Fertilizer-How Much?

By Marvin H. Ferguson, Mid-Continent Director, USGA Green Section

"Feed them whatever they want, whenever they need it," 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. This kind of management requires very careful observation, a knowledge of the effects of nutrient shortages, a knowledge of fertilizer materials, and a degree of clairvoyancy in regard to the effects of weather.

While it is easy to exhort the grower to "observe carefully, consider all factors, and use good judgment" in fertilizing, the multitude of factors which form the basis for good fertilizer practice are complex and varied. The practitioner of turf management may not consciously consider each of the questions involved before using fertilizer but the successful grower is instinctively aware of the implications of the 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 for years of research effort 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. Thus 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 relationship 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 per-

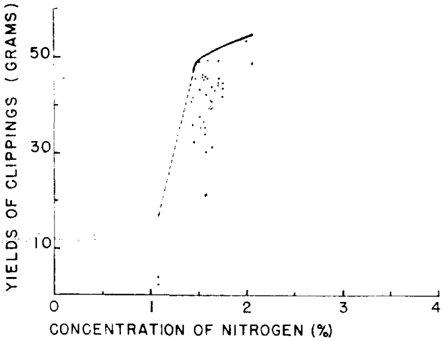


FIG. 1—The relationship between the concentration of nitrogen (on a dry weight basis) and yields of clippings.

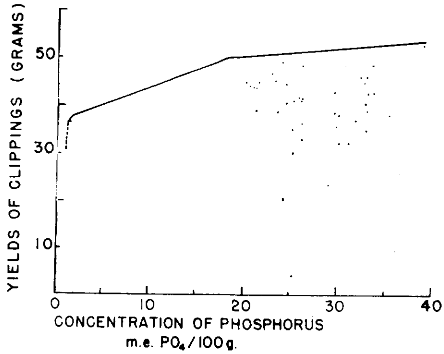


FIG. 2—The relationship between the concentration of phosphorous (on a dry weight basis) and yields of clippings.

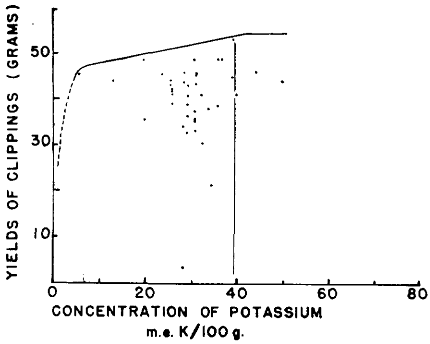


FIG. 3—The relationship between the concentration of potassium (on a dry weight basis) and yields of clippings.

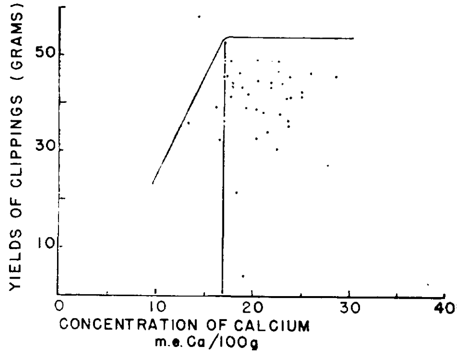


FIG. 4—The relationship between the concentration of calcium (on a dry weight basis) and yields of clippings.

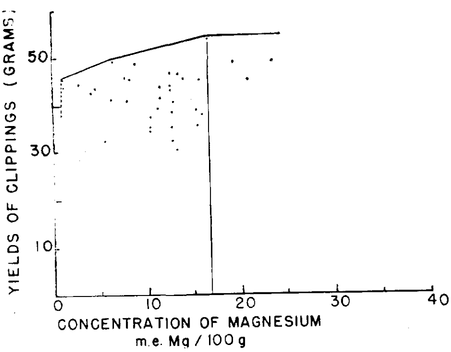


FIG. 5—The relationship between the concentration of magnesium (on a dry weight basis) and yields of clippings.

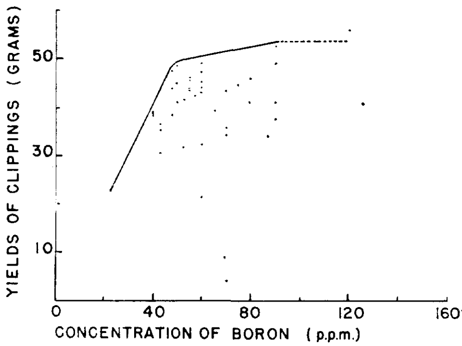


FIG. 6—The relationship between the concentration of boron (on a dry weight basis) and yields of clippings.

These figures show the relationship between varying levels of six nutrient elements and the growth of the plants as determined by measurement of the clippings. The turf used in these studies is Meyer Zoysia. In figures 3, 4, and 5, a vertical line shows the concentration considered to be a "level of sufficiency" beyond which additional quantities of this nutrient will produce no further favorable effect upon growth.

centages. 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. (See Fig. 1.)

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.

Level of Potassium

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 necesary 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 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. While such aims are simple to state, they will require painstaking, tedious, and thorough research effort to achieve.

From the practical standpoint, a 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) is 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 nutrient 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. Thus we may see 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.

The cations which are held on the clay particles by electrical charges may be removed for use by the plant through the phenomenon of "base exchange." Thus clay soils may be the repository for substantial quantities of plant nutrients. It has been said that clay acts as a wise banker which will accept and hold the nutrient ions until they are needed and will relinquish them upon demand to the plant.

