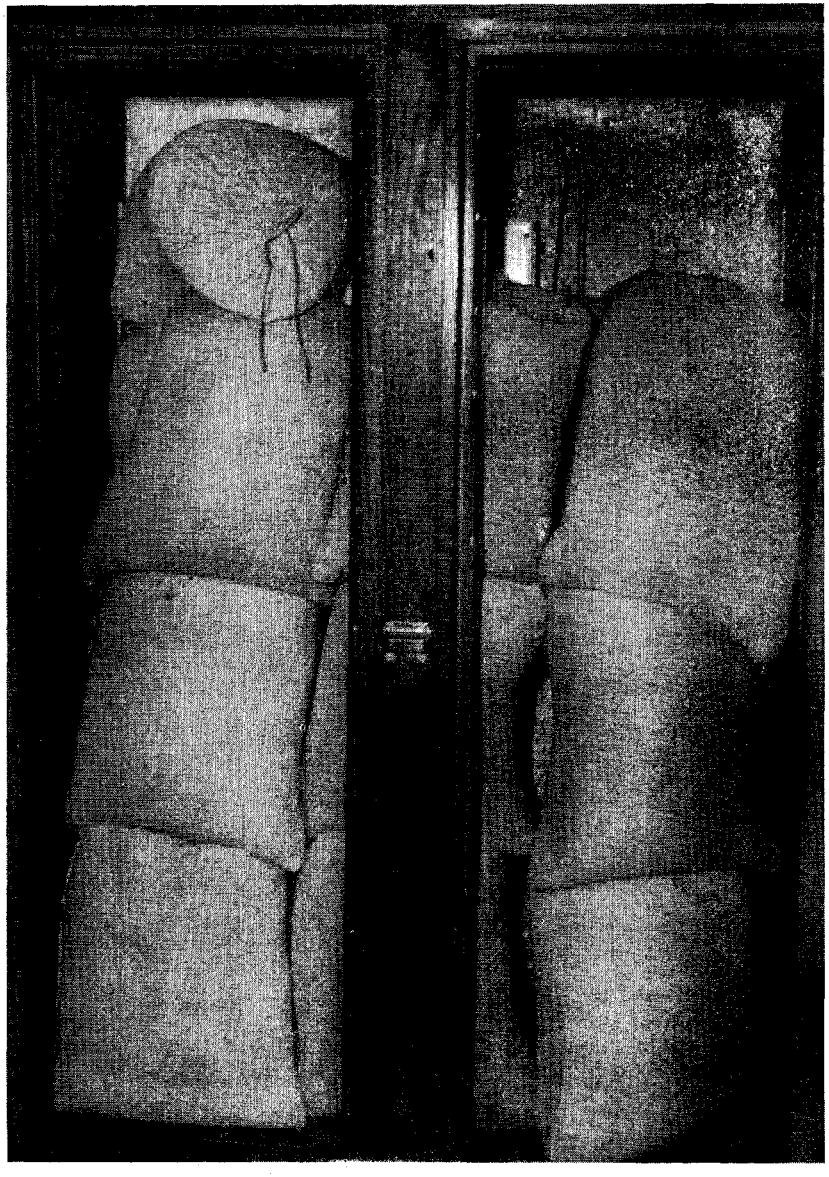

FIG. 7.—It is important during chilling that the seed be saturated and that the sacks be arranged so the cool air can circulate to the best advantage. To prevent drying, which may give a poorer response, the seed is resoaked for three or four hours every two weeks.

to obtain the desired effect. Although the regular 6-week chilling treatment will not impair the germination of any sample of seed, the value of aging or other natural processes should not be overlooked in reducing both the cost and time of treatment.

Drying the seed following treatment has proved to be the most tedious and difficult task of the entire process of treating. Seed coming out of treatment usually contains from 40 to 60 percent excess moisture and thus cannot be subjected to very high temperatures for any length of time without danger of injuring the viability. Small samples may be dried satisfactorily by spreading on the floor of a warm room or by drying on window screen. Frequent stirring and the use of fans to keep the air moving have been noted to speed up the process materially. Studies now under way have as their goal a large mechanical drier for commercial use that will eliminate the trouble and reduce the cost of this phase of treating.

SOURCE AND QUALITY OF SEED

Samples of buffalo grass seed originating from southern Texas and from various points successively farther north to North Dakota have been planted in nurseries and field plots at Hays to determine the effect of origin upon the growth responses in this territory. The results have been interesting and enlightening. In general, plantings made with southern seed exhibited more vigor, heavier yields, better palatability and tendency toward greater resistance to certain foliage diseases than plantings established with northern seed. Such plantings, however, were more susceptible to winterkilling, were usually deficient in seed production, usually produced a thinner turf and the foliage was often frozen down in the fall while growth was yet vigorous. The latter situation is held by some to result in forage of inferior quality for winter grazing.

Seed originating at points from south to north only 100 miles apart showed differences in growth responses of the grass from places having similar altitude. In general, the growth was less and the active growing season shorter for each successive northerly point of origin. Higher altitude, in general, had the same influence as a more northerly point of origin. Similar effects of source of seed have been observed in blue grama and other native grasses which make most of their growth through the summer.

These observations indicate that for average revegetation purposes, native grass seed should be obtained from the better-adapted local sources or from points somewhat to the south, rather than from the more northern locations. To avoid the risk of winterkilling, 300 miles should be considered the south to north limit from point of origin to location of planting.

Because low-seeding rates are generally employed, it is imperative that seed of good quality be used in planting. Purity is the standard measure of quality. It represents the percentage of the bulk that is actually buffalo grass seed as part from other crop seed, weed seed and inert material. A purity of 85 percent might well

be considered as a minimum for good quality seed. Other measures of quality are the number of caryopses per 100 burs, percentage burs that contain viable seed, and the promptness of germination.

Determination of "bur quality" is done by dissection in the laboratory. Good quality seed should contain at least 100 viable caryopses (seeds) per 100 burs and at least 75 percent of the burs should contain one or more viable seeds. Although it is apparent that germination is dependent upon other quality factors, at least 50 percent of the burs should show immediate germination in the laboratory even though pretreating is necessary.

MIXTURES WITH BUFFALO GRASS

Pastures or ranges rarely consist of pure stands of buffalo grass except where continuous close grazing or a period of cultivation has eliminated the other grasses. Likewise, in reseeding it seems that except for special uses, it is more advisable to plant a mixture for pasture than to plant buffalo grass alone. Planting a mixture for pasture has the following advantages: (a) Longer grazing season; (b) greater variety of forage; (c) increased palatability in that the less palatable species are partially taken with those of first preference; (d) greater success in securing stands and in obtaining maximum production as reflected through better adaptation to varying soil and moisture situations; (e) insurance against adversities in climate and grazing which one grass may be able to withstand better than the rest; and (f) maximum erosion protection by assuring the greatest sod density on all parts of the field, regardless of variations in soil and moisture conditions.

Soil type and moisture conditions will determine largely what grasses should make up the mixture. On the heavier soils where frequent flooding does not occur, buffalo grass and blue grama grass should compose the bulk of the mixture. Side oats grama, western wheatgrass and sand dropseed are other native grasses to consider in mixtures with buffalo and blue grama. (Table 6.) Side oats grama is a desirable grass for rocky hillsides, water-favored locations, and the more sandy soils in the western part of the region. It also responds favorably on the heavier soils farther east where moisture is not a limiting factor. Western wheatgrass prefers the heavier soils in the region from Kansas south but it grows well only where runoff water and eroded soil accumulate. North of this territory and at higher altitudes, it makes a better response and has more value for grazing. Sand dropseed is best adapted to the more sandy soils but thrives quite well on a range of soil types. It is one of the first perennial grasses to invade abandoned cultivated land and depleted pastures but gives way to buffalo grass as the latter becomes firmly established. Because of its rather low palatability and quality, unless utilized throughout the season, its use is not generally recommended where buffalo and blue grama are well adapted. Its greatest value lies in its ability to become established in a short

time and during the hot part of the summer on soils which require quick cover for protection against wind and water erosion.

TABLE 6.—*Suggested pasture mixtures and rates of seeding in pounds per acre on various types of soil at the present time.*

GRASS.	Mixtures for various soils.				Seeding rates where planted alone for special purposes.
	Usual run of heavy to medium-heavy soils on dry locations.	Combined upland and bottomland locations with heavy soils predominating.	Heavy to medium soils with stone outcrops.	Medium sandy soils.	
Buffalo grass	3	3	3	1	8
Blue grama	12	5	8	7	15
Side oats grama	.....	4	5	7	15
Western wheat grass	.....	3	.....	.....	15
Sand dropseed	.....	.....	.....	2	10
Totals	15	15	16	17	.....

Special plantings of pure buffalo grass may be practical for small farm lot or corral pastures receiving excessive trampling and grazing because of their nearness to headquarters. Likewise, relatively small pastures used exclusively for sheep might well be seeded to pure buffalo grass. This is especially true if irrigation is to be practiced. In such situations buffalo grass has better chances of surviving than any of the other native grasses because of its habit of spreading by surface runners which root and leaf at nodes.

SEEDBEDS AND THEIR PREPARATION

Probably no crop on the farm requires more careful planning and preparation of the seedbed than does grass. The seed is small, the seedlings are delicate. The plants become established slowly. Also, the processes of erosion and weed competition become serious factors because usually the most sloping, badly eroded, poorest producing land on the farm is chosen for revegetation. Despite these adverse odds, careful planning and good judgment do much toward assuring success.

A good seedbed for grass is characterized by its firmness, freedom from growing weeds, and abundance of moisture near the surface. The soil type, slope, normal rainfall, and susceptibility to blowing determine largely the practices to follow to insure the type of seedbed needed. There are two general types, clean-tilled preparation and those preparations which leave a stubble or crop residue on the surface for controlling mind and water erosion. Since both practices are employed on most, farms in buffalo grass territory, adjustment

to meet the requirements for grass is all that is needed to provide for the planting of this crop.

Preparatory Crops and Fallow. — In the drier areas where soil blowing prevents the use of fallow and in the heavier rainfall districts where fallow is not necessary, Sudan grass or close-drilled sorghums are excellent crops to precede grass. These crops leave the seedbed firm and provide sufficient protection to prevent blowing, runoff, and erosion. Several methods of handling these preparatory crops are used and are dependent upon such factors as rainfall, blow hazard, slope and erosion, and the farmer's need for pasture or livestock feed.

Sudan grass seeded in May and June usually will provide some pasture or hay, in addition to adequate residue for seeding grass. The crop should not be allowed to produce seed, however, because the plants volunteering the second year will compete seriously with the grass. Where the Sudan grass is to be pastured, only certified seed should be used. This eliminates the danger of sorghum or hybrid mixtures that might cause prussic acid poisoning.

In the western part of the buffalo grass region, Sudan grass may be pastured lightly but considerable residue should be left on the land to catch snow and prevent blowing. Sudan grass will usually develop seed despite pasturing, hence, the crop should be watched carefully and mowed before the seed forms to eliminate the volunteer problem. Cutting or binding for hay may be practiced if sufficient growth is produced so that a 12-inch stubble can be left for cover. Although the type of land selected for planting buffalo grass, or mixtures including it, is not so subject to blowing as the more sandy soils, in localized areas it becomes dangerous to remove a hay crop. Usually on such fields the mowed growth should be allowed to remain on the land to furnish additional mulch and protection. Close-drilled sorghums may be substituted for Sudan grass as preparatory crops for grass with good results. The practice is most successful, however, where all of the forage is left on the land or where at least a 12-inch stubble can be left for protection.

Planting Sudan grass or close-drilled sorghums about the first of August on fallow land is another practice that can be used to advantage under certain conditions. Planting at this time usually provides time enough for satisfactory growth, eliminates the need for mowing and usually permits the retention of some subsoil moisture. (Fig. 8.) One risk involved in the use of this practice, however, is the fact that if fall and winter moisture is light, the seedbed may not be settled sufficiently to make the best seedbed for grass. Under such conditions the dangers of deep seeding and surface drying are enhanced, and the damage from pulling the small grass seedlings during the weed-mowing operation is increased.

Heavier rainfall in the eastern buffalo grass territory permits greater utilization of the preparatory Sudan grass or sorghum crops. However, in no instance should pasturing be so heavy, or the hay

be cut so close as to expose the field to erosion or serious loss of drifting snow.

Small grain stubble may be satisfactorily prepared for seeding grass the following spring, if shallow tilled during the fall so as to kill the weeds and volunteer, yet leaving all the residue on the surface to provide maximum protection. This type of land frequently becomes rather loose and ashy by grass-seeding time the next spring, in which event it would be inadvisable to plant unless such suitable packing operations as would prevent blowing could be performed.

Early fall plantings of spring barley or oats on fallow can be used if circumstances warrant, for temporary pasture and as preparation for planting grass the succeeding spring. Such plantings furnish excellent early pasture, and, if not grazed too closely, the surplus

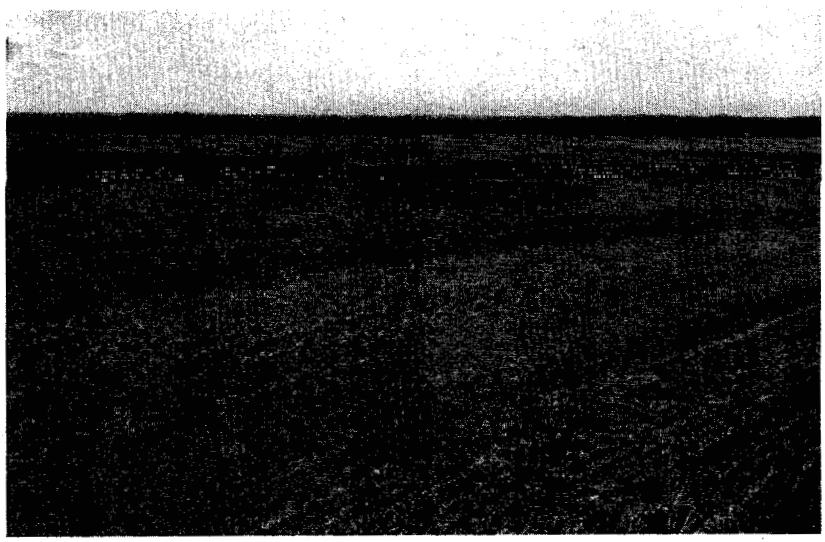

FIG. 8.—Close-drilled sorghum planted in August, 1942, as preparation for seeding grass in 1943. Sufficient growth was produced to protect the sloping soil but mowing was not necessary and the crop did not exhaust the soil moisture so badly as earlier planting would have.

vegetation will freeze down, leaving a mulch sufficient to control erosion and provide an excellent seedbed for grass. Where these crops normally survive the winters, their use cannot be recommended.

