TURF CULTURE

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TURF CULTURE

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TURF FOR AIRFIELDS AND OTHER DEFENSE PROJECTS

JOHN MONTEITH, JR., *

The present crisis has developed a need for an unprecedented expenditure of public funds for turf in connection with airfields, defense highways, housing projects and other facilities for war activities. The agencies that are endeavoring to establish this turf are encountering many of the problems with which our regular readers have been dealing for many years. In a few instances the long experiences of those who have worked with turf have been utilized, but it is hoped that in the near future such valuable experiences may be taken advantage of more fully in the present national effort to produce durable turf quickly.

In the past little or no experimental work has been conducted in this country on problems immediately concerned with turf on airfields. Fortunately, however, many of the facts which have been learned from former research programs on turf for other purposes are applicable to the present problems. The practical experiences of men who for many years have been growing large areas of turf for various needs likewise have provided information that may be extremely helpful in these

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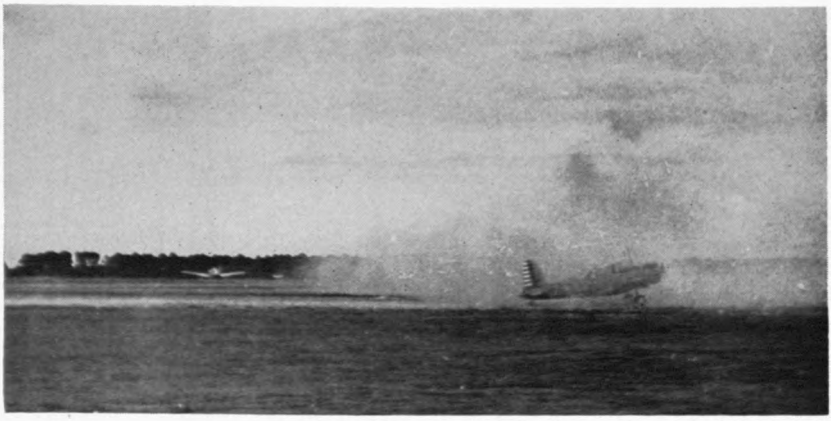
new applications. For instance, the problems of producing a tough, dense cover of turf on airfields in many ways resembles those encountered on fairways. Although the turf on airfields is subjected to more abuse it has the advantage that it can be



Dust from propellor blast on poorly grassed airfield. The plane on the left has created a dust cloud which is enveloping the plane and pilot in the foreground. Such a condition has been reported to reduce the life of airplane motors by as much as 90 percent.

cut higher than on fairways. On other areas the problems are essentially the same as those encountered in the rough of golf courses. The development of lawns for housing projects presents problems which are every-day routine to many of our readers. The present call for speed of establishment is a familiar one to most of those who read TURF CULTURE regularly.

During the past year the Green Section has been called upon on numerous occasions for advice on establishing turf in connection with the national defense program. These experiences have emphasized the need for a summary of available information on this subject. Therefore the following discussion was prepared by the Green Section staff, with the help of

John W. Bengtson, a former member, who is now specializing on turf for the U. S. Engineers at Mobile, Alabama.

It is fully recognized that past neglect in providing funds for a more critical study of turf culture leaves many problems for which no immediate solution is available. This failure, however, can in no way justify an additional failure to use to the best advantage the information and experienced personnel that is now available to most rapidly and efficiently provide the turf that is needed immediately and to rapidly improve present cultural methods.

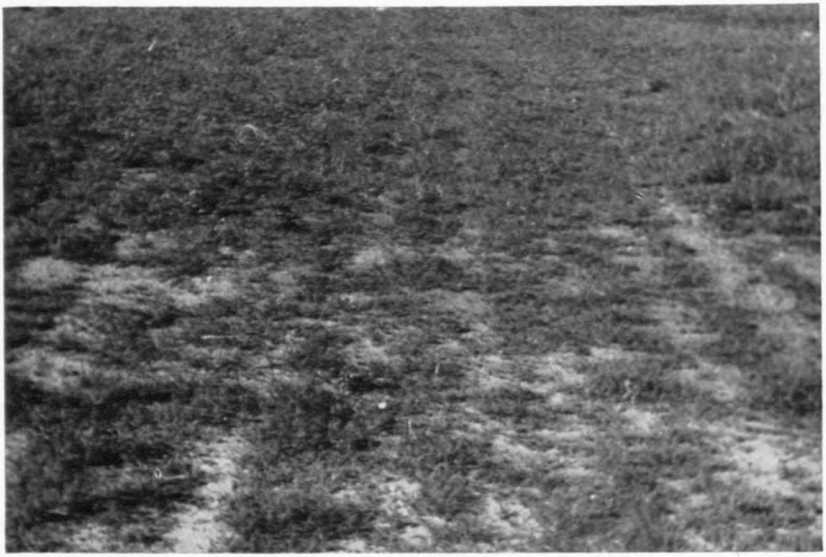
Soil

In preparing an area for turf one of the first problems which presents itself is whether or not to save the topsoil. The physical properties and plant food content of the topsoil in relation to the subsoil are the chief factors affecting the solution to this problem.

In many cases the practice has been to save the topsoil on areas requiring extensive grading. The saving and replacing of large quantities of topsoil involves considerable delay and expense. Assumption that this operation is an absolute necessity should be challenged in view of the fact that in some localities the subsoil is suitable from a physical standpoint and should produce a satisfactory turf provided enough plant food of the right kind is added. The advisability of saving topsoil is particularly questionable in much of the Bermuda grass region where the topsoil itself is poor. The cost of fertilizer represents only a small fraction of the cost involved in moving or saving the topsoil.

Freedom from competition by weeds is another point in favor of using subsoil exposed by grading operations. Topsoil which

is badly infested with weed seed becomes a serious handicap to the establishment of a good stand of grass. There are few viable weed seed on areas from which topsoil has been removed.



Bermuda grass turf which has been sprigged on an airfield. Foreground, on subsoil; background, on topsoil. The difference in amount of vegetation in the two areas is due to a larger number of annual weeds on the topsoil in the background rather than to a heavier stand of grass. Weeds retard the growth of grass and then die in late summer or early fall. A poor cover will remain on the area in the background after the weeds have died.

Soils on which turf must be grown may vary from heavy clays, to loose sands through wide variations in mixtures of sands, silts and clays. Soil mixtures which combine the sand, silt and clay in certain proportions are called loams. When, by fortunate accident, a sandy loam type of soil is present, it provides the most favorable physical condition for grass turf.

Soils on which establishment of turf is difficult because of unfavorable physical conditions can be corrected sometimes by

the addition of suitable soil amendments. Sandy soils may be improved by the addition of clay and possibly organic materials such as peat and muck. The important thing is to add sufficient fine mineral soil to stabilize the sand and retain moisture for plant growth. On the other hand, the addition of sand may help to prevent the development of dangerous slick surfaces on heavy clay soils.

Variation of physical properties of soils is so great in many places that soils ranging from heavy clays to loose sands exist on the same project. Where a great deal of cutting and filling is being done on projects having a considerable range of soil types it may be feasible to use a mixture of light and heavy soils for the top 4-to-8-inch layer of the fill.

Detailed information on soil stabilization studies is available in "Classification of Soils and Control Procedures Used in Construction of Embankments," *Public Roads,* Vol. 22, No. 12, February, 1942. Therefore, the subject will not be discussed here. In general, the improvement of soils from the physical standpoint will help in the establishment of turf provided similar careful consideration is given to the improvement of soil fertility.

Mucking

The term "mucking" is commonly used, particularly in the South, to designate the process of incorporating muck into sandy soil or simply the spreading of it on the surface. The significance of the mucking operation naturally hinges on what is meant by muck.

Loose usage of the word "muck" has given it a variety of meanings which have led to misunderstandings and misinter-

Trench 10 feet wide at the edge of an airfield runway excavated in preparation for "mucking." A 4 to 6-inch layer of muck is used to fill the trench. Natural vegetation growing in the muck is expected to produce a dense cover along the edge of the runway. The muck has already been placed in the trench in the background.

pretations. As the word is often carelessly used, it applies to almost any kind of soil or related material which is black or very dark in color, occurring in poorly drained areas. Due to this incorrect use, the word may include a dark clay or silt material which is essentially a sticky mud with little organic matter, or at the other extreme it may include a well-preserved peat containing practically no clay or silt.

Technically the term "muck" ordinarily is limited to organic matter, dark in color, granular in structure, and in such an advanced stage of decomposition that the original plant remains are no longer recognizable. The commercial mucks ordinarily used for modifying soil contain less than 15 percent mineral matter, but the mineral fraction may reach 50 percent and the material still be called muck. When above 50 percent it is classed as a mineral soil of high organic content.

A true muck therefore falls in Group 8 in the Public Roads Administration's booklet, referred to under "Soil." In this

Ten-foot strip of muck which has been in place along edge of airfield runway approximately one year. Note the dense growth of natural vegetation on this strip which prevents soil from washing onto the runway. Often the vegetation obtained in this way will not survive the dry conditions on airfields since it is usually brought in from low swampy areas.

booklet the "general stability properties" of peat and muck are classified as being "incapable of support."

For airfields and roadsides where load-bearing capacity is important, muck, or peat which is often erroneously classed as muck, is of little permanent value on sandy soils unless combined with marl or other suitable mineral soils which will serve to stabilize the sand. The organic matter will soon decompose when spread out on the surface or worked into the soil. The decay will be hastened if fertilizer is applied. Marl or mineral soils found in many hammock areas in the South or clay or loam soils elsewhere are far more beneficial than muck. Likewise clay and silt soils containing moderate amounts of organic

matter, which are frequently erroneously called muck, are superior to the true muck for improving sandy soils for airfields and similar purposes. The fine soil particles they contain in abundance have a permanent stabilizing effect on the sand and improve the water-retention qualities of the sand throughout the years.

When establishing turf on areas such as lawns for housing projects some classes of muck are helpful. Such materials should be free from sticky plastic residues which harden upon drying. Where muck is incorporated into sand before planting grass it will encourage the growth of grass, particularly if it is reinforced with some fertilizer. On stiff clay soils muck may help in loosening the soil and its use in some instances may be justified for this purpose.

Mucking is also used in the establishment of vegetation by the process described elsewhere in this issue as topsoil planting. While good stands may be established in this manner, it should be remembered that the vegetation naturally growing in the swampy areas from which muck is obtained is usually not of the kind suitable for turf and is not likely to survive long under the drier conditions it will encounter in many places where muck is now being used extensively.

Drainage

No discussion of turf can be considered complete unless it points out the great importance of drainage in the establishment and maintenance of turf grasses. It is impractical, however, to discuss here the subject of drainage systems. It should be borne in mind that water drains more slowly from turf than from pavements and that, therefore, more pitch is required to remove water quickly from a turfed area than

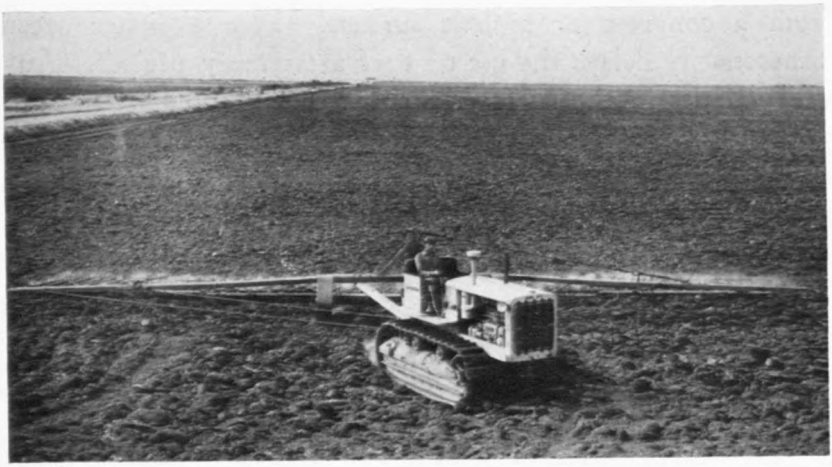
from a concrete or asphalt surface. Poor drainage often unnecessarily delays the use of turf after rainy periods. Any irregularities in the surface, such as those caused by tires in wet weather, are more troublesome in flat areas than those with more pitch. Porous loams or mixtures of loam and clay soils with more than 50 percent of sand, are of great advantage in establishing turf from the standpoint of drainage.

