PRINCIPLES UNDERLYING FERTILIZATION OF TURF

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A fertilizer may be defined as any material which is added to the soil to increase its productivity. In the early history of agriculture, long before anything was known of mineral elements, it was recognized that the waste products of animals and plants would perform this function. Even the early Greeks, Romans, and Chinese used animal and bird manure and wood ashes to enrich their soils. Today, these as well as the various ground meals prepared from bone, blood, cotton seed and many other natural sources are used to encourage plant growth.

FERTILIZER ELEMENTS

With an increasing knowledge of chemistry it has been learned that the essential mineral elements which the plants must obtain from the soil are nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), iron (Fe), manganese (Mn), boron (B) and possibly zinc (Zn) and copper (Cu). The first three of these, nitrogen, phosphorus and potassium, are used in the largest quantities by crops and are therefore removed most rapidly from the soil. They are consequently the elements which must be added in fertilizers, and are the only elements recognized in legislation covering the manufacture of fertilizers.

Nitrogen stimulates leaf development rather than seed production and when present in excess it may even delay flowering,

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Mining of phosphate rock by means of the hydraulic method in Polk County, Florida. Note jets of water coming in from the right.

fruiting and maturation processes. Phosphorus has a marked effect on root growth, stimulates flower, seed and fruit production and maturation processes. Potassium affects the plants indirectly in that its presence influences their general growth processes.

Calcium, the active ingredient of lime, is necessary for plant growth but most soils contain a sufficient amount of it for that purpose. Its primary function in the soil is to correct soil acidity or to improve the physical condition of the soil. It is, therefore, not considered in the trade as a fertilizer.

The remaining elements are known variously as minor, trace, or micro elements because, although essential for plant growth, they are not needed in large quantities. These elements are required in such small amounts that their presence and importance were overlooked for many years. In a large majority of fertilizing programs, however, these elements are not important because in most soils they are present in sufficient quantities to support a satisfactory growth of plants. Moreover, these elements are frequently present in common fertilizers either in chemical combination with the essential ingredients or as impurities accompanying the crude materials which are used in the fertilizers. Whether present as impurities or deliberately added to certain fertilizers, the percentage of these minor elements cannot be included in statements covering the grade of the fertilizer.

Availability of Plant Food

Although all of the essential elements may be present in the soil in quantities sufficient to support growth, they may not be present in a form which plants can use. Such materials as sulfate of ammonia are quickly soluble in water and the nutrients which they carry are therefore readily available for use by plants. Other fertilizer materials such as bonemeal must first be broken down by soil organisms and converted into soluble salts after which the nutrients become available to the plants. The elements contained in such materials are con-

sidered slowly available. Still other materials such as the phosphates are soluble, but when they are introduced into the soil part of them may immediately react with the salts of calcium, magnesium, iron or aluminum to form relatively insoluble salts and therefore become more slowly available or even unavailable to plants. In some states fertilizer labels distinguish between the quickly available nitrogen (water-soluble) and that which is more slowly available (water-insoluble). Likewise "available phosphate" is distinguished from the "total phosphate."

Organic and Inorganic Fertilizer Materials

In adding plant food to the soil, the nitrogen, phosphorus and potassium are the elements which are primarily to be considered. These may be added in the organic or inorganic forms.

Organic materials are substances derived from living matter such as cottonseed meal, dried blood, bonemeal, activated sludge and manures. A large part of the ingredients added in the form of these natural organic materials are slowly available to plants because nutrients must be released by bacterial decomposition in the soil and converted into soluble salts before they can be used. In some instances organic compounds may be manufactured, as for example, urea which contains 46 percent of nitrogen. It behaves, however, much more like an inorganic compound than like the natural organics in that it is soluble and its nitrogen is readily available to plants.

The inorganic sources of fertilizer ingredients are for the most part of mineral origin. Inorganic compounds are prepared commercially from natural mineral deposits and as by-products of gas and coke plants and other industries. These contain nitrogen, phosphorus and potassium in forms readily

available for use by plants. Since they are usually readily soluble some tend to leach out of the soil unless plants are present to absorb them. Others combine chemically with compounds already present in the soil. When organic fertilizers have been subjected to the processes of decay so that the organic nitrogen has been made available it is just as accessible to plants and is leached out as readily as the inorganic.

