CALIFORNIA TURFGRASS CULTURE
FORMERLY, SOUTHERN CALIFORNIA TURFGRASS CULTURE

VOLUME 23, NO. 2 SPRING, 1973

NITROGEN SOURCE INRELATION TO TURFGRASS ESTABLISHMENT INSAND

*By Kenneth D. Gowans and Edward J. Johnson**

Nine nitrogen sources at three rates which included water soluble, slow release, and organic forms were evaluated for the establishment and maintenance of Manhattan perennial ryegrass in sand. All rates **of** *plastic coated nitrogen produced acceptable turf for a nine-month Period with a minimum fluctuation of quality. Ammonium sulfate also produced acceptable turf over most of the eleven-month Period but with considerabh? fluctuation in quality. All other fertilizers produced unacceptable turf after three months.*

A number of nitrogen sources for plant growth are available to the turfgrass manager today. Many are very water soluble and can be soon leached below the root zone of these relatively shallow rooted grasses. In recent years, several slow release nitrogen sources have become available which supply nitrogen to plants over a long period of time.

Interest in the nitrogen available in sand has recently developed because certain sands are used in the construction of highly trafficked areas such as golf greens and football fields. Water enters and drains from these sands at a high rate after compaction which is essential if grass is going to grow on these fields when they are used wet or dry.

Nitrogen, phosphorus, and sulfur have been found to be the limiting plant nutrients when grasses were grown in the greenhouse in many of these California sands. Phosphorus and sulfur can be supplied with several fertilizers which are slowly soluble so that these nutrients are available to plants over a long period of time. On the other hand, nitrogen from most water. soluble nitrogen fertilizers is soon leached beyond the roots of small grass plants.

Alameda Memorial Park, a part of the East Bay Regional Park System, was constructed from unamended sand dredged from San Francisco Bay and was used as the test site. This is a coarse sand with many fine shells. Sand depth above a compacted land fill varied considerably, but appeared to average greater than 12", but less than 24".

Sieve Analysis of Sand of Alameda Park

Sand Description	Percentage
Very coarse sand	1.5
Coarse sand	69.0
Medium sand	12.4
Fine sand	13.2
Very fine sand	1.4
Silt and Clay	1.0

There was a very sparse growth of bromegrasses and clover over the area at the time the site was prepared for planting.

Before the area was seeded, all the fertilizers were applied and lightly raked into the surface one to two inches. Twenty pounds of single super phosphate per thousand square feet was applied over the entire area to provide adequate amounts of phosphate and sulfur. Each nitrogen fertilizer was applied to fifty square foot plots at rates of 3, 6, and 9 pounds of nitrogen per thousand square feet and replicated four times. The entire amount of fertilizer from each nitrogen source was applied before seeding with the exception of ammonium sulfate (ammoniacal (1)). This fertilizer was applied at the same annual rate as the other fertilizers, but was divided into six equal parts and applied every other month.

The nine nitrogen fertilizers used in the trial are shown in Table 1. Several kinds of nitrogen sources have been included. Ammoniacals are the very water soluble nitrogen sources which should soon leach from the sand. IBDU or isobutylidine 'diurea is slowly water soluble; ureaformaldehyde and methylene urea are partially de-

TABLE 1

Description of the nitrogen sources used in the trial.

Material	Pescription
ammoniacal (1)	Ammonium sulfate (21-O-O)
ammoniacal (2)	Best (16-4- 5) ammonic nitrogen.
IBDU	Par-Ex(31-O-O) isobutylidine diurea.
ureaformaldehyde	Nitroform (38-O-O) ureaformaldehyde.
methylene urea	Scott Proturf Starter (18-24-6) methylene ureas + urea.
plastic coated NH4	Agricoat (21- 5- 5) plastic coated ammoniacal and nitrate nitrogen.
chicken manure	Super Grow (3-3-3) processed chicken manure.
sewage sludge (1)	Evergreen (6-4-Z) fortified sewage sludge.
sewage sludge (2)	Triple Six (6-6-6) fortified sewage sludge.

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pendent on bacterial action for the release of nitrogen; the plastic-coated ammoniacal and nitrate nitrogen source must be wet to release nitrogen through the plastic film. All these nitrogen sources are either inorganic or synthetic organic. Processed chicken manure and sewage sludge are natural organic nitrogen sources although the nitrogen content of the seweage sludges has been increased with an ammoniacal nitrogen.