Preparing the Seedbed

The purpose for which turf is to be planted, size of the area, and soil type are all factors which influence the methods to be

In preparing large areas for turf, a double disk may often be used to advantage. A machine such as this one, having a rear disk which throws the soil in only one direction opposite to the front disk, produces a level seedbed. The spike-tooth harrow dragged behind the disk helps to further pulverize and smooth the soil.

used in the preparation of a seedbed. On large areas such as airfields the preparation of soil for planting after the final grading has been done usually can be accomplished in one operation by the use of a disk. This operation may leave the



In preparing the seedbed on some soils, harrowing may be necessary in addition to disking. On large areas, this type of spike-tooth harrow may be used to advantage. The comparatively light draft of the spike-tooth harrow makes it possible to pull a large number of units with a relatively small amount of power. The use of such a harrow tends to level as well as to further pulverize the soil.

seedbed in a rather rough condition but because of the dust problem on dry areas the rougher seedbed is superior to one on which the soil has been finely pulverized, except in cases where good appearance is important.

On lawns or other small areas where the use of a disk is impractical other methods must be employed. Small disks, plows, or motorized tillers may be used on larger lawn areas, but on very small lawns it is often necessary to spade the area by hand to a depth of 3 to 6 inches, depending on the soil type. The practice of hand raking is employed on these smaller areas to smooth and pulverize the soil sufficiently to make it suitable for seeding.

On many large areas regular farm disks may be used satisfactorily. On airfields, however, most farm disks are not suitable for use, unless followed by a drag or harrow, because

they are constructed so that they throw the soil two ways. The use of this type of disk leaves alternate ridges and furrows, and unless these are leveled by some type of drag they cause a great deal of vibration in planes traveling across the field at high speed. Disks can be obtained which throw all the soil in one direction, thereby eliminating the "washboard" effect caused by the ordinary disk. In tightly packed clay soils it may be necessary to disk the area more than once in order to prepare the soil properly. If fertilizer is applied before the final disking, that operation can be used to accomplish two objectives; that is, to work the fertilizer into the soil and to break up the soil properly for planting. The fertilizer should not be disked into the soil so deeply, however, that it is placed below the level at which most of the grass roots will grow.

Fertilizing

The fertilizer requirements of grasses for turf purposes are very different from those of most field crops. Grass produces a large amount of foliage for which nitrogen is primarily required. Because of this, together with the fact that nitrogenous salts are readily leached from the soil, nitrogen usually is the element which is likely to be depleted most rapidly from soil under turf. In general, therefore, the fertilizers which are recommended for use on turf are usually high in nitrogen. Fertilizer mixtures containing approximately half as much phosphoric acid as nitrogen and still less potash have been found to give the best results at the minimum cost in tests made under various climatic and soil conditions.

Soil analyses, when considered in relation to the requirements of the grass to be planted, are useful in helping to determine the types and amounts of fertilizers to be applied. Inorganic

fertilizers of 10-6-4 and similar grades, however, usually should be applied at the rate of not less than 400 pounds to the acre. If fertilizers with different percentages of nitrogen are used, the rate should be modified so that corresponding amounts of nitrogen would be applied. On areas such as roadsides or other places where fertility is extremely low, it may be advisable to apply two or even three times this amount during the preparation of the original seedbed. It should be borne in mind that although phosphorus and potassium may not be rapidly depleted from land planted to turf, the soil may be naturally deficient in these elements. For this reason it may be necessary in some cases to apply larger amounts of phosphoric acid and potash than are present in a 10-6-4 fertilizer. Here again the results of soil tests should be considered in estimating the amounts of these nutrients needed. Where topsoil is involved, the agricultural history of the land may supplement the information obtained from soil tests.

After turf has become established it usually will be necessary to apply fertilizer occasionally to maintain a heavy stand. The frequency and rate of applications will depend on the fertility of the soil and the quality of turf required. A 10-6-4 fertilizer is satisfactory for general use, but where there is ample phosphoric acid and potash in the soil an occasional light dressing of sulfate of ammonia is all the fertilizer that is needed to speed up the development of turf. It is not safe to apply inorganic fertilizers at rates heavier than 40 pounds of nitrogen to the acre (400 pounds of 10-6-4 or 200 pounds of sulfate of ammonia) because of the danger of burning the foliage. Also, to avoid serious burning of the grass, applications should be made only when the blades of grass are dry. Inorganic fertilizers should not be applied to young seedling grass.

In general, inorganic fertilizers should be applied to turf just prior to the time of most rapid growth of the grass concerned. In the cool-humid regions, late summer or early fall applications are to be desired because they encourage the maximum growth of the turf grasses after the annual grasses and weeds have been killed by the first light frosts. In these regions fertilizer applications, if made in the spring at all, should be made very early. In the warm-humid regions, on the other hand, turf of Bermuda grass and other summer-growing grasses should be fertilized in the spring to encourage the spring and summer growth. On light sandy soils, in either region, where the nutrients in inorganic fertilizers leach rapidly, it is advisable to make several small applications during the growing season rather than to make one large application.

For most conditions the inorganic mixtures are more satisfactory than the organic from the standpoint of cost as well as quick availability to the grass. There may be cases, however, where large local supplies of organic waste materials, such as activated sludge, are available. Advantage should be taken of the availability of such materials, but it should be remembered that while their effect may be more lasting than is that of the inorganic mixtures, the immediate response of the grass will not be so quick. The organic fertilizers are often used to good advantage on sandy soils where inorganic fertilizers are leached rapidly. The chemical analysis of such materials should be determined and they should be applied at such rates as to furnish at least 40 pounds of nitrogen to an acre.

In some parts of the country minor elements may be lacking to such an extent that turf may suffer from their deficiency. Such deficiencies may be corrected by including in the fertilizer small amounts of the minor elements which are lacking. These

If the addition of lime is necessary before planting, it may be effectively distributed by inexpensive spreaders such as the above which operate behind an ordinary 1 or 1½-ton truck. This machine can be used also for distributing fertilizer and is less expensive than the side-wheel type.

include boron, zinc, manganese, copper, and other elements of which very small amounts are necessary for the normal growth of plants. Most soils naturally contain sufficient amounts of these elements, but in certain limited areas deficiencies may occur.

Lime may be used to good advantage in some cases in which the soils involved are highly acid. Lime should not be applied, however, until soil analyses have indicated the advisability of using it. Since plants vary widely in their tolerance of acidity or alkalinity, the grasses composing the turf should be considered. Lime is also known as a "soil conditioner." It tends to loosen tight clay soils and to tighten loose sandy soils. Its value for this purpose is rather limited, however, since excessive amounts are usually required to produce a noticeable effect.

Controlled experiments have shown that lime is likely to encourage turf weeds and clover to the extent that turf grasses cannot successfully compete against them, particularly where soil fertility is low.

Finely ground limestone is commonly used. It is usually cheaper than hydrated lime and fully as effective. Unless soil is very strongly acid, the rate need not exceed ½ to 1 ton to the acre. If hydrated lime is used it should not be applied within a period of 2 weeks of the time of application of fertilizers containing ammonium salts.

Planting

Many grasses are propagated either by seed or by the use of fragments of actively growing plants which are known variously as vegetative material, stolons, rhizomes, or sprigs. Also, pieces of established sod may be transplanted with the soil held together by the grass roots. In the establishment of turf throughout the country for various purposes, many different terms have been applied to the several methods used, resulting in considerable confusion. The synonymy among these terms has been carefully considered and has been discussed with members of the Roadside Development Committee of the Highway Research Board, with various workers in the Bureau of Plant Industry, and others who are interested in the terminology. Since these discussions disclosed the desirability of a uniform terminology, the following terms were agreed upon as a recommendation for general use throughout the country. In each case other terms which are applied to the same method are given in parenthesis.

The methods of planting are discussed in the order of increasing amounts of plant material required as well as the increasing

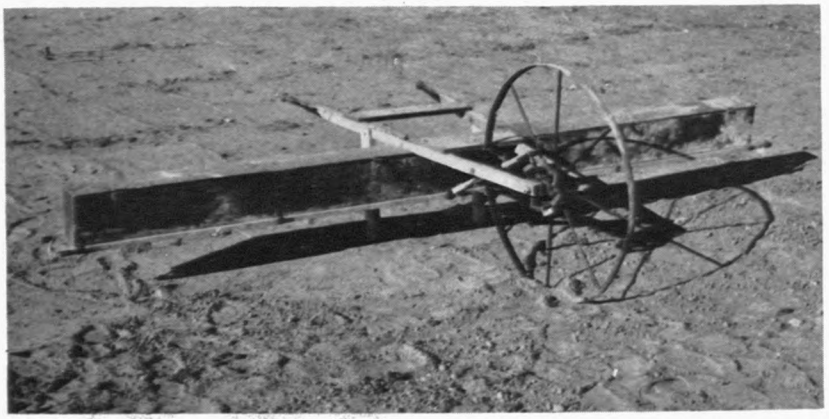
Result of lack of grass cover on airfield. Note the soil which has been washed onto the runway from adjacent bare areas. Such a condition might be prevented if a good grass cover were established.

cost of planting; that is, seeding, sprigging (frequently called vegetative planting), and sodding. In planting seed, even under most favorable conditions, the young seedlings are extremely tender for some time before a tough sod is established. This is associated with the fact that in seeding it is actually the minute embryonic plants within the seeds which are planted. In sprigging, more mature plant material, and larger amounts of it, are used, and therefore a wear-resistant turf is much more quickly established than by seeding. By the planting of sprigs, moreover, it is possible to propagate grasses which do not produce viable seed in large quantities, and also to propagate selected strains which do not come true from seed, as is the case with the creeping and velvet bents. For the actual transplanting of sod, still larger amounts of plant material are used. On the other hand, this is by far the quickest way to

Bermuda grass turf five months after planting in August. Left, seeded; right, sprigged. Had seeding been possible earlier in the season, the area on the left no doubt would have had a much better cover of grass than is indicated in this photograph.

get a tough wear-resistant turf. There are locations on steep slopes and in drainage channels where the use of solid sodding may be recommended. However, combinations of mulching with seeding methods have recently been developed on highway slopes which have largely replaced solid sodding formerly practiced on such areas.

When dealing with grasses which may be established by any of the methods, such factors as cost and the requirements of the turf as well as the speed with which it is necessary to establish the turf should determine the method to be used. In most cases the establishment of turf by the use of seed is much less expensive than by the use of sod or sprigs. On the other hand, a durable turf is produced more quickly by the planting of sod or sprigs than by seeding. This factor is particularly important from the standpoint of some of the southern grasses.



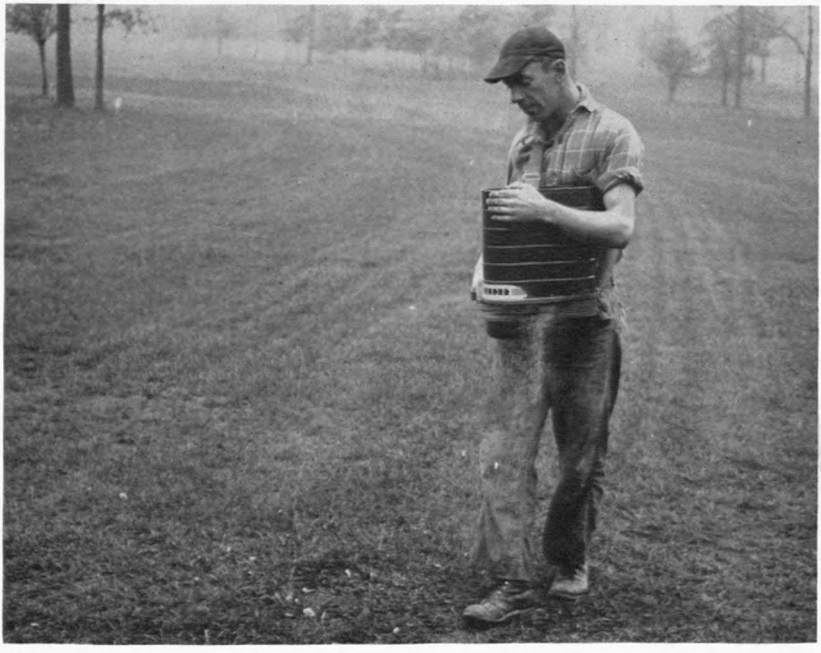
The wheelbarrow grass seeder affords an effective means of distributing seed evenly over the seedbed. Like the cyclone seeder it is limited to use on small scale plantings.