Where the land to be seeded is not too rolling or subject to blowing, grass can be drilled or broadcast on fallow. In the vicinity of Hays, excepting on the steeper slopes, fallow is often preferred because it permits killing a crop or two of weeds previous to planting and the additional moisture assures maximum growth and survival of the grass. The advantage of stored moisture becomes more

apparent in the lighter-rainfall areas and may be resorted to when circumstances permit. Aside from the blowing hazard, other disadvantages of fallow are its susceptibility to erosion, baking, and crusting.

Land which has been devoted to the growing of corn or sorghums in rows has neither the advantage of stored moisture of fallow land nor does it offer the protection afforded by cane-stubble land. Such land probably can be used to best advantage on the more level areas in sections where blowing is not a serious problem. Under such conditions it should be prepared and seeded by methods similar to those suggested for fallow.

Seeding in Depleted Pastures and Weeds.— Thickening up depleted pastures and partial stands of new plantings presents an even more difficult problem than revegetating cultivated land. The presence of weeds and established plants offers severe competition to the new seedlings and yet they cannot be cultivated or the remaining grass will be destroyed. If the amount of old grass present is so reduced that there is little chance of natural repossession of the land for several years, it would be more satisfactory and economical to cultivate the land and prepare by proper methods before doing any planting. Likewise, if there is enough grass present to establish the desired cover within a period of three or four years, it is useless to consider seeding, because the competition will be too great for any new seedlings. The uncertain areas, too good to destroy but not satisfactory to leave, can sometimes be improved by drilling buffalo grass in the present stand early in the spring. Although only a partial establishment of the plants can be expected, the spreading habits of the grass will enable it eventually to occupy the vacant areas and suppress the weed growth. Bunch grasses such as blue grama obviously are not so useful for this purpose because they do not spread vegetatively.

Seeding grass on land which has been allowed to grow to weeds has given rather poor results. If the grass is seeded early without preparation, thick stands of weeds usually emerge immediately, giving the slower growing grass seedlings little or no opportunity for survival. Only slightly better results can be expected where seeding is delayed until one or more crops of weeds have been destroyed. Because of the risks involved with seedbeds of this nature, it generally is advisable to grow a suitable preparatory crop on such land and delay the grass seeding for at least a year.

Nurse Crops.— In general, the use of a nurse crop is not recommended with buffalo grass or mixtures with it. The value of the nurse crop is more than offset by its competition for moisture. Although it is true that once firmly established, the native grasses can compete successfully with almost any plant for moisture, in the seedling stages these grasses are easily crowded out. The shading effect of the taller-growing nurse crop also retards their growth and if excessive, may destroy them. Weeds likewise compete with the grass seedlings for moisture and retard their growth by shading.

Weeds must be controlled the first year to prevent a heavy loss in original stand.

TIME OF SEEDING

Spring is usually the best time to seed buffalo grass and mixtures containing it. The specific time will vary with preparatory seedbed treatments and with prevailing seasonal conditions. Inasmuch as buffalo grass and the species with which it usually is planted are all warm-season grasses, germination will not take place much before the average date of the last killing frost in the spring, regardless of when planted. Thus, plantings in undisturbed stubble of preparatory crops such as Sudan, close-drilled sorghum, and fall-seeded barley and oats should be made approximately two weeks ahead of the last spring frost if seasonal conditions permit. In the vicinity of Hays, April 10 to April 20 represents an average optimum planting date in undisturbed stubble preparations. Planting at this time permits the grass to emerge as soon as the weather is sufficiently warm and before weeds have an opportunity to get established.

In unusually open springs, seeding can be made as much as two weeks earlier without danger of losing the new stands from freezing. Planting at the earlier date gives the grass an equal chance with the weeds which are likewise stimulated by the favorable growing conditions of the earlier seasons. In the few instances where buffalo grass may be drilled in thin stands of established grasses, or in depleted pastures, seeding may well be done any time from March 15 to April 1. Under such circumstances the new plants must compete against weeds and against the grass plants already established, the latter of which green up about the first week in April. Thus, if the seed is in position to get the grass plants established while weather conditions are favorable, the chances for success are greatly enhanced.

Buffalo grass plantings made on fallow and cultivated cropland should be delayed until one and preferably two crops of weeds have been destroyed. Usually, in the vicinity of Hays, this is about a month later than is recommended for seeding in undisturbed seedbeds, that is, about May 15. Deviations either way from this date may depend upon seasonal weather conditions, indicated by the fact that satisfactory plantings have been made as late as June 15.

Deferred plantings on fallow or cultivated cropland have an advantage over the earlier seedings in that the weather has warmed up by this time so that germination can take place immediately. Likewise, rains are usually more frequent and effective, and are more conducive to the establishment of the grass seedlings. Delaying the planting until after June 1, however, usually involves more risk as a few of the rains this time of the year tend to be torrential, often causing serious erosion and crusting of the soil. Temperatures by this time may also be so high as to cause a rapid drying of the surface soil, causing the loss of the seedling before it becomes sufficiently rooted. Other grasses, however, particularly blue grama,

are much more susceptible to injury of this nature than buffalo grass.

The importance of moisture in the seedbed at planting time is dependent upon whether seeding is to be made early in undisturbed stubble or whether seeding will be delayed until several crops of weeds have been destroyed by cultivation. Early plantings in stubble seedbeds may well be made at the most opportune time in relation to moisture conditions, because evaporation in the early spring is normally low. Seed planted in a moist seedbed can germinate and become established as soon as temperatures permit with little danger of the seedbed drying out. Deferred seedings, on the other hand, planted about the middle of May on recently-cultivated seedbeds, are usually handicapped by lack of surface moisture. By this time temperatures are higher, evaporation is greater, and the soil usually dries quickly to a depth below which the seed is planted. Because of these circumstances, planting in May might as well be accomplished whenever convenient, as there usually is no advantage to planting in moist soil. Although most of such plantings will finally be made in dry soil, past results indicate the successes are just as consistent as those made in moist soil. Buffalo grass, in particular, is capable of lying for a considerable period in dry soil and will germinate immediately upon the advent of favorable moisture conditions. The only disadvantage of "dusting-in," as this method often is referred to, is that weeds may get a head start on the grass. This is especially true when a good rain does not occur for several days. However, since rains are more frequent in May, this does not occur often. When it does, the trouble can largely be overcome by mowing the weeds earlier than usual.

RATE OF SEEDING

Rate of seeding will depend upon a multitude of factors such as whether seeding alone or in mixtures, the prevailing price of seed, its quality and germination, the value and productivity of the land on which it is to be seeded, the method of seeding, and the time limit set for the establishment of a satisfactory pasture. Buffalo grass seed is large compared to the seed of other grasses. In a study of 12 lots of seed varying from the poorest type of commercial seed to the best grade of irrigated seed, it was determined that approximately 36,500 seeds (burs) of buffalo grass weighed a pound. In the lightest sample, it took 46,286 seeds and in the heaviest it required only 30,240 burs to make a pound.

At the prevailing price of seed, somewhat lighter seeding rates are suggested than may be optimum when the price becomes more favorable. Rates of seeding for varying soil conditions and types of mixtures are indicated in Table 6. From 1 to 3 pounds of buffalo grass seed per acre is suggested for various mixtures and a maximum of 8 pounds is suggested for plantings of pure seed. For lawns, landscape areas, and airport use, where more expense for seeding is justified, heavier seeding rates are recommended.

As an illustration of the ractors which determine a satisfactory seeding rate, the 8-pound seeding of pure seed, which has consistently provided a successful pasture by the end of the second season, will be analyzed. Assuming uniform distribution and the use of seed of average weight and 90 percent purity, an 8-pound-seeding rate will drop 6 seeds on each square foot of soil. Twenty-five percent field germination, which is considered a minimum satisfactory field germination, will give three plants for each 2 square feet. Assuming one-third of these will succumb to drought, insects, weed competition and erosion, a minimum of one plant per square foot will become established. Plants of this distribution have given satisfactory coverage in two seasons. (Fig. 9.)

FIG. 9.—A field planted with treated buffalo grass in May, 1940, as it appeared at the close of the second season. The land was fallowed previous to seeding and approximately one seedling per square foot was established the first year.

When the price of seed permits and pasturage is desired in a shorter time, fairly heavy seeding rates in 7-inch drill rows will be the best and most practical. The extra seeding rate will insure a thicker stand and thicker stands suppress the weeds sooner, especially if the weeds are mowed two or three times during the season to reduce the competition for light and moisture.

DEPTH OF SEEDING

All grasses should be seeded shallow. The importance of this statement cannot be over-emphasized in planting buffalo grass and mixtures including it. The only complete failures with seeding buffalo grass at this station during the past six years are directly traceable to seeding too deeply. One-half inch is considered the average optimum planting depth on most soils but may increase

slightly as the amount of sand in the soil increases. Unless special care is exercised, planting will invariably be made deeper than is intended because one-half inch seems very shallow compared with the depths wheat and sorghums are seeded. Actual measurements are imperative until experience furnishes a basis for judging depth. One easy, rapid method of determining depth of seeding when a drill is used, consists of uncovering the seed so the actual soil coverage can be determined. If the seed is not buried deeper than the thickness of the little finger, the depth is satisfactory.

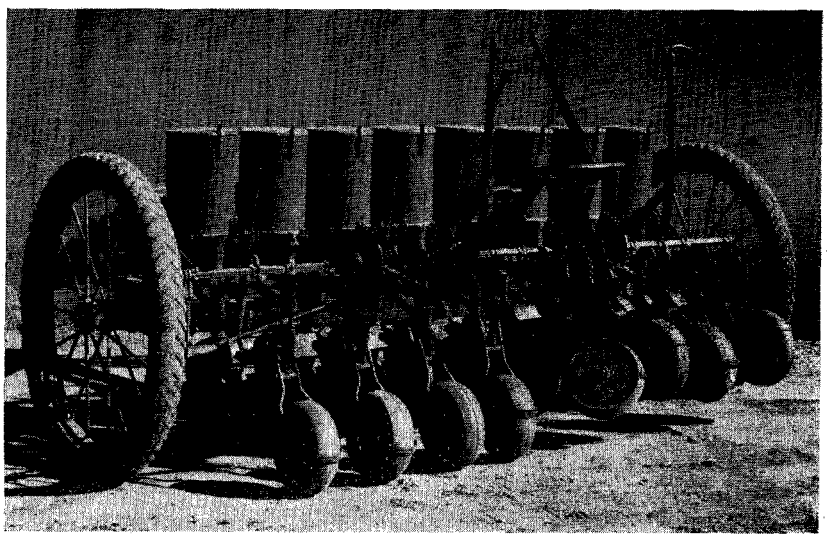

FIG. 10.—The Fort Hays experiment station grass drill constructed similarly to drills developed in the South Plains to facilitate the seeding of light, chaffy seed and to control the depth of seeding. Note depth bands welded to the discs to prevent covering deeper than one-half inch.

The manner of seedbed preparation has much influence upon the depth of seeding. Undisturbed stubble seedbeds are generally well settled and firm. The tendency to plant too deeply is less on this type than on cultivated seedbeds. Sudan grass and closs-drilled sorghum seedbeds are firmer than fall-seeded barley or oats. Cultivated crop land seedbeds or fallow are likely to be loose unless a special effort is made to keep and leave the seedbed firm. Shallow tillage and extra packing are the good methods of obtaining the desired condition. Loose seedbeds are dangerous not only from the standpoint of covering the seed too deep but also because if left in such a condition, the surface dries out so rapidly as to endanger the relatively slow-developing seedling.

Special contrivances and patents have been worked out to insure a uniform depth of seeding. Some of these can be adapted to reg-

ular grain drills, but the most common one is the depth-band which is welded on the disc so that the drill will seed only so deep. This device was worked out by the research men of the South Plains territory and is shown adapted to the Fort Hays station grass drill. (Figs. 10 and 11.) Although such equipment is convenient, especially where large acreages are involved, ordinary grain drills have been and can be used about as successfully if care and vigilance are maintained.

OTHER SEEDING METHODS AND FOLLOW-UP TREATMENTS

There are three general methods of seeding grasses, drilling, hand broadcasting and planting by the hay method. The latter which consists of spreading hay containing ripe seed with a manure spreader, although an excellent, method for native grasses on small areas where erosion is likely to be severe, is not well adapted to seeding buffalo grass (21). The reason for this is that buffalo grass seed is difficult to harvest with hay because of its closeness to the ground and its tendency to shatter when the sickle cuts it off. Thus, the hay may either not contain sufficient seed or it may under very favorable circumstances contain more than would be required, hence, would be wasteful of seed. This is especially true since the seed in hay cannot be treated and heavier seeding rates are necessary to insure immediate stands.