The entire area was planted to Manhattan pkrennial ryegrass. This is a narrow leaf perennial ryegrass which has been grown verv successfully for turfgrass in the San Francisco Bay Area.

Ratings of the turfgrass were started near the end of August 1971, three weeks after planting. They were made every other week or monthly, until the first part of June 1972. A scale of 1 to 10 was used where 10 is excellent; values of 6 and above are acceptable, and those below 6 are unacceptable. Ratings were based on per cent stand, weedmess, and color. To avoid personal bias, the rating of a plot is the average of two or more ratings made by different individuals.

The average quality rating for the four replications of each application rate have been plotted with respect to the time. In nearly all cases, the nine-pound rate of nitrogen gave the highest quality rating followed by the six-pound rate with the three-pound, the lowest. This would be expected. However, if we consider a rating of six or greater to be acceptable, then it is possible to determine in a general way the amount of nitrogen to apply to turfgrass on sand to obtain an acceptable turf.

In Figure 1, the average turfgrass ratings for ammoniacal (1) or ammonium sulfate have been plotted. Turfgrass quality varied considerably and was directly related to when the ammonium sulfate was applied. Most of the ammonium sulfate applied at the time of planting evidently was lost from the sand before the plants germinated because plant quality began to decrease in mid-September. An application of ammonium sulfate was made at this time rather than wait for another month. This application was very important as shown by the tremendous increase in turfgrass quality by the end of September.

All three rates of the pastic-coated ammoniacal and nitrate nitrogen (Agricoat) produced acceptable quality turf for a period of eight months after the one application, as shown in Figure 2. The nine-pound nitrogen rate averaged nearly one quality unit higher than the three-pound rate and produced quality turf for nine months. The ratings decreased very gradually after reaching the highest quality near the end of October. This nitrogen source appeared to be the most desirable for establishing and maintaining Manhattan perennial ryegrass on sand.

IBDU, at the nine-pound rate, Figure 3, produced excellent quality turfgrass in about five weeks. Ammonium sulfate and Agricoat were the only other materials that produced this quaIity grass, but a week to a month later. All three rates of IBDU rated the highest about a month after seeding, then decreased below an acceptable rating in November or at the end of three months.

The quality of the turf produced by ureaformaldehyde, methylene urea, and ammoniacal (2) were very similar. The high rate of ureaformaldehyde produced acceptable turfgrass through December or for a period of four months. The 3 and 6 pound rates of ureaformaldehyde and all rates of methylene urea and ammoniacal (2) produced acceptable turf until early November or for 3 months.

All rates of the organic nitrogen sources, that is, chicken

TABLE 2

Average turfgrass quality ratings for each material for eight dates with summary. The ratings for the three application rates and four replications for each date have been combined. Materials listed with respect to Duncan's Multiple Range Test at 5% significance for average.

No.	Material	Sept.7	Oct. 13	Nov. 24	Dec. 15	Jan. 21	Mar. 4	May 9	June 7	Ave;	Duncan's Multiple Range 1/
		Dates (1971-72)									
1	plastic coated NH_4	5.5	a.75	6.8	7.9	6.9	6.75	6.75	5.0	7.1	u
2	ammoniacal (1)	5.1	7.65	5.25	7.85	6.35	7.9	6.4	7.4	6.85	V
3	IBDU	0.35	7.6	5.25	5.25	4.25	4.1	3.9	3.0	5.75	W
4	sewage sludge (1)	7.85	7.35	5.1	5.3	4.5	4.25	4.25	3.5	5.7	w x
5	ureaformaldehyde	6.0	7.35	5.4	5.85	4.75	4.9	4.75	4.1	5.7	w x
6	chicken manure	5.85	7.0	5.1	6.0	5.1	4.65	5.15	3.9	5.7	w x
7	methylene urea	7.15	6.85	4.9	5.15	4.4	4.35	4.5	3.35	5.5	X
8	ammoniacal (2)	7.25	6.65	4.75	4.95	4.25	3.75	3.65	3.0	5.2	Y
9	sewage sludge (2)	5.85	6.65	4.7	5.1	4.5	3.9	4.0	3.1	5.0	z
	LSD 5%	.08	.44	.39	.50	.38	.38	.39	.30	.22	

l/ Treatments followed by same letter are not significantly different.

manure and sewage sludge produced acceptable turfgrass until November. Sewage sludge (1) produced the highest rating, followed by a chicken manure. The lowest ratings were produced by sewage sludge (2).