When circumstances require late planting of these there is a danger that seedlings may not survive over winter. In such cases as this, plantings of sod or sprigs are better able to establish themselves sufficiently to withstand the cold.

Seeding

The chief points of concern in seeding are: even distribution of seed, depth of planting and rate and time of seeding. The matter of even distribution is usually taken care of, if mechanical seeders are properly employed. The depth of planting will vary somewhat with the type of seed used. The small seeded grasses such as bluegrass, redtop, Colonial bent, Bermuda grass and carpet grass should be covered only slightly. The brome grasses, ryegrass and the fescues can be safely planted to a depth of one-half inch.

Since rates of seeding are dependent upon the species of grass used, they are discussed separately under each grass listed. Par-



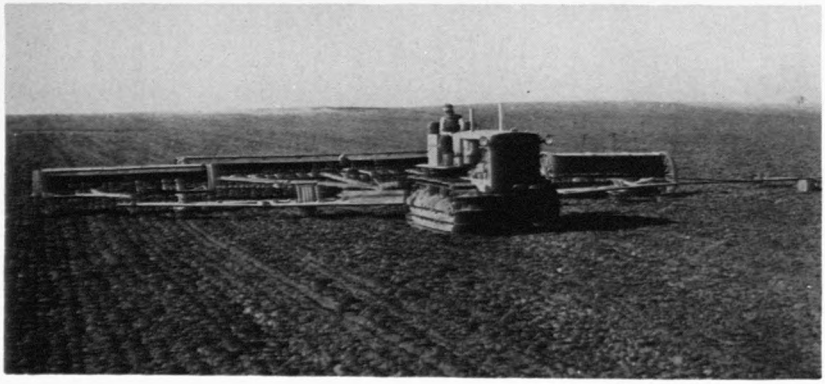
Hand operated cyclone grass seeder which distributes seed by centrifugal action. Such seeders are very useful on small areas such as lawns or roadbanks that are inaccessible to other types of seeders.

ticular consideration should be given to the most favorable time of year for seeding, in order to give the grass the best possible chance for survival. Since the time varies with the climatic regions as well as to some extent with the kind of grass to be seeded, this problem is discussed in general in the presentation of climatic regions and specifically under certain of the grasses.

The several types or methods of seeding commonly used are described in the following paragraphs. In general, the method used should be determined by the size of the area to be seeded, and the nature of the equipment at hand.

Broadcast seeding may be done by hand or with mechanical seeders such as the wheelbarrow or the cyclone types. To insure even distribution of seed it is suggested that half of the seed be sown over the entire area in one direction and the remaining half be sown crosswise. A rake, drag, cultipacker, or harrow may be used to cover the seeds to the desired depth.

Drill seeding is often practiced on fairly large areas, especially with the larger seeded grasses. Drills have the advantage of



Large scale seeding and fertilizing may be accomplished in one operation by the use of tractor-drawn drills.

being able to distribute seed and fertilizer in the same operation. Drill tubes on most drills are spaced 4 to 8 inches apart and spaces between the rows are ordinarily covered within a few weeks. Care must be taken in drilling the finer seeded grasses to see that they are not covered too deeply. Drills may be used to good advantage in reseeding thin, poor turf because seeds can be placed in the ground without damaging the turf already on the area.

Row seeding may be used where mechanical row seeders are available or by the use of drills in which part of the holes are closed. This method also presents the difficulty of planting seeds deeper than is desirable. It is not commonly used except in the planting of nurseries, where it is desirable to have the plants in rows.

Hay mulch seeding is a method sometimes used, particularly in the dry regions of the western states, in seeding certain native grasses, the seed of which is difficult to harvest. Hay is cut from native stands of such grasses after the seed is mature and scattered over the area to be seeded. The straw acts as a mulch or cover and is beneficial in protecting the young seedlings when not applied too heavy.

Sprigging

The term sprigging is recommended for the method of propagation which makes use of fragments of the growing grass plants. This method can be used particularly successfully in the case of grasses which spread rapidly by the production of runners either above or under ground. Runners produced above ground are called stolons, while those produced underground are known as rhizomes or rootstocks. Each node or joint of these runners will produce roots when covered with soil and provided with sufficient moisture. It is suggested that fragments of runners which contain nodes either with or without roots be called ***sprigs***, and the method of propagation which involves the planting of this material be called ***sprigging***.

With this method, sprigs which are dug out of a meadow or nursery with little or no soil attached are chopped or separated by shredding and are then planted. Sprigs with roots

Sprigging Bermuda grass on a southern airfield. Note the "army" of men necessary for large scale planting by the hand method. Bermuda grass sprigs are being placed in furrows by hand, after which they will be covered. Some mechanical planting method would not only greatly reduce the time required for this operation, but would prevent the drying out of sprigs before covering.

are preferred, but roots are not necessary when weather conditions are favorable. Sprigs must be covered immediately after planting to prevent drying out. The time of planting is very important when this method is used. Moisture and other climatic conditions must be such as to encourage the rapid growth of the newly rooted plants. As compared with sodding, sprigging is a relatively cheap method of planting, because little or no soil is taken up with the sprigs and less plant material is used.

Various types of sprigging are in common use. These types are described in the following paragraphs in the order of increasing amounts of plant material required.

Check sprigging is the planting of sprigs at regular intervals in rows. This method requires the least amount of planting

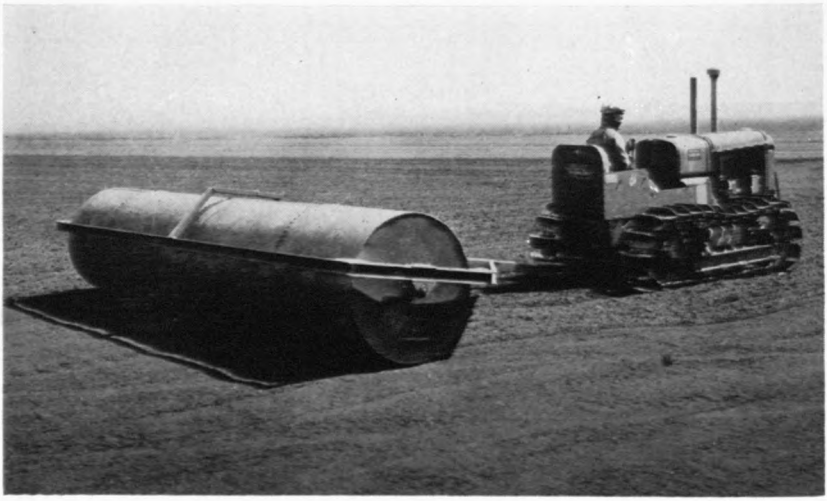
Bermuda grass sprigs may be scattered with a manure spreader such as the above much more rapidly than they can be planted by hand. When planting large areas in turf, the use of power equipment will often save much time and labor.

material of any of the methods listed. While check sprigging does not require as much planting material as the other methods mentioned, it should be borne in mind that when less planting material is used a longer period of time is required to establish a dense cover of turf.

Row sprigging is the planting of sprigs more or less continuously in rows. This may be accomplished by placing the stolons in furrows and covering with a plow, drag or hand rake; by dibbling in the sprigs by hand; or by the use of mechanical planters. These latter machines are still in the experimental stage but considerable progress has been made in the development of such equipment. In row sprigging, more planting material is used than in check sprigging.

Broadcast sprigging refers to the method by which shredded

or chopped stolons are broadcast over an area. This may be accomplished either by hand or by the use of machinery. Where small areas are being planted, the chopped stolons are merely scattered by hand, rolled, and then covered with a thin top-dressing of soil or compost. This method is commonly used in propagating selected strains of creeping bent on golf courses



After seeding or sprigging, the soil should be firmed by rolling. This process places the soil in close contact with the seed or sprigs and thereby aids in more rapid germination of seed or more rapid growth of sprigs.

and is known as vegetative planting. Naturally, hand methods are much too laborious for use on large areas. If large-scale plantings are made, the stolons may be distributed over the prepared surface by a manure spreader. Only grasses which produce stolons, however, should be distributed by this method. In order to cover the stolons lightly and firm the soil, the spreader must be followed by a disk and roller.

Sodding

The transplanting of sod with the soil held together by the grass roots is known as sodding. Thin sod is obviously cheaper to move than thick sod. Also, thin sod cut at 1 inch or even three-quarters of an inch has more surface roots exposed, and therefore becomes anchored more quickly than does thick sod, but it dries out much more quickly. Thin sod should not be used, therefore, unless plenty of moisture is assured either in rainfall or through available watering facilities. On the other hand, sod cut at 2- to 4-inch depths will not dry out so quickly but the grass will be more slow to become anchored and established. Several kinds of sodding are in general use. These are listed below in the order of increasing amounts of plant material required.

Check sodding (block sodding, tuft sodding or spot sodding) involves the planting of small blocks of sod at regular intervals. This method should be employed only when the grasses to be used are species which spread rapidly from stolons or rhizomes. The method is used chiefly in areas subject to periods of drought where plantings by methods such as sprigging are likely to fail. Buffalo grass which is slow to start growth and requires a small core of soil and undamaged roots in order to survive periods of drought, is the species most commonly planted by this method. It is important not to cover buffalo grass with soil after planting.

Strip sodding (trench sodding) requires more sod than check sodding but less than solid sodding and may be used successfully in many cases on slopes which are too steep for other planting methods to succeed. Spaces between strips may be seeded or sprigged.

Solid sodding (block sodding, also frequently simply referred to as sodding) is the complete covering of an area by strips or blocks of sod. This method is by far the most expensive because of the large amount of material and labor required. It may be used to advantage, however, on lawns, drainage channels, and areas adjacent to catch basins along highways and runways where immediate cover is necessary.

Topsoil Planting

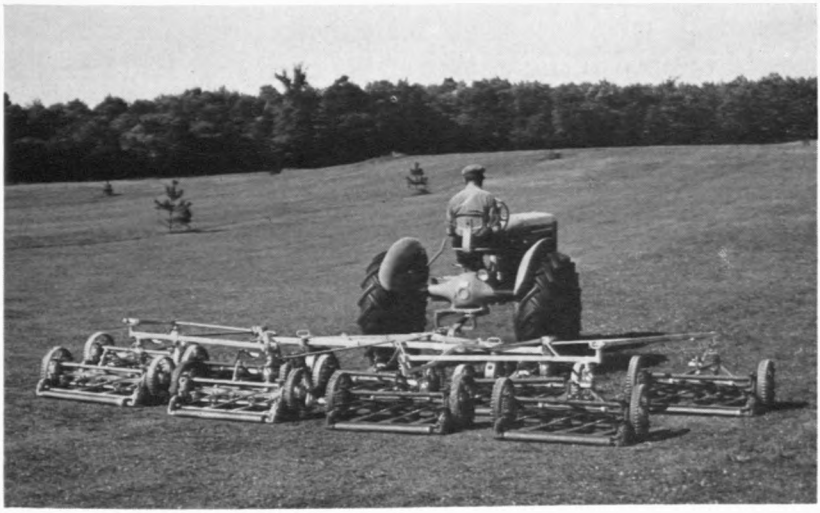
This method, which is otherwise known as broadcast sodding, mulch sodding, or grass mulching, has been used rather extensively in the establishment of turf, particularly in the South. It is a method which combines the spreading of topsoil and planting in one operation.