Drilling is usually considered the best method of seeding buffalo grass. Its advantages are uniform distribution of the seed, a fairly uniform depth of seeding, and it permits the use of lighter seeding rates. Pure buffalo grass seed is readily seeded through all common grain drills. However, because of the light fuzzy nature of such seed as blue grama, mixtures containing these grasses cannot always be drilled with ordinary equipment. The suggested mixture composed of 3 pounds of buffalo and 12 pounds of blue grama can hardly be drilled unless the blue grama seed has been processed to improve its test weight and compactness. Mixtures including side oats grama and western wheat grass may be drilled if all the seed is reasonably clean before mixing. This is possible because smaller quantities of blue grama are used in this mixture and because the other two grasses are somewhat similar to oats in their adaptation for drilling. Some drills cannot be closed down sufficiently to seed pure buffalo grass at a rate of 8 pounds per acre. When this is the case every other hole on the drill should be plugged up. Measuring off a portion of an acre and determining the actual seeding rate are always desirable until familiarity with the seeding tendencies of the drill is established.

Special drills using cotton-planter boxes for seeding units are now being manufactured to enable the handling of all types of grass seeds and mixtures. Credit for the development of these drills also goes to various research men in the South Plains region where the use of blue grama, bluestems and other fuzzy-seeded grasses adapted to the lighter soils made it imperative that a drill capable of seed-

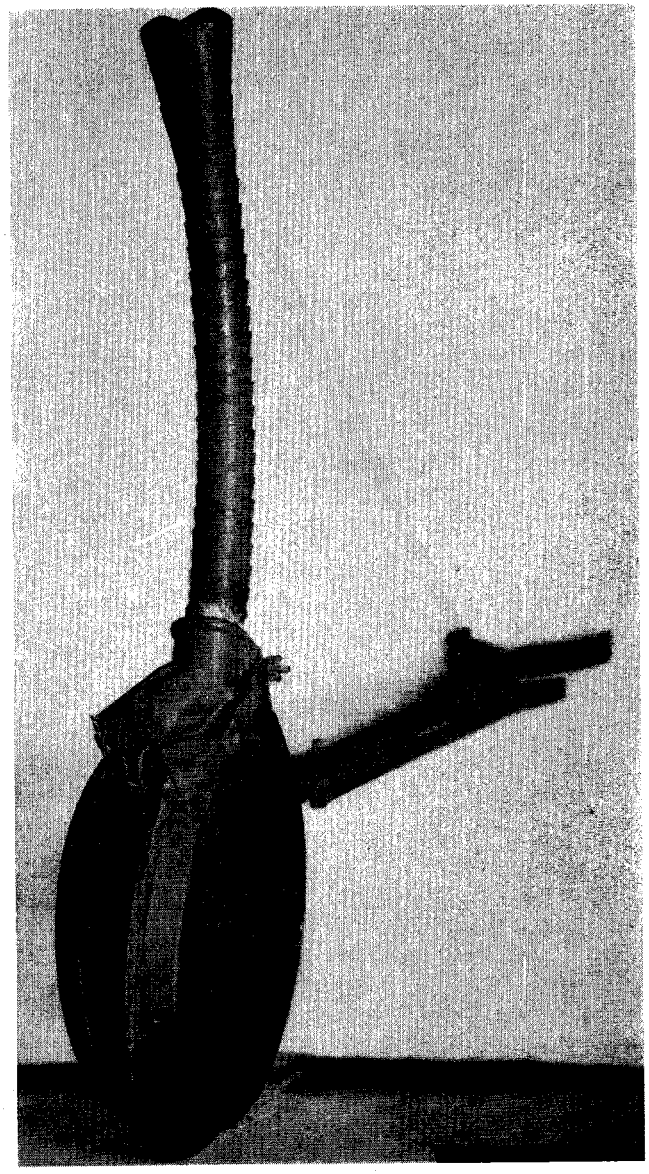

FIG. 11.—A pair of discs showing depth bands welded to the discs in a manner to prevent covering deeper than one-half inch.

ing in stubble-mulch seedbeds be perfected (12). This helps to eliminate the danger of blowing, which always becomes a problem after the mulch is destroyed in the preparation of seedbeds. An improved type of special grass drill was constructed in the shop of the Fort Hays Branch Experiment Station. (Fig. 10.)

When grass seed is drilled with the ordinary type of drilling equipment it is advisable to follow up with a packer to firm the soil around the seed and level the ridges to lessen danger from covering by torrential rains.

Hand broadcasting has given satisfactory results where special care was taken to spread the seed uniformly and then to cover it shallow. Disadvantages of the method are its wastefulness of seed and danger of not obtaining uniform coverage. However, until suitable drills and processed seed of the fuzzy-seeded species become more generally available, this method, despite its limitations, can be used in seeding mixtures which include buffalo grass.

Uniform distribution of seed can best be obtained by first learning to apply a proportionate amount to a small area. When an idea of the proper distribution is obtained it is not difficult to judge the proper rate. By dividing the field and seed into small units before planting, it is possible to eliminate the danger of having too much or too little seed left at the last. Planting one unit of seed on each unit of land will insure more uniform distribution over the entire field. Good distribution can frequently be obtained by broadcasting from the rear of a truck or wagon as it is driven through the field. This kind of seeding should be done on days with a light breeze for best results. Crossing the field at right angles, seeding half of the desired amount each direction, will usually be better than broadcasting in one operation,

Broadcast plantings on undisturbed stubble may best be covered by going over the area with an empty wheat drill set for shallow seeding. Criss-cross operations are better than a single operation. Plantings on cultivated crop land seedbeds and fallow may be covered in the same manner but more care is required in setting the drill to cover shallow. Sometimes the packer wheels on the drill will cover the seed sufficiently without setting the discs down. A disc harrow with discs straight or a drag harrow can at times be adapted to the situation successfully. The harrow should be used only on very firm cultivated seedbeds which are not likely to blow. The seed should be covered about one-half inch deep. This gives the seedling optimum-growing conditions and reduces the chances that it may be blown or washed away.

MOWING WEEDS

Weeds are invariably a troublesome factor in any native grass seeding. Seedbeds desirable for grass are equally desirable for most weeds. Since the weeds grow faster than the grass seedlings, some provision must be made to control them or they are sure to reduce the stand of grass. Shading and competition for moisture are the

most harmful effects of weeds. These ill effects may be reduced and the weeds controlled quite satisfactorily by clipping from two to four times during the first season.

Pigweed, Russian thistle, stinkgrass, and foxtail are some of the more common weeds that infest new grass seedings. On the heavier soils where blowing is not so likely to result, waiting until they have attained a height of 8 or 10 inches and then clipping low as possible without dragging the sickle bar, has given the best results. If earlier or higher cutting is practiced, the weeds tend to branch or stool and increase their aerial density, thereby effectively depriving the grass of much needed moisture. Cutting close in more delayed stages of growth is a severe shock to the weed, frequently killing it outright, but generally weakening it so it is much less effective in its competition. Buffalo grass and most of the other native grasses rarely grow high enough the first season to experience much pruning effect, consequently suffer very little ill effect from close cutting. Unless the weed crop is unusually large or heavy, the residue dries up sufficiently to cause no damage to the growing grasses.

From one to two clippings may be necessary the early part of the second season. When circumstances permit, quick grazing of the weeds with livestock is a convenient and satisfactory substitute for clipping. The weeds are succulent and readily taken at this time and, if the animals are not left on too long, will do little damage to the grass.

GRAZING YOUNG STANDS

Buffalo grass and most other native grasses grow and establish themselves so slowly, particularly under normal weed competition, that no grazing can be expected the first season without involving considerable risk to the stand. The risk may not be only in thinning the stand from pulling and trampling, but may also actually result in lower forage yields in the first few years. In a preliminary yield study with buffalo grass under irrigation, yields the second season, and to some extent the third season, were depressed by clipping the first year.

Under average rainfall, some grazing can usually be expected by the middle of the second season. Thereafter a rotational system of grazing will provide considerable pasturage and allow for complete establishment of the grasses.

New plantings of grass, when included with older plantings or native stands, usually are more palatable and may be injured if grazing is not regulated. To prevent this, where it is at all feasible, pastures should be rotated periodically for a few years and eventually the preference becomes less noticeable. Severe overgrazing of new stands reduces the vigor and yield and encourages the encroachment of weeds. Where mixtures with buffalo grass have been planted, such plantings result in a gain in the proportion of this grass at the expense of the other grasses which are less able to withstand such treatment.

MANAGEMENT OF BUFFALO GRASS PASTURES

The term "buffalo grass pastures" is used in this discussion in its broadest sense, including all native and reseeded areas which contain buffalo grass as a major component of the existing vegetation. The most profitable management of such areas will include coordinated practices that are a part of the management plan for the entire farm. Such a plan will insure the maintenance of stand, vigor, and production of the pastures at all times through proper stocking. This is best obtained through the use of supplemental pastures, through the employment of a flexible system of livestock management which may take into account periods of shortage or excess, and provision for adequate feed reserves to augment the native grass.

GRAZING METHODS

Although the proper grazing method for any individual farm will be dependent upon the livestock management system peculiar to that farm, the success of the grazing practices is always measured by their yearly returns in grazing. With practically no exceptions, the most profitable grazing methods are those which assure the greatest and most uniform production over a period of years. Such production is possible only from the best pastures. Good buffalo or short grass pastures are made possible only through the maintenance of the vigor of the grass stand which is best assured by those grazing practices that permit the plants to make enough top-growth to function properly. This cannot be over-emphasized because, once the stand is lost, many years and much expense are involved in either rejuvenating the original stand or in reseeding.

One of the most vulnerable periods in the life of perennial grass plants is in the spring of the year when new growth starts. At this time all growth is being made from reserve food which was stored in the roots by the growth of the previous season. If this new growth is repeatedly removed by grazing and no period allowed during the season for replacing this store of reserve food, the effect upon the vigor and stand is readily apparent. Soon the vigor is weakened and eventually the stand will be lost. Buffalo grass, because of its extensive above-ground system that develops so close to the surface, escapes injury better than the bunch-type grasses that grow more upright. Since these commonly associated, bunch-type grasses such as blue grama and side oats grama are valuable components of the pasture mixture, it is important that the grazing practices followed protect the bunch grasses as well as that of buffalo grass. Therefore, livestock should not be turned on the grass in the spring until it has made sufficient growth to provide adequate pasture. Usually in the vicinity of Hays, native pastures are in condition for grazing by the middle of May. Next to grazing too early in the season, overstocking is probably the most common abuse of native short-grass pastures.

Since most buffalo grass pastures contain mixtures of other grasses such as blue grama, it appears that where circumstances permit,

rotational grazing will provide an opportunity for increased pasture yields. This system of grazing, which calls for dividing large pastures into two or three smaller units which are grazed periodically either in succession or in a deferred and rotated order, keeps the grass thrifty and stimulates production. In a clipping experiment on native buffalo grass pasture, conducted from 1934 to 1940, inclusive, yields of airdry grass were 456 pounds per acre when clipped an average of six times from May 1 to September 15, as compared to 823 pounds per acre when clipped only on July 1 and September 15. (Table 7.) In the early years of the study, more than six clippings were required to keep the vegetation cropped on the frequently-cut plot, but in the later years less than six were required. Weeds, likewise, increased under the more exhausting treatment which reduced the thrift and vigor of the grass. Dickson and his associates (2) obtained similar results in Texas from a two-year clipping study in which it was found that clipping at intervals of eight weeks gave greater yields than more frequent clippings. Dickson's findings were corroborated in the findings of a clipping test conducted at Hays during the spring of 1943 in which it was found that substantially greater production was secured from clipping pure buffalo grass every eight weeks than from clipping every week. In an actual grazing study on buffalo grass at Mandan, North Dakota, J. T. Sarvis (10) found that over a period of 18 years, deferred and rotated pastures produced better gains per animal, more beef per acre, and the grass was maintained in better condition than where continuous grazing was practiced on pastures stocked uniformly at one head for each five acres of grass.

TABLE 7.—*Seven years' results of clipping native buffalo grass 2 and 6 times from May 1 to September 15,*[1]

TREATMENT.	Material.	Pounds of airdry material per acre.							
		1934	1935	1936	1937	1938	1939	1940	Ave.
Cut July 1 and Sept. 15 each year at height of 1¼ inches.	Grass	660	920	240	596	2,416	448	484	823
	Weeds	.....	.....	.....	44	46	40	30	23
	Total	660	920	240	640	2,462	488	514	846
Cut 6 times from May 1 to September 15 at height of 1¼ inches.	Grass	660	760	400	170	730	196	278	456
	Weeds	.....	.....	.....	280	180	240	118	117
	Total	660	760	400	450	910	436	396	573

1. The areas had the same treatment prior to 1934, thus were quite uniform in cover. By the end of the third year weeds had increased to where they were affecting yields on the frequently-clipped area. Thereafter yields of grass and weeds were indicated separately to give a more accurate measure of the influence of the two systems to clipping.

Application of the rotational system of grazing may not be possible or practical where too much fencing is required or where water facilities are not available.

WATER CONSERVATION PRACTICES

Water conservation practices by farmers were extensively employed with varying results during the drought years from 1932 to 1939. Pasture furrowing was probably used more extensively than any other single practice but reports of results are highly variable. (8) Seemingly many factors such as cover and vigor of grass, kind of grass, type of soil, slope, time of construction, type of subsequent seasons and normal rainfall determine the value of the practice.

WEED CONTROL

Weeds generally do not constitute a serious problem in properly managed buffalo grass pastures. The grass in thrifty pastures covers the ground so completely the weeds have little chance to compete with the grass. However, when weeds do get a start as a result of temporary thinning of the stand, it is often with much difficulty and usually after a considerable length of time before the pastures may be brought back to their weed-free condition again.