Repeated Use of Nutrient Elements

In most virgin soils the elements are present in sufficient quantities to support vegetation, since those which are absorbed from the soil are returned to it by the decay of plant and animal refuse. In the process of growth, plants remove nitrogen, phosphorus, potassium and other elements from the soil. Within the plants, these elements are used in the building up of proteins and other organic compounds of which living tissues are composed. The plants may be eaten by animals, in which case the elements remain in the complex organic state within the animal body. Eventually, either in plant or animal refuse, these organic compounds containing the nitrogen, phosphorus and potassium which were used by the plants are returned to the soil. Living plants are unable, however, to utilize the elements as they occur in these complex and insoluble compounds. The decay producing micro-organisms which are universally distributed in the soil attack the plant and animal refuse and break down the tissues and the compounds which they contain into soluble salts. In this form the nutrients can be absorbed again and used in growth processes of plants.

The nitrogen-fixing bacteria which live in the nodules on roots of legumes such as alfalfa, vetch and clover furnish another natural source of available nitrogen. They are capable

of using the elemental nitrogen present in the air spaces in the soil and converting it into nitrates which can be used by plants.

Mining of phosphate rock with dragline in Polk County, Florida.

When nature is left alone soils tend to remain fertile, but when crops are removed annually those elements which are utilized in plant growth are withdrawn from the soil. To be available to plants, the materials must be soluble in water to some extent. Because they are soluble they are washed from the soil by the rains. In view of the fact that 90 per cent or more of most soils is composed of inorganic material arising from the slow disintegration of the rocks of the earth's surface there remains a reserve supply of minerals in the soil which continues to become available slowly.

Fertilizer Requirements of Crops

The function of fertilizers is to add to the soil elements in which it is naturally deficient and to assist in the replacing of those elements which are removed from the soil by crops and leaching. In most crops minerals are needed which will encourage the development of stalk, flower, fruit and seed. In most farm and truck crops, maturation of the crop is of primary importance. For these purposes phosphorus is particularly important, although potassium is used in smaller quantities and some nitrogen is needed to encourage a good vegetative growth. Since an excess of nitrogen may delay the maturation processes it is not usually added in large amounts. Most farm fertilizers, therefore, are relatively low in nitrogen.

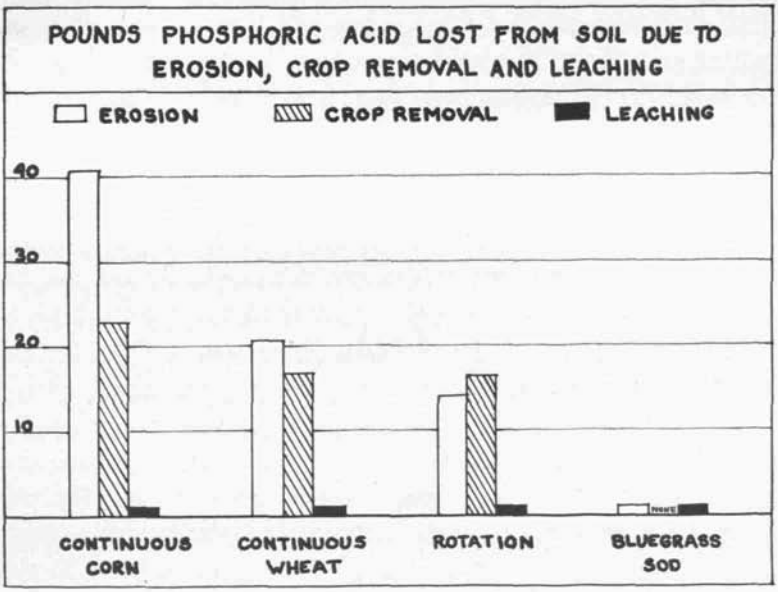
Fertilizer Requirements of Turf

In turf, on the other hand, the elements which are needed are those which will encourage a vigorous production of healthy leaves. At the same time it is desirable to discourage flower and seed production and delay the maturation processes. Fertilizers for grass, therefore, include large amounts of nitrogen and less phosphorus and potassium.