The area to be planted is graded to any desired depth below the finished grade, sometimes as little as 1 to 2 inches. Topsoil obtained from a field upon which a desired grass is growing is then spread over the area to fill up to grade. The grass is indiscriminately mixed with the topsoil during the moving process and under favorable conditions resumes growth in the new location. When the soil used is dark in color and obtained from swampy areas, this operation is usually referred to as "mucking," which has already been described.

Mowing

One of the most critical periods in the establishment of grass is that time between germination, or beginning of growth in the case of sprigs, and the development of a good cover. If weeds are allowed to grow unmolested during this period the grasses suffer badly or may die due to competition. Usually such losses can be prevented if sensible mowing is practiced

during the early stages of development. Proper height and frequency of mowing are largely determined by the types of grasses of which the turf is composed and the use to which the turf is to be put. Generally speaking, mowing which develops



Reel type gang mowers may be effectively used on large open turfed areas. This type of mower is operated at a higher speed and is much more effective in controlling weeds than the ordinary sickle-bar type. The time required for mowing may be kept at a minimum by using 7 or 9 unit gangs of these mowers.

the maximum density of turf and keeps down the taller growing weeds without damaging the grass may be termed sensible mowing.

Even after a good stand of grass develops, mowing is still important. In the case of airfields and similar areas, however, mowing closer than 2½ or 3 inches is not necessary and should be avoided. The best service will likely be obtained on such areas from the use of a reel or a rotary type mower rather than the sickle-bar types. Mowing should be done when the grass

requires it rather than at set dates. Naturally more frequent mowings will be necessary during the periods of greatest growth.

During seasons when there is little or no growth of grass, mowing can be eliminated entirely provided weeds are not present. If troublesome weeds are present they must be kept mowed to prevent smothering of the grass and also to prevent their seeding.

Watering

When large areas are being put into grass the high cost involved in the application of water in amounts sufficient to be of any value will probably prohibit its use. Since the addition of more than 27,000 gallons of water to the acre is necessary to equal 1 inch of rainfall, it is obvious that watering at the rates that will help the grass will be extremely costly on large areas. On small areas, where costs are not a limiting factor, watering is often advisable, particularly during the germination period, and before the start of growth in the case of sprigs.

Renovating

Whenever possible, old existing turf should be preserved, for it takes much longer to grow tough turf than is ordinarily realized. In some portions that are slightly ridged or uneven it is possible to improve the old turf by cutting in various directions with a sharp disk harrow. The harrow should be set almost straight so that it will cut into the turf but will not turn it over. If reseeding is to be done, a drill may be used so that the seeding and cutting may be done in one operation. The turf should then be fertilized and rolled. This treatment given to old Bermuda grass turf in the spring or to bluegrass

turf in the fall results in noticeable benefits. In treating old turf on stiff clay soils, an application of coarse sand in addition to this cutting will benefit the turf by improving the soil structure.

Selection of Grasses

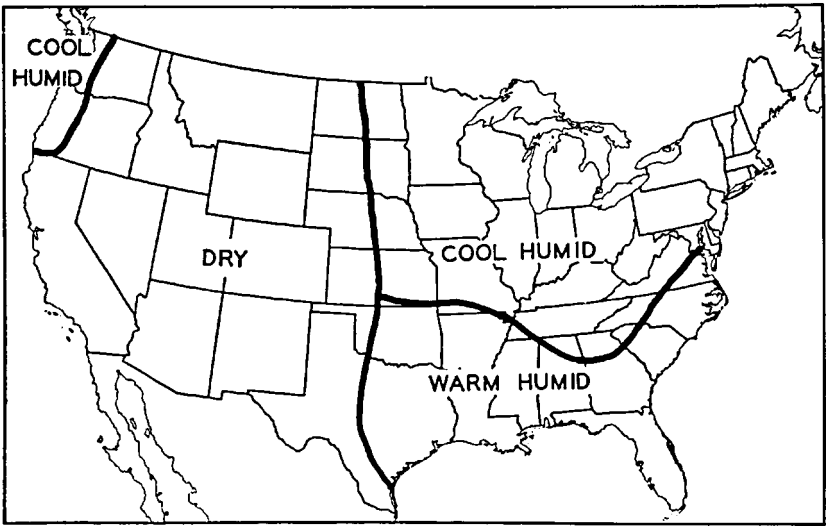
Grasses, to be useful for lawns, pastures, golf courses, etc., must meet certain specific requirements adapting them to the purpose for which they are selected. Likewise, if turf on an airport, roadside, or cantonment area is to be successful it must be composed of plants capable of meeting the requirements of such turfed areas. Among some 1,100 known species of grasses occurring in the United States only approximately 30 have been used for turf purposes. This does not mean that others may not be used. It merely indicates that in the past their use for turf has not been investigated.

A grass selected for use on airfields, roadsides, drill fields, and recreation areas should be tough and resistant to the rough usage to which such areas are subject. Far more important than the fine texture sought in lawn grasses is the ability to withstand wear and tear of heavy traffic. Since turf on many areas is often required on relatively short notice, rapid growth and the ability to "cover up" quickly are also of major importance in the selection of the grasses. In many cases, dust, so detrimental to the motors of planes and other mechanized equipment, can best be checked by the rapid establishment of a grass cover. Any turf subject to wear by planes, trucks, etc., is likely to suffer badly from scars unless it is composed of rapidly growing species which heal quickly.

The selection of grasses that require minimum maintenance costs is of considerable importance. Other factors being equal,

low-growing species should be used in preference to the tall, upright ones, since mowing costs often involve large sums of money.

Finally, planting material, either seed or stolons of the grasses to be used, should be readily available commercially. Seeds of some turf grasses are imported and as a result are not



Map depicting three general climatic regions of the United States. The grasses to be used in each region are determined by the climatic factors of that region.

available at this time. Also seed of some recently developed strains of turf grasses must be increased before they are available in large quantities.

Even for airfields or other specific requirements, no one or several grasses can be recommended for general use in turf throughout the country. Rather, the types of grass to use will depend primarily on the geographical location of the particular areas in question. Grasses, like most plants, are pecu-

liarly adapted to growth in certain specific geographical and climatic areas. Attempts to use species outside of their range of adaptability almost invariably meet with failure. The final selection of grasses within each geographical area will depend on the soil and moisture conditions of the locality and a consideration of the naturally occurring grasses within that specific area.

For the present treatment the United States has been divided into three climatic regions (see accompanying map), and in the table on page 224 a number of grasses are suggested for use in each region.

The correct time of planting various grasses is determined primarily by the location of the region in which the grasses are used. Most seeding in the cool, humid regions should be done in late summer or fall. In the southern portion of the region this is an absolute necessity if a good stand is to be expected. In the northern part of the cool, humid region satisfactory turf may sometimes result from early spring seeding. Turf grasses of this region are not ordinarily used singly, but in mixtures.

Grasses of the warm, humid region should be planted either during the spring or summer months—not in the fall. One may find rare exceptions to this in the extreme South where Bermuda grass stolons have been planted in February. If stolons are planted at this time they merely remain dormant in the soil until conditions become favorable for growth.

In contrast to the northern grasses, those of the warm, humid region are usually used singly rather than in mixtures. There are a few exceptions to this rule. For example, carpet grass is often used in combination with Bermuda grass and other species.

The time of planting in the dry region will depend primarily on the method of planting employed. If sprigs or sod are used they should be planted in the spring or early summer. Seeding is done either in the spring or fall, depending on

GRASSES AND LEGUMES WHICH CAN BE USED FOR TURF IN THE THREE CLIMATIC REGIONS OF THE UNITED STATES. THE ACCEPTED METHOD OF PLANTING IS GIVEN FOR EACH. WHERE A PLANT MAY BE PROPAGATED EITHER BY SEEDING OR SPRIGGING, THE MOST COMMONLY USED METHOD IS GIVEN FIRST.

Common Name	Scientific Name	Method of Planting	Page No.
Cool Humid Region			
Kentucky bluegrass	*Poa pratensis* L.	Seed	226
Canada bluegrass	*Poa compressa* L.	Seed	227
Trivialis bluegrass	*Poa trivialis* L.	Seed	227
Redtop	*Agrostis alba* L.	Seed	228
Red fescue	*Festuca rubra* L.	Seed	228
Meadow fescue	*Festuca elatior* L.	Seed	228
Perennial ryegrass	*Lolium perenne* L.	Seed	229
Annual ryegrass	*Lolium multiflorum* Lam.	Seed	229
Common ryegrass	*L. perenne* and *L. multiflorum*	Seed	229
Colonial bent	*Agrostis tenuis* Sibth.	Seed	230
Creeping bent	*Agrostis palustris* Huds.	Sprigs and Seed	230
Quackgrass *	*Agropyron repens* (L.) Beauv.		231
White clover	*Trifolium repens* L.	Seed	231
Warm Humid Region			
Bermuda grass	*Cynodon dactylon* (L.) Pers.	Sprigs and Seed	231
Centipede grass	*Eremochloa ophiuroides* (Munro) Hack.	Sprigs	233
Narrow-leaved carpet grass	*Axonopus affinis* Chase	Seed	233
Broad-leaved carpet grass	*Axonopus compressus* (Schwartz) Beauv.	Seed	233
Japanese zoysia	*Zoysia japonica* Steud.	Sprigs	234
Manila zoysia	*Zoysia matrella* (L.) Merr.	Sprigs	234
Bahia grass	*Paspalum notatum* Flügge	Seed and Sprigs	236
St. Augustine grass	*Stenotaphrum secundatum* (Walt.) Kuntze	Sprigs	236

Common Name	Scientific Name	Method of Planting	Page No.
Common lespedeza	*Lespedeza striata* (Thunb.) H. and A.	Seed	237
Korean lespedeza	*Lespedeza stipulaceae* Maxim.	Seed	237
Perennial ryegrass (temporary)	*Lolium perenne* L.	Seed	229
Annual ryegrass (temporary)	*Lolium multiflorum* Lam.	Seed	229
Common ryegrass (temporary)	*L. perenne* and *L. multiflorum*	Seed	229
Dry Region			
Buffalo grass	*Buchloë dactyloides* (Nutt.) Engelm.	Sprigs and Seed	237
Kikuyu grass	*Pennisetum clandestinum* Chiou.	Sprigs	238
Smooth brome	*Bromus inermis* Leyss.	Seed	239
Downy brome *	*Bromus tectorum* L.		239
Blue grama *	*Bouteloua gracilis* (H.B.K.) Lag.	Seed	239
Sideoats grama *	*Bouteloua curtinpendula* (Michx.) Torr.	Seed	239
Bermuda grass	*Cynodon dactylon* (L.) Pers.	Sprigs and Seed	231
Crested wheatgrass	*Agropyron cristatum* (L.) Beauv.	Seed	239
Western wheatgrass	*Agropyron smithii* Rydb.	Seed	239
Kentucky bluegrass	*Poa pratensis* L.	Seed	226
Curly mesquite *	*Hilaria belangeri* (Steud.) Nash		239
Russian wildrye	*Elymus junceus* Fisch.	Seed	239
Sand dropseed *	*Sporobolus cryptandrus* (Torr.) A. Gray	Seed	239

* May be established by the hay mulch seeding method or natural stands may be utilized when available.

whether or not one is located in the northern or southern dry regions. In the North, spring seeding may bring good results, whereas in the South fall seeding is to be preferred, unless a southern grass, such as Bermuda grass, is used.

It is realized that conditions vary widely even within each climatic region and the fact that a number of grasses are suggested for use in each of the climatic regions should not be taken to mean that all or any of these can be used successfully in all locations in any one area. There are certain situations where, under present conditions, it will be extremely difficult, if not impossible, to grow any grass at all. Attempts to produce turf on such places is merely a waste of time, effort, and planting material.

In establishing turf for defense purposes it may be necessary to depend on temporary covers for short periods of time. There are a number of plants including grasses which may be used for this purpose and information regarding their use may be obtained upon request.