Perennial weeds such as prickly pear cactus and field bindweed present difficult problems and require special methods of control. Prickly pear, which spreads rapidly throughout the Central Plains area during the drought years when grass stands are thin, has been controlled with reasonable effectiveness by natural means. However, the seed of prickly pear is now scattered more widely and thoroughly than ever before. Since these seeds will lie dormant for many years, every precaution should be taken to maintain the stand and vigor of the grass, and in this way prevent cactus seedlings from becoming re-established.

BURNING

Reasons frequently given for the burning of pastures are to destroy weeds and weed seed, and remove old, unpalatable growth so that the new grass may have an opportunity to make an early, even growth. These benefits are obtained, though it is acknowledged that reductions in yield invariably result. Since burning of the short grasses cannot be practiced at the time of the year most effective in controlling the common weeds infesting these pastures, the only result that can be expected from the practice is a lowering of the yield and a weakening of the stand.

IRRIGATION

For the best success with irrigation, at least two pastures are necessary. Rotating the use of these pastures permits irrigation and the recovery of the grass sufficiently to maintain the vigor. It is not a wise practice to defer the grazing of irrigated pastures until the close of the growing season for winter use, as is often done with native pastures, because the forage makes such a rank growth it becomes woody and unpalatable to the stock and is not so nutritious as forage produced under natural rainfall conditions. Thorough

utilization throughout the season has none of these disadvantages, and the grass is apparently as nutritious as that produced on dry land.

Forcing buffalo grass by irrigation speeds up the natural tendency for the grass to reach the static unresponsive condition commonly referred to as "old-age" or "sod-bound." In fact, indications are that after from three to five years of irrigation, the vigor goes down and weeds increase to a point where it is no longer profitable to irrigate.

FERTILIZING

Moisture is the limiting factor in the productivity of buffalo grass in short-grass pastures. Well-rotted barnyard manure may possibly have value on the lighter, less-productive soils in heavier rainfall areas of the eastern buffalo grass region but the actual response will need to be determined by trial. In preliminary trials at Hays, fertilizing irrigated seed blocks has given no response in either seed or forage production.

BUFFALO GRASS FOR SPECIAL PURPOSES

In addition to being an excellent pasture grass, buffalo grass has many other uses for such purposes as lawn and landscape development, erosion control, airfields, highway development, athletic fields, golf courses, parks, and cemeteries. In the early days, settlers even used sod for the construction of homes and service buildings and a few farmsteads in the western territory still have buildings of this type in use today (1943). Native stands of the grass were used directly for the purposes desired but since successful and economical seeding methods have been developed, the use of the grass can be extended to many places where virgin sod is no longer available.

LAWN AND LANDSCAPE PLANTINGS

Buffalo grass is an ideal lawn grass over most of the Great Plains region where it is naturally adapted and distributed. It is the only grass that can withstand all combinations of cold, heat, and drought, yet maintain an attractive turf under maximum usage with a minimum of care. Its years of survival under such conditions in nature have tempered its value to a point where it is excelled by no other grass for dry-land lawns on the heavier soils in sunny locations. Kentucky bluegrass is not consistently successful even under irrigation except at high altitudes and in shady sites. The standard Bermuda grass is not winterhardy in the Central and Northern Great Plains and bentgrasses require a maximum of water with persistent care.

Because of its ability to make an attractive turf covering with a minimum of care, buffalo grass makes an ideal farm lawn. It is equally satisfactory for large landscape and park areas in the average small town or about larger country homes where only a minimum of maintenance expense is justified. Although buffalo grass

does not do well in dense shade, this factor seldom limits its use in the Plains territory where irrigation is not generally practiced. Few people object to the fact that buffalo grass shows full green late in the spring and turns brown in the fall with the first freeze because these natural tendencies are in harmony with nature at this season.

During the drought years, buffalo grass was pushed east considerably out of its natural habitat and although it responded quite favorably at the time the return of average rainfall has made conditions more favorable for better adapted grasses. Under such conditions the slower, low-growing buffalo, which is intolerant to shading, is soon crowded out unless special measures are taken to discourage the adapted grasses and retain the buffalo. Sometimes this is accomplished by clipping closely, allowing maximum sunlight exposure and giving the turf maximum usage. However, it does not seem advisable to stretch these natural limits of adaptation to the point where excessive care and maintenance are required to keep the buffalo grass thrifty.

Establishing Lawns. — Two methods of establishing buffalo grass lawns are available. They are the same as those available for establishing pastures, namely, transplanting pieces of sod and planting seed. Because of expense, the sod method is used only for establishing lawns having special characteristics not obtainable by planting seed. For example, sod has to be used in perpetuating a lawn with special or selected type of foliage characteristics, because buffalo grass has not been improved to the point yet where the seed will transmit all the desirable characteristics of its parent. Also, the sod method of planting has to be used if a lawn established entirely of pistillate or female plants is desired because from a planting of seed approximately an equal number of staminate and pistillate plants are produced. Lawns from pistillate plants are desirable because they produce no staminate inflorescences (pollen-bearing structures) which extend above the foliage and detract from the appearance of the lawn. In all probability, however, the number of these so-called "luxury" lawns to be established will be small, not only because of the expense involved in starting them but because the sources of desirable planting material are strictly limited. Furthermore, when other buffalo grass is within a reasonable distance, there is a chance of cross pollination and volunteering of the hybrid plants resulting in a reversion to many of the characteristics of common buffalo grass. This is especially true in the case of pistillate lawns. Approximately half of the volunteering plants will produce staminate inflorescences.

Where lawns are to be established by the sod method, usually the only variation from the system previously described for starting pastures will be that more care is required in transplanting to leave the surface smooth and level. Usually, too, the sod pieces are set closer together and watering may be employed to obtain better survival and more rapid coverage.

The source of seed for planting lawns is a matter of considerable importance, particularly if special characteristics are desired. Seed grown locally can be expected to produce a lawn with vegetative characteristics very similar to the average virgin lawn or pasture. Likewise the growth period of the grass will be similar. The use of northern-grown seed on the other hand will usually result in a short, dense, slow-spreading type of vegetation that requires fewer clippings during the season. The growth will turn green about the same time in the spring but will go dormant and turn brown slightly earlier in the fall. Plantings of northern seed come into flower slightly earlier and the staminate characteristic is especially strong or pronounced. Usually the foliage is more susceptible to leaf rust and the leaf-blotching disease which cause the foliage to turn dark and unattractive during the winter. The only advantage of lawns established from northern seed is the shorter, denser growth which requires fewer clippings. Generally the disadvantages offset the advantages except where little or no maintenance is to be provided.

Plantings of southern-grown seed spread rapidly, produce an abundance of tall, rank foliage that does not turn green any earlier in the spring but stays green later in the fall. Lawns from such seed require more frequent clipping and the turf is not so dense as that from local or northern-grown seed. The foliage is usually more resistant to the common leaf diseases and cures to an attractive light-brown color during the winter. From observations made at this station, it appears that in respect to the characteristic of greenness, the more southern the origin, the more pronounced the characteristic.

Lawn seedbed preparation for planting buffalo grass differs very little from good preparations for other lawn grasses. First, it is imperative that the lawn be properly graded. Once the grass is established this task becomes impossible without destroying the grass and beginning all over again. Following grading, the seedbed should be carefully worked to destroy all weeds. It should be settled to prevent rapid drying. The ideal lawn seedbed is garden-mellow on the surface but firm underneath, free of live weed growth and well supplied with moisture. Fertilizing is usually unnecessary as buffalo grass does well even on excavated clay soils, provided they have been satisfactorily prepared for seeding.

In the vicinity of Hays, buffalo grass seed may be planted for lawns any time from April 15 to June 30. Where water is available for irrigating to insure germination, the planting period can be extended to August 15. Early plantings, although troubled more from weeds, will provide a solid lawn sooner than later plantings, provided the weeds are controlled. Plantings made during the first 15 days of May are made after at least one crop of weeds has been destroyed. The soil is warmer and usually the rainfall is heavier. This permits maximum response. If planted according to the recommended procedure and properly weeded, a solid lawn cover normally can be expected in about 100 days. Plantings made as late as June 30 have a good chance of spreading together before frost but some-

times watering is necessary to stimulate growth during dry periods. Plantings made later than August 15 run the risk of not getting sufficiently well established to withstand the winter.

For best results, planting the seed in rows approximately one foot apart is recommended. Planting in rows permits weeding with a hoe or garden cultivator. This eliminates tedious hand weeding and the plants soon spread together. Planting can be done by hand or with a suitable garden seeder. Lawns large enough to accommodate a grain drill can also be seeded with this implement. If the holes in the drill are too close together, every other one can be plugged to secure more desirable spacing. Usually it is advisable to run the rows across the slope on the contour, to prevent washing out or covering too deeply. On steeply-sloping lawns, strips of sod laid at intervals on the contour may be advisable to check erosion. Steep terraces usually should be sodded solid or planted with seed and protected with some suitable covering through which the seedlings can emerge.

Seeding buffalo grass by the broadcast method is not recommended for lawns for two reasons. First, the seed obviously cannot all be covered uniformly to the proper depth. Second, weeding cannot be accomplished efficiently. If weeding is accomplished it must be done by hand, a practice that not only involves much labor but one which often results in considerable thinning of the stand. If the weeds are left undisturbed, the lawn becomes unsightly and final coverage is slowed up materially. Moving or clipping the weeds can be accomplished by various means but the competition still exists. This delays final coverage.

Seed should be applied at the rate of from ½ to ¾ pound per 1,000 square feet of lawn area. This seeding rate is readily obtained by spacing the seed ½ to ¾ of an inch apart in the row, or by dropping from 15 to 25 seeds per foot of row, in rows spaced a foot apart. Once the desired planting rate is determined, either for machine or by hand, the lawn may be seeded uniformly with little possibility of poor results. Although this seeding rate is considerably thicker than is recommended for pastures, the average lawn is so small that the added coat is insignificant compared to the benefit obtained in securing a satisfactory lawn at an early date.

To insure maximum results the seed should not be covered deeper than one-half inch. This cannot be too strongly emphasized, particularly on the heavier soils, because covering too deeply leads to certain failure. The thickness of the little finger is an approximate measure of a satisfactory covering depth. Until experience in planting is obtained, some method of actual depth measurement should displace all guess work.

When soil moisture and climatic conditions are reasonably favorable for germination, watering to bring the grass up is not necessary. Watering tends to stimulate weeds and in that respect sometimes does more harm than good. Plantings after June 30, however, frequently require artificial watering to insure a good stand as the soil

dries out quickly at this time. Proper watering is best accomplished by extended, gentle sprinklings each evening and enough water should be applied to keep the surface moist during most of the following day. These daily waterings should continue, if started, until the grass has emerged. Thereafter, water is required only when necessary to supplement the rainfall to be sure the grass becomes established and grows properly.

Weeds are invariably a problem on all new lawns but generally are more serious where watering has been necessary. Complete coverage may be expected several months sooner, however, if the weeds are efficiently controlled. Thus, the row method of planting has its advantages in that such plantings can be hoed or cultivated while the weeds are still very small without damage to the grass. In broadcast plantings, on the other hand, weeds often become so large before the grass makes much of a showing that many of the seedlings are injured in destroying the weeds. Weeded lawns not only produce a complete cover much sooner but are more attractive in the meantime.

New lawns should not be clipped the first season except in areas where blowing soil is likely to collect in the rows of grass and result in a rough lawn. Clipping new growth reduces the vigor and although the reduction may not be apparent, its effects are there over several seasons. These statements apply not only to lawns established by seed, but also to lawns started by the sod method.

Care and Maintenance of Buffalo Grass Lawns.— With proper care buffalo grass lawns may be maintained in an attractive, serviceable condition for several years. Practices such as watering and clipping are of vital importance.

Watering.— A satisfactory lawn of buffalo grass may normally be maintained without the use of water if proper clipping is practiced and the turf is not used excessively. In general, watering is not recommended for farm lawns where labor and maintenance costs must be held to a minimum. Usually, too, under such conditions a temporary browning of the lawn during dry spells is not considered objectionable or out of harmony with the existing surroundings.

However, where a green lawn and dense turf are desired throughout the season some irrigation is necessary. As watering involves considerable expense, encourages weeds, and tends to shorten the life of the lawn, its use should be thoroughly understood. It is of most value during severe and extended drought periods when the grass not only turns brown but actually runs the risk of being thinned in stand. At this time it is most effective if applied heavily enough to wet the soil thoroughly to a depth of at least two feet. This may be accomplished by flooding, where conditions permit, or by slow continual sprinkling. One or two effective irrigations of this type, judiciously spaced, are generally sufficient to keep the grass green and growing throughout the season and are less harmful than over-watering. Light daily sprinklings, instead of being beneficial, are often seriously harmful in that they encourage shallow

rooting and may even result in the depletion of underground food reserves to a point where the lawn may actually be more susceptible to weed invasion and severe droughts than if no water had been applied.

Clipping.— Unwatered buffalo grass lawns should be clipped occasionally at heights varying between 1 and 2 inches. Clipping gives the lawn a clean uniform appearance and is better for the grass than nonclipping. Newly established lawns, if not clipped or used sufficiently to reduce the top growth, will actually smother themselves out in three or four years. This is especially true of lawns established with seed from a southern source.

Watered lawns require closer and more frequent clipping to maintain the appearance and to prevent the encroachment of undesirable weeds and grasses. Clipping at heights between 3/4 and 1 inch is recommended. Watered lawns require on the average a clipping every 10 days or two weeks, or approximately 12 clippings during the season. Dryland lawns generally require about half this number.

The clippings should be removed, especially on watered lawns, as thinning sometimes results from the smothering effect of the slowly decomposing residue.

Use of Fertilizers.— As a rule the use of fertilizers in western Kansas is a waste of time and money. Buffalo grass grows well on even the poorest soils and any attempt to rejuvenate old, weedy, thin lawns by the use of fertilizers usually results in a beneficial response from the weeds, with little influence on the grass.

