THE USE OF SOLUBLE FERTILIZERS FOR LAWN CARE

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One of the most interesting developments in turfgrass management within the past several years has involved the promotion and use of liquid fertilizer materials. These have included complete fertilizer formulations as well as nitrogen solutions. All have been employed with varying degrees of success on turf of different types, such as, home lawns, golf greens and tees.

The unique feature of liquid fertilizer treatments is that the nutrient carrier is water rather than a solid which is characteristic of dry formulations. The liquid may carry nutrients dissolved in it directly to root or leaf surfaces where absorption takes place. Where relatively insoluble materials are suspended in water and sprayed on the turf the liquid does not have the value cited above. The fertilizer response would not be expected to be different than that from a dry formulation.

Generally speaking the term liquid fertilizer refers to solutions of nutrient salts (table 1) formulated singly or in various combinations. Liquid fertilizer ratios and nutrient salt formulations vary with different products (table 2) the same as for solid fertilizers. In many instances liquid fertilizers also contain additives for which various beneficial claims are made. (table 3). Since ratios and nutrient salt formulations and types of additives vary with product it would be expected that the rate of application would also vary (table 4). In the same respect there is great variation in the cost of these materials (table 5).

With the supply of products available the question foremost in the mind of the turf manager is - "How does liquid fertilization of turfgrass fit into my maintenance program?" In order to answer this question it is important to review the various types of growth response which may be expected from the use of liquid formulations.

ROOT FEEDING

Conventional fertilizer applications made in the dry form are effective only in root feeding. Liquid fertilizer treatments may also be of value in this regard. In general, little is gained from the standpoint of economy or efficiency from the use of liquid fertilizer in the seed bed. In this instance the trend has been toward the use of higher analysis fertilizers applied dry. Where large areas are involved the inconvenience of handling large gallonage of solution is considerable.

Applications of liquid fertilizers to turf must penetrate a canopy of leaves before reaching the roots. It is necessary to dilute the material with sufficient water to carry it without burning the foliage. With most formulations this involves the use of large amounts of water. In these instances such as on golf courses which have fairway watering or on turf fields which have permanent or portable irrigation systems into which liquid fertilizer can be fed, it is possible to fertilize in this way. Difficulties are encountered at times in obtaining uniform distribution of fertilizer and this frequently results in uneven growth responses.

Since nitrogen is the element which often becomes limiting first it is applied most often in supplementary treatments during the growth season. Liquid fertilizer formulations are effective in this regard. On the other hand, it has long been recognized, that the natural organics have a slow break-down and release of nitrogen in the soil. This means a longer potential nutrient supply from each application. The proper use of organic nitrogen sources, however, does not make the frequent use of liquid fertilizer unnecessary. Climatic factors which regulate the breakdown and release of plant food from natural organic fertilizers cannot be completely controlled. Thus the occasion often arises when supplemental light fertilization with a quickly available nutrient source is desirable. The development of slow release synthetic organic fertilizers has further emphasized the value of including supplementary liquid fertilizer treatments in management programs which place emphasis on use of solid formulations for meeting major nutrient requirements. It is evident that supplying power is a key concept here. In the case of the liquid it is brought about by the time of application being adjusted to continually meet the needs of the plant for inorganic nutrients. In the case of the organic solid it is realized through the slow breakdown and release of elements from the compound. Outside of a possible quantative edge in nutrient availability given to the use of liquids applied at frequent intervals the difference between the two methods is labor, several treatments versus one to few.

Where the area to be fertilized is relatively small such as the home lawn, a putting green, athletic field or other specialized turf area it may often be safer and easier to do a uniform job with a liquid than with an inorganic solid. It should be remembered, however, that applications of liquid will undoubtedly result in higher total cost since more expensive fertilizer materials are used. Further, more labor is involved per unit of plant food applied. Comparisons of liquid fertilizer costs with those for applications of organic solids often show little difference.

