town, city, county, state and federal governments regarding electricity, gas, gasoline and noise levels. They must know what, how much and how often different chemicals can be used, labor laws and building codes. They are engineers, for they must rebuild or construct greens, tees, fairways, bridges, cart paths and in some cases buildings. They are diplomats maintaining good relations with their members, club officials, their employees, other superintendents, salesmen and various groups within their professional sphere.

Our men are great people but to be at their best, they need our understanding and our cooperation. Your man may need to release tension by talking to you. He isn't really asking for advice, just for the one he loves to listen to him. Often problems resolve themselves just by talking about them. He needs to know you love him and that you understand that he loves you. You may not understand his problems and be able to give advice, but if you don't listen, you never will understand that it is his self-respect, his integrity and his desire to make the best living he can for **you** that keeps him on the job when **you** want him home.

Some Agronomic Aspects of Turf Fertigation[1]

by G.H. SNYDER and E.O. BURT[2]

The pros and cons of turf fertigation (fertilization through the irrigation system) have been presented many times, but the lists vary little from author to author. The chief disadvantages cited relate to engineering problems, such as uneven water distribution, equipment corrosion and fertilizer precipitation within irrigation lines. Considerable attention has been paid to these problems. Methods of injecting fertilizer into irrigation systems have been described elsewhere. However, agronomic aspects of fertigation have received little attention from research scientists. In general, fertigation has been practiced on an "all or nothing" basis which makes agronomic evaluation difficult. Greatly needed is research utilizing randomized, replicated plots which provide accurate comparisons among treatments and statistical evaluation.

We have attempted to provide scientifically gathered information on agronomic aspects of fertigation for several years. However, considerably more time is needed to get a reasonably complete picture in our geographical region. Moreover, research by others is needed in other regions. Thus at this time agronomic discussions of turf fertigation must combine educated speculation with limited research data.

Light, Frequent Fertilizations

The primary advantage of fertigation is that fertilizer may be applied with very little labor required beyond that needed for the usual irrigation. Because of this, fertilizer can be applied very frequently, but at low rates per application. This aspect of fertigation is sometimes overlooked or underemphasized.

It is widely felt that frequent, light fertilizer applications will minimize the effects of poor water distribution. Observations made during the course of our research agreed with this contention, although the study was not designed specifically to test this theory, and the degree to which the theory holds will vary among irrigation installations. Probably the best reason for using frequent light applications of fertilizer is to encourage relatively constant grass growth with respect to time. Particularly in the case of nitrogen (N), frequent light applications will minimize unwanted flushes of growth which alternate with periods of N starvation, a cyclic condition that generally results from periodic heavy applications of N. We have found little difference in this respect between daily and weekly N applications through the irrigation system, which agrees with data of other workers using conventional application methods. But we feel that the above mentioned cycling may be observed with N fertigation intervals of greater than one week. Turf comes closer to requiring weekly, or even more frequent irrigations than most other field-grown crops, and in this respect is well suited to fertigation.

Reduced Leaching Losses

Since very little fertilizer will be present in the soil solution at any one time when light frequent applications are made, the efficiency of plant uptake should be good. In support of this, we have observed reduced N leaching losses when daily N applications through the irrigation system are compared to conventional N fertilization at three week intervals. Fertigation is often promoted as a

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Fertigation is used by Mr. Bill Bayless to make light, frequent fertilizations on the Huntington Sea Cliffs Country Club in Huntington Beach, California.

way of reducing fertilizer rates and less fertilizer usage under golf course conditions has been reported. We were not able to establish that lower rates are justified when fertigation was compared with an efficient slow-release N source. However, the N leaching observations, cited above, suggest that fertigation may reduce the amount of N fertilizer needed as compared to rather inefficient, though commonly practiced, N fertilization methods such as infrequent applications of soluble N sources.

