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LAWNS IN KANSAS

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Fig. 1.—A lawn seriously damaged by close clipping, improper watering, and lack of fertilizers. Photographed September 20, 1929.

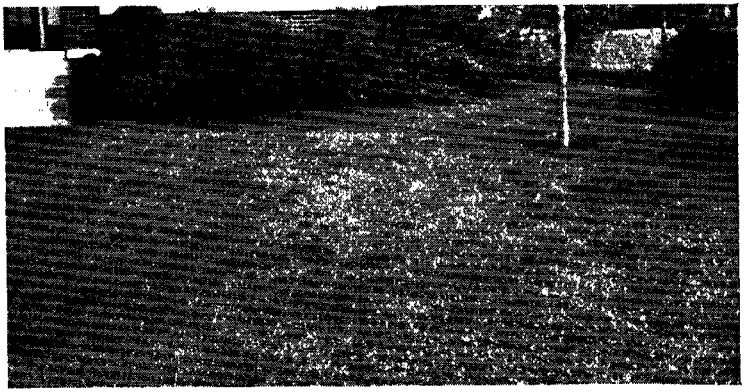

Fig. 2.—A vigorous growth of bluegrass. This lawn has been cut 2 inches high and fertilized. No water other than the natural rainfall has been used on this lawn for six years. Photographed September 20, 1929.

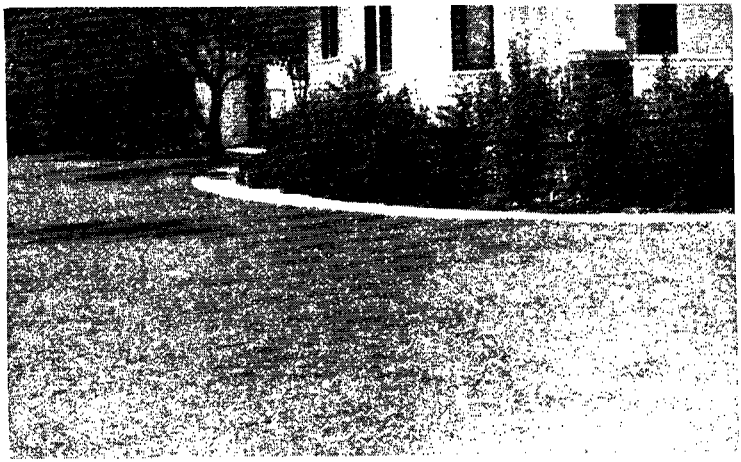

Fig. 3.—A good lawn of buffalo grass in west central Kansas three years after planting. This lawn was started by setting 4-inch cubes of sod 2 to 3 feet each way.

LAWNS IN KANSAS[1]

J. W. Zahnley and L. R. Quinlan

PURPOSE

Grass is of great economic value to the state of Kansas as live-stock feed, but it is likewise of importance for its esthetic and practical value to home grounds, to public grounds, and to attractive natural landscapes. This bulletin has been written primarily to discuss the establishing of a lawn and its care under the climatic and soil conditions found in Kansas.

LANDSCAPE VALUE OF LAWNS

The beauty of grass is not always realized until during a time of extreme drouth when home grounds and landscapes have lost their beautiful green color or when brush or prairie fires have turned colorful landscapes to charred and blackened wastes. The beauty of any landscape is due fundamentally to the presence of grass. It is the foreground of the home and every landscape picture and the setting for architectural and garden features. A beautiful green lawn with trees and shrubs contributes greatly to the value of the home and to the enjoyment and personal satisfaction of the owner. Lawns may be made to appear larger if they are not interrupted by plantings of shrubs or beds of flowers. These should be kept back in the borders of the lawn in order to give the area an enclosure and to concentrate attention on the beauty of the lawn and the garden as a unit. Trees may be so located as to keep the hot afternoon sun off the greater portion of the lawn. Their long evening shadows extending lace-like across the greensward add a pleasing contrast and an artistic touch to any landscape. Lawns are indispensable in creating a naturalistic or open woodland effect. This is especially true in large city parks, modern park cemeteries, and large private estates.

Aside from the esthetic value of lawns they provide a soft yielding carpet on which to walk. Grass is also of practical value in preventing erosion of the soil and in softening abrupt and ugly angles in ground surfaces often found in man-made landscapes.

NATURAL CONDITIONS FOR GRASS IN KANSAS

Only the eastern one-fourth of Kansas lies within the area of the United States that is naturally adapted to the growth of tame grasses. Protracted periods of drouth and extreme heat during certain periods of almost every summer make the maintenance of tame grass lawns very difficult throughout the major portion of Kansas. This is particularly true of the central third of the state. It is difficult to maintain bluegrass in the western third of Kansas with the possible exception of the northern one or two tiers of counties.

The climate and soils of Kansas cover a wide range of variations. The average annual rainfall in the extreme eastern part of the state is about 40 inches. This diminishes to the westward at an average rate of nearly 6 inches for each hundred miles to about 17 inches along the western border.

The soils in the northeastern part are of glacial origin, generally fertile and well suited to growing grass. This comprises the region lying north of the Kansas river and east of the Blue river.

South of the glaciated region the soils are residual in origin, less fertile, and consist largely of rather heavy clay loams with tight subsoil.

1. Contribution No. 227 from the Department of Agronomy and No. 119 from the Department of Horticulture.

Soils of the central and western parts of the state are for the most part suitable for growing grass but the deficiency in moisture and high summer temperatures limit tame grass production. Some soils within this area are too sandy for the growth of grass.

VARIETIES OF GRASSES FOR LAWNS

KENTUCKY BLUEGRASS

Kentucky bluegrass, *Poa pratensis*, is the best lawn grass for the eastern third of Kansas. If water is available for irrigation its range may be extended to include a much greater portion of the state. As a lawn grass it has many desirable characteristics. Growth begins early in the spring and continues late in the fall, long after frost has terminated the growth of tender vegetation. It reproduces by underground stems which form a network below the surface and give rise to new plants thus producing a perfect sod in the upper layers of soil and a dense even turf over the surface.

Bluegrass is a long-lived grass which can be maintained almost indefinitely under favorable soil conditions and with proper cultural treatment. There is a natural tendency for bluegrass to make comparatively little growth during midsummer in this state. This is partly due to hot weather and low humidity and partly to the natural habit of the grass to go through a period of semidormancy following the normal period of seed production. With proper watering, mowing, and fertilizing, a green lawn may be maintained throughout the summer.

BERMUDA GRASS

The use of Bermuda grass, *Cynodon dactylon,* for lawns in Kansas should be limited to the southern part of the state. It may be grown in the northern half but will be severely injured by freezing during normal winters unless grown in protected locations,

It is much more resistant to drouth and high temperatures than bluegrass but possesses several undesirable characteristics. The chief objections to Bermuda grass in this state are its tendency to winterkill and the fact that the leaves are killed by the first frost. Growth starts late in the spring leaving the lawn covered with dead grass from October until May. After severe winters, when many of the underground stems are killed by freezing, a good cover of grass will not be had before midsummer. Bermuda grass grows vigorously during warm weather and should be mowed frequently. The density of the turf and tendency to allow it to grow too long gives rise to the common objection that it is difficult to mow. It spreads both by underground stems and by runners which keep close to the ground and take root at the joints thus starting new plants. It does not thrive in shade. Due to its aggressiveness, Bermuda grass is frequently regarded as a weed. Its tendency to encroach upon gardens, flower beds, around shrubs, and in other places where it is not wanted is an important objection to it as a grass for lawns.

BUFFALO GRASS

In the western third of Kansas, buffalo grass, *Bulbilis dactyloides*, is the only known grass suitable for lawns which will thrive without thorough irrigation. For large lawns and for fairways on golf courses where artificial watering cannot be practiced but where frequent mowing is desirable, buffalo grass has no equal for the western half of Kansas. It withstands more severe drouth and greater extremes of temperature than any other lawn grass in the state, and is not injured by close mowing. Watering and fertilizing are ordinarily detrimental to buffalo grass. They encourage the growth of weeds and other grasses. Buffalo grass will not

stand shading, hence if tall grasses and weeds are allowed to grow it will not thrive. Frequent mowing to keep down competition from other plants is essential.

Buffalo grass spreads by means of runners which take root at the joints. New plants are formed where these runners take root thus forming a uniform sod. A dense even turf that resists tramping is formed, making it an ideal grass for lawns. The leaves are killed by the first freezing weather in the fall and new growth starts late in the spring, hence the lawn appears green only from May to October.

BENTGRASS

In this state, Bentgrass, *Agroxtis spp.*, is used mainly for putting greens on golf courses. No variety has been found which is suitable for lawns in Kansas unless more than the usual amount of time and effort can be spent on its care. This grass produces a much denser turf than bluegrass and the leaves are finer. The roots are shallow and frequent watering is necessary in order to maintain an attractive growth. Fertilizers must be applied regularly as the shallow roots and dense leaf growth quickly deplete the plant food in the layer of surface soil in which the roots feed. Bentgrass is susceptible to a fungus disease known as brown patch which is very destructive to it. The disease can be checked promptly by treatment with certain chemical preparations, but this does not prevent its recurrence with a few days.

The density of the turf produced by bentgrass is due to numerous surface runners which take root at the joints and form new plants. In order to keep the turf in good condition it is necessary to cover these runners occasionally with a top-dressing of compost. With sufficient effort, very attractive lawns can be produced with bentgrass. Such an expenditure is not justified in most cases, however, and bentgrass cannot be recommended for lawns except under special circumstances.

MIXTURES OF GRASSES

Under certain conditions a mixture of grasses should be used in preference to a single species. A mixture will usually insure a more complete stand where there is variation in the character of the soil, topography, moisture, shade, etc. The use of mixtures also provides for some quick starting grass to form a ground cover to prevent washing and to hold weeds in check while the slower and more permanent grasses are getting established. The grasses most suitable for use in mixtures for lawns in Kansas are discussed in the following paragraphs.