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 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.

Pursuing the interrelationships further, we note that oxygen in the root zone is necessary to the process of respiration. Respiration is a process wherein carbohydrates in the plant are used to produce the energy whereby nutrients are taken into the plant and transported. In the absence of oxygen respiration ceases or is drastically reduced, the permeability of membranes in the root cells is brought about and the uptake of moisture and nutrients cannot occur.

Thus the chemistry of the soil affects the physical characteristics and both biochemistry and biophysics are involved in the supplying of nutrients to the plants. In light of these facts it is not surprising that the world's fertile soils are neither sands nor very heavy clays but rather the loam and clay loam soils such as are found in our prairie states and in our river flood plains.

Thus soil texture and structure affect the answer to the question—how much fertilizer?

Kinds of fertilizer

In an earlier statement we have said that plants respond equally to nutrients, regardless of the source. The well-being of the plant, however, does depend upon a steady, balanced supply of nutrients, and it is adversely affected by a "feast and famine" type fertilizer program. In order to provide the steady, balanced diet the turf grower must recognize the characteristics of different fertilizer materials and use them in such a way that he achieves desired results.

With all the major elements the turf grower has a choice between materials in which nutrients are readily soluble and therefore quickly available and those which are less soluble and which release nutrients more slowly and over a longer period of time. His choice will depend upon how the materials fit into his schedule and which approach he takes in feeding his turf.

SO—HOW MUCH?

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 this 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. This has been done for Meyer Zoysia. (Figs. 1-6.) We have some ideas about the needs of other 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. It may be possible in some cases to supply potash, phosphorus, lime and similar materials on an infrequent schedule.

While nitrogen offers less flexibility in relation to the soil type, it too may be used more or less frequently depending upon the choice of the source. Fertilizer materials should be chosen to fit the soil, the needs of the plant, and the personal preference of the user.

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.

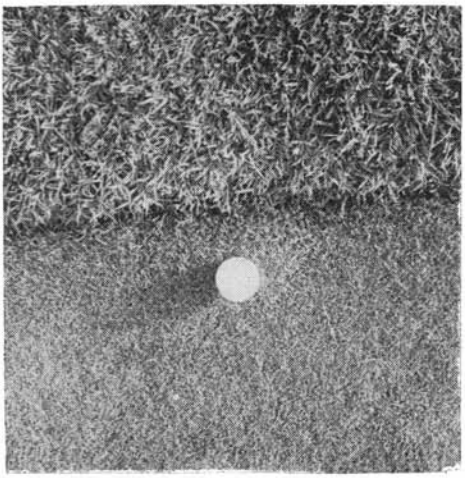
1. In a sandy soil, apply nutrients frequently and in small amounts. **Study production of clippings and turf quality. Adjust rates and frequency accordingly.**

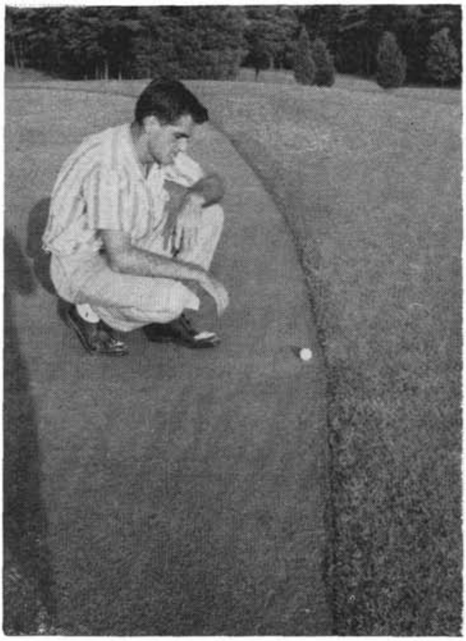
2. In heavier soils, applications may be spaced at greater intervals. **Study production of clippings and turf quality. Adjust rates and frequency accordingly.**

3. With a readily available nitrogen fertilizer, apply lightly and frequently. With a slowly available nitrogen fertilizer interval may be increased. In either case, **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.





Supt. John Cook of the Country Club of Virginia, Richmond, Va., inspects work of power edger which keeps bermudagrass runners in apron from infesting the bentgrass green. The edger is used weekly to keep the bentgrass green uncontaminated. Above, a close-up of the defined bermuda-bentgrass line.

COMING EVENTS

November 15-18
American Society of Agronomy Meeting
Kansas City, Missouri

November 18-20
MGCSA Turf Conference
Normandy Hotel
Minneapolis, Minn.

December 3-4
Winter Turf Conference
Illinois Turfgrass Foundation
Urbana, Illinois

December 7-9
Texas Turfgrass Conference
Texas A&M University
College Station, Texas

January 4 - March 12
Winter Course for Turfgrowers
Rutgers College of Agriculture
New Brunswick, N.J.

January 27-28
Virginia Annual Turfgrass Conference
John Marshall Hotel
Richmond, Virginia

January 29
United States Golf Association Green Section Educational Turf Conference
Biltmore Hotel
New York, N.Y.

February 1-3
Southern Branch of the American Society of Agronomy
Adolphus Hotel
Dallas, Texas

February 7-12
GCSAA Conference
Sheraton-Cleveland Hotel
Cleveland, Ohio

February 22-23
Southern Turfgrass Association Conference.
Peabody Hotel
Memphis, Tenn.