In turf, the removal of nutrient elements from the soil by erosion, crops, and leaching is much less than it is from soil planted to field crops. Figures are available from the Missouri Agricultural Experiment Station showing that only 0.2 pound of phosphorus per acre was lost annually by erosion from land planted to bluegrass, whereas 90 times as much was lost from land of the same soil type on which corn was grown continuously. Even land which was under the corn, wheat, clover

rotation lost 31 times as much phosphorus as did that which was under bluegrass continuously.

On fairways and lawns where the grass clippings are per-



Note the great amount of phosphoric acid lost by erosion and crop removal when land is under cultivation as compared with that lost from land used for turf. The amount lost by leaching is the same regardless of the crop grown.

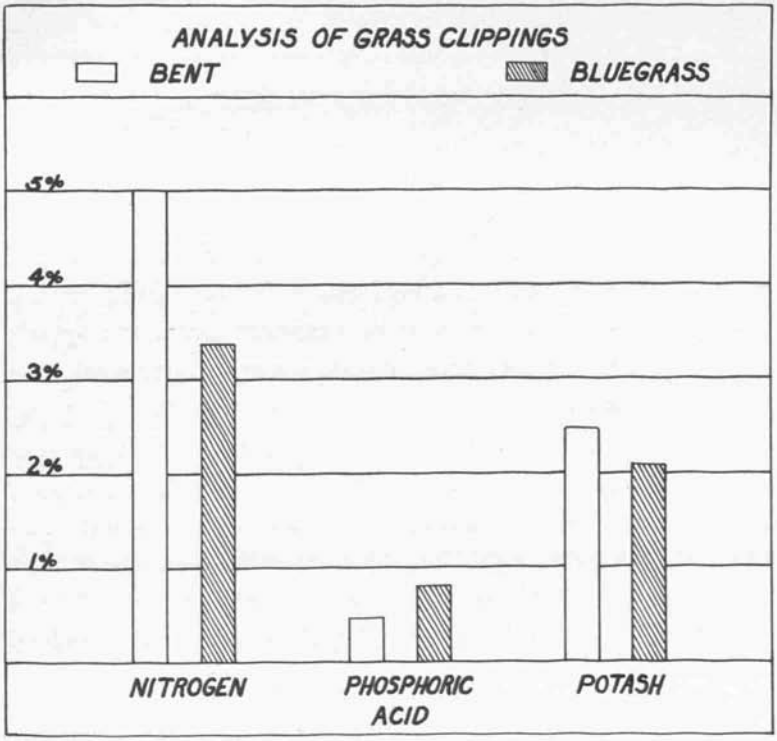
mitted to fall on the turf the mineral elements which are removed from the soil in the process of growth are returned to the soil so that there is practically no permanent loss of phosphorus from the soil as there is by field crops or in pastures. A normal corn crop will remove nearly 25 pounds of phosphoric acid per acre per year, whereas bluegrass turf to which clippings are returned will remove none. From calculations on losses by erosion and farm crops it is seen that about

70 pounds of phosphoric acid are removed per acre annually when such a corn crop is grown and 350 pounds of superphosphate would have to be supplied to maintain the soil fertility. On the other hand, when this land is in turf, losses from these two causes do not occur and the addition of large amounts of phosphoric acid to correct for these two losses is not necessary. On bluegrass turf, therefore, the amount of phosphoric acid and potash which must be added to replace the nutrient elements lost by erosion, crop removal, and leaching is much less than that which must be applied for the same purpose to land which has been planted to field crops. Results from fertilizer trials on field crops, therefore, should not be used for making recommendations for the fertilization of turf.

On putting greens and bent lawns from which clippings are removed, however, large amounts of the mineral elements are removed in the clippings and fertilizers must therefore be applied at higher rates than is necessary for turf to which the clippings are returned. Figures have been obtained for the amounts of mineral elements removed annually from bent grass in the clippings from some of the well-kept plots at the Arlington Turf Garden. The results obtained from these determinations at Arlington indicate that some 2 tons of field dry material containing a total of approximately 200 pounds of nitrogen, 20 pounds of phosphoric acid, and 100 pounds of potash may be removed annually from each acre of turf. When clippings must be removed, it is advisable to use them in the compost pile or to scatter them on poor turf so that the plant food they contain may be returned to the soil.