Bluegrass. — This grass should form the chief constituent in a mixture of lawn grasses in sections of the state where it can be grown successfully. Some advantage may be derived from the addition of other grasses under certain conditions. Perennial rye grass and redtop are sometimes sown with bluegrass to good advantage. Such a mixture is desirable on areas subject to erosion from heavy rains. Where bluegrass alone is likely to be injured by competition with weeds, as is often the case with spring seeding, a mixture is often desirable.

Perennial Rye Grass. — Perennial rye grass, *Lolium perenne,* starts quickly and makes its best growth the first year after seeding. It is a short-lived grass and usually disappears rapidly after about the second season. For this reason and because it does not form an even sod it is not a good lawn grass if used alone. By using a mixture of seed of bluegrass with 25 to 50 per cent by weight of perennial rye grass, a good ground cover can be obtained in a somewhat shorter time than if bluegrass alone is used. As the bluegrass becomes established the rye grass will gradually disappear.

Redtop. — Redtop, *Agrostis alba,* forms a dense even sod by producing new plants from underground stems in the same manner as does bluegrass. It is adapted to a wide range of soil conditions, thriving in wet or undrained soil, yet having the ability to withstand considerable drouth. When undisturbed it grows taller than bluegrass and the leaves appear coarse. If kept mowed, however, the leaves become finer and a smooth even turf can be produced. Under favorable conditions with a mixture of bluegrass and redtop, bluegrass will take possession of the lawn within a few years, tending to crowd out the redtop in most cases.

A mixture of one part by weight of redtop seed to four parts of bluegrass is satisfactory for lawns where a mixture is desired. Some redtop is especially desirable in a mixture for large lawns, fairways on golf courses, polo fields, and the like. Under such conditions the proportion of redtop seed may be as high as 50 per cent of the total weight of the mixture.

White or Dutch Clover. — White clover, *Trifolium repens,* is extensively used in mixtures with bluegrass for lawns. The two thrive together and there is some evidence that on poor soils the grass is benefited by the clover. Whether white clover should be sown with the grass is a matter of personal preference. Except for the possible objection to the appearance of clover growing with the grass, the mixture is desirable. One pound of white clover seed to three or four pounds of bluegrass makes a suitable mixture for average conditions in this state.

Where it becomes necessary to seed in the spring a more extensive mixture is usually desirable. A suitable mixture for such conditions consists of the following constituents in the proportions indicated by weight:

4 parts bluegrass
2 parts perennial rye grass
1 part redtop
1 part white clover

ESTABLISHING LAWNS

SOIL AND SEED BED

Grading

Proper grading is one of the most essential steps in establishing a lawn. On it depends the success or failure of the undertaking. The first consideration is to provide suitable drainage from buildings, walks, and drives. It is also important to eliminate all small hollows and depressions where water might stand after rains. Small pools of water standing for any length of time are sure to kill the grass. This is especially true during the winter months. Grading that is done properly will also add beauty and interest to the lawn. The beauty depends to a great extent on the contour of the ground and the uniformity of the turf. It would be well to have the ground in the front lawn of the average home slightly convex and sloping away from the house. A fall of 2 to 4 inches in 10 horizontal feet usually is sufficient for drainage. The slope should be no greater than necessary for good drainage during heavy rains. Too steep a slope adds to the difficulty of keeping the soil moist or maintaining the grass. The slope away from the house should reverse gracefully in a flowing concave surface near the property line or sidewalk. (Fig. 4, A.) The grading of the side lawn and rear garden should be done in the same manner if conditions permit. In yards where the whole lot slopes steeply to the rear or to the front it is best to build retaining walls rather than steep-terraced slopes, which are always difficult to establish and maintain. (Fig. 4, B.)

The surface of all walks should be 2 inches higher than the ground

surface at their edge. This will prevent water from standing on the walk, and when the grass is cut at the proper height it will be even with the surface of the walk.

The grading of lawns around newly built houses requires considerable care and precaution in watching that the contractor does not leave old boards, bricks, spalls, mortar, and lime around the basement wall, where it is often covered with soil without the owner's knowledge. Soil that has been placed over debris of this kind will never grow a good lawn.

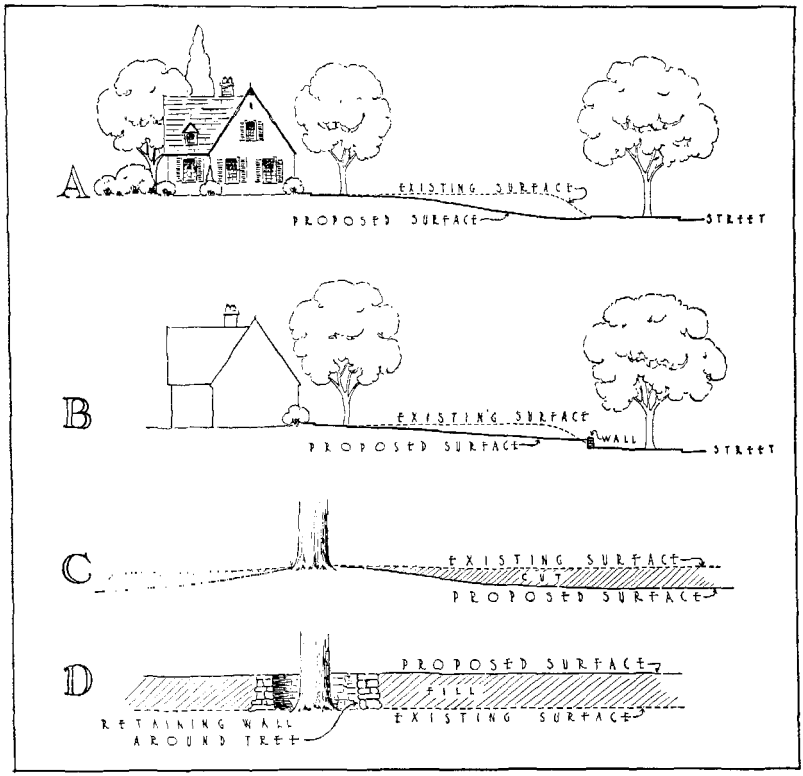

Fig. 4.—Suggestions for grading:
A—Sketch showing the house somewhat higher than the street with the lawn having a gracefully sweeping surface to the sidewalk.
B—Sketch showing a gentler south slope. Note that this is accomplished by building a retaining wall at the front walk.
C—Sketch showing a soil-cut made near a tree so as not to expose the roots.
D—Sketch showing how a tree may be saved by constructing a small retaining wall around it.

In locations where the top soil is of good quality and the subsoil is unfit for growing grass, it is well to strip the top 6 inches of soil and place it in piles before the grading is started. After the rough grading has been completed the top soil may be replaced and worked down to an even uniform surface preparatory to seeding. It is a common mistake to try to start a lawn on very heavy clay soil that has been dug from the basement.

Where the surface drainage from adjacent property is a menace, it is well to construct a shallow ditch along the upper property line. This

could be sodded or grassed over to prevent washing. In low-lying areas or areas where surface drainage is not sufficient, it may be necessary to lay tile drains. This, however, is seldom required in Kansas.

The problem of grading about large trees on the lawn is an important one if the trees are to be retained. If a fill of soil deeper than 18 inches around the tree is necessary it is usually advisable to build a rock wall to the height of the required grade around the tree trunk to keep the soil from coming in contact with the bark of the tree. (Fig. 4, D.) The wall should not be closer than 12 inches from the trunk. If a cut of soil is necessary near large trees, soil should not be removed so as to expose the roots. (Fig. 4, C.) A few of the shallowest roots may be cut off without doing much harm, but if many are removed the tree is sure to be damaged. Judgment must be used in grading so that the least amount of soil is removed around the base of the tree and more as the distance from the trunk is increased. This leaves an unnatural-appearing mound about the tree which cannot be avoided entirely, but can be improved if care is exercised; for example, if the cut can be more gradual on one side than on the other.

Character of the Soil

Grasses are shallow-rooted plants. For this reason, it is important that the surface soil be of such texture as will retain moisture and fertility and remain sufficiently firm to prevent the grass from burning out by too thorough aeration. Very sandy soils or those with sandy or gravelly subsoil are not well adapted to grass. In Kansas, a medium to heavy loam soil, such as silt or clay loam, is better for lawns than a light or sandy soil. The texture is of greater importance than the natural fertility. The fertility can be modified readily by artificial means but the texture can be changed only by removing the soil and replacing it with soil of a different kind, or by adding soil which is widely different in texture.

Grasses have no taproot hence it is not important that the soil be loose and open to great depth to permit root penetration. The roots of grasses are fine and fibrous and will be found mainly near the surface. Usually 90 per cent or more of the roots of bluegrass will be found in the upper 6 inches of soil. The subsoil should be one having a high water-holding capacity. A clay or clay loam is suitable as it retains moisture well. As previously stated, coarse material as sand, plaster, and other waste from building should not be left in the lawn. Even though such material is covered to a depth of a foot or more with soil, it produces a condition unfavorable to the maintenance of grass.

The practice of filling in with a layer of several inches of light loam soil rich in organic matter in order to stimulate the growth of the grass, is not recommended. In this climate, bluegrass will burn out on such soil more readily than on heavier soil containing less organic material. On heavy clays an application of fine or very fine sand equivalent to about an inch thick over the entire surface will be beneficial. This should be worked into the soil to a depth of 3 or 4 inches. On very sandy soil, a similar application of clay worked into the surface will materially improve conditions for grass.

Preparation of Seed Bed

Plans for getting the ground in condition should be made several weeks, or better several months, before seeding. It should be made as free from weeds and weed seed as possible and should have accumulated sufficient moisture and available plant food to give the grass a good start. The soil should be well settled and firm with the surface finely pulverized and sufficiently loose to facilitate covering the seed. Such conditions can be obtained only by allowing plenty of time for natural changes to take place.

If the ground is weedy or contains much weed seed, it should be plowed in late spring or early summer before any weeds have gone to seed. An application of well-rotted manure may be plowed under if the soil is lacking in fertility or is of heavy texture. One or two tons are sufficient for the average lawn on a city lot 50 by 150 feet. Manure containing weed seed should not be used. Plowing should be followed by frequent thorough cultivation until planting time to destroy all weed growth and to hold moisture. A still better plan, but one which is objectionable to some, is to plow the ground late in the fall and plant to early garden crops such as beans, peas, and potatoes the following spring. These crops should be kept well cultivated to keep down all weeds until the garden crops are harvested. The ground should then be fallowed until fall. An ideal seed bed can be prepared in this manner and some returns obtained for the labor expended.

