

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 $\frac{1}{2}$ 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