Weed Control.— The control of weeds constitutes one of the most difficult problems in the maintenance of buffalo grass lawns. The problem is not too serious in new lawns but becomes increasingly worse as the lawn becomes older. Once lawns become thoroughly infested, control measures are not only expensive but are relatively ineffective. The best control measures are those practices of watering and clipping which maintain the vigor and stand of grass and consequently discourage the encroachment of weeds.

Watering too early or too late in the season, watering too frequently and watering in excess of the needs of the grass are practices that are more favorable to the weeds than the grass. Weeds such as tansy-mustard, shepherd's purse, little barley, dandelion, pepper grass, and six-weeks fescue are especially stimulated by out-of-season watering. They become established and grow while the grass is dormant. Weeds and weedy grasses with prostrate habits of growth, which enable them to withstand close clipping, increase at the expense of the grass when over-watering or too frequent watering bring about conditions favorable for their establishment. Some of the more common weeds in this class include the mat spurges, windmill grass, crabgrass, annual dropseed, sand dropseed, purple poppy mallow, western fleabane, tumblegrass, witchgrass, prostrate knotweed, and puncture vine.

Preliminary trials[6] with Lawn Sinox have indicated that the use of this selective spray is not practicable for the control of many weeds in seriously infested buffalo grass lawns. Its use is expensive and, although it demonstrated its ability to kill mat spurge, western fleabane, prickly lettuce, puncture vine and dandelion, its effects are only temporary as the areas soon become reinfested from seed. The buffalo grass and weedy-type grasses are injured temporarily but grow out in from three to four weeks. Although no other selective weed sprays or chemicals have been used, the results from these trials indicate that when lawns become seriously over-run by weeds it will be more satisfactory to re-work and re-seed.

BUFFALO GRASS FOR EROSION CONTROL

The value of buffalo grass in controlling runoff and erosion is well demonstrated in the results of a study made by the Soil Conservation Service at Hays, Kansas, during the 9-year period, 1930 to 1938.[7] This study was conducted on fertile upland soil having a uniform slope of 5 percent and all tillage and planting operations were performed up and down the slope. Buffalo grass sod lost an average of 6.13 percent of the annual rainfall whereas kafir land lost 16.83 percent where the crop was grown continuously and 19.23 percent where it was grown in a rotation with wheat and fallow. Land farmed continuously to wheat lost 12.13 percent of the rainfall, wheat in rotation lost 12.51 percent, and fallow land lost an average of 15.77 percent. Soil losses were even more striking in that buffalo grass sod showed an average annual loss of 0.44 of a ton per acre while continuous kafir land lost 14.40 tons and kafir in rotation with wheat and fallow lost 15.83 tons. Continuous wheat land showed an average annual soil loss of 4.03 tons, wheat in rotation 4.41 tons, and fallow 13.36 tons.

BUFFALO GRASS FOR AIRFIELDS

Because of its turf-forming qualities and ability to withstand rather heavy use, buffalo grass makes a very desirable turf for the smaller airfields and flight strips in the drier sections of the region where Bermuda grass is not sufficiently hardy. In the past, areas of native or virgin sod have been selected and used for municipal or private airfields and since the war began, many air bases and training fields, including the one at Hays, have been seeded to buffalo grass or mixtures with it. The grass seems to have the ability to become established under fairly heavy use and soon spreads sufficiently to withstand heavier use. Because of its spreading habits it produces a smoother turf than bunch grasses and for

6. Studies conducted coöperatively with F. L. Timmons, in charge of noxious weed investigations at the Fort Hays Branch Experiment Station during the fall of 1941 and spring of 1942.

7. The following data were furnished by F. G. Ackerman, Associate Soil Conservationist, Soil Conservation Service, United States Department of Agriculture, from results which are to be presented in a publication entitled, "Ten-Year Summary Report of Soil and Water Conservation Investigations at Hays, Kansas."

this reason is superior to blue grama which is sometimes used. On the larger fields used by heavier planes, buffalo grass is not able to stand up under runway use but does provide a satisfactory cover between the concrete or asphalt runways.

Because of the varying circumstances in connection with construction, the prevailing soil conditions and seriousness of blowing, the amount of necessary usage, etc., it is impossible to formulate any specific instructions relative to pre-seeding preparations. These must be worked out on the ground in order to permit the successful establishment of grass and yet obtain the required service. With fields on which time and immediate service are not limiting factors, preparations similar to those for establishing pastures can be used to an excellent advantage. Similar seeding and maintenance practices may also be used except heavier seeding rates are desirable to insure a quicker turf cover.

Army and navy cantonments, forts, ordnance plants, and similar units in the buffalo grass region may well be seeded to buffalo grass where a vegetative cover is desired to keep down dust and reduce erosion. Methods of seeding and maintenance are similar to those discussed for pastures or lawns, dependent on circumstances.

BUFFALO GRASS IN HIGHWAY DEVELOPMENT

Buffalo grass may be used effectively in present-day highway development. With the current trend toward wider rights-of-way, wider shoulders, and more gentle slopes, buffalo grass can be established readily and maintained. Its establishment not only adds to the beauty but will actually reduce the maintenance costs by reducing erosion to a minimum. Well-sodded shoulders also add to the safety and serviceability of the highway, particularly in wet periods. Buffalo grass usually does not grow satisfactorily in the bottom of the borrow pit, because of excessive flooding and a certain amount of silting, but western wheatgrass does well-under these conditions and generally should be seeded with buffalo grass.

New highways should be planted with a suitable preparatory crop such as cane, Sudan grass, or spring barley previous to drilling the grass seed the following spring. Heavier grass seeding rates than those suggested for pasture may be advisable. Mixtures with western wheatgrass and other adapted grasses which are particularly suited to different soil and moisture conditions should be used where the soils are variable to give better assurance of success. The first year following seeding, the weeds must be controlled to give the grass an opportunity to become established. Once the grasses are established the number of mowings required for effective maintenance will be smaller than on unseeded areas. Drilling buffalo grass on the shoulders and slopes of old construction now covered with weeds and annual grasses is possible and practicable, but the time required for the buffalo to become established is considerably prolonged and frequent close clipping is necessary to give the tender seedlings an opportunity for establishment.

BUFFALO GRASS FOR ATHLETIC FIELDS, GOLF COURSES, AND CEMETERIES

Buffalo grass has distinct advantages for football fields and other playground areas. Planting seed in the spring, as recommended for lawns, followed by proper weeding and watering during the summer, will insure a usable turf by fall. After the grass is established, watering usually is not necessary unless the area is used excessively or unless the seasons become adverse. When watering does become necessary, usually three good irrigations which soak the soil to a depth of several feet will be all that are required to keep the grass growing and thrifty and are more beneficial than frequent and excessive watering which may actually result in thinning the stand.

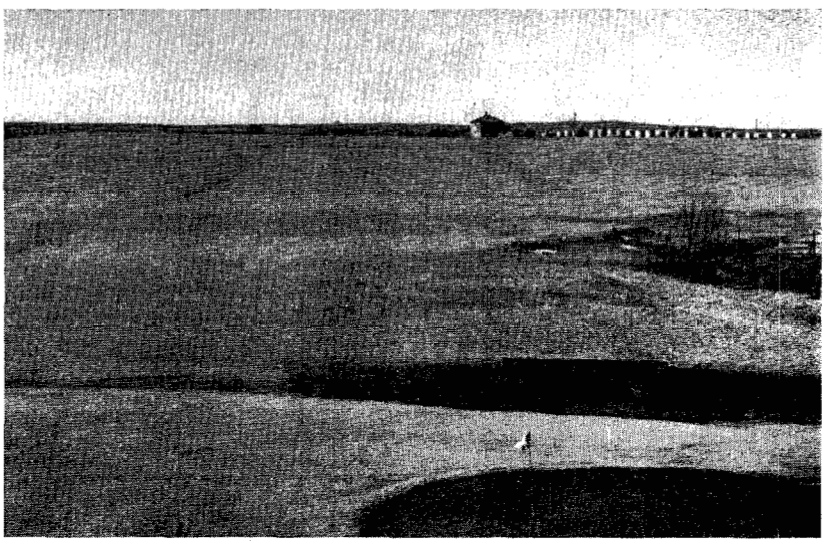

FIG. 12.—Buffalo grass on the golf course at Hays, Kansas. With proper care a dense, serviceable and attractive turf is easily maintained. Sand greens are generally used.

Buffalo grass is unexcelled for use on golf courses where close clipping, drought, heat, and cold prohibit the use of other grasses. (Fig. 12.) Likewise, for cemetery plantings in the Plains region, it is an excellent grass because of its low, sod-forming habits which enable it to produce an attractive erosion-resistant, serviceable turf with a minimum of care.

DISEASES OF BUFFALO GRASS

Buffalo grass is susceptible to several diseases. The true economic importance, however, of each disease has not been fully determined and it is likely that still other diseases will be discovered as research with the crop continues. Fortunately, none of the present known diseases appears to cause excessive loss where the grass is

used strictly for grazing. Where it is grown for seed production under cultivation, as appears at present to be a practical procedure, disease troubles are generally aggravated and are of more serious concern.

False smut.—One of the most serious diseases of buffalo grass is the false smut disease caused by the organism *Cercospora seminalis*. This disease to the casual observer resembles rather closely the common kernel smut of sorghum, both in appearance and effect. The diseased part of the fruiting structure, whether it is only the external portion of the stigma or the entire kernel, is usually replaced by the black fungus growth of the organism. (Fig. 13.) Where the kernel becomes infected, the viability is consequently lowered, with the extent of damage being in proportion to the degree of infection. Fortunately, all of the kernels in a single bur do not always become infected, in which case the germinating strength of the seed (bur) is not lowered to the same extent as the degree of infection. For example, in 1941, a year of very severe infections, 65 percent of one lot of seed showed infection but 80 percent germination was still possible since part of the diseased burs also contained healthy seed.

The organism seems to be rather prevalent over the entire buffalo grass territory, but the disease tends to develop into more serious proportions in the districts having higher rainfall. Heavy seasonal rainfall during the months of May and June, even in the west, are conducive to the development of the disease. Where buffalo grass is grown under irrigation for seed-production purposes the disease is of serious economic concern. Conditions for infection are not only made more favorable by the watering treatments but here the disease directly affects the source of income. In pastures the disease causes little concern since it is not a foliage disease and pastures only occasionally produce seed crops heavy enough to justify harvesting.

Dusting trials with sulphur during the 1942 season failed to effect any consistent degree of control. Selection of resistant types or types which escape infection and the use of managed irrigation methods which tend to discourage the development of the disease, appear to be the best methods of control.

Leaf Blotch.[8]—Leaf blotch caused by the fungus *Helminthosporium inconspicuum* var. *buchloes* is an important foliage disease causing a premature drying of the leaves. Symptoms of the disease may appear in June when the grass has the appearance of suffering from drought. Darkened or black blotches on the leaves near the extremities usually serve to identify the disease. The infected leaves may take on a characteristic curling and as the season progresses, both this and the blotching become more evident. Diseased

8. This disease has been referred to in earlier writings as "leaf spot" caused by the fungus *Helminthosporium inconspicuum var buchloes*. Because the term "blotch" more aptly describes the symptoms, it has been suggested by several pathologists that the name "leaf blotch" be used instead. To eliminate the confusion of a misnomer, the name leaf blotch is used herein.

plants usually possess a dull, unthrifty appearance by fall and after freezing weather become even darker. Healthy plants, on the other hand, usually remain a bright light-brown color throughout most of the winter.

Although actual killing of the grass is rare, the disease is certain to reduce the production of forage. Certainly it destroys the ability of the grass to cure into palatable, nutritious winter feed because of the rapid deterioration that takes place in diseased material. No doubt seed yields are indirectly affected, where the crop is used for this purpose, because of the reduction in effective leaf area. The

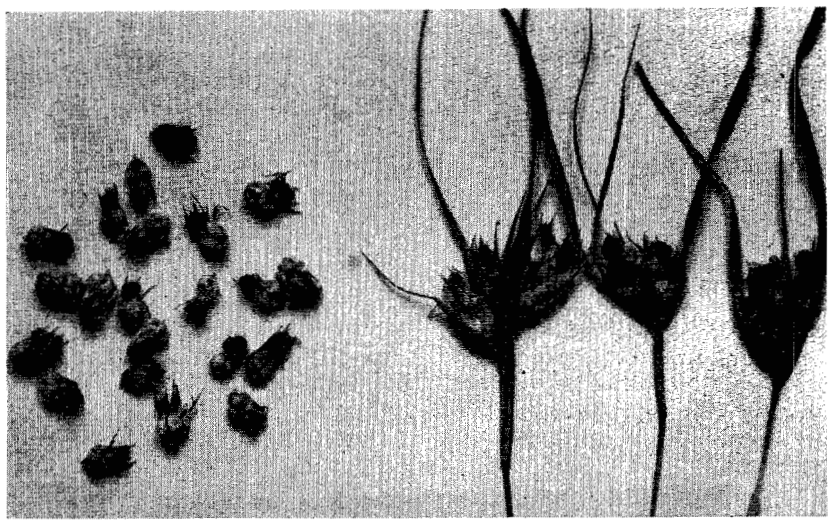

FIG. 13.—False smut, one of the more serious diseases of buffalo grass, which lowers the viability of the seed when heavy infections occur. Note the fungus protruding from the tips of the bur. Leaf rust, another disease of this crop, is also apparent on the leaves in this picture.

disease is also objectionable in lawn and landscape plantings because the infected areas detract from the uniform appearance of the lawn, particularly during the winter months.

Seasonal conditions and grazing systems appear to influence somewhat the degree of infection and consequently determine the extent of economic loss. However, no method of control or evasion of the infection has been worked out yet. Strain differences in respect to susceptibility offer a possibility of control through a rigid selection program.