Two or three weeks before time for planting the seed, the surface should be well cultivated and made level by planking or dragging. An application of commercial fertilizer a few days before sowing the seed is sometimes desirable. Usually a fertilizer containing only nitrogen, as ammonium sulphate or sodium nitrate, is sufficient. This should be applied at the rate of 4 or 5 pounds to 1,000 square feet and worked into the surface soil. Methods of application are discussed under the heading, "Use of Fertilizers," page 18.

Allowing insufficient time for soil preparation is the chief cause for failure in obtaining a good stand of grass. There is no substitute for an elapse of time in making the land free from weeds and providing for the liberation of plant food and the accumulation of moisture. If sufficient time is allowed for these processes and the necessary work done to provide the conditions here described, success in securing a stand of grass is almost assured if good seed is properly planted.

Effect of Trees

It often has been said that bluegrass will not grow well in most places in Kansas unless it is in the shade. It is true that under many conditions bluegrass will grow better in partial shade if the grass does not compete with shallow roots of trees. Frequently grass grows luxuriantly in the shade of a building. Shallow rooted trees, however, such as the American elm and the soft maple, not only deprive the grass of much needed moisture but valuable plant food as well. In most cases where it is not practicable to remove such trees from the home grounds they may be root pruned. Whenever good-sized roots are dug into during ordinary plowing or spading, these roots should be cut off as near the trunk of the tree as possible and removed. A smooth cut should be made so that it will heal readily. Some of the branches of the tree likewise must be pruned in order to compensate for the roots that have been removed.

This pruning also will allow more light to fall on the grass and will improve its vigor. This is especially true of trees that cast very dense shade. Deep spading under the trees, without cutting the large roots, usually will help conditions for a short time only as the roots will soon grow back into the surface soil. Heavy fertilization of the soil will increase the vigor of the grass, but one must remember that he is also feeding the shallow roots of the trees, which will in turn come nearer to the surface of the soil.

SEED AND SEEDING

Choice of Seed

In starting a lawn from seed the utmost care should be taken to secure a good stand from the first seeding. Thin areas allow weeds to obtain a foothold besides making the lawn uneven and unattractive. A well pre-

pared seed bed and good seed are essential. No amount of subsequent care can compensate for poorly prepared ground or low-grade seed. The kind of grass to use will depend upon the locality. Kentucky bluegrass is used more extensively than any other and has no superior, particularly in the eastern half of the state. The suitability of various turf-forming grasses to certain regions of Kansas has been discussed earlier in this bulletin under the heading, "Varieties of Grasses," page 6.

Seed of good quality should be used. The best seed is almost always cheapest in the end. It should be free from noxious lawn weeds and viable as shown by a high germination test. Such seed usually will be well graded to remove empty hulls and other inert material. High-grade bluegrass seed should weigh from 20 to 24 pounds per bushel, and the germination test should be 80 per cent or above. No seed should be purchased for planting which has not been tested for both purity and germination. The results of these tests should be carefully considered before purchasing. The purity expressed in percentage is not so important as the character of the impurities. Seed which is 99 per cent pure would be very undesirable if the 1 per cent impurity contained noxious weed seed, while seed which is 90 per cent pure may be satisfactory, provided the 10 per cent impurities are free from noxious weeds.

Time of Seeding

Bluegrass should be seeded in the fall. As a rule the most favorable period for seeding is sometime during the first half of September. If the ground can be kept wet by artificial watering, seeding may be done earlier but usually nothing is gained by sowing before September 1. Spring sowing is extensively practiced but has several disadvantages. There is always much trouble from weeds in spring-seeded lawns, and the grass does not become well established before hot dry weather begins. The young plants stool better in the fall when the weather is cool and become well established before the ground freezes. Grass in this condition will fully occupy the ground soon after growth starts in the spring and will not be so subject to injury from drouth, summer heat, or weeds.

Method and Rate of Seeding

Where bluegrass alone is used, or where it makes up the main part of a mixture, 70 to 90 pounds per acre, or approximately 2 pounds of seed to 1,000 square feet, is ample for ordinary lawn plantings.

Drilling is the best means of planting grass, particularly on large areas. Small drills suitable for use on lawns are not often available, hence nearly all lawn seed is broadcast by hand. Hand sowing is satisfactory provided care is taken to distribute the seed evenly. A good practice is to divide the quantity of seed to be sown into two nearly equal parts, sowing one half in one direction and the other half at right angles. If large seeded grasses, as perennial rye, are used in mixtures with bluegrass the rate of seeding should be increased. The seed should be covered lightly with a garden rake or light drag and rolled. If water is available the surface of the ground should be kept moist until the seedlings are well rooted.

Seeding on Steep Slopes. — It usually is difficult to obtain an even stand of grass by sowing seed on steep slopes without some means of checking erosion and preventing run-off. A layer of light or loosely-woven burlap provides a simple means of overcoming these difficulties by holding the seed in place and retaining moisture. An inexpensive covering consists of cheap jute bags or bran sacks ripped so that a single thickness of the material may be spread over the soil. Sugar sacks or other heavy material should not be used. The covering should extend from the top to the bottom of the slope and should be pinned down by means of small wooden

pegs. The full length of the pegs should be pressed into the soil so that they will not interfere with mowing, The covering need not be removed as the grass comes up through it, and it rots within a few months and completely disappears by the time the grass sod is fully established.

A light mulch of straw or hay is sometimes used on slopes and is beneficial, but not so effective as burlap. Such a mulch may sometimes be used to advantage on level areas to check evaporation and aid in obtaining a stand.

VEGETATIVE PLANTING

Buffalo Grass[2]

Buffalo grass (fig. 5) is native to western Kansas. This, in addition to its growth habits, makes it desirable for lawns in that section. New stands, however, can be obtained only by transplanting or broadcasting parts of the sod or by setting out pieces of the running stems. Very little seed is produced, which is of low viability and so located on the plant that it cannot be harvested economically. Fortunately there is no difficulty in obtaining sod for planting.

Fig. 5.—Buffalo grass plants: Left, staminate or pollen-bearing plant; right, pistillate or seed-bearing plant. The runner at the right will take root and start a new plant. Both kinds of plants produce runners.

Obtaining the Sod.—The sod should be taken from the purest area of buffalo grass available. A sod cutter is more desirable to use than a plow for cutting the sod as a smoother cut and a more even surface will be had. The sod cutter can be easily made by a blacksmith. It consists merely of a U-shaped flat piece of steel, sharpened on the cutting edge, and mounted on the bottom of a wooden sled. If the steel is so shaped as to cut a piece of sod about 12 inches wide, one team of horses can pull it easily.

Time of Plantings—Buffalo grass sods may be set out almost any time during the year without danger of the plants' dying before becoming established. However, the grass will spread more rapidly if set out dur-

2. Experiments with buffalo grass were carried on mainly at the Fort Hays branch station, Hays, Kansas by D. A. Savage assistant agronomist Office of Forage Crops, and Diseases, Bureau of Plant Industry, United States Department of Agriculture.

ing the period of March to June. Rainfall and temperature conditions usually are favorable at this time and evaporation is light. Under average conditions a complete sod (fig 3) can be obtained in two to three years by transplanting pieces of sod or by broadcasting shredded sod.

Method of Planting. — In starting a lawn with buffalo grass the ground should be prepared as if grass seed were to be sown. The results of experiments carried on at the Fort Hays Branch Agricultural Experiment Station show that the grass may be planted either by setting pieces of sod or by shredding the sod and sowing the plants broadcast. When the former method is to be used the sod should be plowed or cut 4 inches deep and cut into pieces to form cubes about 4 inches square on the surface. These pieces are set in rows 2 to 4 feet apart so that the plants alternate in adjacent rows. It is important that the sod be set just even with the surface of the ground on land that has been smoothed and firmly settled. If set too shallow the pieces will appear as high spots in the lawn after it is established, while if set too deep the growth of the grass is retarded.

If the plants are to be broadcast on the surface the sod should be plowed or cut very shallow, usually not over 2 inches deep. This may readily be torn apart by hand and the plants sown broadcast and pressed into the soil by rolling. Experiments at the Fort Hays station show that where large areas are to be planted, such as pastures, parks, or golf courses, the sod may be distributed more efficiently with a manure spreader, which will tear the sod apart and spread the plants at one operation. It is as desirable to have the surface soil in a loose condition before broadcasting as it is to have the land firmly compacted before setting out pieces of the sod by hand. The land should be firmly packed after broadcasting.

Irrigation. — Buffalo grass lawns may be established and maintained in western Kansas without the use of irrigation. If water is available, however, it would be desirable to irrigate immediately after the lawn is set out and during excessively dry periods thereafter. Watering to excess promotes the development of objectionable weeds and other grasses and retards the spread of buffalo grass.

Clipping.—Clipping the sod at intervals of 10 days to two weeks is essential in securing rapid spread and maintaining a pure stand of buffalo grass. A lawn mower is more efficient than the ordinary mowing machine for clipping the grass. Buffalo grass does not thrive in shade, hence weeds must not be allowed to grow in competition with it. Since it spreads almost entirely by surface runners, it cannot be cultivated Careful hoeing to control weeds while the grass is becoming established would be beneficial.

Bermuda Grass

In Kansas, Bermuda grass must be started by vegetative planting rather than from seed. Plants started from seed sown in the spring seldom become sufficiently established to live through the first winter, and fall plantings are certain to be destroyed by the first hard freeze. For vegetative planting the ground should be plowed in the fall and worked down in the spring to good seed-bed condition preparatory to planting. Propagating material may be obtained by plowing through a well established stand of the grass and picking out the rhizomes or underground stems. Plants should be obtained from patches that have been growing in this state for several years, as they are more hardy than those from southern states. Unless planting is done immediately after digging, the plants may be stored in a cool place and kept slightly moist without loss, provided they are not allowed to heat or become moldy.