Kentucky Bluegrass

As this species produces a dense durable turf over a wide range of soil conditions in the cool humid region of the United States, it should be the chief component of most plantings in that area. Where it is watered, it also thrives in the northern half of the dry region. Unlike the southern grasses, the growth of the bluegrasses is confined to the cooler seasons of the year. Growth starts early in the spring, is retarded during the hot summer months, and is accelerated in late summer or early fall. This species is slower to produce a strong turf than are some of the southern grasses, but once it has become established it forms, with proper management, a dense, permanent sod. A number of strains of Kentucky bluegrass have been selected which differ widely in texture, height, ability to spread, and disease resistance. Among these some of the coarser, spreading types are better adapted for airfield and general turf use than are the usual commercial strains.

On lawns and similar areas bluegrass is seeded at the rate of approximately 4 pounds to 1,000 square feet. For larger areas, seeding at the rate of 50 to 75 pounds to the acre should be adequate. When possible, seeding should be done in late summer or early fall rather than in the spring, **never in mid-summer.** This is especially important in the southern part of the bluegrass range. In the North, early spring seedings may sometimes be successful.

Canada Bluegrass

This species has approximately the same distribution as Kentucky bluegrass. It is most often found on soils of low fertility and may sometimes be used as a turf grass on such soils. Canada bluegrass is coarse, stemmy, and a very poor substitute for Kentucky bluegrass; however, it may serve as a ground cover on poor soils where a dense turf is not needed. This species should be seeded at the same rate as that suggested for Kentucky bluegrass.

Trivialis Bluegrass (roughstalk bluegrass)

This is definitely a shade grass and has little application for use outside of shaded moist soils or other cool moist locations. It is not a grass to be used in turf that receives any appreciable amount of heavy wear.

The fact that seed of trivialis bluegrass is produced outside of the United States and will not likely be available in quantity until after the emergency should be kept in mind when drawing up seeding specifications. Trivialis bluegrass is often recommended in seed mixtures and if such mixtures are used in seeding specifications, projects may be unnecessarily delayed due to the fact that trivialis bluegrass is not obtainable.

Redtop

In the northern part of the United States redtop is often used in varying proportions in seed mixtures. It forms a quick cover which serves as a temporary turf until the more permanent grasses have become established. It does well under a wide range of soil conditions and will tolerate poor soils much better than most grasses.

In turf, redtop does not usually persist more than 2 or 3 years if it is growing in competition with other species. After the first year's growth it becomes coarse if it is growing on fertile soils, but this would not be objectionable if used on airfields or roadsides. Seed of this species may be obtained at a much lower cost than that of other grasses, and therefore it is apt to be given undue prominence in seed mixtures. When used in mixtures it should rarely constitute more than 20 percent of the mixture by weight, and usually not more than 10 percent.

Fescue

The fescues are well adapted to the well-drained, sandy loam soils of the northern half of the United States and may also be used on some heavy soils provided drainage is adequate. Fescue invariably fails when it is used on poorly drained, heavy clay soils. So far as climatic adaptation is concerned, the range of fescue is approximately the same as Kentucky bluegrass. Fescue, however, is better adapted to shade conditions than Kentucky bluegrass. Some of the most beautiful shaded lawns in the northern part of the United States are composed of fescue. It is not ordinarily used alone but in combination with bluegrass, redtop, and the bents. In regions where it is well adapted it may constitute 50 percent of the mixture in

which it is used. Fescue seed is usually expensive, therefore the matter of cost should be carefully considered when the use of this species in seed mixtures is contemplated. This does not mean that cheap seed is recommended, but there is obviously no justification for increasing the cost of seed mixtures by adding fescue if the mixture is to be used on soils which are not adapted to the growth of fescue. For most turf purposes red fescue chewings is preferred to other species. For roadsides and other rough turf, however, meadow fescue may sometimes be used to advantage.

Ryegrass

Two species of ryegrass, perennial and Italian, may under certain conditions be used to advantage in turf. The ryegrasses are rarely used alone but usually as a temporary cover

Ryegrass seeded in late fall on area where Bermuda grass had been planted too late to produce a satisfactory cover. Left, Bermuda grass; right, Bermuda grass plus ryegrass.

or as a nurse crop for some more permanent species. In the North perennial ryegrass will, under ordinary conditions, persist in turf for a period of 3 or 4 years. However, in the

southern part of the cool, humid region and in the South ryegrass remains only as scattered plants after the first or second year. Italian ryegrass is an annual and persists for one season only. The ryegrasses are tough and will survive considerable rough treatment. The fact that they are tough, however, makes mowing them rather difficult.

In recent years a mixture consisting of perennial and Italian ryegrasses has been used extensively in this country. The mixed seed is sold under the name of "Common" or "Domestic" ryegrass. It may be used for any purpose for which perennial ryegrass is used and some tests tend to indicate that for turf purposes the mixture is superior to either of the two species used separately.

When used as a nurse crop ryegrass should compose not more than 10 percent of the seed mixture by weight. If it is used alone as a temporary or winter cover seed should be sown at the rate of 50 to 100 pounds to the acre.

Creeping and Colonial Bent

Either of these grasses may serve as satisfactory turf species in the northern part of the cool humid region. They are especially useful as roadside grasses in New England and the Northwest. When used alone bent grasses will not withstand heavy traffic. However, Colonial bent may be used in combination with bluegrass and fescue on large-scale plantings subject to hard wear. Creeping bents, with the exception of seaside, are propagated by stolons and Colonial bent by seed.

The bents when used in combination with other species should normally compose not more than 5 or 10 percent of the seed mixture.

Quackgrass

This is a vigorous, persistent, and rapidly spreading perennial which occurs in abundance north of the Ohio and east of the Missouri Rivers. This species is usually considered a weed where it occurs in abundance. It has caused enormous damage to farm lands, nevertheless it is not entirely worthless since it can be utilized in the production of a rough turf. On areas subject to hard wear quackgrass may be used to advantage since it produces a durable turf if properly mowed. Its use, however, should be limited to locations where it occurs voluntarily in abundance.

White Clover

Turf seed mixtures often include varying proportions of white clover. On many soils of the cool humid region clover may be used to advantage in combination with bluegrass, redtop, or fescue. The clover tends to remain greener during the hot, dry periods than do some grasses. Its presence therefore aids the appearance as well as the density of turf during the summer months. It should be seeded in the spring and at a rate of approximately 20 pounds to the acre.

Bermuda Grass

This grass, without a doubt, is at present more widely used in the South than any of the others mentioned. It is also fairly well adapted to the southern part of the dry region. Bermuda grass thrives under high temperatures and its rapid summer growth, together with its low creeping habit, makes it an excellent turf species in many parts of the southern United States. It does well on a wide range of soils and will survive a great deal of wear and tear. Bermuda grass, like many others,

Cereal rye planted on an airfield as a temporary winter cover. Seeding in this instance was made too late in the season to produce a good stand.

is extremely variable and several selected strains are superior to the ordinary commercial types. Most of these, however, must be increased before they are available for extensive plantings. It is also probable that other strains could be developed which would be better adapted to use on airfields than the usual commercial stock.

Bermuda grass may be planted either by seed, sod, or sprigs. Hulled seed should be sown at the rate of 20 to 30 pounds to the acre. When speed is an important factor in the establishment of Bermuda grass turf from seed, one should insist that the seed be hulled since the germination of unhulled seed is usually slow. The amount of sod or sprigs required for planting

any given area will vary with the method used. Generally speaking, 1 square foot of good sod should plant 20 square feet. If thin sod is used as a source of planting material the planting ratio must necessarily be changed. In many cases 1 square foot of sod will plant no more than 10 square feet. Bermuda grass, like most southern grasses, must be planted either in the spring or summer, since the plants are semi-dormant during the winter months.

Centipede Grass

The range of adaptability of this species is not as great as that of Bermuda grass, nevertheless in many parts of the South centipede grass forms an excellent turf. Although this grass may sometimes be killed by hard usage, this objection is partially compensated for by its rapid growth and spreading ability. Centipede grass has not been tested on airfields, but it seems likely that it will not stand up under the wear such turf receives.

A number of selections have been made of centipede grass but these need to be increased before they are available in large quantities. It is also probable that further tougher strains might be selected and developed which would be better adapted to airfield use than those which are now in existence.

Centipede grass is ordinarily planted by sprigging at a ratio of approximately 1 to 25; that is 1 square foot of good sod is used to plant 25 square feet.

Carpet Grass

This grass forms a dense heavy turf on those southern soils to which it is adapted. It requires more moisture than does Bermuda grass and it generally thrives better in soils of rather high clay content. There are many areas in the South in which

Manila zoysia growing along roadside. This grass was not mowed throughout the growing season, yet its height, as indicated by the ruler on the right, is not more than 6 inches. Note the persistence of the grass at the edge of the road where it has been subject to wear and tear of traffic.

carpet grass appears voluntarily as soon as the soil is disturbed. This fact should be taken advantage of when turf is to be established on those areas where carpet grass occurs naturally. On the other hand, an attempt to grow carpet grass on the drier, sandy soils is not likely to meet with success.

Except in special cases, carpet grass is planted by seed. Under favorable conditions seeding at the rate of 25 to 35 pounds to the acre will produce a good cover. Like redtop, carpet grass is best used in a mixture rather than alone.

Zoysia

Two species of *Zoysia,* namely Z. *matrella* and Z. *japonica,* offer possibilities as turf grasses in the South and in the intermediate zone composing the southern part of the cool humid

Load-bearing capacity of Manila zoysia. This area was driven over by a truck at a time when the soil was wet. Note how the depth of track decreased as the truck proceeded from thin to well-established sod. The load-bearing capacity of well established Manila zoysia sod is unparalleled by most grasses.

and northern part of the warm humid regions. Japanese zoysia, commonly referred to as Japanese or Korean lawngrass, is the coarser of the two species. Some strains are winter-hardy and one planting in Boston, Massachusetts, has survived several severe winters.

Manila zoysia (Manila grass) has a narrow leaf and produces a finer textured turf than does Japanese zoysia. It apparently is not as winter-hardy as is Japanese zoysia, but it has been able to survive southern New England winters.

Japanese zoysia and Manila zoysia are still in the experimental stage but have demonstrated some interesting possibilities

for turf purposes. For example, the entire season's growth is only a few inches and therefore for many situations, such as airfields and roadsides, zoysias need no mowing. They are slow in becoming established, but when once they form a thick turf they compete successfully with weeds. The turf of these species will withstand much heavy wear, as well as rather prolonged periods of drought.

Seed of zoysia is not available commercially at the present time. Therefore it must be planted by sprigging. One square foot of good sod will plant approximately 25 square feet.

These two species of *Zoysia* are very different from *Zoysia tenuifolia* and should not be confused with that species.

Bahia Grass

Temperature is the chief limiting factor in the use of Bahia grass as a turf species. Since it is able to withstand but little cold it should be planted only in the southern portion of the warm humid region. Under favorable conditions Bahia grass spreads rapidly and forms a dense durable turf. It is adapted to a wide range of soil types. Bahia grass may be propagated either by sprigging or by seed. Seeding is to be preferred even though seed germination is often low. Seed should be sown at the rate of 30 to 35 pounds to the acre.

St. Augustine Grass

Although this species forms an excellent lawn turf in the extreme South it is not well adapted to airfield and general roadside use since it requires considerable moisture for best growth. It is tolerant of both shade and sun as well as a wide range of soil conditions—provided adequate moisture is available. St. Augustine grass is planted by sprigging at the rate of approximately 1 to 20.

Lespedeza

This plant is used primarily as a forage or hay crop in the warm humid region. Nevertheless it may supplement grasses as an airfield or roadside turf component in this region. Lespedeza is tolerant of high temperatures and is extremely drought resistant. None of the annual lespedezas will withstand severe frosts. Therefore their use is limited to the southern states. Of the two available annual lespedezas, "Common" is to be preferred for turf use since it does not cease growth after flowering, as does "Korean." Lespedeza produces a satisfactory cover on many acid soils of low productivity.

Seeding is done in early spring (March or April) at a rate of approximately 25 pounds to the acre.

Buffalo Grass

This is a rapidly spreading, low growing, drought resistant species which forms a tough sod and is used extensively in the dry region. Its low growth makes frequent mowing unnecessary. The buffalo grass seed available commercially is expensive but fortunately only a small amount of seed to the acre is necessary to produce a good stand. Untreated buffalo grass seed usually germinates poorly. Certain simple seed treatments have been devised, however, which will often increase germination by as much as 50 percent or 75 percent. Information concerning these methods may be obtained from the U. S. Department of Agriculture or State Agricultural Experiment Stations.