Leaf Rust.—Leaf rust caused by *Puocinia kansensis* is generally considered less serious than the leaf blotch disease. Its development and actual seriousness is more dependent upon seasonal climatic conditions. Under pasture, lawn, or golf course conditions where the foliage is removed closely and regularly, infection is

seldom severe except during the wettest seasons. Its symptoms are similar to those of leaf rust of wheat and the losses no doubt are brought about in much the same manner; namely, through the use of food by the organism and premature drying of the leaf, preventing further food manufacture.

Young plantings and fields left for seed or hay are more subject to attacks by rust. Under such conditions losses may become of serious concern. No method of control is known but in the nursery, northern and local material is much more susceptible than plants from extreme southern points. Resistance to the disease generally is lost, however, in the first cross with local material, hybridization being necessary to regain winterhardiness and seed-yielding ability which the southern strains lack.

Witches'-broom. — A condition referred to as witches'-broom, apparently caused by the presence of *Eriophyses* mites, often occurs in newly-established areas of buffalo grass, particularly nursery plantings. It is characterized by "clubbing" or dwarfing of plant parts in varying degrees of intensity. The malformation is most conspicuous in plantings the first year. It may be present the second year but rarely causes any concern in older plantings, regardless of the use made of the grass. Twenty-five percent of the individual plants established in the selection nursery during 1939 exhibited some degree of witches'-broom that year while 30.8 percent of all plants in the nursery in 1940, and 53.9 percent of all plants in the nursery in 1941 showed infestation the first year. Witches'-broom is affected by the season but to date the specific factor or factors causing the variations have not been determined. Strains likewise vary widely in their reaction to the trouble. In 1941 several strains had progeny showing 100 percent susceptibility while others showed only 2 percent. In general, southern accessions are less susceptible than local or northern material. Measurements from selection nurseries during the last four years show, strangely enough, that healthy plants average less spread at the end of the first season than the susceptible plants, indicating one of two things: Either that the most vigorous plants are attacked; or that the presence of the mites stimulates the spreading of the grass.

The exact nature of witches'-broom and the economic effects it may have upon the various uses of the grass are not fully understood. At present it is not regarded as serious except in the growing of isolated plants where the dwarfing characteristic reduces the amount of forage production and largely prevents the formation of seed. Strain resistance appears to be the only method of control.

Nematodes. — Trouble from nematodes in Kansas is definitely of little economic importance at this time, although Pladeck (9) indicated that the disease was fairly widespread in Texas. The nematode form is an undescribed species of *Anguina* and its effect upon both forage and seed production takes place through the development of galls at the nodal point, thereby restricting further development into normal stolons and fruiting branches. Fortunately,

not all buds of any single plant are attacked by the organism, thus, many of the buds proceed to develop normally, giving little evidence of the presence of nematode unless a careful watch is maintained. The galls, which are only slightly larger than the seed bur, are sometimes recovered in the seed during the harvesting operation. However, the normal percent of infection is so light that the purity of the seed is not affected appreciably. Control measures have not been studied.

Yellows.—A condition referred to as the yellows occurs under both irrigated and dry-land conditions at Hays. It is of special annoyance in lawns as its presence detracts materially from the appearance. Irrigation is felt to aggravate the condition although during wet years it may be rather serious on dry-land plantings. Sometimes weakened vigor is associated with the trouble which is thought to be the result of an iron deficiency (or the existence of this element in an unavailable form) in the soil. Definite control measures have not been worked out although different selections of buffalo grass do vary in respect to their resistance or susceptibility to this trouble.

INSECT ENEMIES OF BUFFALO GRASS

Very little is known about the insect enemies of buffalo grass and the extent of their damage to the crop. Grasshoppers no doubt are the most serious, particularly to new seedings. The grass in early growth is palatable and damaged easily by defoliation. In seasons when grasshoppers are numerous, serious damage often results. During the spring of 1938 when the native pastures in the territory, stimulated by the favorable moisture of that season, were recovering from the drought, grasshoppers were reported and observed to do tremendous damage. The greatest damage was to the runners which were chewed off frequently before they rooted, leaving them to wilt and die. Effective control may be obtained in new seedings by keeping the weeds clipped quite short and by repeated spreading of poison bran mash.

Other insect enemies of buffalo grass include the leaf hopper, June beetle, and mound-building prairie ant. Their damage to the grass is similar to that done to other crops on which they prey. No doubt this grass has other pests and as research with it continues they and their effects will be studied.

IMPROVEMENT OF BUFFALO GRASS

Improvement of buffalo grass is of very recent origin, the work actually covering a period of less than a decade (19). Its objectives are simple but highly significant. They are aimed at domesticating, in so far as is necessary and possible, the existing habits of the grass that make it difficult to adapt to present-day farming methods and at improving the general productiveness. Although the work is in its infancy and space does not permit elaboration, a short preliminary report of the current progress will be of interest.

The improvement of most crops is accomplished by two general methods or combinations of these methods—selection and hybridization. Where a great deal of variability exists selection is usually the first logical step. When the degree of variability no longer permits the isolation of superior forms, hybridization is necessary to induce varriation and to combine desirable characters which previously did not exist in the same plant. Reselection then is again necessary to fix or retain the desired characters. Although the procedure sounds simple and easy, it is neither. The program at its best requires a long time and is probably never-ending.

The intensive program of improvement which was begun in 1936 soon showed that buffalo grass was highly variable. In fact, variations were found to exist in almost every known character for which improvement was desired and it is now known that even wider variation can be obtained by manipulating the seed source. In fact, the range of existing variations would permit the obtaining of an ideal variety today if these desirable characters could be assembled into one plant and so definitely fixed that the progeny of succeeding generations would always possess the characters of its forebears. Naturally, the solution of the problem is not this simple. First, it is difficult to find very many of the desirable traits combined in one plant. Second, it is even more difficult to retain them in succeeding generations.

Because of the great variability, plant selection is being used most extensively. Some hybridization has been accomplished but as yet its use has not been extensive. Several good selections have already been obtained and the better ones at present are under intensive study in order to determine which will be of greatest value on the farm. Although it may be several years before improved types capable of "breeding true" are perfected, the feeling that the present improvement will more than offset the lack of uniformity is an urge to make these improved types available to the farmer as soon as possible so that he may capitalize upon the value of current improvement. This is especially true since the crop is to be used principally for grazing where a lack of uniformity would not be serious.

SELECTING FOR DESIRABLE SEEDING CHARACTERISTICS

The average run of native buffalo grass produces a very small amount of seed and produces it so close to the ground that mechanical harvest is not only expensive but for a long time was impossible. These factors are responsible for the scarcity of seed on the market and high price. The aim of the improvement program is to overcome this situation by putting plenty of seed on the market at a reasonable price. Plants which produce large amounts of seed at favorable heights and yet are desirable in other respects are the types selected for improvement. The progeny of such plants are grown and the most favorable types again reselected These steps are repeated time after time in order to fix the desirable traits in

the selection and to eliminate as many of the undesirable characters as possible. When a selection appears highly promising, it is given more exhaustive tests under actual field conditions and if proved fully worth while, it is finally released to farmers.

Much of the original selection work was accomplished in native pastures where the characteristics of the plant and its response to grazing could be compared with other associated plants. Selections from this material today comprise some of the most promising types. Although most of the improvement work has been done with local material, a few accessions from northern and southern points in the Plains have been included. In respect to seeding characters northern types are inferior primarily because they tend to produce the seed so close to the ground. Production of seed in satisfactory amounts and of good quality is usually possible unless the season is extremely favorable for the development of the false-smut disease. The slightly earlier-blooming date appears to be an advantage in escaping high temperatures during pollination and seed forming. Southern types produce their seed at favorable altitudes but production is low usually and the quality may be poor because of the high temperatures and drier conditions which exist during pollination and seeding.

The selection nurseries, which contain approximately 7,000 individual plant progenies from between 100 and 200 selections each year, are always maintained under dry-land conditions in an effort to retain the drought-resisting qualities of this grass. (Fig. 14.) The better plants are determined by careful study and are selected and harvested for yield determinations. Some of these results are very illuminating and indicate that the possibilities of harvesting high yields of seed, with machinery adapted for the task, greatly exceed earlier expectations. Yield results of several buffalo grass selections are presented in Table 8, where it may be seen that they averaged from 299 to better than 1,000 pounds of seed per acre during the years 1940 to 1942. Season, of course, has a strong influence on yield, but a consistent yield of 300 pounds of clean seed per acre would be highly practical for any dry-land planting regardless of how it was tended. Seed heights of from 3 to 4 inches will also permit successful harvesting with combines equipped for low cutting.

IMPROVING YIELD AND QUALITY OF FORAGE

Although good seed production and tall seed stalks have been stressed in the past, improvement efforts designed to increase the forage-yielding ability of buffalo grass have also been under way. Variations in respect to forage production occur as frequently as variations in respect to seed production. The differences, however, are not so great and the possibility of obtaining improvements in proportion to seed-production improvements seems rather remote.

Nursery yields of three tons of cured forage are not uncommon and some of the best forage types have given yields of twice this amount under extremely favorable weather conditions. Such favor-

able yields cannot be expected to hold up, however, under pasture conditions for two reasons. First, these nursery yields have been stimulated by the cultivation which is necessary to keep weeds down and the plants separate. Second, yields of buffalo grass are known to decline as the plantings get older, regardless of management. A worth-while improvement in forage productiveness seems possible, however, but is anticipated primarily through the improvement of such characters as longer growing season, greater resistance

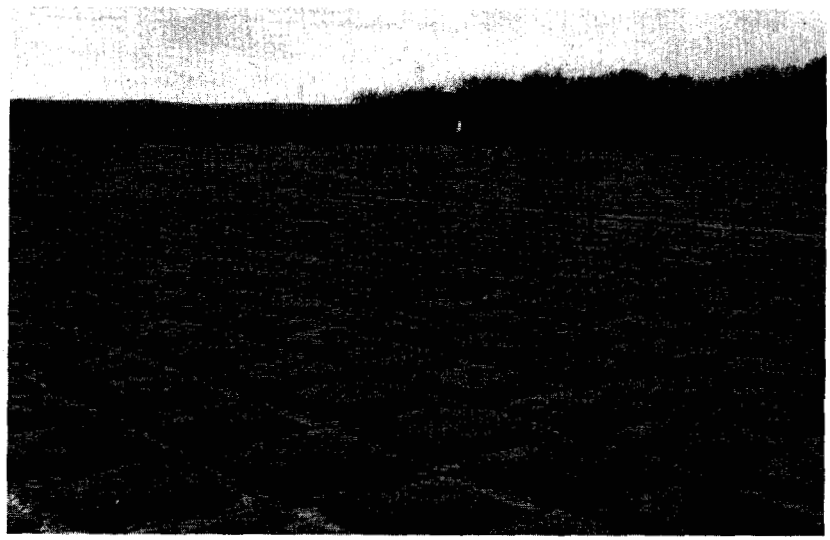

FIG. 14.—One of the buffalo grass selection nurseries at the Fort Hays experiment station. A number of good types have already been isolated.

to disease, improved vigor and better adaptation. Better adaptation connotes a lower water requirement ratio.

Usually the heaviest forage producers are not the best seed producers and frequently may produce very little seed at all. This situation is not unparalleled since similar reactions have been noted in some of the other grasses and even in the sorghums. Neither is the situation seriously alarming, for some of the heavy seed producers also show quite desirable yields of forage. (Table 8.)

The introduction of southern rnaterial, both for making selections directly and for providing hybridizing material, has recently been undertaken. The greater vigor, longer growing season, increased resistance to certain diseases, and better palatability of southern material, offer possibilities both for increased forage yields and a better quality product. A few obstacles, however, are being encountered. They involve lack of winterhardiness and light seed production of the southern material, and the tendency for diseaes

TABLE 8.—*Seed and forage yields of buffalo grass selections hand-harvested from spaced plant nurseries during the 3-year period, 1940-'42. Season of 1940 was not favorable for the production of seed; 1941 was unusually favorable; and 1942 was somewhat better than average.*

DESCRIPTION.	Height of seed, inches.		Pounds seed per acre.		Tons cured hay per acre.	
	Average of all selections.	Highest yielding selection.	Average of all selections.	Highest yielding selection.	Average of all selections.	Highest yielding selection.
1940 yields of 112 2-yr.-old selections from 1939 nursery	3.9	.....	299	.....	3.89	.....
Highest seed-yielding selection	.....	4.3	.....	841	.....	3.88
1941 yields of 210 3-yr.-old selections from 1939 nursery	4.6	.....	1,431	.....	3.14	.....
Highest seed-yielding selection	.....	5.0	.....	4,318	.....	5.09
1941 yields of 42 2-yr.-old selections from 1940 nursery	4.8	.....	1,171	.....	3.73	.....
Highest seed-yielding selection	.....	4.5	.....	2,924	.....	4.64
1942 yields of 17 3-yr.-old selections from 1940 nursery	5.1	.....	815	.....	2.93	.....
Highest seed-yielding selection	.....	5.5	.....	1,595	.....	2.86
1942 yields of 88 2-yr.-old selections from 1941 nursery	4.7	.....	727	.....	3.56	.....
Highest seed-yielding selection	.....	3.0	.....	2,259	.....	2.85

resistance to disappear rapidly in crosses with susceptible types. Only time will reveal the actual practical benefit to be derived from these improvement efforts.