Average ratings for eight dates and a summary are shown in Table 2. The rating for each date in the table is a combination of the three rates of fertilizer and the four replications, or a total of twelve individual ratings.

Plastic-coated ammoniacal and nitrate nitrogen produced the highest ratings. These ratings were significantly greater (5% level) than those produced by the ammonical (1) nitrogen applied bi-monthly, but both materials produced turfgrass with an average rating above the acceptable level.

IBDU, sewage sludge (1)) ureaformaldehyde, and chicken manure produced ratings significantly lower than the ammonium sulfate. Methylene urea was significantly lower than IBDU, followed by the ammoniacal (2), and finally, the sewage sludge (2).

Discussion

Several different nitrogen release characteristics were involved with the nitrogen sources included in this trial. Each influenced the quality of the turfgrass a little differently. It is well to keep in mind the conditions of this trial because it is questionable whether the exact same relationships could be duplicated if the conditions were changed. These changes might include sand versus a finer textured soil such as loam or clay, fall versus spring planting or perennial ryegrass versus Kentucky bluegrass.

The turf responded very quickly to applications of ammoniacal (1) nitrogen as shown by the change in rating from 5.5 to 10 in two weeks after the mid-September application. It is very possible that the turf ratings after each application approached 10 for the high rates but because the grass was not rated at peak quality these ratings were not recorded. Similarly, lower ratings may have resulted than were recorded. In other words a greater degree of fluctuation could have occurred than was observed. It would appear that about six pounds of nitrogen per 1,000 square foot per year from ammonium sulfate applied. monthly should produce a desirable turf on sand.

Release of nitrogen from the plastic coated nitrogen source depends upon moisture diffusing through the plastic coat or membrane, dissolving the nitrogen salt in the pellet, and the nitrogen solution diffusing out of the pellet where the fertilizer becomes available to the plant. By controlling the thickness of the pastic coat as well as mixing pellets with different plastic thicknesses a wide range of nitrogen release characteristics can be developed. This particular formulation produced a rather uniform turf quality over a relatively long period.

The nitrogen source from the plastic coated material is about 12% ammoniacal and 9% nitrate nitrogen. It is not possible to determine from the results of this trial whether or not nitrate nitrogen influenced the quality of the turf differently than the ammoniacal nitrogen.

Turfgrass quality appears directly related to the solubility of the IBDU over a period of time. Turf quality decreased with time in a near straight line relationship after reaching a peak one month after planting. Particle size will make some difference in the release of the nitrogen; that is the finer size will be more soluble. Of the two sizes available the finer was used in this trial. It is possible that the nitrogen may have been available for a longer period of time if the coarser material was used.

Turfgrass quality produced by the ureaformaldehyde, methylene urea, ammoniacal (2), chicken manure and the sewage sludges was similar although the peak quality varied somewhat. Sewage sludge (2) had an average p&k quality of about 7.3 and sewage sludge (14) rated 9.3 at its peak. The other four materials had a peak quality near 8. There appeared to be some nitrogen slowly releasing from the chicken manure and- ureaformaldehyde because the turf quality remained between 5 and 6 until May 1972 whereas quality dropped below 5 in the other materials during the period of November to January.

The results of this trial should only be interpreted in relation to the establishment and maintenance of perennial ryegrass on sand. In a heavier soil, such as a clay, nitrogen might leach more slowly. Likewise, when grown in sand, a slow gerinating variety like Kentucky Bluegrass may not make as efficient use of nitrogen fertilizers applied at planting as would perennial ryegrass, a much faster germinating species.