Much buffalo grass seed on the market is non-viable. There-

fore, before large plantings are made the viability of the seed to be used should be determined by germination tests.

The species also lends itself readily to propagation by check sodding, which is the usual method employed in the establishment of buffalo grass turf. Intervals between the blocks of sod, which are usually 3 or 4 inches square, vary a great deal, depending on the speed of coverage desired and the expense justified in the particular planting job at hand. On lawns or other small areas where a rapid cover is desired, these blocks of sod may be placed at intervals as close as 12 inches. On the other hand, large areas such as airfields would require such great amounts of sod that the expense would be prohibitive if the blocks of sod were placed at very close intervals. On such areas the intervals may be extended to as much as 4 feet. Other species, particularly blue grama, which may be desirable in combination with buffalo grass, may be seeded at the same time the sod is placed. Seedlings resulting from this planting serve as a ground cover until the buffalo grass has time to establish a solid cover.

Locally adapted rather than introduced strains of buffalo and grama grass should be used whenever possible.

Kikuyu Grass

This is a perennial with heavy rhizomes which has comparatively recently been tested as a pasture and turf grass in several localized areas. It has been grown with considerable success in parts of Australia and plantings along coastal areas of California have indicated that it may be successfully grown there. It is also probable that it may be well adapted to some parts of the south Atlantic coastal plain.

Experiments in Australia indicate that kikuyu is highly drought resistant. These results have not as yet been dupli-

cated except in limited tests in this country. Kikuyu produces very little seed. It must, therefore, be propagated by sprigging. The planting rate suggested for Bermuda grass will apply also to kikuyu.

Brome Grass

Two species of brome grass, *Bromus inermis* and *B. tectorum,* are worthy of consideration for rough turf purposes. *B. inermis* is the larger and coarser of the two species and requires considerable mowing if used as turf. It does, however, produce a fairly good cover when mowed. *B. tectorum,* an annual, and a weed under many conditions, occurs voluntarily in many parts of the Mid-west and might be used to advantage on those places where it occurs in abundance. For turf purposes *B. inermis* should be seeded at the rate of approximately 200 to 300 pounds to the acre.

Grama Grass

In the southern and central plains regions, grama grass (blue and sideoats grama), produced from local seed, has possibilities for airfield and roadside use. A combination of buffalo grass sod and grama grass seed produces a sod more rapidly than either of the species used separately. The use of such a combination reduces the amount of buffalo grass sod required for planting any given area.

Russian wildrye, crested wheatgrass (preferably Fairway strain), western wheatgrass, curly mesquite, and sand dropseed grass may also be used for the production of turf in certain parts of the plains region, where they are adapted. With the exception of crested wheat (Fairway strain) these grasses are not really turf species. Nevertheless, under favorable conditions they may be used in the establishment of a rough cover on roadsides, airfields, etc.

WAR AMONG PLANTS

O. S. AAMODT *

Many species of plants, and more particularly those used for hay, pasture, and turf purposes, are sown in mixtures. Dominance of any given species in any particular environment has usually been attributed to differential moisture, temperature, light, and fertility requirements. Investigations have shown that the development and activity of the roots of certain species of plants may be affected by the growth of adjoining roots and that some species of plants may have a specific effect on other species which follow in the rotation. There is considerable difference of opinion in the literature as to the cause of specific interactions which have been noted. Toxic secretions, deficient oxygen, excessive carbon dioxide and moisture, harmful pH, nitrogen starvation, and changes in soil microflora are among the more important factors listed as possibly being involved in specific root interactions. Plants, just like human beings, have antagonisms toward each other. Wars are going on between species and strains. One plant may excrete a substance from its roots which will inhibit the normal development of some other plant. These problems are very important factors in plant associations.

The deleterious effect of black walnut trees on near-by plants has been observed and studied both in cultivated fields and in forests. In places where this effect is evident there is conspicuous around the tree a zone or so-called toxic court in which certain species are absent or dwarfed although in the surrounding areas they are flourishing. Alfalfa, tomato,

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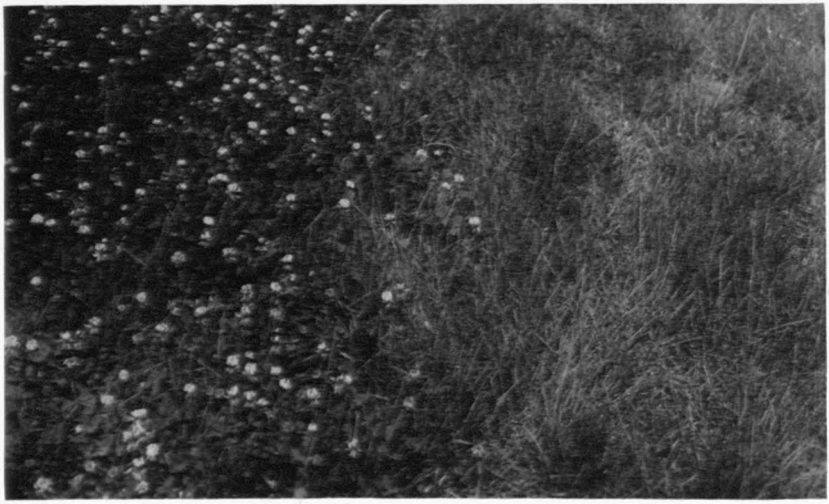
loblolly pine, and apple have been listed among the species which are most susceptible to walnut injury. Other species of trees of similar size, growing in the same area and apparently using just as much soil moisture and nutrients as the walnut, do not interfere with the growth of these plants. In fact, the inhibitory effect has been shown to be dependent on a root-to-root contact between the walnut tree and the affected plants.

A similar antagonistic relationship exists among some of our grasses and legumes. Extensive botanical studies have been made on the effect of various fertilization and management treatments on the productivity and survival of a number of species of plants used for hay and pasture.

The species studied included Kentucky bluegrass, timothy, redtop, red clover, alsike clover, and white clover sown as a mixture. Field observations made since the experiment was initiated seem to indicate the occurrence of a number of species interactions which cannot be accounted for on the basis of differential response to light, temperature, moisture, fertilization, and management. White clover and red clover were seldom found in dense, closely grazed quackgrass sod, whereas alsike clover appeared in comparative abundance. Canada bluegrass, although not seeded, invaded areas not fertilized with commercial nitrogen. In mixed plantings, Canada bluegrass, redtop, timothy, and Kentucky bluegrass were observed to occur as definite colonies rather than blending uniformly throughout the sward. Redtop was eliminated early by Kentucky bluegrass.

In another experiment six replications of timothy, Kentucky bluegrass and two strains of brome grass were grown under various soil treatments and management programs. One of the variables consisted of a mixture of red, white, and alsike

clovers sown across the grass plots. All of the plots had perfect stands of grasses and legumes in the fall before growth was stopped by low temperatures. The following winter was mild but with little snow cover. In the spring a very marked differential interaction between the clovers and one of the grasses was evident. The Kentucky bluegrass was practically



Competition between white clover and Kentucky bluegrass. White clover was established uniformly on both of these plots.. It persisted with the bluegrass strain on the left but was practically eliminated by that on the right.

eliminated from that portion of each plot on which the clovers were growing in association with the grass. The stands of the two strains of brome grass and timothy were uniformly good on all the plots regardless of treatment or association with legumes.

At the U. S. Regional Pasture Research Laboratory, State College, Pennsylvania, intensive breeding programs with Kentucky bluegrass and white clover are under way. Hundreds

of strains of these two species have been selected and are now being tested in small plots. Several of the better strains of each are being tested in various combinations. While certain of these strains have grown well together, some strains of bluegrass have almost completely inhibited the development of white clover. Likewise some strains of white clover have predominated over the bluegrass.

Bent grass seed mixtures produce a mottled or mosaic turf because of variability in color, growth habits, disease reaction, etc., of the plants composing the mixture. Very often a particularly aggressive strain is found occupying a larger area than would be expected normally if moisture, nutrients, etc., were the only factors limiting growth and spread. In experimental bent grass plots, also, strains growing in adjacent plots show marked differences in ability to invade other strains or sometimes to resist invasion by other strains apparently having greater vigor when grown in pure culture. C-15 and C-52 are good examples of bent grass strains which are particularly aggressive when grown under certain conditions.

Special strains of grasses may be developed that are not only more persistent in competition with other strains of the same species but that also possess characteristics enabling them to check or inhibit invasion by other grass species, clover, or weedy plants. In 1941 an unusually severe invasion of bent grass turf by *Poa annua* was reported, particularly in the East. Observations on Experimental Greens of the U. S. Golf Association Green Section verify the observations made over a period of years on the Turf Garden at Arlington Experiment Farm, that certain selected strains of creeping bent are conspicuously more resistant to invasion by *Poa annua* than are commercial strains,

These observations and limited experimental evidence would appear to indicate that harmful root interactions may occur between various species of plants. These interactions are no doubt profoundly influenced by environmental conditions, but their full significance will not be known until they have been tested adequately under various light, moisture, fertility, and management conditions. There is need for intensive fundamental study relative to the nature of these interactions and their effect on grass species now commonly used for turf. The possibility of using these interactions in the control of clover and weeds in turf is a problem deserving of prompt consideration by turf culturists.

PROTECTION AGAINST FALSE CLAIMS FOR FUNGICIDES AND INSECTICIDES

ERRETT WALLACE AND W. M. DAVIDSON *

The Insecticide Act of 1910 is administered by the Insecticide Division of the Agricultural Marketing Service and it is important to understand what protection against false claims for fungicides and insecticides may be expected from its enforcement. This law requires that the labels of insecticides and fungicides entering into interstate commerce or marketed in the District of Columbia or the Territories shall not bear any false or misleading claims regarding such articles and that they shall not injure vegetation on which they are intended to be used. Manufacturers and distributors are held strictly responsible in this respect. However, since the burden

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of proof is on the Government, sufficient time for adequate tests must elapse before action can be taken in cases of violation of the law.

The law does not cover products which are manufactured and sold in the same State without entering interstate commerce, or give the Department authority to take action against claims made in advertising literature unless such literature accompanies the package in which the insecticide or fungicide is shipped or unless the label on or literature accompanying the package makes reference to such advertising literature. The Department, therefore, has no jurisdiction over advertisements appearing in newspapers, periodicals, or in circulars and other literature published by manufacturers and sent out by mail or otherwise shipped independently, unless such advertising material is referred to on the label; nor does it have authority to control radio advertising.

While some manufacturers limit the claims in their advertising literature to those permitted to appear on their labels, many do not and frequently claims are made in such literature which are not permitted to appear on labels.

It is always the wisest policy for any greenkeeper, when in doubt, to appeal either to the authorities at his local Experiment Station or to the Green Section for advice as to the most effective and economical type of fungicide and insecticide to meet his requirements and how to use it to best advantage.

The Insecticide Division has no authority under the law to certify insecticides or fungicides nor to advise as to the relative merits of different products, nor does it publish the results of its findings unless a product has been found to be in violation of the law, in which case notice of judgment of the court is issued. While the research worker or technical adviser is vitally

concerned with such matters as relative costs of the materials and treatments which they recommend, this is not a consideration in the enforcement of the existing law as it gives no control over prices nor profits which a manufacturer may make.

THE PRACTICAL ASPECTS OF SEXUAL AND ASEXUAL REPRODUCTION IN TURF GRASSES

WILLIAM L. BROWN *

Greenkeepers, nurserymen, and others interested in the propagation of grasses are often faced with difficult problems in the maintenance of pure stocks of selected turf grasses. Even in supposedly well managed grass nurseries it is not unusual to find numerous "off types" appearing from time to time. Unfortunately these are not usually recognized until they are placed in turf, where it is often too late to eliminate them. Greenkeepers often feel that such aberrant forms are the result of mixed stocks of stolons they have received. Errors of this sort are not impossible but, as will be shown here, most of such mixtures probably arise in the propagation nurseries and not at the source of the original stocks. If one is to know how and why such "off types" occur he must have some knowledge of the reproductive process in the grasses.