Planting should be done about April 1. Furrows 2 or 3 inches deep and 2 to 4 feet apart are made with a hoe, garden plow, or cultivator

equipped with one large shovel on each side. The plants are torn apart somewhat, dropped in a continuous row in the furrow, pressed down with the feet, and covered about 2 inches deep. The land should then be leveled by hand and rolled. Care must be taken not to tear out the plants while leveling the surface. It is desirable to keep weeds hoed or cultivated out until the Bermuda grass runners cover the space between rows. If this is done the grass usually will cover the ground completely before the end of the first summer. If weeds are not kept down by cultivation they should at least be kept closely mowed.

Bentgrass

The method of starting bentgrass vegetatively is described under the heading, "Establishing Bent Grass Putting Greens," page 28.

Sodding Bluegrass

Starting a lawn from bluegrass sod should be done in the spring soon after growth starts. At this time new roots are being formed which enable the sod to become more quickly anchored in its new position.

Sodding is the quickest method of establishing a lawn; however, its chief objection is the expense involved. On steep slopes it is the most practical way of getting a turf started. The preparation of the soil should be similar to that for seeding a lawn except that the soil should be made more compact. The sod should be cut in strips, usually 12 inches wide and approximately 1 inch in thickness. These strips may be rolled to a size convenient for handling and laid down by simply unrolling them on the area to be planted, or the strips may be cut into squares if it seems to be more practical. It has been found that thin sod will become established more quickly than thick sod. Thin sod also has the advantage in being lighter to ship and handle. Another advantage of thin sod is that its removal does not destroy the stand and the grass comes back quickly. It is important that the sod be the same thickness or the surface of the lawn will be uneven.

The sod may be laid snugly together, or a space may be left between the pieces, in which case good soil will have to be worked into the crevices to prevent evaporation. It is thought by some that the latter method provides a better condition for growth. Whichever method is followed it is advisable to rake soil over the surface of the newly sodded lawn to give it a more even appearance and to fill in any spaces that were missed. The newly laid lawn should be rolled or tramped to keep the sod firmly pressed against the soil. On steep slopes the sod should be held in place by means of wooden pegs driven into it at right angles to the slope so that the top of the peg is flush with the surface. When strips of sod are used on steep slopes, the long dimension of the strip should be laid at right angles rather than up and down the slope in order to prevent washing between the pieces of sod. After the process of sodding is complete the newly sodded lawn should be given a liberal watering and kept well watered until the grass is established.

MAINTAINING LAWNS

The maintenance of bluegrass lawns in Kansas requires careful attention to watering, mowing, fertilizing, and the control of weeds. The neglect or the improper use of any one of these essential operations may result in weakening the grass, allowing weeds to get started, and eventually losing the grass.

WATERING

With good management bluegrass will thrive on most soils in eastern Kansas without watering, provided there is not too much competition from other plants such as roots of large trees in the lawn. A more satis-

factory turf can be maintained, however, if it can be kept well watered. Experiments conducted at Manhattan by the Kansas Agricultural Experiment Station show that for the six-month period, April to September, inclusive, an average of from 6 to 10 inches of water is needed in addition to the normal rainfall of about 23 inches for that period. The amount needed varies widely in different seasons on account of a great variation in the amount and distribution of rainfall.

The most economical use of water to maintain a vigorous growth of grass is by medium-heavy applications whenever the grass shows signs of needing water. As a rule the equivalent of one-half inch to one inch of rainfall should be added each time the lawn is watered. This should be applied slowly to avoid uneven distribution or loss of water by run-off. Covering a certain portion of the lawn with half the amount needed and repeating the application within a few hours or on the following day will give better distribution of moisture in the soil. The soil should be kept moist to a depth of a foot or more and at no time should the grass be allowed to suffer from lack of moisture.

Frequent light applications of water are of little value at best and are frequently detrimental. Many lawns are sprinkled a little every evening during hot dry weather, while the soil remains dry just beneath the surface. This produces a very undesirable condition. It revives the grass during the night only sufficiently to make it more susceptible to damage from heat and drouth the following day. New roots are formed in the moistened soil near the surface, only to perish as the soil becomes dry. This temporary revival of growth is made at the expense of the reserve energy stored in the underground parts, and if continued for a time this reserve becomes exhausted and the plants die. Watering after light showers during periods of drouth is very desirable.

MOWING

Height of Clipping. — Nowing is necessary in order to keep the lawn attractive and to maintain a dense turf. Cutting too close and too often, however, is extremely injurious. Probably more lawns in Kansas are destroyed by frequent close clipping than from any other cause. (Fig. 1.) It should be understood that the food which supplies the energy for growth and certain vital processes in the roots, as well as in the parts of a plant above the ground, is manufactured in the leaves. Constant removal of the leaves by close clipping removes the source of this energy and reduces the vitality of the plants. No perennial plant can thrive without sufficient top growth to supply the energy needed for the development and maintenance of a strong root system.

Experiments have shown that the root system of bluegrass cut 3 inches high is from two to four times as extensive as that of grass cut only 1 inch high. Likewise, the amount of rhizomes or underground stems is from two to three times as great in grass cut 3 inches as in that cut 1 inch high. It can therefore be seen that high clipping is essential in producing a thick stand and a strong growth of grass (fig. 2), since vigorous growth is dependent upon a vigorous root system and the density of the sod upon abundant underground stems. In this climate where grass is put to a severe test of vigor almost every summer, close cutting must be avoided.

Experiments carried on by the Agricultural Experiment Station at Manhattan indicate that bluegrass should not be cut closer than to leave a stubble 2 inches high and in most instances 2½ inches are more desirable. Some lawn mowers cannot be set to cut high enough to avoid injuring the grass. Before purchasing a mower to be used on a bluegrass lawn in Kansas, measurements should be taken to determine the maximum

height at which it will cut. This may be done by setting the mower on a level surface as a floor or sidewalk and measuring the distance from the surface on which the drive wheels rest to the cutter bar or knife edge against which the revolving blades cut. (Fig. 6.)

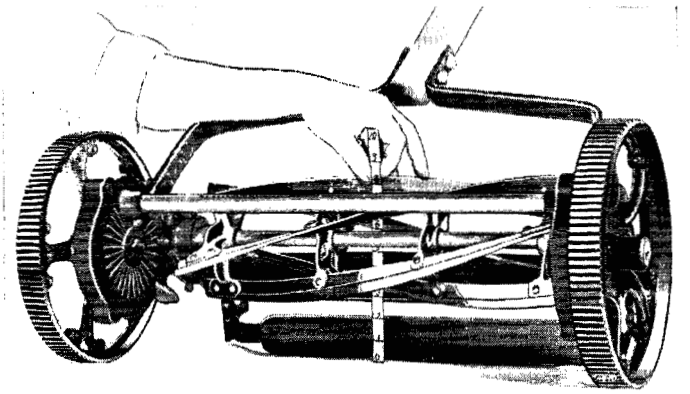

Fig. 6.—A new departure in mowers—a high-grade machine that will cut 3 inches high. Lawns should seldom be cut closer than 2 inches in Kansas, and on south slopes or terraces as high as 3 inches may be desirable.

Used mowers may be made to cut higher by enlarging the drive wheels and roller. Iron bands or a piece of drive chain from an old grain binder may be clamped, tied, or bolted on the wheels to increase their diameter. This reduces the speed of the revolving knives, however, and may make the mower run harder. At least two lawn-mower manufacturing companies have recently begun building mowers that will cut at the proper height for maintaining the vigor of bluegrass in this climate. These mowers cost no more than other high-grade mowers and are more economical in the end because they do not destroy the grass. A mower which cuts so close as to destroy the grass is a poor investment.

Time and Frequency of Mowing.—A new lawn should be cut for the first time when the grass becomes so tall that it will not stand erect. It should not be allowed to fall over as this tends to smother out some plants and produce a more open sod. For the benefit of the grass, established lawns should be mowed no oftener than is necessary to keep the grass from falling over or getting too tall to mow. For greatest attractiveness, mowing must be done somewhat more frequently, but the vigor of the grass must not be sacrificed by cutting too often. During extremely hot dry weather mowing should be delayed, if possible, until a cloudy day unless the lawn can be watered.

Removal of Clippings.—As a rule clippings should be removed. Where the growth is not too heavy the first cutting of a new lawn or the first in the spring on an old lawn may be left, but a large accumulation of this material on the surface is undesirable. It adds very little plant food and, if allowed to accumulate, becomes detrimental to the growth of the grass. Bluegrass sod does not require the addition of organic material. The fine fibrous roots of the grass which are constantly dying and being replaced by new ones add as much organic matter as is needed.

USE OF FERTILIZERS

Need of Fertilizers.—Grasses for the most part are shallow-rooted plants. The myriads of fine fibrous roots relatively near the surface tend to exhaust the upper layer of soil of certain plant foods, particularly nitrates. Growth continues late in the fall until the weather is so cool that soil organisms that prepare nitrates become inactive. In the spring, growth starts before the soil has become warm. As a result of this combination of conditions, lawns which have been established several years will appear yellowish, the stand will become thin, and the rate of growth will be greatly reduced. If no fertilizer is added the stand will become so thin and growth so slow that weeds will gain a foothold.

Grass responds more readily to applications of fertilizers than most other crops. This is particularly true when fertilizers containing nitrogen are used. (Fig. 7.) In experiments carried on by the station at Manhattan, the growth, measured by the weight of clippings removed, was more than doubled by applying nitrogenous fertilizers, even on fertile bottom land. The results of these experiments are given in Table I and illustrated by figure 7.

TABLE I.—EFFECT OF NITROGENOUS FERTILIZERS ON BLUEGRASS.
Three-year period, 1928 to 1930.