The following nine points are considered important in obtaining the most benefit from the use of liquid fertilizers:

First, it is recognized that the chemical components of a fertilizer formulation will determine to a large extent its toxicity to turf foliage. In general, the greater the percentage of urea nitrogen the less the toxicity; the more ammonia nitrogen the greater the leaf burn expected. Nitrate nitrogen normally is more toxic than urea but less harmful than ammonia. Some grades of urea contain sufficnent biuret* to be toxic to plant foliage. Biuret concentrations from 0.2% to 0.25% cause injury to some plants. Normally fertilizer urea will not contain more than from 1.0% to 1.5% biuret and this level is not considered toxic to turfgrass foliage unless applications are made at high rates and/or in concentrated solutions. Where liquid fertilizers are applied in about 25 gallons of water per 1000 sq. ft. it is often necessary

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* In the manufacture of urea heating above 271°F. in the absence of water results in the loss of ammonia and the formation of a substance called biuret. Chemically urea is $Co(NH_2)_2$ and biuret is $NH(CoNH_2)_2$.

to keep concentrations at or below one half pound of nitrogen per application in order to prevent foliar burn. Three quarters to 1 1/2 pounds of nitrogen per 1000 sq. ft. generally cause increasingly severe injury unless applied with large amounts of water.

Second, application of liquid fertilizers to turf which has become dormant in response to high temperatures and dry soils may cause injury as the grass resumes growth later in the season. Accumulation of soluble salts at or near the soil surface has been found detrimental to plants when made available in small amounts of moisture.

Third,since liquid fertilizers are immediately available they have a pronounced effect on soil acidity. In general, Nitrates raise soil pH, urea slightly lowers it and ammonia reduces it even further. Sandy soils respond more quickly to these changes than do heavier soils. Most liquid fertilizer formulations have an acidulating effect on soils. This often means that periodic adjustments of the pH are necessary by making applications of ground limestone.

Fourth, color response in turf resides in the foliage. Through regular clipping much of the improved color may be removed so that complete satisfaction from frequent treatments with liquid fertilizers may not be realized.

Fifth, continued applications of an element such as nitrogen may cease to provide a growth response under certain environmental conditions. This may be related to a deficiency of some other element or elements which retard the utilization of the nitrogen. In other instances it is believed that the plant reaches a point of diminishing returns in the relationship between growth response and additional fertilizer applications. Turf situated on sandy well drained acid soil of inherently low fertility will often give a significant color response to an application of iron where liquid fertilizers have been used previously. Where the initial levels of iron are relatively low, the application of phosphorus as phosphoric acid (a common source in liquid fertilizers) could be effective in precipitating the iron and in initiating a deficiency. It would not be expected in most instances that this would occur during the first year or two of liquid treatments. Where soils are heavier and have a pH value between 6 and 6.5 response to iron following the use of liquid fertilizers is usually less except where very high rates of fertilization have been carried out.

Sixth, since applications of liquid fertilizer may increase the growth rate of the grass, the removal of clippings depletes the soil of micronutrients faster than normal. As indicated above, applications of minor elements may be required where these nutrients are not included in the liquid formulation.

Seventh, too high or too low levels of one element or another in the soil are undesirable from the standpoint of producing desired turf quality. For example, high levels of potassium are not needed by grasses and where present clover is often stimulated and shows greater aggressive tendencies. For this reason fertilizers with descending ratios are commonly recommended for established lawns. Where a complete liquid fertilizer with a low potassium content is used, it's continued frequent application may keep available potassium levels higher than necessary for the best growth of turf grasses. Despite the fact that ample nitrogen is provided to putting greens, clover often invades areas which contain excessively high levels of potash.

Eighth, crabgrass may benefit more than turfgrass from frequent light fertilization during late spring and early summer. Care should be taken to avoid frequent fertilization where crabgrass has not been controlled chemically.

Ninth, over stimulated turf is often more susceptible to adverse climatic conditions. Frequent applications of liquid fertilizer may cause turf to be more easily injured from wilt. Soft succulent grass is less likely to enter a normal period of growth recession or dormancy, under the influence of high temperature and low moisture levels. It is more likely to be seriously injured by these conditions.

FOLIAR FEEDING

Use of liquid fertilizers may have as its objective either foliar feeding or root feeding; however, in either case foliar response should be considered since applications to the roots normally cover the foliage before contact with the soil. Although two different techniques of application may be followed, growth responses are often related to a combination of reactions involving both foliar and root systems.

It should be emphasized that landscape plants are developed to absorb plant food through a root system growing in a soil environment. The soil provides a more stable and abundant supply of these inorganic elements than does the atmosphere. Anatomically the leaf does not have the same structural characteristics as the root and yet within limits chemical elements sprayed on leaf surfaces can be absorbed and translocated throughout the plant in a way similar to that observed in roots. The leaf system, however, is not as capable of meeting total needs of the grass as the root system. Just as root function varies between species so the behavior of leaves in foliar feeding varies with different species. As would be expected differences in growth response are frequently observed. Seven important factors which influence these responses may be listed as follows:

I. The numbers and location of tiny openings in the leaf surface called stomata have a direct relationship on the immediate uptake of plant food sprayed on the leaf. Some plants have most of the stomata on either upper or lower surfaces while in others they are present on both sides of the leaf. The degree to which a leaf surface containing these openings is coated with the liquid fertilizer will determine the immediate response.