IMPROVING THE TURF QUALITIES OF BUFFALO GRASS

A desirable turf-type buffalo grass differs from a pasture type mainly in that it has shorter, denser leaves, and the runners have shorter nodes which branch more profusely, thereby producing a highly resistant turf. It is also especially desirable to have it turn green early in the spring and remain green late in the fall. Plants

FIG. 15.—Selections of buffalo grass being tested under dry-land and irrigated conditions at the Fort Hays experiment station, for their lawn- and turf-making qualities.

having all of these characters, except the long season, may be readily recovered from northern material and at the outset a number of such selections were made. These types require a minimum of maintenance and it was felt the short season would not be seriously objectionable. However, because of their short season and susceptibility to foliage diseases, they have met with small favor and it looks as though it will be necessary to sacrifice somewhat in quality of turf and economy of maintenance to obtain the longer season and greater disease resistance of southern types. Much work and time are needed before any material improvement along this line is accomplished. Figure 15 will give some idea of how selections are tested for their turf-making qualities.

SELECTING FOR DISEASE RESISTANCE

In an effort to eliminate the normal losses in productiveness and quality, the improvement program is striving to introduce greater disease-resisting or escaping qualities into selections which are superior in other respects. Variations in these respects occur in proportion to those which occur in other characters. For example, selections made in 1941 varied in respect to bur infection to false-smut from 1 to 76 percent among those particular selections harvested and inspected. Even the progeny of a single selection varied from 5 to 70 percent. Similar variations were found in respect to susceptibility to leaf blotch, leaf rust, and witches'-broom.

In a few instances the effect of origin upon time of pollination and the development of the plant seem to play an important role in determining disease resistance. As a rule, accessions from points far south will be found freer of disease. The exact possibilities of capitalizing upon these qualities are not definitely known, but the work so far indicates that resistance diminishes rapidly as hybridization with susceptible types takes place. Fortunately, enough variation occurs in local material to indicate that a reasonable degree of improvement can be obtained through careful selection within this material. The perfection of strains that are wholly free of any disease liability, however, seems quite remote at this time.

GROWING BUFFALO GRASS FOR SEED

Because native pastures cannot be depended on for consistent seed production and because yields are invariably low, the growing of improved strains of buffalo grass under irrigation, where large, consistent yields of high-quality seed may be readily harvested with low-cutting combines, appears to be the most practical system of production. This makes the production of buffalo grass seed for the market strictly a specialized business, made so by the need for heavy capital outlay and special machinery, the need for a special knowledge of the crop and all phases of its management.

PRODUCTION FROM NATIVE PASTURES

Native pastures are neither productive nor reliable as a source of seed. Many factors contribute toward this situation but the chief reason is the low annual rainfall. Being a perennial crop, the grass occupies the land during the entire year. This and the fact that growth is greatest during the season of highest rainfall permits no period for building up a reserve of moisture which can be carried over for the production of a seed crop. For the above reasons, seed is produced only in those seasons which have an abundance of rainfall from the fall of one year until July, or the normal-ripening period, of the next year.

Other factors contributing toward low seed yields from native pastures include the natural mixtures of blue grama grass in all

but naturally-revegetated pastures, the normal proportion of male plants, and the existence of inferior seeding types. Weed seed such as that of little barley, which is prevalent over much of the eastern buffalo grass territory, also presents another problem in the harvest of seed from pastures. Its seed, which ripens at the same time as buffalo grass seed, is obtained with the latter and, being of similar size and weight, is practically inseparable. This is objectionable since a mixture of this weed in pastures results in a lowering of yield and quality of forage.

Yields of seed from native pastures can be expected to vary from failures to 100 pounds per acre. In 1938, the most favorable season for native pasture production at Hays in recent years, a yield of 34 pounds of seed per acre was obtained from relatively pure buffalo grass areas in the station's pastures. In 1941, a very favorable year for native pastures in western Kansas, reported yields of commercial harvests ranged between 50 and 100 pounds per acre. During 1942, native pastures in eastern Colorado were reported to yield from 10 to 100 pounds with 30 and 40 pounds being an average. For the most part, seed harvested commercially in these western areas was obtained from land which had been cultivated once but which was allowed to revegetate naturally. The areas were largely pure buffalo grass. Small, shallow, temporary lake areas, locally called lagoons or buffalo wallows, more frequently provide good harvests of seed than pastures and account for some of the higher yields per acre reported. These areas, however, are small in size and have a potential production of a very limited amount of seed. In the light of the foregoing information, when considering the cost of harvest, the frequency of good seasons, the low seed yields per acre, the chances for weed mixtures and the fact that unimproved seed is obtained, it is readily apparent why native pastures are not considered a practical source of seed for the market.

PRODUCTION UNDER DRY-LAND CULTIVATION

Growing buffalo grass under dry-land conditions where seed is expected as the main source of income, is attended with considerable risk but should be more practical than relying upon native pastures. Two general methods of handling are possible namely, growing in rows or maintaining in solid-turf form. Planting in rows and providing some cultivation are partial insurance against deficient rainfall, and lower yields from this method of handling need not be expected. Cultivation, however, tends to make the land rough and harvesting somewhat difficult unless care is maintained during the operation. Annual weeds also create more of a nuisance on cultivated fields than they do on solid-turf areas.

Since it always requires a full season for the establishment of buffalo grass after seeding, no return can be expected the first year. When weeds are serious and rainfall is light it may even require a second year, but, once the grass becomes established yields from failures to 200 pounds per acre can be expected, depending upon the

season. Higher yields than from native pastures are possible since such areas contain no mixtures with other grasses and the response from cultivation is obtained. The use of improved seed types will further increase the chances of higher yields. Fields established by seed and grown under dry-land conditions usually are the most productive from the second to the fifth years after which a reduction in vigor and a lowering of yield takes place until yields approaching those from native pastures are all that can be expected.

Because of the cost of establishment, the machinery overhead, the relatively short period of productiveness and the chances for rather low yield when the seasons are unfavorable, this method is neither as reliable nor as practical as where irrigation can be used. It will, however, provide for more frequent crops with larger yields than native pastures and the hay or pasturage afforded during years of poor seed returns will prevent it from being a complete financial failure.

IRRIGATING BUFFALO GRASS FOR SEED PRODUCTION

Growing buffalo grass under irrigation appears to be the most successful and reliable method of producing seed. By the use of improved types and the employment of good management methods, high yields of good quality seed can be consistently produced.

Response of Unimproved Material to Irrigation.— Irrigating native pastures may result in from one to three years of fairly good seed production. Yields of as high as 250 pounds per acre may be expected but because of the mixtures with other grasses and the tendency for such areas to go down rapidly in vigor, the method has its limitations. Planting unimproved seed under irrigation, specifically for the purpose of growing seed, may provide a fair return but the practice does not give promise of being as profitable as where improved types are used. If complete coverage is obtained the year of seeding, average seed yields of from 100 to 400 pounds per acre may be expected for a period of four or five years. By the end of this time the planting becomes either so weedy or so reduced in vigor that the lower yields make continued irrigation impractical.

Seed produced from native pastures or from fields established with unimproved material is not likely to find as ready sale or demand so favorable a price as seed grown from improved types. Such seed, because it is produced on shorter seed stalks and from plants more susceptible to disease, is likely to be low in quality because of its greater susceptibility to the false-smut disease. This, combined with the fact that it cannot be expected to produce pasturage on a par with improved types, will no doubt lessen both the price and the demand for this type of seed.

Response of Improved Strains to Irrigation.— Results during the four-year period, 1939 to 1942, indicate that maximum seed production can be secured only by growing improved types of buffalo grass under suitable conditions of irrigation. Seed yields from the best strain tested up until 1942, not only averaged over 1,000

pounds per acre, but the production was consistently high from year to year and the seed quality was generally good. (Table 9.) The value of the hay produced in addition to the seed also amounted to considerable as can be determined from Table 9. Such hay properly cured and stored has excellent feeding qualities as determined from both laboratory analysis and actual feeding trials at the station. Fortunately even better seed production can be anticipated in the future as the manifestations of continued improvement efforts and better management practices become apparent.

Seed grown under irrigation is felt to possess all the qualities of seed produced under dry-land conditions. This is true because all improvement work is conducted under dry-land conditions. Thus, growing the crop for one generation under irrigation is little different in effect than an extremely favorable season.

Because buffalo grass produces seed only on female or monoecious plants, the method of establishing the grass has much to do with the potential yield of seed. Likewise, management in the form of irrigation and utilization of the forage, has much to do in determining the yield and quality of the seed. These factors are discussed subsequently under appropriate headings.

TABLE 9.—*Seed and forage production of Selection 1-i buffalo grass under irrigation and the effect of two systems of management on the height, production and availability of seed.*

YEAR.	Effect of management practices A and B:[1]							
	Height of seed, inches.		Pounds seed per acre.		Availability of seed with special combine.		Tons cured hay per acre.	
	A.	B.	A.	B.	A.	B.	A.	B.
1939.....	6½	2½	860	1,074	80	35	4.96	2.70
1940.....	5½	2	2,861	1,408	80	15	4.40	1.69
1941.....	4½	2	1,930	1,471	80	20	3.29	1.51
1942.....	5	1½	1,227	1,451	80	10	2.73	1.13
Average...	5½	2	1,720	1,351	80	19	3.85	1.76

1. In treatment A the foliage was never clipped or grazed except to harvest the seed. In treatment B the foliage was clipped twice each May, at one-half inch to simulate grazing. This planting was established with sod in May, 1938.

METHODS OF ESTABLISHING SEED FIELDS WITH IMPROVED MATERIAL

Two general methods of establishing seed fields with improved material are possible; namely, by planting improved seed, or by transplanting sod of a selected type. Each method has its advantages and its limitations, making a wise choice possible only after proper consideration of all factors. The sod method has one distinct advantage in its favor. Maximum seed yields are possible.

This is true since seed plantings contain approximately 50 percent male plants whereas it appears that only from 10 to 20 percent are required for satisfactory pollination. Another reason for the higher yields of sod-planted fields is the slightly larger yield per unit area of seed-producing material, simply because improvement has not yet reached the point where these improved strains will "breed true" when planted from seed. For the same reason seed from sod fields is generally considered of more value for planting pastures or seed-producing areas than that from fields established with seed because it is one generation less removed from improvement.

Planting seed has the advantage of being a cheap easy method. Sod is not only bulky and cumbersome to handle, but it may be

FIG. 16.—A seed-increase field of an improved type of buffalo grass under irrigation at the Hays station. Large, consistent yields of superior quality seed are possible by this method of production.

difficult, if not impossible to secure unless increased on the farm contemplating its use. Few nurseries or individuals are willing to provide stocks of the sod because of the limited demand. Developing planting material is relatively rapid and inexpensive, however, and an acre of two-year-old sod cut into sizes convenient for handling will provide enough material to establish from 100 to 150 acres of land for seed purposes. Labor naturally is excessive, approximately 100 man hours per acre being required for establishing the 10-acre increase field on the station in 1941. (Fig. 16.)

Both seed and sod fields will spread together more rapidly where the grass is established in rows and the weeds are controlled by cultivation. A beet and bean cultivator is preferred for cultivating as it disturbs the soil less, leaves the field smooth, and permits more rapid spreading of the grass. Rows spaced 30 inches apart and treated as indicated will normally spread together the first year and begin producing seed the second season.

INFLUENCE OF MANAGEMENT UPON SEED YIELD AND QUALITY

Timely irrigation, early harvesting, and avoidance of grazing are conducive to maximum seed production and quality. Where buffalo grass is being grown for seed the crop should never be allowed to suffer because of the lack of water. A shortage of water following harvest may result in a lowering of vigor and stand; a shortage during the winter months may result in a partial loss of stand due to winter-drying and winterkilling; a shortage at blooming time will result in a poor crop; and a shortage at filling time will result in low-quality seed. Seed production is also indirectly affected by any shortage of water that results in a thinning of stand or a lowering of vigor, which encourages the development of weeds.

To permit timely irrigation, the seed crop should be harvested as soon as it ripens, which at Hays is about July 20. Immediately following harvest, the seed field should be irrigated to insure a rapid recovery of the grass. This permits the crop to make sufficient regrowth to cover the ground quickly. This prevents the establishment of weeds, and allows the grass to restore its root reserves so that it can maintain its vigor the following season.

Although fall and winter irrigations tend to encourage the establishment of certain winter-annual weeds such as horse tail, prickly lettuce, and tansy mustard, the grass should never be allowed to enter the winter with the soil dry. Harvesting as soon as the seed is ripe, and irrigating immediately, provides some protection against the establishment of weeds when fall or winter irrigation is necessary as the grass covers the ground and makes weed growth difficult. In some years the grass may make a second seed crop which will usually ripen about frost time. This crop is generally very light compared to the July crop, however, and should not be harvested at all or at least not until just before growth begins the next season.

Irrigations during the spring season will depend largely upon the rainfall. Never more than three waterings are required, however, for maximum seed production even in dry seasons. Since excess water is costly and detrimental to the stand, a check of the moisture content of the soil should be maintained at all times and irrigation practiced only when necessary to keep the grass thrifty and growing. The growing crop must never be allowed to suffer at any time during the seed-formation period, as subsequent irrigations are likely to cause the development of a later crop of seed. This process generally results in poor seed quality and unsatisfactory production as compared to what can be expected from proper watering practices.

The false smut organism develops most rapidly during the last half of May and the first half of June. Whenever irrigation is necessary during this period an attempt should be made to water on hot, dry days. Such a practice helps to discourage the development of the disease and by so doing, encourages a better quality of crop.

Although the actual grazing season would be short, the growth before flowering starts may be very vigorous and tempting as a source of pasture or hay. Grazing then or any time during the

period of seed development is certain to reduce the yields of seed. (Table 9.) The actual reduction in seed yield may not be so serious as is the lowering of its availability for harvest with combine machinery. Grazing or clipping the forage, at this time reduces the height of the foliage, which automatically lowers the seed and its availability. This is true even of the tallest seed-stalk types. The extent of this danger is brought out in the table where the most severe defoliation treatment is compared with non-clipping. (Table 10.) Lowering the height of seed production invariably increases the infection of false smut as humidity and other conditions for the development of the organism are more favorable near the surface of the soil. The disease, as pointed out under the discussion, "Diseases of Buffalo Grass," lowers the quality of seed in proportion to the degree of infection. This is brought out in Table 10, which compares the seed from the two management methods.