TREATMENT	Yield, pounds per acre				
	1928	1929	1930	Av., 1929 to 1930	Relative yields
No treatment	1,465	2,363	2,831	2,597	100
Sodium nitrate	1,875	6,096	5,894	5,995	231
Ammonium sulphate	1,731	5,997	6,424	6,210	240
Ammonium sulphate and compost	2,088	6,731	6,713	6,722	259
Urea	.....	7,111	5,723	6,417	247

Kinds of Fertilizers.—These experiments indicate that the form in which the nitrogen is applied is not a matter of importance when measured by the increase in growth produced. The kind of fertilizer to use should therefore be determined by such factors as cost per unit of nitrogen, convenience of application, and effect upon weed growth. Ammonium sulphate containing 20 per cent nitrogen should sell at a higher price per pound than sodium nitrate which contains 16 per cent nitrogen. A commercial fertilizer in fine crystalline form is more easily distributed than one in large crystals of uneven size. Ammonium sulphate has under certain conditions been found to discourage weed growth.

On some soils phosphorus and potassium may be beneficial, particularly on old lawns, but on fertile soil at Manhattan no increase in growth was produced by these fertilizers on bluegrass sod which had been standing three years. The general use of complete fertilizers is therefore not recommended. The lawn can be maintained more economically by the addition of superphosphate to the nitrogen fertilizer only once every year or two at the time of the first application in the spring. Potassium is seldom needed in this state.

Time, Method, and Rate of Application.—Nitrogen should be applied to bluegrass every year. On old lawns two or three applications may be needed to maintain vigorous growth and a dense sod. Four or five pounds

of ammonium sulphate to 1,000 square feet of lawn applied in early April and again the latter part of May are recommended. (Fig. 7.) If the grass appears to need more fertilizer, an application about September 1 may be made. It usually is not advisable to apply fertilizers during the summer months. If some other form of fertilizer is used the amount may be varied according to the percentage of nitrogen it contains. For example, 5 pounds of sodium nitrate containing 16 per cent nitrogen is equivalent to 4 pounds of ammonium sulphate containing 20 per cent nitrogen.

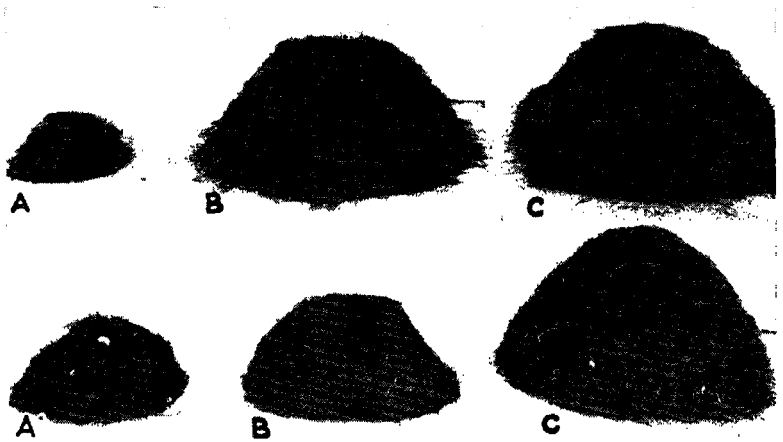

Fig. 7.—(Upper) Piles of clippings from 100 square feet of bluegrass with and without fertilizers. (A) No fertilizer; yield 54 grams. (B) Sodium nitrate used; yield 512 grams. (C) Ammonium sulphate used; yield 600 grams.

(Lower) Piles of clippings from 100 square feet of lawn receiving different amounts of ammonium sulphate. (A) Five ounces of fertilizer; yield 221 grams. (B) Ten ounces of fertilizer; yield 441 grams. (C) Fifteen ounces of fertilizer; yield 1,074 grams. Note dandelions in (A).

In applying the fertilizer, care should be taken to distribute it evenly and to avoid burning the grass. The amount to be used may be divided in half and the second half sown crosswise of the first. Ammonium sulphate, urea, and some other fertilizers will burn the grass severely if allowed to remain on the leaves, These should be applied only when the grass is dry and washed down immediately by sprinkling with a hose, or applied just before a shower.

A mixture consisting of 1 pound of ammonium sulphate to 3 or 4 pounds of soybean or cottonseed meal has some advantages over ammonium sulphate alone. Nine to 12 pounds of this mixture to 1,000 square feet should be used to supply the equivalent of the nitrogen in 4 or 5 pounds of ammonium sulphate. This mixture is more easily distributed evenly because of the larger bulk, and there is less danger of burning the grass. The beneficial effect extends over a somewhat longer period.

Use of Manure.—Barnyard manure is not a desirable fertilizer for lawns. It attracts grubs and leaves a residue of organic matter on the surface which is not beneficial and may be harmful if allowed to accumulate from year to year. There is also danger of introducing weed seed. If manure is to be used it should be of a kind which will supply a maximum of plant food with a minimum of organic matter. Fresh poultry droppings free from litter are the best of the farm manures for lawns. From 3 to 5 bushels to 1,000 square feet are ample. After spreading it,

a hand rake should be used to break up any large masses and distribute it evenly. Sheep manure is used extensively but it is less desirable than poultry droppings as it contains a higher proportion of organic matter. Well-rotted barnyard manure may be used occasionally but it is usually undesirable. If used it should be applied in early winter and all residue raked off soon after growth starts in the spring. On the whole, commercial fertilizers are much more satisfactory.

Lime.—Very few soils in Kansas require lime for the best growth of bluegrass. In the southeastern part of the state there are some soils on which lime may be beneficial. In other portions of the state it should not be used as it tends to encourage the growth of troublesome lawn weeds.

ROLLING

Rolling the lawn in early spring is beneficial when the surface soil has been loosened and the plants raised by alternate freezing and thawing. Once over with a 300-pound roller is sufficient to press the plants back into the soil and reduce root exposure. Repeated rolling throughout the season is likely to be harmful, as it tends to make the surface soil too compact.

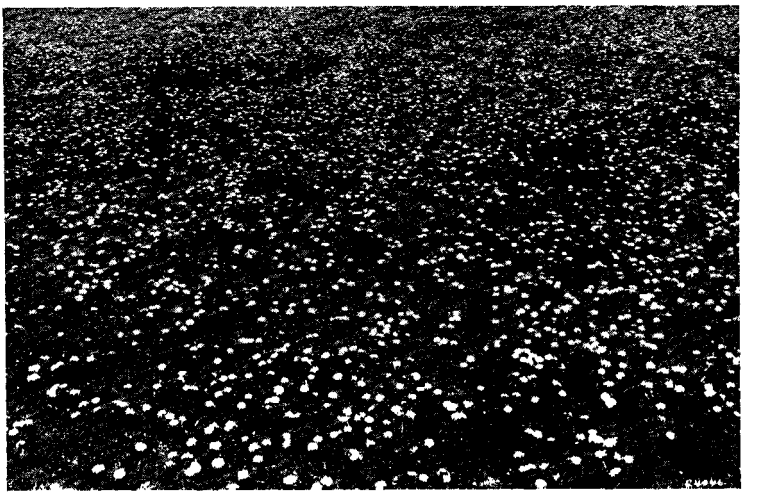

Fig. 8.—A heavy infestation of dandelions. The grass has been clipped too close and starved, allowing the weeds to become established.

WEED CONTROL

Noxious Lawn Weeds.—The control of weeds constitutes one of the most difficult problems in the maintenance of lawns. (Fig. 8.) The fight begins early in the spring against dandelion, chickweed, henbit, shepherd's-purse, and others which live over winter or start from seed very early in the spring. (Figs. 9 and 10.) From early summer until fall, crabgrass, foxtail, and other weedy grasses, and prostrate spurge are most troublesone. (Fig. 11.) Sheep sorrel dock, dandelion, and certain species of plantain grow from early spring until fall and compete with grass throughout the entire growing season.

Clean Ground and Pure Seed.—The first essentials in obtaining a good lawn are clean ground and pure seed. If the ground is foul with weed seed it is better to delay seeding and cultivate one entire season if necessary to get the ground free of weeds. If pure seed is used on such ground

Fig. 9.—Two noxious weeds of lawns in early spring. (A) Chickweed. (B) Henbit.

the labor of maintaining the lawn will be greatly reduced. Some weeds will appear in spite of these efforts and they should be removed promptly.

Hand Weeding. — Hand weeding is necessary, particularly while the lawn is young. No weeds should be allowed to go to seed at any time, hence one must be constantly on the lookout for them. Weeds which cannot be pulled readily may be removed by cutting off the root an inch or two below the surface of the ground. A sharpened putty knife or a table knife filed square on the end and sharpened is useful for this purpose. A few minutes spent each week in going over the lawn will be all that is

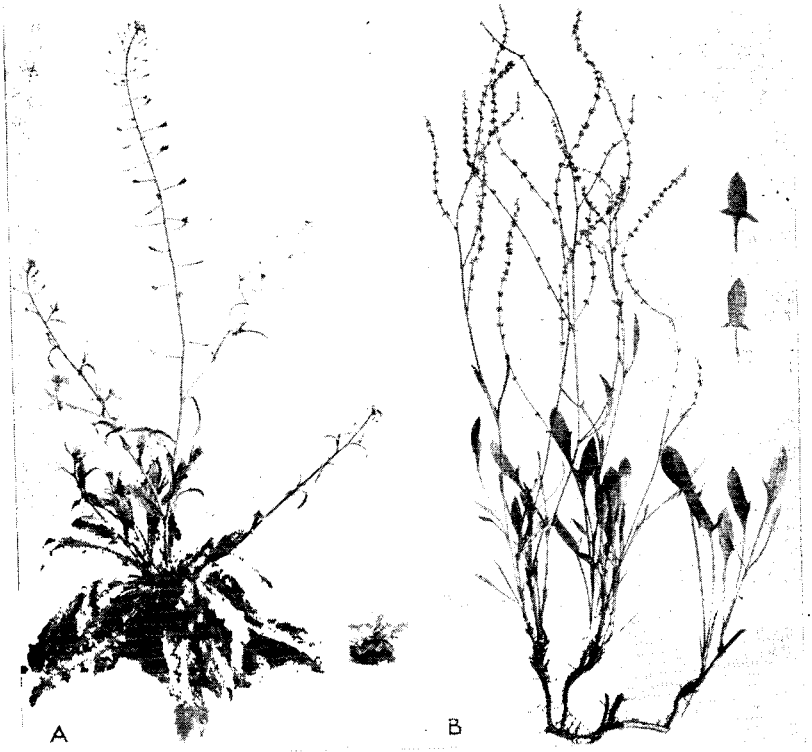

Fig. 10.—Noxious lawn weeds. (A) Shepherd's-purse, a winter annual, especially troublesome in early spring. (B) Sheep sorrel dock, a troublesome perennial.