In the past much has been written on the breeding behavior and types of seed production among the grasses. In fact, the subject has been so widely discussed in recent years that it has

* Geneticist, United States Golf Association Green Section.

been brought to the attention of those individuals who are primarily concerned with the purely practical aspects of grass work. Written reports on the subject, however, have appeared almost exclusively in technical journals and as a result are not available to those who are without specialized biological training. Nevertheless, the types of reproduction involved in the grasses play an important role in the development and maintenance of turf and some knowledge of the subject should be of special interest to those dealing with selected strains of the numerous turf species. Therefore, a discussion of the more common phenomena involved in reproduction in the grasses seems appropriate at this time.

In most plants, reproduction takes place by sexual means, that is through the union of egg and sperm. When both egg and sperm are involved the offspring naturally bears characteristics of both the male and female parents. In most of the grasses the male and female reproductive organs are borne on the same plant and in a great many grasses within the same flower. At maturity the anthers burst, shedding the pollen which bear the male cells. Some of the pollen grains are then distributed, usually by wind, to the pistils. When a pollen grain reaches the tip of a pistil it germinates, sending forth a tube which penetrates the tissue separating it from the ovary. After the pollen tube reaches the ovary the male cells are discharged into the embryo sac, where one of them unites with the egg forming an embryo or beginning of a new plant. The plant resulting from this union, therefore, contains a combination of materials from both the male and female parents from which it originated. It may then develop into a plant different from either of the two parents.

In certain of the grasses a type of reproduction is encoun-

tered very different from that just discussed. In a number of species it has been shown that reproduction may take place without the union of male and female cells. In such cases the non-fertilized egg cell or a cell of the ordinarily non-reproduc-

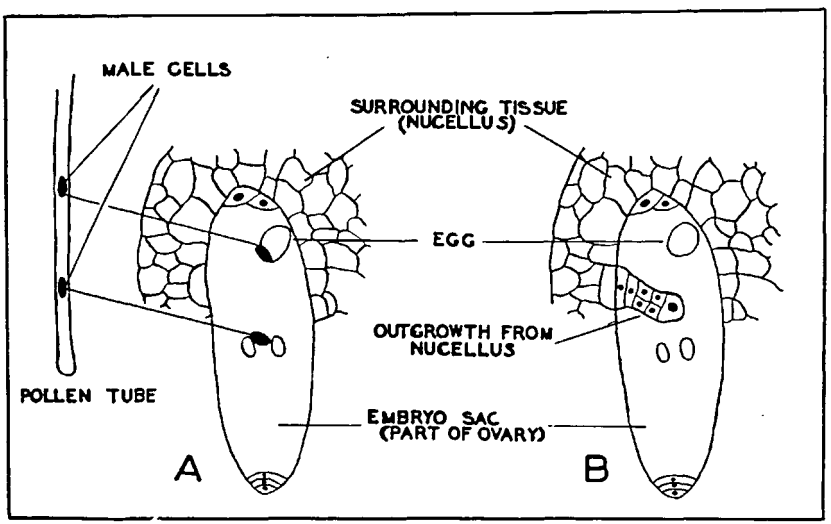


Diagram of sexual and apomictic reproduction as seen under the microscope.

A: Sexual reproduction. One of the male cells from the pollen tube unites with the egg to form an embryo, thereby bringing together in the offspring characters of both the male and female parents. The second male cell of the pollen tube unites with the polar bodies to form an endosperm (source of nourishment for the young seedlings).

B: A type of apomictic reproduction. In this case there is no sexual fusion of the male and female cells. Instead, an outgrowth of the nucellar tissue develops as an embryo within the embryo sac. Since the nucellus is purely maternal tissue the young seedling from this seed will be identical with the female parent from which it came.

For simplification not all structures are shown and both drawings are highly diagrammatic.

tive ovular tissue functions as an embryo, thereby eliminating any possibility of bringing into the offspring characters from the paternal parent. Actually, it is a case of vegetative reproduction through seeds. Many variations of this type of behavior have been encountered and a complicated terminology

Kentucky bluegrass strains in nursery at Arlington. Second row from right, progeny of an apomictic strain of bluegrass. Note the uniformity in these plants. Such strains may be reproduced from seed without contaminating the original stock.

describing them has evolved. Generally speaking, however, the process may be referred to as ***apomixis.***

It can readily be seen that the practical consequences of apomixis may be great and it is of immediate importance to those interested in turf grasses in so far as it relates to the propagation and maintenance of selected strains. In order to keep such strains pure it is necessary to limit propagation to vegetative methods. If the selected strains are sexual and are allowed to set seed, the plants resulting from that seed will in many instances differ widely from the parents and will

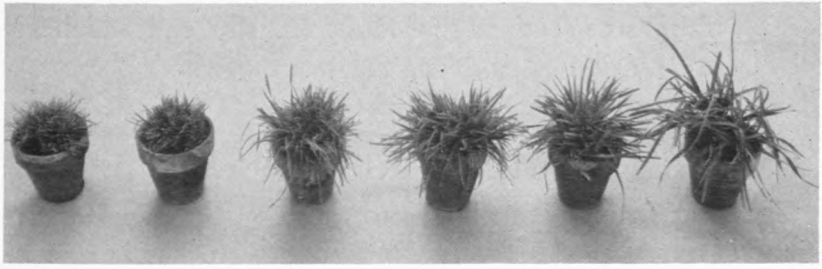
within a few generations develop into mixtures. Such procedures may soon result in a total loss of the selected types.

If the selected type is an apomictic one, reproducing it from seed will not result in the outcropping of new and different types. Rather, the seed will produce plants like the maternal parents only, since no sexual fusion occurs in the reproduction process, as illustrated in the accompanying diagram. The occurrence of a few sexually reproducing plants in a predominantly apomictic strain will not likely have a harmful effect on the strain as a whole. However, among the bluegrasses there are certain supposedly apomictic strains which produce approximately 20 percent of their offspring by the sexual method. Naturally a variety of forms would soon result if such a bluegrass selection were reproduced from seed. Also certain bluegrass strains and most of the bent grasses reproduce almost wholly by sexual reproduction. It is in these, of course, that the greatest variation occurs. Progenies of Kentucky bluegrass have been observed in which the varying types range from fine-leaved, low-growing plants closely resembling *Poa annua* to types which are almost as coarse as orchard grass. Also, plants have been observed among the progeny of fine-leaved creeping bents which are hardly distinguishable from mature plants of redtop.

Although apomixis has been demonstrated most often in the bluegrasses it has been known to occur in a number of other genera and species and is undoubtedly rather widely distributed throughout the grass family. Among the turf grasses, however, the majority of the species most widely used appear to reproduce sexually. These include redtop, creeping and Colonial bents, and the fescues.

A knowledge of reproduction in the grasses has an immedi-

ate application in the management of grass nurseries. For example, the creeping bents which have been selected and distributed by the Green Section are not genetically pure but will remain true to type as long as they are propagated by vegetative methods. If they are allowed to set seed in the nursery, the plants resulting from those seed undoubtedly in many cases will be very different from the original selection. It is of utmost importance, therefore, in the management of



Variation in progeny of a sexually reproducing selection of Kentucky bluegrass. Obviously this strain will produce many "off types" if allowed to set seed in the nursery.

nurseries in which selected strains are being grown to prevent seed setting. In large nurseries it is very easy to overlook a few scattered seed heads, yet if these are allowed to mature the entire stock may become contaminated. During the past few years the occurrence of "off types" in C-1 bent have been reported. Undoubtedly these types have arisen from seed which has been allowed to form in some nursery.

The same precautions should be taken in the management of fescue nurseries as have been described for the bents, as they too reproduce largely by sexual methods. Genetically pure lines may be developed eventually in this species but all those available at present are extremely variable.

Some bluegrass strains may be allowed to set seed without

fear of contaminating the stock. These, of course, are those strains which reproduce apomictically. Sexual bluegrass strains must be propagated solely by the vegetative method if they are to remain true to type, and this method is, of course impractical unless it is done on a small scale. Unfortunately, we have as yet no easy and quick method of distinguishing between sexual and apomictic bluegrass strains. Attempts are being made at present, however, to determine by progeny analyses and through cytological studies which of the Green Section bluegrass selections reproduce sexually and which are apomictic. Until that is done, the safest method is to treat all of those which are being propagated for turf as sexual plants.

SUBSTITUTE FOR MERCURY FUNGICIDES

Since war requirements have put a ban on the manufacture of mercury fungicides for turf purposes there has been considerable interest in substitutes. For some time the Green Section has been testing other fungicides and in *Science,* March 28, 1941, p. 311, reported that the most promising was tetramethyl thiuramdisulfide. It was found that this chemical controlled brownpatch and dollarspot as well as some other diseases, the causes of which were not definitely determined. Two ounces of the chemical to 1,000 square feet were not sufficient to give reliable control but partially checked the disease. Four ounces to 1,000 square feet gave complete control. In all the tests that have been made it has not caused injury to turf. Our recent tests have shown that this chemical also controls snowmold when applied at the same rates that are used for bichloride of mercury or calomel. Tetramethyl thiuramdisulfide is manufactured for use as a rubber activator. It does not provide a more economical control than mercury but since the latter is no longer available this new chemical may prove useful.

WHAT OTHERS WRITE ON TURF

In this department will be given the substance of research in the various fields of scientific investigation which seems to have a definite bearing on turf improvement. The articles will summarize results of recent investigations made in various parts of the world. They are not published here as recommendations but simply as information for our readers and as suggestions which may have practical applications in many situations. Where the Green Section's tests or the information it has obtained from other reliable sources in this country substantiates or contradicts the results obtained by other investigators, comments to that effect may be included as a guide for our readers. In all other cases the reader will receive in brief the results and conclusions as given in the original papers.

WEED CONTROL IN TURF

During the year 1941 several of the experiment stations have issued publications on the control of weeds in lawns. Of these, the Ohio Agricultural Experiment Station Bulletin No. 619 is probably the most complete. In it F. A. Welton and J. C. Carroll summarized their weed control experiments conducted from 1928 to 1940 on 26 different species of weeds, most of which are generally recognized as turf weeds. A great deal of attention is given to the control of dandelion, broadleaf and buckhorn plantains, and crabgrass. It is true that some of the weeds discussed, such as burdock, pokeweed, wild carrot, sour dock and poison ivy, are not usually considered a problem in well-maintained lawns. The bulletin is beautifully illustrated with excellent photographs of the weeds as they appear in turf as well as of single isolated plants, showing the habit of growth of roots, stems, and leaves. In addition to a discussion of the control of each of the 26 species of weeds in turf there is a section devoted to the killing of weed seeds in compost piles with chloropicrin, cyanamid, and Sinox.

A circular from the Utah Agricultural Experiment Station prepared by D. C. Tingey and B. Maguire gives a general discussion of weed control methods in lawns and then includes carefully prepared drawings of the principal lawn weeds of that section—dandelion, mouse-ear chickweed, broadleaf and buckhorn plantains, smooth crabgrass, annual bluegrass, and Bermuda grass.

These drawings illustrate in detail the flowers and fruits as well as roots, stems, and leaves of the weeds. A list of lawn weeds of secondary importance is also included. It comprises 10 annuals and 8 biennials or perennials.

WATER REQUIREMENT OF KENTUCKY BLUEGRASS

All plants require water for growth but they vary in the quantity of water used to produce a pound of dry matter. This quantity is spoken of as the water requirement of plants. The water requirement of a plant may vary with conditions and with the treatment to which it is subjected while growing.

V. G. Sprague and L. F. Graber in Wisconsin studied the variation in the water requirement of Kentucky bluegrass under several different cultural conditions throughout the season, and a report of their work appeared in the Journal of the American Society of Agronomy.

The plants were grown in a greenhouse in the fall in such a way that the water used in growth could be measured. On April 9 all plants were cut to one-half inch. Half of the plants were given nitrogen whereas the others were not. One-half of both the fertilized and the unfertilized plants were cut to one-half inch each week whereas the remainder were permitted to grow undisturbed until June 13, at which time all of the plants were given a final cut to one-half inch. The material produced was weighed and by comparing the production of dry matter with the quantity of water used the water requirement was determined.