II. Stomata do not provide the only means of plant food entry into grass leaves. The cuticle or extreme outer layer of the epidermis of the leaf transmits some nutrients directly through it into the tissue below. This system of nutrient entry is slower than that involving the stomata and depends to a large extent on the chemical composition of the cuticle itself. These properties are also reflected in the wettability of the leaf surface. It is generally recommended that a detergent, spreader or sticker be used to insure maximum coverage. Leaves which have a hairy or pubescent surface are difficult to wet. In some instances the cuticle may be thin enough to allow absorption directly through the cell wall. These specialized cells may be of extreme importance in foliar feeding in some species.

III. The over-all leaf shape is important in-so-far as this characteristic influences the target area in spraying. The total area coated with nutrients will also be determined by these growth characteristics. Close clipped turf often responds less to foliar applications than higher clipped grass.

IV. The age of the leaf and its nitrogen status influence response to foliar feeding in many plants. In general, younger leaves and those of higher nitrogen content are more responsive to foliar application. Clipping keeps grass foliage young which provides for a potential maximum response. Turf suffering from severe nitrogen deficiency should not be expected to respond to foliar feeding as well as better nourished stands.

V. Temperature and humidity are known to alter affectiveness of foliar applications. High temperatures and dry air conditions are not conducive to optimum response.

VI. The chemical composition of the nutrient spray has an effect on ion antagonisms similar to those found in soils. For example, the rate of absorption can be varied by changing the concentration of calcium. This ion is known to be active in slowing uptake of other nutrients.

VII. Loss of plant food applied to leaves may occur through volatilization, drip from leaves or complete failure of the solution to contact the leaf surface. Materials which wash into the soil are of value in root feeding.

There are, then, three main limiting factors to the use of foliar feeding methods to completely meet turf needs. They are, the poor supplying power of the leaf, the inefficiency with which required elements can be distributed throughout the plant and the essentiality of having a favorable soil-nutrient environment for the growth of roots. These limitations on foliar feeding processes result in poor quality turf where this method is followed exclusively. Plant needs are better satisfied where the major nutrients are absorbed through the soil-root system. The value of foliar feeding lies in its getting small amounts of elements in short supply in the soil (either because of a complete lack or because of being unavailable) quickly to the interior of the plant. For example magnesium applications to the soil will often take longer to be absorbed than they will following application to the foliage. Iron is more likely to be fixed before absorbtion from the soil than when supplied through the leaves. Symptoms of chlorosis from minor element deficiency can often be greatly reduced by applying the required element directly to the leaves. Small amounts of nitrogen can be applied in this way with a distinct improvement in color of the foliage.

METHODS OF APPLICATION

The method of application of foliar treatment should be recognized as different from those used in root feeding. The total amount of solution applied and the fineness of spray in foliar feeding are adjusted to apply the fertilizer at the proper rate (small amount) in the least amount of water possible that will still give complete coverage. In root feeding it is desirable to use higher total amounts of water so as to prevent burning of foliage. Since applications of fungicides and selective herbicides are made in the same way desired for foliar feeding it is possible to make dual applications of fertilizer and pesticides. This is frequently done successfully on lawns and greens where applications are carefully made at frequent intervals throughout the growth season. Small amounts of nitrogen are used in these applications where most of it is expected to stick to the leaf. As little as 1/16 pound of nitrogen per 1000 square feet is not uncommon and 1/8 pound approaches the upper limit. Where pesticides are added with the fertilizer care should be taken to see that the chemicals are compatible before mixing. During application precautions should be taken to avoid drift of spray to nearby vegetation which may react unfavorably to the chemicals used.

SUMMARY

The value of foliar feeding lies in making supplementary fertilizer applications rather than as a means to complete plant food supply. This does not mean that foliar feeding or the use of liquid fertilizers in turfgrass management is not important. To the contrary the turf manager is living in an age of "prescription fertilization" which can be most easily carried out by use of liquid formulations. Our knowledge concerning the relationships between fertilizer, environment and turf quality is steadily increasing. It is realized that control of soil factors affecting the release and availability of inorganic and organic fertilizer materials is extremely complicated and difficult. Seasonal variations in the inorganic nutrition of the grass are recognized as important in the production of quality turf. The use of nutrient sprays provides a means of more accurate nutrient supply to the plant. In so far as this is accomplished the use of liquid fertilizers will have value in the management of fine turf.