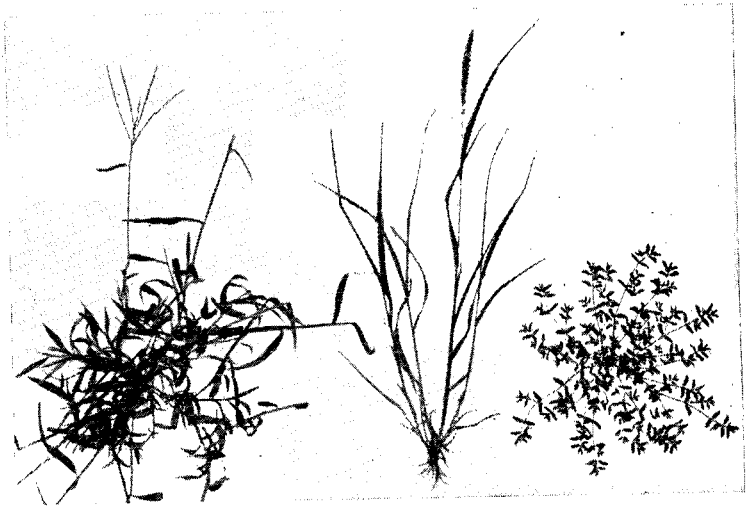

Fig. 11.—Three annual weeds troublesome in lawns in midsummer and early fall. Left to right: Crabgrass, foxtail, and creeping spurge.

necessary if it is given a proper start. This regular care must be kept up from early spring until after frost in the fall. If this is done for the first two or three seasons a weedless lawn can be kept thereafter with comparatively little effort, if the vigor of the grass is maintained.

Keeping the Grass Vigorous.—Weeds very rarely take a lawn until after the grass has been Weakened by improper care, The chief causes of trouble from weeds in lawns are (1) close clipping, (2) starvation of the grass from lack of plant food (fig. 12), and (3) improper watering. Cut-

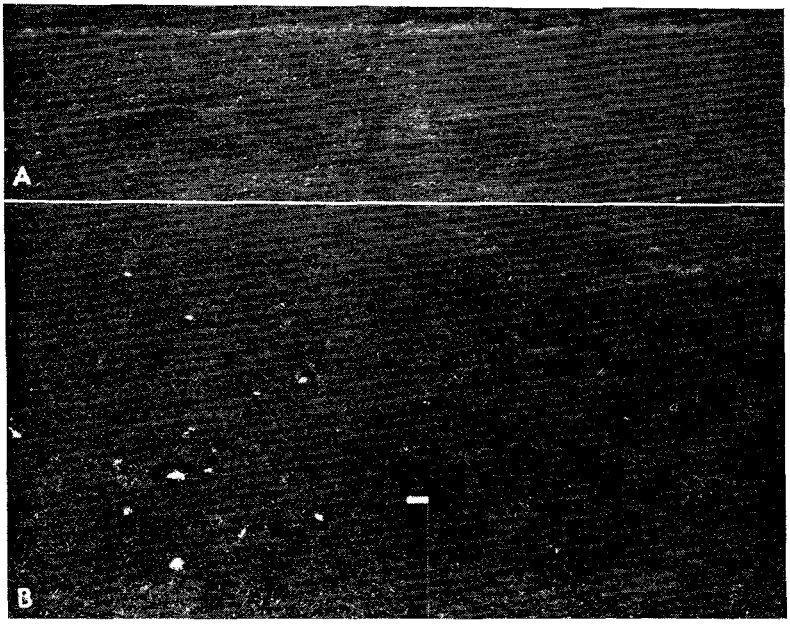

Fig. 12.—Experimental plats showing effect of fertilizers on the growth of dandelions in grass. (A) Left, no fertilizer, 187 dandelions on 100 square feet; right, sodium nitrate fertilizer used, 9 dandelions on 100 square feet. (B) Left, no fertilizer, compost used, 66 dandelion plants on 100 square feet; right, ammonium sulphate used, only 1 dandelion on 100 square feet.

ting to leave a growth at least 2 inches high and fertilizing enable the grass to develop a strong root system and a dense sod. The tall growth also shades the ground sufficiently to prevent weed seedlings from becoming established. Experiments carried on by the Agricultural Experiment Station at Manhattan show that there is a definite relationship between height of cutting and weed growth. These results are given in Table II.

The results given in Table II show that there were approximately 10 times as many plants of crabgrass on the plats cut seven-eighths of an inch high, and 5 times as many on plats cut 1 5-16 inches high, as on plats cut 2 3-16 inches high. (Fig. 13.) There were approximately 60 times as many dandelions on the closely cut plat as on plats cut 2 3-16 inches high, and 10 times as many on the plats cut 1 5-16 inches high. All of the fertilizers used produced about the same effect on the growth of grass, hence there was no consistent difference on weed growth. The value of fertilizers in weed control is due mainly to the increase in growth of the grass which enables it to compete more successfully with weeds.

Fertilizer should not be applied during July or August as it tends to

TABLE II.—RELATION OF HEIGHT OF CUTTING AND FERTILIZERS TO THE GROWTH OF WEEDS IN BLUEGRASS.

Height of cutting (Ins.)	Average number of crabgrass plants per 100 sq. ft.				Average number of dandelions per 100 sq. ft.			
	Complete fertilizer, 4-12-4	Ammonium sulphate	Ammonium sulphate and superphosphate	Av. of all fertilizers	Complete fertilizer, 4-12-4	Ammonium sulphate	Ammonium sulphate and superphosphate	Av. of all fertilizers
2 3-16	31	21	19	24	0	Trace(*a*)	1	Trace(*a*)
1 5-8	41	28	67	45	2	3	3	3
7-8	143	292	167	201	32	32	27	30

Equal amounts of nitrogen and phosphorus were used on all plats—225 pounds ammonium sulphate per acre or its equivalent at each of three applications per year, and 305 pounds superphosphate at one application.

(*a*) A trace indicates less than 1 per 100 square feet.

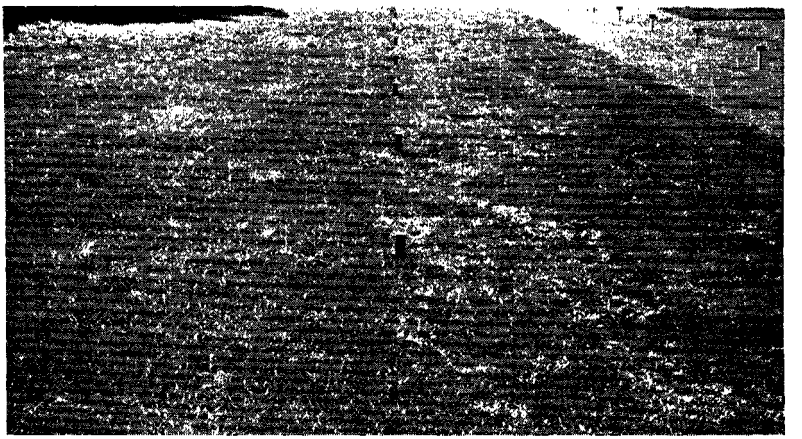

Fig. 13.—Experimental plats showing effect of height of cutting on the growth of weeds. Left, cut 1 5-16 inches high, 3 dandelions and 45 crabgrass plants on 100 square feet. Right, cut seven-eighths of an inch high, 30 dandelions and 201 crabgrass plants on 100 square feet.

stimulate the growth of crabgrass and certain other weeds which are naturally adapted to hot weather. Bluegrass normally makes little growth during that period and therefore is not benefited by the fertilizer.

From these results and from observation and study of many lawns it is evident that the best means of controlling weeds is to provide conditions which are more favorable for the growth of grass.

Use of Chemicals.— Dandelion plants can be killed by applying a few drops to a teaspoonful of a strong solution of sodium chlorate to the heart of the plant. The solution may be made by dissolving 1 pound of sodium chlorate in a quart of hot water. This may be applied with an oil can or a small spoon.[3] This method is more convenient and effective than cutting out the plants as dandelions sprout up again unless cut at least 2 inches

3. Care must be taken not to allow sodium chlorate either dry or in solution to get on the clothing or any other material that will burn, as such mixtures are easily ignited when dry and burn violently.

below the crown or removed when quite young. Kerosene or gasoline may be used in the same way as suggested for sodium chlorate, but they are not so effective.

In recent limited experiments at Manhattan, spraying with a solution of sodium chlorate has been effective in killing chickweed, buckhorn, and young dandelion plants. The solution is made by mixing one-fourth to one-half pound of the chemical to 1 gallon of water, using this amount to 100 square feet. Applying the solution about August 15 and repeating the treatment about November 1 were satisfactory for buckhorn. For chickweed and young dandelion plants the chemical should be applied about October 15 and again when growth starts the following spring, usually about March 15. This does not kill old dandelion plants and it may injure the grass somewhat but usually the injury is temporary. There is some danger of checking the growth of the grass to the extent that crabgrass may become a menace. The application of one-half pound of ammonium sulphate or sodium nitrate to 100 square feet will stimulate the growth of the bluegrass and aid in its recovery.

Chickweed can be killed without destroying the stand of grass, by spraying with a solution made by dissolving 1 pound of ammonium sulphate in 1 gallon of water. One gallon of the solution usually will cover about 1 square rod, depending upon the growth of the weeds. Sufficient material should be used to wet all the leaves thoroughly. It should be applied in early spring when the first chickweed blooms appear and repeated three or four weeks later if necessary. The grass may be burned by the spray but it will soon recover, its growth being stimulated by the ammonium sulphate which is a valuable fertilizer.