FIG 1

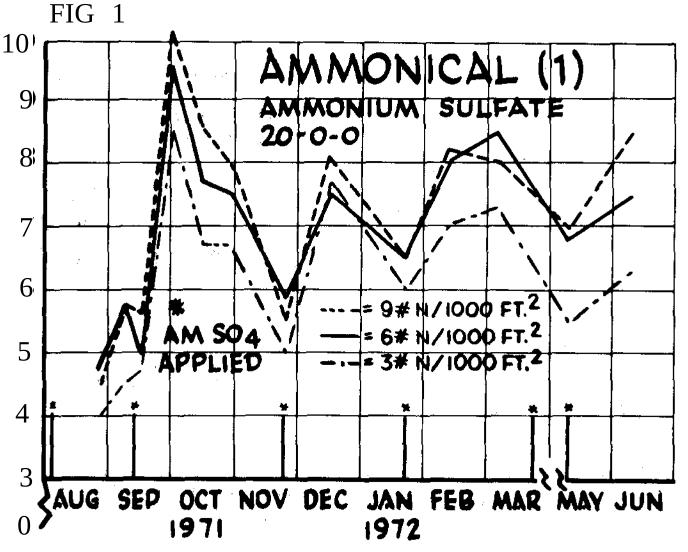
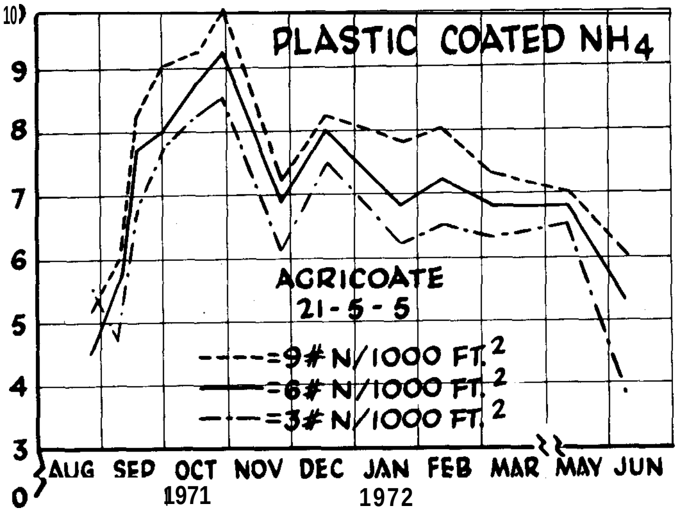


FIG 2



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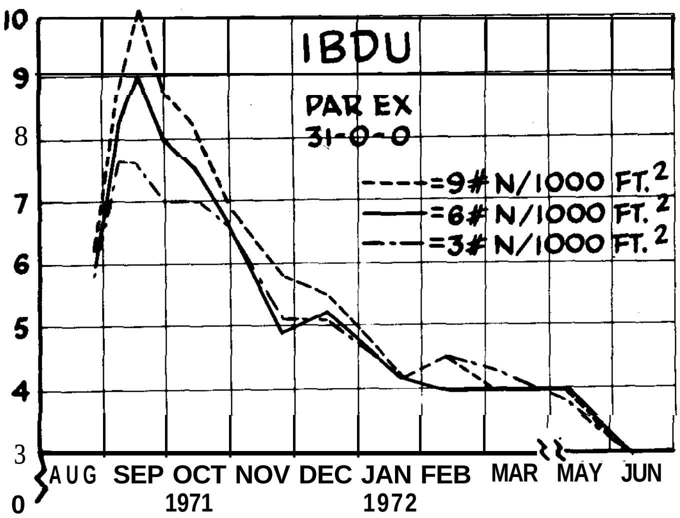

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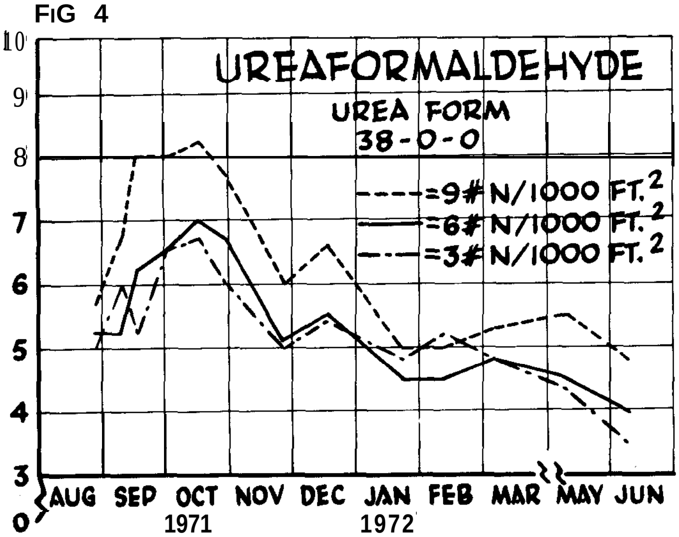