Simulates Slow-Release Fertilizers

In principle, fertigation can simulate the use of slow-release fertilizers. Considerable research has gone into developing slow-release fertilizers that release nutrients at a rather constant, desired rate. This rate, however, is affected by various factors such as temperature, moisture, micro-organism activity, etc. These factors are not entirely controllable by the golf superintendent. The superintendent does have complete control over the amount of nutrients applied with each fertigation. This control can be useful to the intelligent, knowledgeable superintendent, but may only confuse the less competent individual who may prefer to use slow-release materials which act on their own. We have obtained growth at least as consistent, and at times more consistent, by using N fertigation as compared to a slow-release N fertilizer. The cost of N sources suitable for fertigation is, of course, much lower than that of slow-release sources.

N Sources

We are currently studying N sources for fertigation. This work is not complete. The all-ammonium (NH_4^+) source has proven superior to a combination of ammonium and nitrate ($NH_4\ NO_3$), all nitrate (NO_3^-) or urea under our conditions. This most likely occurs because we have problems with high pH. The all-ammonium source is the most acid forming N source of the group, which improves manganese (Mn) availability. In this respect, fertigation with these sources affects soil pH in the classical manner. Thus far, it appears that the sources are equally effective when Mn is sufficiently available, under our conditions. Work is needed in other regions to determine the best N source(s) in those locals. Anhydrous ammonia (NH_3) is frequently applied to field crops in irrigation water when flood or furrow irrigation is used. But it generally is not recommended as an N source for application by sprinkler irrigation because large quantities can be lost by volatilization. Volatilization is much reduced at low concentrations. Thus when used in light, frequent applications so that NH_3 concentration in the irrigation water remains very low, volatilization losses may be acceptable if other circumstances (price, availability, convenience, etc.) greatly favor its use.

Fertigation + Conventional Fertilization

Fertigation probably can be best used to apply nutrients in light, frequent applications over the

large acreage of a golf course. The complexity of the system is greatly increased if the superintendent desires to use fertigation differentially over his course, to make heavier applications on greens and tees, for example. These heavy use areas, which will receive a low maintenance level of fertilizer by fertigation, can receive supplemental fertilization by conventional methods. Nutrients which are well retained by the soil can be conventionally applied, also, if desired. Using fertigation does not require that the fertilizer spreader be thrown away. But fertigation does offer a simple way of fertilizing the greatest acreage of a golf course—the fairways—and hopefully will allow a superintendent and his crew more time to concentrate on those portions of the course where their attentions are more appreciated (greens, and tees, for example).

Nutrients For Fertigation

Nitrogen and sulfur (S) are poorly retained by most soils. Fertigation offers a means of maintaining an adequate level of these nutrients in the soil. Sand soils do not hold potassium (K) well, and fertigation may prove useful for K in sand soils. Under high pH conditions, certain micronutrients are retained so well by the soil that they become unavailable to the grass. Fertigation may be a way of maintaining adequate availability of these nutrients. It has been successfully used to apply manganese (Mn) where high pH was causing a Mn deficiency. Fertigation may, or may not, be useful for applying other nutrients. Much will depend on the availability of soluble fertilizer mixes at acceptable prices. A superintendent may wish to make his own mixes from dry sources. However, it may prove more convenient and less expensive to purchase pre-mixed fertilizer as a liquid if a competent dealer is available. Expensive liquid fertilizers that are sold especially for foliar feeding are probably of no particular advantage for turf fertigation, since high volumes of water are used and little fertilizer will remain on the foliage. Most liquid fertilizers are competitively priced with their dry counterparts.

The Superintendent's Decision

Thus for golf turf there appear to be many agronomic advantages to maintaining a relatively constant, low level of available nutrients in the root zone. Fertigation is only one of several methods that can be used to achieve this objective. Slow-release fertilizers and frequent conventional applications of soluble materials are others. Relative to these, however, only fertigation is economical both in terms of labor and fertilizer cost, but it places new responsibility on the golf superintendent. For this reason, a Green Committee probably cannot successfully force fertigation upon a superintendent who is not convinced that it will be advantageous from a total management standpoint. On the other hand, a superintendent who is properly motivated and interested can usually make a success of fertigation in spite of unanticipated problems which always arise. They can take heart in the fact that many superintendents are using fertigation successfully in Florida and elsewhere, and its use seems to be on the rise.

In order to study the effect of fertigation on nutrient leaching soil water samples are taken from below the turf roots and chemically analyzed.