An analysis of bluegrass clippings shows that about 4 times as much nitrogen as phosphoric acid is removed. The return of the clippings replaces practically all of the phosphorus but

some of the nitrogen is lost. Therefore to replace the nutrients that the grass is actually removing from the soil a fertilizer



This chart shows the relative amounts of these nutrients that are present in the clippings of bent and bluegrass. Note that in both grasses the quantity of nitrogen is many times that of phosphoric acid.

supplying a larger quantity of nitrogen than phosphoric acid is needed.

As a result of considering both the demands of the crop and the quantity of nutrient elements lost by erosion and by crop

removal, therefore, it is evident that the problem of fertilizing turf is quite different from that of fertilizing agricultural crops.

Naturally Occurring Fertilizers

The compounds which are used to furnish the fertilizer elements to soil vary in their nature and origin. Naturally the ones which were used earliest were those originating as waste products of animals and plants.

The first organic fertilizers to be used were the natural manures. More recently, however, many different finely ground products have been prepared from naturally occurring organic materials such as bone, dried blood, sewage, cottonseed, soybean, and others.

The first inorganic fertilizer was wood ash, which has been used to increase the fertility of the soil as far back in antiquity as human records go. Although of plant origin, wood ash is really an inorganic fertilizer, since in obtaining the ash the organic material is driven off by heat leaving only the mineral salts. About 1840 the possibility of using naturally occurring crude mineral salts as fertilizers was given an impetus by Lawes and Gilbert, who at that time established the Rothamsted Experimental Station in England. They demonstrated the benefits to be derived from the use of crude nitrate of soda, mineral phosphates and potash salts as fertilizers.

This use of the naturally occurring crude salts led to the development of methods of manufacturing organic as well as inorganic compounds which would act as carriers for the three principal fertilizer elements. The characteristic which all of these manufactured compounds have in common is that they

are water soluble and that the nutrients which they carry are, therefore, readily available for use by plants.

Mixed Fertilizers

While in some instances the application of only one of these plant nutrients is necessary, in many cases two or three are needed at the same time. In such cases it is cheaper to mix compounds containing the desired elements and apply the mixture rather than to apply each separately. These mixtures are termed mixed fertilizers and when they contain all three of the principal elements in appreciable amounts they are called complete fertilizers. It is possible in preparing these fertilizers to get mixtures containing the three elements in almost any desired proportion.

The need for mixed fertilizers has become so universal in this country that they are prepared commercially and sold in large quantities. In 1934 the total tonnage of fertilizer sold in 1,053 different mixtures was 3,227,000. Of these mixtures 175 were sold in quantities exceeding 1,000 tons a year. Some fertilizers are also put out under trade or brand names. These trade names may or may not be significant to the user. Although these names may sound attractive many are meaningless and the best of them usually add to the cost of the fertilizer because of the sales value of the name.

Use of Waste Products

Certain waste products from industrial plants may often be used to advantage as fertilizers. As turfed areas are frequently located near such industrial plants the cost of transporting these waste products is small and when they can be secured at low

cost their use may be advantageous. Even though they are low-grade fertilizers and their supply is too limited for them to be considered as agricultural fertilizers, it may nevertheless be well worth while to consider them for the purpose of fertilizing nearby turfed areas. Some of these materials may be used to advantage in compost piles or in soil beds for the preparation of top dressing material or in preparing the soil for seeding. Not only do they add plant nutrients but many of them supply large quantities of organic material to improve the physical condition of the soil.

This group of materials includes waste from silk, wool and cotton factories; tea and coffee grounds; cocoa-shell dust; brewers' grain; peanut shells; bagasse from sugar refineries and many others. In some of these instances the fertilizer value is surprisingly high. For instance, waste from felt-hat factories has been found to contain 14 percent of nitrogen. Hair and feather waste may contain anywhere from 8 to 16 percent of nitrogen. Shoddy and felt waste may contain from 4 to 12 percent of nitrogen. Sweepings from powder mills have been found to contain as much as 10 percent of nitrogen and nearly 35 percent of potash. Local supplies of sewage sludge and ground garbage tankage are often used to good advantage on turf.

As a result of cooperative efforts of agricultural scientists and men in the fertilizer industry, the number of grades of fertilizer on the market was reduced from approximately 1,300 grades in 1934 to slightly less than 1,000 in 1939. Important economies would result from further reduction in the number of grades.