The water requirement (the ratio between the water used and the dry matter produced) was with one exception higher for the plants which were cut each week to one-half inch than for those plants which were permitted to grow at hay height. In all cases the water requirement during the period following June 14 was materially greater than during the spring, being two to three times as great in the cut plants, but only one to one and a half times as great in the plants allowed to grow at hay height. This residual effect of the cutting prior to June 14 is striking. The water requirement during the summer period was decidedly higher for the cut than for the tall plants—2.75 times as high in the fertilized plants, but only 1.15 times as high in the unfertilized plants.

In all cases except one, the water requirements of the plants which had received the nitrogen were less than the unfertilized plants. This was

particularly true of the plants grown at hay height.

These observations are interesting, but it must be remembered when interpreting them that the investigators were comparing grass grown as hay with that cut once a week to one-half inch during the early part of the season. It would be interesting to learn if there is any difference noticeable in the water requirements of bluegrass cut at 2 inches as compared with ¾ inch.

FUNGUS CAUSING SNOWMOLD

At Pennsylvania State College last year an attack of snowmold was observed on Colonial bent which has been considered resistant to the snowmold caused by *Fusarium nivale*. The affected grass, therefore, was studied critically by C. C. Wernham, who found the causal fungus to be *Typhula itoana*, which had been described earlier by Miss Remsberg in Minnesota as causing snowmold "on turf and lawn grasses in the eastern United States." He reported his observations in a recent issue of Phytopathology. The same treatments apparently are effective in the control of the two organisms. Wernham refers to the disease symptoms caused by *Typhula* as "Eastern Snowmold" to distinguish it from the snowmold caused by *Fusarium nivale*. He does not present any evidence, however, which would seem to justify his broad conclusion that "the work of Remsberg and the writer indicate that snowmold in the eastern part of the United States is caused by *Typhula itoana* rather than *Fusarium nivale*."

HOW DEEP SHOULD GRASS SEED BE PLANTED?

This subject has been studied in the past and in 1939 R. P. Murphy and A. C. Arny in Minnesota have published a report of their researches in the Journal of the American Society of Agronomy. They planted seed in five soil types, varying in texture from a loamy fine sand to a silty clay loam. Several species of legume and grass seed were sown in each soil type, one set in a greenhouse and one in the open. Among these species was Kentucky bluegrass, which was sown on the surface and at depths of ½, 1, 2, and 3 inches. In every case but one more plants of this species were established, both in greenhouse and in field plantings, when seed was sown on the surface than when placed at a depth of ½ inch, though on the average there was little difference in the result from these two planting depths when seed was planted in the field. At 1 inch few plants were established

and at greater depths none came through.

While surface seedings may be successful on pulverized soil the Green Section has found that they do not succeed on established turf. In that case the surface is not loose and open, and rolling has no effect in covering the seed as it does on loose open soil. Experience on the Arlington turf gardens has taught us that when seedings are made on established turf without further treatment the seed is often washed off the small bare areas and into the surrounding grass clumps.

BERMUDA GRASS TURF FROM SEED

In connection with the problem of establishing meadows and pastures of Bermuda grass in Arkansas, the factors involved in the establishment of this grass from seed were studied in nursery strips at the Arkansas Agricultural Experiment Station by E. L. Nielsen. For three successive years from 1938 to 1940, inclusive, he seeded well-prepared and leveled soil at the rate of 5 pounds to the acre at weekly intervals over the 14-week period from the last week in March to July 1, at 0-, ⅛-, ¼-, ⅜-, and ½-inch depths. The aim was two-fold—to determine the most favorable depth of planting and the climatic conditions necessary for the development of the best stand of grass. Hulled commercial Bermuda grass seed harvested in Arizona with an average purity of 93.9 percent and 86.6 percent germination was used for all the experimental seedings.

From the data presented in the Arkansas Agricultural Experiment Station Bulletin No. 409, Nielsen concludes that "seeding should not be made before a mean daily temperature of 65° F. is attained. Lack of sufficient moisture or low temperatures retarded seedling emergence and stolon development. Heavy rains retarded seedling emergence regardless of prevailing temperatures. Relatively high mean temperatures and sufficient available moisture favored rapid stolon development." Results also indicated that seed should not be covered to a depth of more than one-half inch.

Data were also accumulated indicating the importance of such factors as weed competition and winter injury on the establishment of Bermuda grass turf from seed. Isolated plants were rather easily killed as a result of the heaving of the soil in the winter, either following seeding or sodding. In areas where a definite sod had been established, however, there was little winter injury.

All of these plantings were made

in 8-foot nursery strips or approximately 100-square foot plots. The author is desirous, therefore, that the results be considered as preliminary and merely a basis for more extensive field tests.

A DISEASE AFFECTING THE GERMINATION OF PERENNIAL RYEGRASS SEED

It has been noticed repeatedly by the official seed-testing service in New Zealand that occasionally the crop of perennial ryegrass (*Lolium perenne*) seed has exhibited phenomenally low powers of germination. This has been particularly striking when wet weather prevailed between the time of flowering and harvest. Italian ryegrass (*Lolium multiflorum*) is also affected at times, but to a lesser extent.

It was previously thought that perhaps this low germination was the result of defective fertilization due to excessive moisture. Recently, however, it has been shown that the low germination of otherwise apparently sound, well-harvested seed is caused by a disease-producing fungus. J. C. Neill and E. O. C. Hyde, in discussing the disease in the New Zealand Journal of Science and Technology, proposed the name Blindseed disease. According to them, the disease has been found in every seed-producing district in New Zealand and in samples of perennial ryegrass seed grown in England, Scotland, Wales, Ireland, Sweden, Tasmania, and Victoria.

The affected seed is outwardly indistinguishable from healthy seed, and, although heavily infected, a sample of seed may appear plump, bright, and of good bushel-weight. It is only when the seed is tested for germination that the presence of the disease can be detected in the mature seed. It can be detected shortly after cessation of flowering, by careful dissection of the florets, which reveals a colorless or pinkish slime surrounding the immature seed. This cannot be observed after drying takes place.

Field experience supports the idea that true perennial ryegrass is highly susceptible and Italian ryegrass is almost immune. The authors suggest that this may be associated with the fact that Italian ryegrass flowers later than the perennial ryegrass and after the main discharge of the spores of the fungus. Experiments are in progress to determine relative susceptibility and immunity of a range of hybrids and of strains of true Italian and perennial ryegrass.

The fungus is described, but has not as yet been named, except that it has been placed provisionally in

the genus *Helotium*. This genus is closely related to *Sclerotinia*, the genus to which the dollarspot organism has been assigned recently. It is carried over from one season to another in diseased seeds that fall to the ground. In due time reproductive bodies are formed on these seeds and spores are discharged into the air and borne by the wind to the open flowers of the ryegrass, where a new infection is started. Later in the season reproductive bodies are formed in the flowers first infected, and from these other flowers are infected. These later infections cause the most trouble, since the seed are further developed before infection and therefore appear heavy, plump, and sound, although they may only germinate 20 percent. The disease apparently does not have any deleterious influence on ryegrass which is not to be used for seed production.

It appears that in certain cases the fungus remains viable in seed stored for 20 months. More information is required on the time limit of the survival of the fungus within infected seeds and on conditions of storage and of possible seed treatment, as affecting the survival limit. No satisfactory control measures have yet been devised, but the authors believe that the most hopeful line of attack is the breeding or selection of resistant strains.

PREVENTABLE SABOTAGE

A saboteur caught in the act of pouring sand into airplane motors and thus reducing their efficiency by as much as 10 percent would be given maximum penalties under the law and his arrest and conviction would be dramatically told in headlines all over the country.

Yet, a recent case of damage to airplane motors from preventable dust reduced the motors' efficiency by 90 percent, required overhauls costing $320,000 and will be repeated again and again on the nation's dirt-surfaced flying fields for want of intelligent and relatively inexpensive remedial steps.

The remedy lies in . . . the establishment of an advisory service and research program on the culture of turf grasses. There is enormous waste, failure to benefit from what has been learned in grass culture and little or no success in making the grass grow. Miniature "dust bowls" are being created everywhere, and new dangers are added to the hazards of flight training because of dust and mud that could be grass covered. — Editorial, *The Evening Star*, February 24, 1942.

OUR LETTER BOX

The Green Section receives numerous inquiries concerning local turf problems and is always glad to reply to them. With the hope that some of these questions and answers may be helpful to others besides the original correspondent, a few of them will be published. While most of the answers will have a general application, it should be remembered that each recommendation is intended for the locality designated at the end of the question.

Control of Pearlwort.—A friend of mine who has a private golf course is getting such an unusually heavy growth of pearlwort in his greens that it is almost impossible, or from the standpoint of expense, impractical to cut out the spots as they appear. The subsoil of all of these greens is almost entirely sand. The only loam is that which he adds in top dressing each year. If there are certain fundamental conditions which usually exist when pearlwort is prevalent and an effective treatment of which you know, I shall be grateful for your sending this information to me. (Massachusetts.)

ANSWER.—Ordinarily pearlwort is most troublesome under conditions of poor drainage, hard surface or starved soil. The possibility of poor drainage is eliminated since the soil is sandy. It is therefore possible that the soil may be too hard or that the grass may not be fed sufficiently with nitrogen. It may be that your friend is rolling his greens too heavily, in which case we would suggest that this procedure be abandoned, and that the greens be spiked to loosen the surface soil to some extent. It would also be well to apply fertilizer, such as sulfate of ammonia, freely until the grass is well established.

If pearlwort still persists he might try our new chemical treatments, as described in TURF CULTURE for January, 1939. These have given, on several occasions, very satisfactory control of pearlwort.

* * *

Reseeding the lawn.—What grass can I seed in spring on a lawn that had a good cover of crabgrass in 1940? (Maryland.)

ANSWER.—Where crabgrass has been abundant there is little use in seeding a permanent lawn grass in spring. The crabgrass will smother the Kentucky bluegrass during the summer. Better wait until fall to reseed. Meanwhile, Italian ryegrass

can be seeded to make the lawn look green until the crabgrass starts growth. Sow about 5 to 15 pounds to 1,000 square feet.

* * *

Weed control with arsenicals.—Can you give me information as to what chemicals to use for the treatment of chickweed and other weed growths, what quantities to apply and whether to spray or apply it in sand? (New York.)

ANSWER. — Our recommendation is to use sodium arsenite at the rate of 4 ounces to 1,000 square feet when applying it with a spray, and ¾ pound when applying it in sand. Either method will work. For a large area the spray treatment is by far the most economical. On small areas, however, the sand treatment can be used satisfactorily.

* * *

Scale of Bermuda Grass.—I am enclosing some Bermuda grass taken from our fairways. As you will notice there is a scale working on this grass at the joints. In time the grass dies back completely. The scale is most active in the fall and spring and I fear that, if not checked very soon we are not going to have any grass on our fairways. How can we most effectively control this pest? (Florida.)

ANSWER.—The name of your scale is *Odonaspis ruthae*. It is a difficult insect to handle since it has a protective covering on both sides. The most effective and cheapest spray is Kerosene emulsion but this is ordinarily impractical for fairway use.

Sometimes scale insects become troublesome on plants that are starved but are harmless when the plants are well fertilized. We suggest that you make certain that lack of fertilizer, particularly potash, is not the cause of your trouble. We generally recommend for golf turf a fertilizer containing a high percentage of nitrogen and less phosphorus and potash but in certain sandy soils potash is more essential.

This year marks the one hundredth anniversary of the first preparation of superphosphate by treating rock phosphate with sulfuric acid. It was in 1842 that John Benet Lawes of Rothamsted (an experimental station about 20 miles north of London which was an estate at that time) invented and patented this method of manufacturing superphosphate after several years of experimenting with various possible means of improving soil for plant growth. This was the first case of manufacturing a mineral salt for plant food and therefore marked the beginning of the fertilizer industry.


UNITED STATES GOLF ASSOCIATION
ORGANIZED 1894