No chemical has been found to be effective in ridding lawns of crabgrass. Numerous chemicals have been tried in experiments carried on at the Agricultural Experiment Station but without success except in the cases mentioned above. Iron sulphate, which has been recommended in some states, has not been found effective here as a weed killer except when applied in sufficient quantities to injure the grass seriously.

REJUVENATING OLD LAWNS

A long-established lawn with a thin stand of grass is usually an indication that the grass is in need of plant food and proper care. If the soil is not being deprived of its much needed plant food by roots of trees it is possible to rejuvenate the lawn by proper fertilization, watering, and mowing. Reseeding alone will not greatly improve an old lawn, for the new plants will flourish no better than the old ones. What is needed is something to bring back the vigor of the plants already established. If this is done the weakened plants will grow and stool out and a thick turf will result. A thin stand of grass, especially where the ground may be seen, provides an ideal condition for the entry of objectionable weeds. If the lawn is badly infested with dandelions or other noxious weeds and grasses it usually is advisable to remake it completely.

Old lawns in regions of fairly heavy rainfall are benefited by a top-dressing of compost consisting of one-fourth sand, one-fourth well-rotted manure, and one-half clay loam soil. This mixture should be composted two years before use. All of the ingredients used in a compost should be entirely free from weed seed. The compost pile should be turned over at the end of the first year. At the end of the second year it should be so fine that after it has been applied to a depth of one-fourth to one-half inch over the lawn there will be nothing to rake off. The compost should be applied about every two years in the fall or very early spring. Where large bare spots occur in the lawn it is best to spade the areas and reseed.

INSECTS AND ANIMAL PESTS

Grubs. — The white grubs that usually are injurious to lawns are larvae of the June hug or May beetle. The injury from grubs is characterized by areas of dead turf from which the dead plants may he lifted from the soil with ease. At the first indication of damage the soil should be treated with arsenate of lead. Five pounds of this poison should he mixed thoroughly with a bushel of sand or moist soil and spread uniformly over the lawn. This quantity is sufficient to treat 1,000 square feet of turf. It is advisable to water the area immediately in order to wash the poison into the soil and prevent the poisoning of live stock or poultry. Mercuric chloride, corrosive sublimate, will also be found effective when used at the rate of 2 ounces to 50 gallons of water or 2 ounces to 2 cubic feet of dry sand. This quantity is enough to cover 1,000 square feet of soil if applied uniformly over the turf. The lawn should be given a liberal watering after using this poison or the grass will be badly burned.

Close clipping and frequent light watering provide conditions favorable for the adult beetles to deposit their eggs and for the growth and development of the grubs. The grubs seldom do much damage in a thick stand of grass which is not cut closer than 2 inches.

Earth-worms.—Earthworms are not often troublesome in lawn soils hut on putting greens they are commonly a serious pest. The use of mercuric chloride at the rate mentioned above for grubs will be found effective for ridding the soil of earthworms. The worms will come to the surface of the soil in a few minutes, after which they may be removed and destroyed. More than one application may be necessary to eradicate the worms.

Ants.—Ants are rather difficult to control but often are not so troublesome in lawns as in the flower garden. One or two tablespoonfuls of carbon disulphide injected into each hole by means of an oil can will bring good results. The quantity should be less when applied to small colonies. After the solution is applied the holes should be covered with soil to prevent the fumes from escaping. The fumes of carbon disulphide are highly inflammable.

Fall Army Worms.—These insects, if not controlled, will occasionally eat over large areas of bluegrass and bentgrass lawns. The use of arsenate of lead at the rate of 1 pound to 10 gallons of water will control them if the solution is sprayed on the foliage where the infestation is greatest.

Moles.—Moles are perhaps the most destructive animal pests in lawns and gardens. Their narrow winding tunnels are made in search of food, which consists largely of grubs and earthworms. For this reason, and because digging is easy, they work more in moist fertile soil and where the grass is thin or dying. The damage is much less in lawns having a thick stand of vigorous grass. In making their tunnels the grass roots are cut or broken and the soil raised to form an unsightly ridge over which the grass dies and turns brown. These ridges of soft earth interfere with mowing and cause the surface of the lawn to become rough. They should be rolled or tamped down as soon as possible after they are formed.

Trapping seems to afford the best means of controlling moles, although patience and persistence are required to make it effectvie. If one is alert to utilize favorable weather and soil conditions when the moles are most active and working near the surface, the lawn and garden can be kept relatively free from damage. Several types of traps have been devised. The double three-tine harpoon, the scissor-jaw, and the choker loop types are satisfactory if properly managed. In addition to the manufacturer's directions, experience and care in selecting the run and setting the traps

are essential to success. A more complete discussion of this subject may be found in Farmers' Bulletin 1247.[4]

DISEASES

Mildew and Slime Mold.—Occasionally following spells of damp weather leaves of grass may appear covered with a whitish or an almost black growth which at first sight causes alarm. This is probably due to mildew or slime mold. This condition most commonly occurs in shaded locations where the grass has made considerable growth since it was last mowed. These are not serious diseases and will seldom do much injury to the grass. Mow the grass and avoid watering for a few days and as soon as the damp weather is over the diseases usually will disappear. Pruning trees and shrubs to allow better circulation of air will be helpful.

Bluegrass is very free from attacks of diseases. A serious disease of bentgrass known as brown patch is discussed under the heading, "Maintaining Bentgrass Putting Greens."

Fig. 14.—Bentgrass experimental plats at Manhattan, Kan. Nineteen varieties were tested on 81 plats of 100 square feet each from 1925 to 1932.

BENTGRASS FOR PUTTING GREENS[5]

The same care necessary in establishing and maintaining a lawn is also essential for putting greens for golf courses. Cultural practices differ, however, in many respects.

Grasses suitable for putting greens must produce a very dense even turf, and stand close mowing and considerable wear. Certain strains of bentgrass (fig. 14) possess these characteristics to a high degree and with proper care produce turf that is superior in density, uniformity, and fineness. Kentucky bluegrass is not well suited to this purpose as it will not resist the close mowing that is essential for a good putting turf, and the growth is not sufficiently dense.

VARIETIES OF BENTGRASS

During the period, 1925 to 1932, 19 varieties and strains of bentgrass have been grown in tests at the Agricultural Experiment Station at Man-

4. Scheffer, Theo. H. American moles as agricultural pests and as fur producers. U. S. Dept. Agr. Farmers' Bul. 1247:1-20. 1930.

5. Credit is hereby given the United States Golf Association Green Section for financial assistance and valuable counsel in carrying on the experimental work with grasses for putting greens.

hattan. Four of these strains — the Washington, Metropolitan, Cocoos, and Astoria—proved superior in quality of turf and in ability to withstand extremes of temperature and humidity during the summer in this state.

Both the Washington and Metropolitan are strong creepers and produce a dense even turf of fine texture when kept closely mowed. The Metropolitan is of a bluish or metallic green, while the Washington is bright green. Both strains are propagated altogether by stolons.

Cocoos and Astoria are propagated mainly by seed. This is a more economical method of starting greens than by the use of stolons, which probably accounts for the increasing popularity of Cocoos within the last few years. The Coccos is a more vigorous creeper than the Astoria but does not produce rhizomes or underground stems as does the latter. Although the Astoria has not been tested thoroughly in this section on greens subject to heavy wear, its method of reproduction and its uprightness of turf indicate that it should be very satisfactory.

ESTABLISHING BENTGRASS PUTTING GREENS

Soil Requirements

The very shallow root system and heavy concentration of roots within the top 1 or 2 inches of soil, the restriction of top growth by frequent close clipping, the heavy wear to which the grass of putting greens is subjected, and the necessity of frequent watering comprise a set of conditions which are not common to the growth of grass for purposes other than for putting greens. In order to produce good turf under these extreme conditions special attention must be given to provide a suitable soil. Heavy soils, as clay loams, grow good grass under ordinary conditions, but become so compact with much tramping that moisture does not penetrate readily, air is excluded, and they become so hard, when dry, that they will not hold a pitch shot satisfactorily. On the other hand, light or sandy soils do not retain moisture or plant food, permit too free circulation of the air through them, and become too soft for putting greens. A condition intermediate between these extremes is desirable and this should be provided before the grass is planted.

Heavy clay soil may be benefited by working the proper amount of sand or sandy loam soil and organic matter into the surface. Soil which is too light or sandy may be changed by adding clay and organic matter. Where much grading is done in making the green, the top soil is frequently removed from one portion leaving bare subsoil, while the remainder of the green receives added top soil. Under such circumstances it may be advisable to add sand and organic material to one portion or replace some of the surface soil which was removed, in order to make the surface of the entire green as uniform as possible.

Preparing the Soil

For putting greens the ground should be prepared in much the same manner as for starting a lawn. Plowing, disking, harrowing, and smoothing with a drag are usually the essential operations before planting. The grading and plowing should be done several weeks before time to plant in order that the ground may become well settled and in good tilth. Immediately before planting, the surface should be made smooth by dragging or rolling, or both. If seed is to be sown, the surface should be roughened lightly in order to facilitate covering the seed.

Planting Bentgrass

Planting Seed. — Fall planting is preferred for both seed and stolons as there is less trouble from weeds and the grass becomes more fully established before severe summer weather sets in. Seed should be sown

at the rate of 3 pounds to 1,000 square feet. Great care should be taken to obtain even distribution. This may be accomplished best by mixing the seed uniformly with top soil, as the larger bulk thus produced can be sown more evenly. Dividing the bulk in half and sowing one-half crosswise of the other will also help. The seed should be covered by raking lightly with a garden rake, weeder, or improvised light harrow made by driving large nails or pegs through a plank. There is a tendency to drag the seed into rows or bunches with a rake unless it is used carefully.

After the seed is covered, the surface should be rolled and wet down with a hose. The water should be applied slowly and at no time allowed to stand on the surface or run, as this will drift some of the seed and produce an uneven stand. Careful attention must be given to watering until the grass is well started. At no time should the surface be allowed to become dry before the grass is up. It may be necessary to water two or three times a day in order to keep the surface thoroughly moist, but if this is done seed that is barely covered will germinate, whereas if the surface is allowed to dry down to a depth of a quarter- to a half-inch while the seed is germinating, the entire stand may be lost. After the grass is up and the surface appears green, it does not require such frequent watering.