Table 1

Common Sources of Nutrients Used in the Formulation of Liquid Fertilizers

Fertilizer Ratio		Name
15-0-0	40 % Ca -	Calcium Nitrate
33-0-0		Ammonium Nitrate
20-0-0		Ammonium Sulfate
45-0-0		Urea
16-0-0		Sodium Nitrate
13-0-44		Potassium Nitrate
12-61-0		Monoammonium phosphate
11-48-0		Monoammonium phosphate*
21-53-0		Diammonium phosphate
0-0-60		Potassium chloride
0-0-48		Potassium sulfate
0-0-0	30% Ca -	Calcium sulfate

*Commercial grade

Table 2

Formulations of Liquid Fertilizers

Number	Fertilizer Ratio	Percent Nutrient	Nutrient Source
3	7-7-7	2.3% N	Anhydrous Ammonia
		4.7% N	Urea
		7% P_2O_5	Phosphoric Acid
		7% K_2O	Muriate of Potash
4	3.6-5.3-2.7	.8% N	Potassium Nitrate
		1.0% N	Mono Ammo Phosphate
		1.8% N	Urea
		5.3% P_2O_5	Mono Ammo Phosphate
		2.7% K_2O	Potassium Nitrate
11	15-30-15	6% N	Ammonium Phosphate
		9% N	Urea
		30% P_2O_5	Ammonium Phosphate
		15% K_2O	Potassium Chloride

Table 3

Additional Ingredients Claimed to be Beneficial in Common Liquid Fertilizers

Number	Fertilizer Ratio	Additional Ingredients Claimed to be Beneficial
1	10-8-4	plus Calcium, Boron, Iron, Manganese, Thiamine
2	24-12-12	plus Calcium, Magnesium, Sulphur, Iron, Manganese, Zinc, Copper, Boron, Molybdenum
3	7-7-7	plus Chlorophyll, Trace elements,including Molybdenum, wetting in and wetting back agents, Formula 21 growth stimulant and a pure food celloid.
5	12-8-4	plus Virilphyl
8	36-3-6	plus Fertidine
10	7-0-0	plus 12% Soluble Iron and Traces of Calcium, Cobalt, Manganese, Magnesium, Silicon, Titanium, Vanadium, Copper, Aluminum, Sulfur, Molybdenum, Potash and Phosphoric Acid
11	15-30-15	plus Nutregenes (chelated trace elements) 0.49% Magnesium, 0.18% Manganese, 0.15% Iron, 0.06% Copper, 0.06% Zinc, 0.04% Boron, 0.009% Molybdenum
13	23-21-17	plus Vitamin B_1 and B_2

Table 4

Rates of Application of Liquid Fertilizers

Number	Fertilizer Ratio	Rate of Application
1	10-8-4	1 qt. to 10 gal. water/5000 sq. ft.
2	24-12-12	4 lbs. to 20 gal. water/1000 sq. ft.
3	7-7-7	1 qt. to 15 gal. water/1500 sq. ft.
4	3.6-5.3-2.7	1 qt. to 15 gal. water/400 sq.ft.
5	12-8-4	1 qt. to 25 gal. water/1000 sq. ft.
6	20-20-20	2 lbs. to 24 gal. water/1000 sq. ft.
7	15-10-5	1 qt. to 15 gal. water/1000 sq. ft.
8	36-3-6	1 lb. to 20 gal. water/1000 sq. ft.
9	21-15-7	3 lbs. to 20 gal. water/1000 sq. ft.
10	7-0-0	1/2 lb. to 2 gal. water/500 sq. ft.
11	15-30-15	40 lbs. to 40 gal. water/1000 sq. ft.
12	12-8-4	1 qt. to 30 gal. water/1000 sq. ft.
13	23-21-17	1/3 lb. to 7 gal. water/1000 sq. ft.
14	10-5-5	1 gal. to 19 gal. water/1000 sq. ft.

Table 5

Cost of Liquid Fertilizer Formulations

Number	Fertilizer Ratio	Container	Price
2	24-12-12	50# bag	$12.75
3	7-7-7	55 Gal.	270.00
5	12-8-4	20 gal.	39.00
6	20-20-20	50# drum	15.00
8	36-3-6	10# bag	8.95
9	21-15-7	2,000 lbs.	225.00
11	15-30-15	5 lbs.	4.98
13	23-21-17	10 lbs.	8.75