
*The author discusses the factors affecting plant growth & lays down some*

"Feed them whatever they want, whenever they need it." This is a summary of one of the modern philosophies of infant feeding. It might also be adapted to the "feeding" of turf plants. Of course, we must not attribute to grass plants an ability "to want." We can, however, attempt to ascertain the requirements of plants for optimal growth and to meet those needs.

The grower of turfgrass determines by careful observation and by soil tests the nutrient status of his plants and he supplies or withholds fertilizer according to his judgment of the plant's requirements. While he may not consciously consider each of the following questions involved before using fertilizer, the successful grower is instinctively aware of the implications of the following variables.

*PLANT REQUIREMENTS*

How do we know how much calcium or phosphorus a plant requires for optimal growth? This seemingly simple question has been the basis of research effort for years by students of mineral nutrition. Von Liebig, one of the first students of plant nutrition, offered his concept of "the law of the minimum" in which he contended that any nutrient element which was deficient controlled the amount of growth. So, if the plant growth was limited by one element, the grower could supply an ample quantity of that nutrient, then the element which was next lowest would become limiting. This early concept has not been completely discredited even though subsequent research has brought about modifications.

The "balance of nutrients" concept is another which is controversial, but which is accorded a degree of validity by many mineral nutritionists. Briefly stated, this concept holds that the amount of each nutrient element present in the plant produces an effect on growth but that the total amount is modified by its relationship to the amounts of other elements present. H. D. Chapman considered these complex interrelationships to be important and he summarized his views by stating " . . . it is both the balance and the total which count."

The use of tissue analysis, to determine the levels of nutrient elements existing in plants, has been helpful in relating growth to nutrient content. However, there is not a direct relation-


# Fertilizer - how much?

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*simple rules to guide the superintendent in turfgrass feeding*

ship except in the case of deficiencies. Lundegardh states, "it has been objected against leaf analysis that the nutrients can vary a great deal without a corresponding variation in yield. A thorough investigation shows that this is true only at supra-optimal percentages. A distinct limit can be distinguished, below which growth inevitably decreases. Values below this limit are the only ones which have an interest from the standpoint of fertilization." Lundegardh's concept is one with which the author's investigations show agreement.

Unfortunately for the turf grower, there has been relatively little research aimed at relating the nutrient content of plant tissues to optimal growth or to the supply of nutrients in the soil, and in turn to the need for fertilizers. One notable effort in this direction is that of Noer and co-workers in which clippings from bermudagrass putting greens in Memphis and bentgrass putting greens in Milwaukee were weighed and analyzed to determine the quantities of nitrogen, phosphorus, and potassium removed by the plant. These were well-fertilized greens in both cases. The conclusion may be drawn that the amounts of materials contained in grass clippings is indicative of the ratio in which these elements are needed by the plant. It has been used as a basis for the compounding of fertilizers of a 3-1-2 ratio.

One of the facts which serves to confuse such conclusions is that potassium, particularly, is subject to being taken into the plant in much larger quantities than are needed. This "luxury consumption" appears to be more nearly related to the amounts of potassium present in the soil and to the levels of other cations present than to the needs of the plant. Hence, it is difficult to establish the necessary level of potassium.

Likewise, it is recognized that additional nitrogen will result in increased vegetative growth. The increase of growth may not be desirable. It may result in a soft succulent, disease susceptible turf. Therefore, in drawing conclusions with respect to the need for nitrogen, we must be sure to relate nitrogen supply not only to total growth but to turf quality and to those other management factors such as mowing frequency, mowing height, and irrigation.

We must conclude that we still are in need of research to answer clearly the question "What

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does the plant require?" The direction of the research appears clear. (1) We must measure the growth of turfgrass plants supplied with various definite levels of nutrients. (2) We must measure the amounts of nutrients contained in plants and relate these findings to the amounts of nutrients supplied. (3) We must determine at what levels (in the tissue) we observe less than maximum growth and at what levels we achieve less than the best quality turf.

From the practical standpoint, the turfgrass grower solves the problem by making use of soil tests to insure that there is an excess of nutrients such as calcium, magnesium, potash, and phosphorus. He then judges the need for nitrogen by the amount of growth which occurs. Lacking complete knowledge of precise nutrient needs, the grower finds such an approach to be effective and practical.

*SOURCE OF NUTRIENTS*

The supply of nutrients for turf (or for any other plant) are derived from the soil or from added fertilizers. The relative amounts derived from each of the two sources are dependent upon the residual fertility of the soil and upon the management practices.

Golf course roughs are seldom fertilized. For this type of growth fertilizer might be harmful because it might change the composition of the vegetative cover and it might cause so vigorous a growth that mowing would become much more of a problem.

Some fairways are fertilized very little. Carpetgrass fairways in the South and buffalograss fairways in the Great Plains area may do very well with only the nutrients they derive from the native soil.