Planting Stolons. — Good material for vegetative planting can be best produced by planting rows of the grass 4 to 6 feet apart a year or so before the greens are to be planted. The grass in rows will produce runners a foot or more in length, making a row of sod 2 or more feet in width. Under favorable conditions these runners, known as stolons, are capable of producing roots and a shoot at every joint. To prepare them for planting, the row of sod should be cut about an inch below the surface and removed in pieces of a size convenient for handling. This sod should be chopped into bits or shredded so that the runners are cut into pieces 1 to 3 inches long. These pieces constitute the material from which the new plants must be started. It is not necessary that a piece of stolon contain more than one joint. Planting long pieces containing several joints is wasteful of material.

The shredded material is sown evenly over the surface in the same manner as seed is sown. The rate of planting will depend to some extent upon the quality of the stolons used. As a rule, 1 square foot of good sod will plant 10 to 20 square feet of surface. If planted thinner, a longer time is required to obtain good turf.

As soon as the stolons are spread they should be covered immediately with about a quarter of an inch of compost or good soil of medium texture. The top-dressing should be spread evenly, taking care not to move the stolons. It may be applied with a sieve or by hand to hold the stolons in place. As soon as the top-dressing is applied, the surface should be rolled and then watered. Here again one should be careful not to dash water on the surface but to sprinkle gently in order that the top-dressing may not be washed off the stolons. The surface must be kept continuously moist until it is well covered with grass. Clipping should begin as soon as there is any growth to clip, and a light top-dressing applied as soon as runners 2 or 3 inches long become numerous.

MAINTAINING BENTGRASS PUTTING GREEKS

Weeding

The turf should be kept free from weeds at all times, particularly while it is becoming established. Considerable hand weeding may be necessary at first but this work should diminish as the growth of grass increases in density. On old turf that is well maintained very little hand weeding will be necessary if the compost used is free from weed seed.

Watering

Bentgrass is very sensitive to drouth and cannot be maintained in Kansas without using a considerable amount of water in addition to the natural rainfall. Adequate water judiciously applied is essential in maintaining good turf. At no time should the grass be allowed to suffer. In hot dry weather the greens must be watered every day. The water should be evenly distributed and applied only as fast as it will soak in, and only in sufficient quantity to maintain the turf in good growing condition. Where soil conditions are unfavorable it is especially important that the watering be done carefully. A uniform schedule for watering all greens is often a very bad practice, since the soil conditions of different greens may vary widely, as may also the evaporation due to exposure; hence the frequency of watering and the amount of water that should be used should differ accordingly.

Excessive Watering.--Excessive watering is always detrimental. It encourages development of brown patch diseases, tends to make heavy soils soggy when wet and brick-like when dry, and leaches or washes plant food away from the roots in the lighter or more sandy soils. A healthy vigorous growth of grass cannot be maintained under these conditions.

The green should never be watered to make it soft. Only sufficient water should be used to keep the soil moist and the grass in good condition. With proper attention to mowing, top-dressing, and fertilizing, a good putting surface can be maintained, whereas any attempt to soften the surface by adding excess water will ultimately result in a weakened grass cover and poorer putting turf.

Time of Watering. — Watering may be done at any time during the 24-hour period each day. However, if it can be done at night with proper supervision, there will be less interference with the use of the greens by players. Watering in the morning, or at a time when the grass will dry off quickly, is desirable where brown patch is causing trouble.

Occasionally it is desirable to water the greens in midwinter, but this should be done during a spell of mild weather when the ground is not frozen. Usually a single thorough irrigation is all that is necessary to hold the grass in good condition until rain or snow comes.

Mowing

In order to maintain a satisfactory putting turf it is necessary to keep the grass cut short at all times. The common practice is to mow three or four times a week. Three times a week should be regarded the minimum. Daily clipping is most desirable during favorable weather conditions. As a rule, the grass should be clipped as closely as can be done without crowning. Close clipping tends to make the turf denser, more uniform, finer in texture, and enables the green-keeper to detect disease more readily. Clipping the grass higher than usual is a very poor corrective for fast or bumpy greens. Such objectionable features should be remedied by proper top-dressing, watering, and rolling.

Top-dressing

Top-dressing the greens with compost or suitable soil is essential in maintaining a good putting turf. About 1 cubic yard of this material to each 6,000 square feet of green ordinarily should be applied every four to six weeks during the growing season. This practice aids in keeping the soil in proper physical condition for growing grass, keeps the surface smooth, and adds some plant food. It also keeps the soil in condition to absorb and hold moisture and covers runners which are undesirable if allowed to come to the surface.

The character of the material used for top-dressing should depend upon the composition and condition of the soil on which the green is established. As much as 50 per cent sand may be used on some greens, while on others good loam soil with no sand may be desirable. The application of pure sand is never advisable.

In general, a very good material for top-dressing consists of compost made by mixing 1 part by volume each of sand and heavy manure with 2 parts of good loam soil. Sand of a texture a little finer than that used for plastering is usually desired and should be well screened to remove all gravel or coarse material. Well-rotted manure or compost formed from manure or other organic material should be used in preference to fresh manure. The compost heap should be made at least a year, and better two years, before it is to be used. The materials may be built up in alternate layers of manure, soil, and sand to form a flat-topped pile or rick which can be kept moist to aid decay of the manure. The pile should be shoveled over once or twice the first year in order to mix the materials and hasten the composting process. Weeds should not be allowed to grow and bear seed on or near the compost pile.

The material should be screened through a sieve of about one-fourth-inch mesh before being used for top-dressing. Just after the green has been mowed the top-dressing should be applied, usually by hand, distributing it as evenly as possible. It should then be smoothed out and lightly brushed in with the back of a garden rake or a broom, and rolled. No set rules can take the place of good judgment in regard to the kind of top-dressing to use or the frequency of application. The condition of the soil and of the turf should be the main factors in deciding whether top-dressing is needed and whether it should consist of much or little sand.

Fertilizing

Bentgrass requires frequent applications of commercial fertilizers. The very shallow root system and dense top growth, which is restricted by constant close clipping, deplete the surface layer of soil of plant food, making it necessary to feed the grass in order to maintain a good turf. Since nitrogen is the most unstable of the important plant-food elements and is used in a large quantity for the production of vegetative growth, fertilizers carrying that element are most needed. Four or five pounds of ammonium sulphate to each 1,000 square feet of green, applied at intervals of four to eight weeks during the growing season, will usually maintain a vigorous growth of grass. On old greens the application of 4 or 5 pounds of superphosphate or its equivalent once a year, in addition to the nitrogenous fertilizer, is recommended.

The fertilizer may be mixed thoroughly with the compost and the two applied together, or it may be dissolved in water and applied with a sprinkler. Whichever method is used, the grass should be watered immediately afterward in order to prevent burning of the leaves. A convenient method used on many courses is to dissolve the amount of fertilizer needed for a green in a barrel of water and, by means of a "T" at the hydrant and a short hose connecting one side of the "T" to the barrel, draw the fertilizer solution into the stream of water from the hydrant through the hose which is used for watering the green. By adjusting the size of opening of the lead from the barrel, the proper amount of fertilizer can be applied while watering the green and in a solution so weak that there is no danger of burning. In this state it is usually best to avoid the use of fertilizer during July and August, or reduce it to about one-half the amount used in spring and fall.

Diseases

Brown Patch. — This is the most widespread and troublesome disease of bentgrass. It is caused by fungus which thrives best in warm humid

weather. It appears first as a fine weblike growth among the leaves, and may be observed when in spots no larger than a small coin. Within a few hours the infected spot will be as large as the crown of a hat and will appear as a circular area of grayish-green color. The loss of the bright green color is due to the wilting and dying of the leaves, which later become bleached and discolored to form a brown patch of grass on which the leaves are all dead.

There are two forms of this disease; namely, large brown patch and small brown patch. The latter, which is also called dollar spot, is the most virulent, and usually kills stems as well as leaves, thus making a dead spot, which, although usually small, may, by the merging of many of the small spots cover an area of several square feet. These dead patches, unless resodded artificially, are covered only by the spread of new runners from adjacent plants, a process which usually requires several weeks. Recovery from large brown patch takes place within a few days as this form kills only the leaves without seriously injuring the stems.

Both forms of the disease develop with amazing rapidity when conditions are favorable, and the green-keeper must be constantly on the lookout or considerable damage will be done before the presence of the disease is detected. The disease can be checked immediately by treating with certain mercury compounds which are available on the market under various trade names, as turf calomel, calochlor, colorgreen, upsulun, semesan, etc. Directions for their use will be found on the labels of the containers.

Insects and Animal Pests

The insects and animal pests which damage putting greens in this state are for the most part the same as those which attack lawns. A discussion of these pests will be found on page 26.

PUBLICATIONS ON HORTICULTURE, AGRONOMY, AND FARM MANAGEMENT

Previous publications of the station dealing with horticulture, soils, farm crops, and certain phases of farm management include the following:

Bul. No.

242 Alfalfa Production in Kansas. (42 pp., 12 illus.)
249 Soybean Production in Kansas. (31 pp., 10 illus.)
251 Types of Farming in Kansas. (111 pp., 42 illus.)
253 Tame Pastures in Kansas. (39 pp., 10 illus.)
254 Growing an Orchard in Kansas. (43 pp., 13 illus.)
260 Soil Fertility. (59 pages., 21 illus.)

Circ. No.

64 The Home Vegetable Garden. (8 pp., 2 illus.)
134 Grape Growing in Kansas. (32 pp., 10 illus.)
150 Accounts for Kansas Farms. (35 pp., 4 illus.)
153 Pruning Fruit Plants. (23 pp., 8 illus.)
162 Strawberry Growing in Kansas. (14 pp., 6 illus.)
163 Korean Lespedeza. (6 pp.)
172 Growing Tomatoes in Kansas. (14 pp., 4 illus.)

Copies of any of these publications in which the reader may be interested may be secured as long as available by addressing a request to: AGRICULTURAL EXPERIMENT STATION, MANHATTAN, KAN.