TABLE 10.—*Effects of season and management practices on the infection of false smut in the seed of Selection 1-i under irrigation*

YEAR.	Nature of season by months.			Quality of burs.		Caryopses per 100 burs.	
	April.	May.	June.	Percent of infection.	Percent viability[1] (with healthy seed).	Diseased.	Healthy.
	Clipped at ½ inch twice in May of each year to simulate grazing						
1939.....	V. dry...	V. dry...	Wet.....	0.5	99.0	1	239
1940.....	Normal...	Normal...	Normal...	66.8	66.3	116	114
1941.....	V. wet...	Normal...	V. wet...	78.5	56.0	138	84
1942.....	V. wet...	Dry.....	V. wet...	54.0	78.5	84	138
			Average..	50.0	75.0	85	144
	Foliage never clipped except to remove seed						
1939.....	V. dry...	V. dry...	Wet.....	1.0	94.0	1	227
1940.....	Normal...	Normal...	Normal...	11.3	91.3	17	213
1941.....	V. wet...	Normal...	V. wet...	65.0	80.5	105	154
1942.....	V. wet...	Dry.....	V. wet...	47.0	76.0	74	150
			Average..	31.1	85.5	49	186

1. Some of the diseased burs may yet contain healthy caryopses, thus are viable or capable of growing. This is possible since the bur has divisions for more than one seed.

SEED HARVESTING MACHINERY

Although the development of machinery for harvesting buffalo grass has been in progress for years, it was not until 1941 that any appreciable amount of seed actually reached the market. Several factors have been responsible for the slow progress. Uncertainty of the seed crop and low yields from native pastures have been largely responsible. The fact the seed is produced so close to the ground and that it normally shatters easily has also been an important consideration. Likewise, the absence of detailed information concern-

ing the normal growth and reproductive characteristics of the grass impeded the progress along these lines in early years.

In 1935, the Fort Hays Branch Experiment Station, in cooperation with the Soil Conservation Service, began experimenting with harvesting machinery. The first machine was constructed on the principle of a large vacuum cleaner which sucked the seed off the ground after it had shattered. Although this original machine was not entirely successful because it lacked means of cutting grass and weeds ahead of the suction apparatus, its vacuum principle was found in tests to be 92 percent efficient where the obstructing foliage was removed previous to collecting.

Two general types of vacuum machines are now in general use. One employs a series of small, flexible vacuum units to allow for the unevenness of the ground. These units are preceded by a low-cutting sickle bar and elevating device to remove the tall growth and weeds so that a more effective vacuum can be created. The vacuum units also have revolving agitators which are an aid in loosening the seed from the soil and in stripping unshattered seed from the foliage. The other type vacuum machine embodies a principle similar to that of the whirl-wind-type lawn mower in that it has a rapidly revolving cutting blade which operates horizontally at the surface of the ground. As the foliage is cut the propeller-like blades lift and blow the material into the cleaning device of the machine. This lifting action creates a vacuum which seems to be quite efficient in picking up the seed off the ground, especially where close cutting can be practiced.

Wind-blast machines operating somewhat on the principle of a vacuum unit in reverse are also now in use. In general, these machines have an agitator which loosens the seed from the soil and from among the foliage so that the wind blast created by a high-speed fan can blow the seed on to a sliding shoe or catching device. From this point it is conveyed to the cleaning devices of the machine where the seed is reclaimed. Usually the agitator precedes the wind-blast unit, which is directed at the point of contact between the agitator and ground. In some machines, the fan that creates the wind blast operates close to the ground so that flexible agitating hammers mounted between the fan blades can reach the ground. Thus, the moment the seed is loosened it is blown or forced by centrifugal action in the catching unit of the machine. The latter-type machine, which was recently developed and added as an attachment to the station's low-cutting combine, seems to have distinct advantages in that it is simple, compact, and yet is as efficient as any other type in present use. (Fig. 17.)

Seed harvested by the vacuum and wind-blast machines, after it has passed through a winter season on the ground, may show germination slightly higher than average because of the natural weathering that has taken place. Such seed, however, usually does not germinate sufficiently high to justify planting without treatment. Treatments necessary to induce satisfactory germination, though,

usually are cheaper and easier than for seed combined before natural weathering results. Disadvantages of the vacuum and wind-blast machines are: First, that seed of lower purity and quality often results because of inseparable foreign material which is picked up during harvest. Second, neither type of machine alone lends itself to harvesting irrigated seed fields during the summer when the forage is green and at a time when maximum yields of both high-quality hay and seed are available. Since native pastures are unreliable as a source of seed, there will be years, when such machines have limited value.

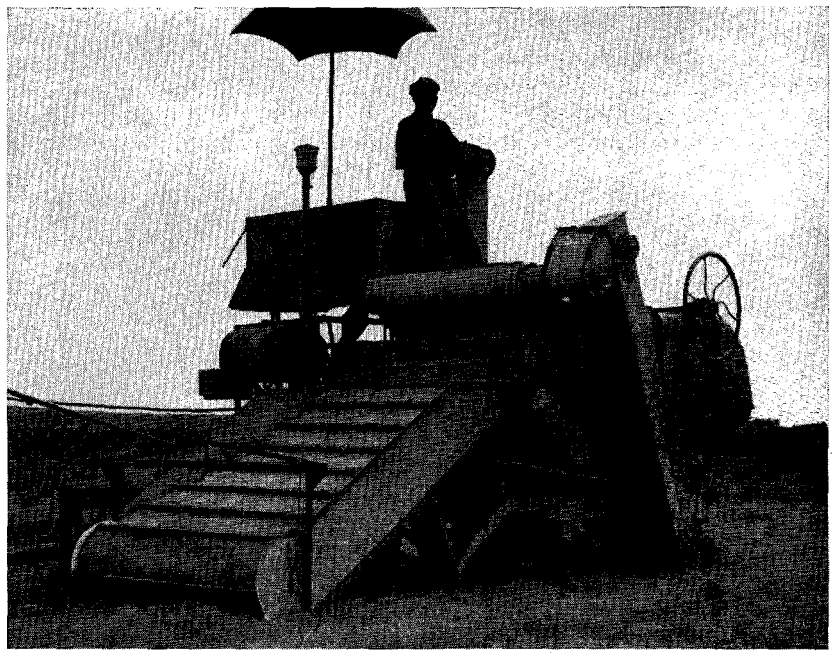

FIG. 17.—The Fort Hays experiment station grass combine with low-cutting attachment for harvesting buffalo grass seed.

The production of buffalo grass seed from cultivated fields, planted especially for that purpose and generally irrigated, has necessitated the use of more suitable equipment. Such areas are characterized usually by very heavy forage yields, relatively tall seed-stalks, and heavy seed yields. Furthermore, such plantings have to be cut just as soon as the seed is ripe to obtain the best quality hay and the highest yields of seed. This means harvesting while the grass is yet green for often it contains between 40 and 50 percent moisture at this time. Harvesting with a regular mower equipped with a lespedeza (close-cutting) bar with pan attached to catch the shattered seed, was first tried and although it was suc-

cessful, it proved impracticable. To eliminate the extra operations of threshing later, a small combine was equipped in 1941 with a low-cutting bar and provided with extra screening facilities. Its performance was quite satisfactory so an improved model was constructed during the summer of 1942. (Fig. 17.) This machine with the wind-blast attachment previously described, embodies all of the principles which have been found necessary for successful performance; namely, low-cutting bar, fast sickle action, auxiliary motor to permit varied speeds through the field, satisfactory intake apparatus, maximum separation, and a pickup device for recovering shattered seed.

SUMMARY

The value of buffalo grass for pastures, erosion control, airports, roadside development, lawns, athletic fields, golf courses, and general landscaping purposes in the Central Great Plains area has long been recognized. However, the scarcity of seed in the past, the poor results from the first attempts at planting seed, and the high cost of sodding have prevented its widespread use.

Today, successful methods of growing, harvesting, treating, and planting buffalo grass seed have been developed so that the grass can now be planted where adapted with general success.

Buffalo grass occurs naturally throughout the Great Plains region but is best adapted to the heavier soils in the Central Plains where it and blue grama grass compose better than 90 percent of the native vegetation.

From 25 to more than 40 years are required for buffalo grass to become naturally re-established on abandoned farm land. Although successful methods of sodding were developed, the requirements for labor were so high as to render this method prohibitive except for special purposes. Planting treated seed on a satisfactory seedbed in an approved manner will normally result in a productive, erosion-resistant pasture by the end of two years.

Treatment of the seed is usually necessary to overcome the natural dormancy of the seed which for years was considered of poor quality and low viability. The recommended treatment consists of soaking the seed for 24 hours in a 0.5-percent solution of saltpeter. Following soaking the seed is chilled wet for six weeks at 41 degrees F., and then dried immediately at a temperature below 120 degrees F. This treatment will raise the germination of the usual run of seed from approximately 10 percent to better than 70 percent.

Adaptation trials indicate that seed should be secured from the better-adapted local sources or from slightly southern points rather than from more northern locations. For pastures, mixtures with blue grama and other adapted native grasses are usually more desirable than buffalo grass alone.

On the more level land in areas where soil blowing is not serious, clean-tilled or shallow-cultivated preparations including fallow may be used as seedbeds for grass and a beneficial response expected

from the conserved moisture. On the steeper, more erosive slopes and in sections where blowing is serious, preparatory crops which leave a protective stubble such as Sudan grass or close-drilled sorghums have distinct advantages. Extent of the forage utilization from the preparatory crop is dependent upon the need for protection. Under less severe conditions, August plantings of Sudan grass or sorghum will normally provide enough growth for protection and yet will not deplete all of the stored moisture. Early fall seedings of spring barley and oats on fallow may provide both limited pasturage and a suitable seedbed for grass on areas needing only light protection.

Plantings in undisturbed stubble in the vicinity of Hays, Kansas, should be made from April 10 to April 20, while deferred seedings in cultivated seedbeds or fallow should be made approximately a month later. Deviations from these dates may be necessary because of the season. Satisfactory plantings have been made as late as June 15.

Three pounds of good quality treated buffalo grass seed per acre in a mixture with other suitable native grasses will provide a satisfactory proportion of buffalo grass because of its spreading characteristics. Eight pounds of buffalo grass alone have proved capable of producing satisfactory results where pure stands were desired.

The seed should be drilled one-half inch deep or broadcast and covered to approximately this depth. The importance of shallow seeding cannot be over-emphasized. Packing the soil previous to seeding is an aid to controlling the planting depth on cultivated seedbeds and usually results in better germination.

Weed growth should be clipped at intervals during the first season to admit light and to reduce the competition for moisture.

Grazing cannot be expected the first season after seeding without involving considerable risk to the stand. Usually by the middle of the second season judicious grazing can be practiced.

Grazing too early in the spring and overstocking are the most common abuses of short grass pastures. Providing supplemental grazing during the early spring season and conservative stocking throughout the year are practices that will do much toward maintaining the vigor of the grass and providing maximum returns. Where circumstances permit, rotational grazing offers possibilities for increased yields.

Pasture furrowing appears to be of limited value where a good cover and growth of grass is maintained by careful grazing practices. These structures are of greatest value in conserving runoff in drought years on areas where plant conditions are poor. The employment of a good system of diversion dykes and spreader dams, where circumstances permit, is a satisfactory and successful method of increasing forage yields.

The application of effective weed-control measures is advisable where depleted stands have permitted the encroachment of weeds or infestations of prickly pear cactus or field bindweed have occurred. Good pastures, properly grazed, usually do not become weedy.

Burning short grass pastures is always accompanied by a temporary reduction in yield and vigor of grass.

Greatly increased yields of pasturage are possible by irrigation. Irrigated buffalo grass pastures are relatively short lived, however, and the forage must be grazed throughout the season; otherwise it becomes woody and unpalatable and is not so nutritious as dry-land forage.

Buffalo grass is unexcelled for dry-land lawns in sunny locations throughout the Central Great Plains. Planting from ½ to ¾ pound of treated seed per 1,000 square feet of lawn area in rows approximately a foot apart is the recommended method of establishment. Planting in rows facilitates weeding, eliminating much of the hand labor necessary in this connection, and the grass soon spreads together. Lawns planted in this manner and carefully weeded usually provide a solid turf in approximately 100 days. With proper clipping and watering treatments, buffalo grass lawns may be maintained in an attractive, serviceable condition for several years.

Because of its growth characteristics and superior adaptation, buffalo grass may be used effectively on small airfields and flight strips; on army cantonments, forts, around ordnance plants and other army units; for highway development; and for athletic fields, golf courses, cemeteries, and general landscaping purposes throughout the Central Plains area where the soil is of the suitable type.

Buffalo grass has several natural diseases and insect enemies that may cause varying degrees of concern. The true economic importance and successful methods of control of each have not been determined fully.

An intensive program of buffalo grass improvement was begun in 1936. This program has already exhibited results and possibilities far beyond early expectations. Improvements in seed production and height of seed-stalk have been particularly encouraging. Improved forage production, disease resistance, and turf qualities are other characteristics receiving special study.

Native pastures are unreliable, nonproductive sources of common seed which does not possess any of the desirable traits of improved types. This factor is largely responsible for the limited availibility of seed and high prices.

Growing improved types under irrigation has given consistently high yields of both seed and forage. This system of production is capable not only of putting superior seed on the market, but, when put into general practice, will do so at a favorable price. Irrigation does not appear to affect the drought resistance of the grass any more than a favorable season.

Seed-harvesting machinery embodying various principles of operation has been developed and perfected both by the experiment station and by private interests. The success of each machine is dependent upon the conditions under which the harvest is to be made.

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