On the other hand, bermudagrass, bluegrass, and bentgrass fairways require additional nutrients and these must come from the fertilizer bag. Apparently grass responds equally to plant nutrients supplied, regardless of the source. When plants respond adversely, the trouble usually lies in the amount, the timing, or the method in which the nutrients are supplied.

*SOIL TEXTURE*

The inherent fertility of a soil depends to some extent upon the texture of that soil. Texture is related to the soil particle size and therefore to the amount of surface of soil particles in a given volume. Because sandy soils have the least surface, they can hold relatively small amounts of plant nutrients and they are notoriously low in fertility. Clays on the other hand have tremendous surface area and these tiny particles are negatively charged. Thus, the positively charged mineral nutrient ions (the cations such as $Ca^{++}$, $Mg^{++}$, and $K^{+}$) are held on the clay by an electrical bond. Silts are intermediate in size and in surface area. We can see now that with respect to nutrient supplying power, the clays rank highest, with silts being poor, and sandy soils are very low.

The texture of a soil also affects the fate of added fertilizer materials. Potassium, calcium and magnesium are likely to find a place on the clay particle where they will be held tightly and prevented from leaching. Also, since clays usually are associated with slow water movement, leaching does not occur so rapidly.

In coarse textured soils, those nutrients which go into solution are subject to ready leaching or to ready uptake by the plant. In both coarse textured and fine textured soils, some of the nutrients are likely to react with other elements to form insoluble or slowly soluble compounds.

*SOIL STRUCTURE*

Soil structure is related to texture in determining nutrient supplying power. Structure is also interrelated to the content of cations in the soil.

Cations such as hydrogen ($H^{+}$), sodium ($Na^{+}$), and potassium ($K^{+}$) carry one positive charge and they satisfy one of the negative charges of the clay particle. On the other hand, the cations such as calcium ($Ca^{++}$) and magnesium ($Mg^{++}$) carry two positive charges. They sometimes will be linked to two clay particles having one of the charges satisfied by a single negative charge from each of two clay particles. Enough of this "bridging" or "linking" occurs to cause clay particles to become aggregated.

Very acid clay soils (known sometimes as hydrogen saturated clays) have a large percentage of their negative charges satisfied by hydrogen ions ($H^{+}$). Because of the single charge of the hydrogen ion, there can be no aggregation as a result of cationic "bridging" and such a soil is usually puddled or "run together". This is the reason that liming often produces an improvement in soil structure.

Thus, we see that the chemistry of the soil affects structural characteristics. Structure and texture are both important in determining the distribution of pore space in the soil.

Capillary pore space holds water even after good drainage has removed the excess water. Non-capillary pore spaces are larger, and after drainage occurs they are filled with air. If a soil is high in silt and clay, the non-capillary pore space percentage will be quite small unless the

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soil is well aggregated. When non-capillary pore space is limited then air is necessarily limited also and this implies a shortage of oxygen in the soil. Aggregation of soil particles is a function of the kinds of cations present and it depends also upon cultivation or the maintenance of good tilth. Because the ability of a grower to cultivate the soil under turf is limited, adequate supplies of calcium and magnesium become particularly important in the maintenance of a crumb-like soil structure under a turf cover.

Soil texture and structure, you can see, affect the answer to the question—How much fertilizer?

When we consider all the rather complicated interrelationships of plant needs, soil effects, and fertilizer characteristics, we find that there is no positive answer that can be given to the question of "how much". We must establish the following as our aim: to supply the plant, at a steady rate, the nutrient elements it needs for efficient growth consistent with our use of it. Note that we have not said maximum growth. Maximum growth may be completely unsuitable for our needs. We must determine what the needs of the plant are. We have some ideas about the needs of turf plants, but definitive research is required to establish these needs more precisely.

Each grower must determine the characteristics of his own soil as these characteristics pertain to the nutrient holding and supplying power.

*A PRACTICAL APPROACH*

The grower of turf seldom can choose his soil. He uses the variety of grass suited to his geographic area and his need, and he often finds himself restricted in the use of adequate fertilizer by budget considerations. Nevertheless, he must carry on and adjust his program to his needs as well as possible. A few rules stated rather briefly and simply should keep a superintendent out of serious trouble.

1. In a sandy soil, apply nutrients frequently and in small amounts.
2. In heavier soils, applications may be spaced at greater intervals.
3. With a readily available nitrogen fertilizer, apply lightly and frequently. With a slowly available nitrogen fertilizer, interval may be increased. In either case, and in rules one and two above, *study production of clippings and turf quality. Adjust rates and frequency accordingly.*
4. Depend upon soil tests to guide you in keeping soil reaction near neutral. Tests also are reliable indicators of the soil supply of potassium, magnesium, calcium, phosphorus, and sulfur.
5. Learn as much as possible about fertilizers. No other management tool available can do more to determine the quality of your turf. □