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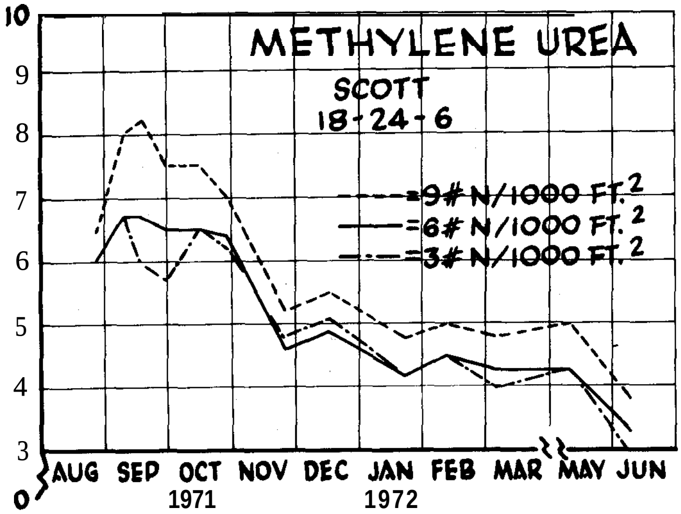

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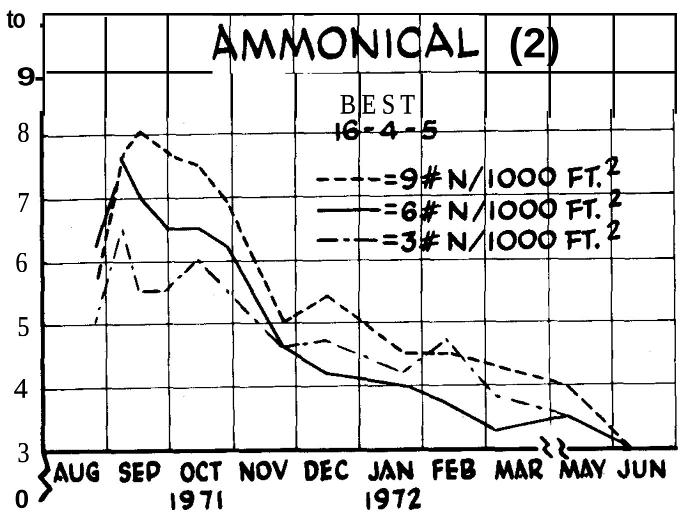

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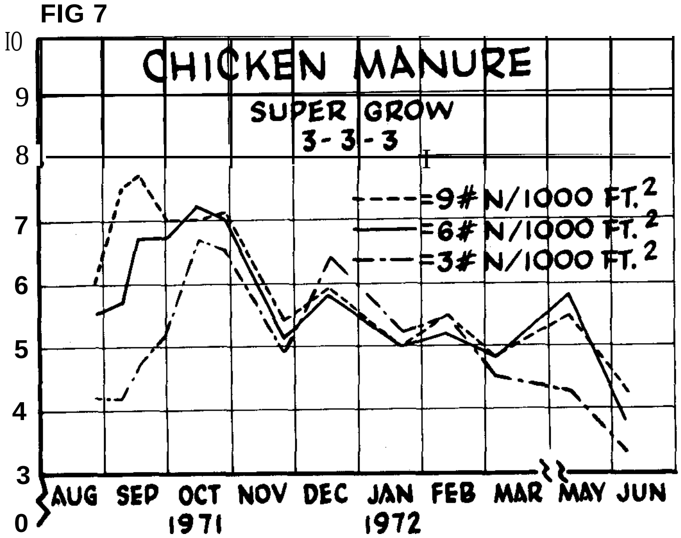
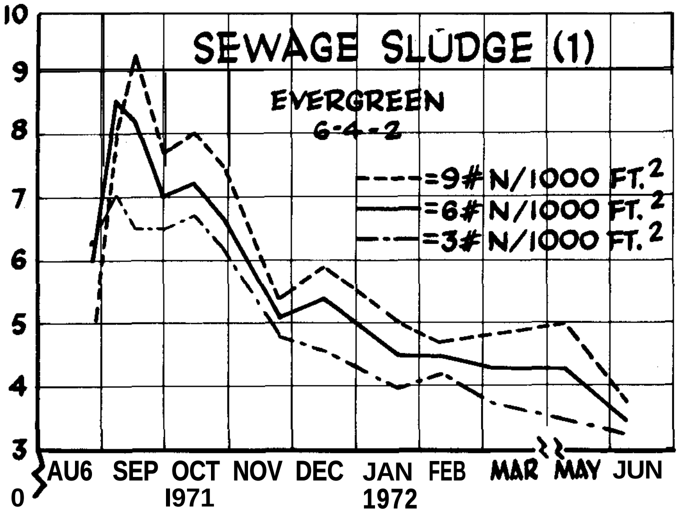


FIG. 8



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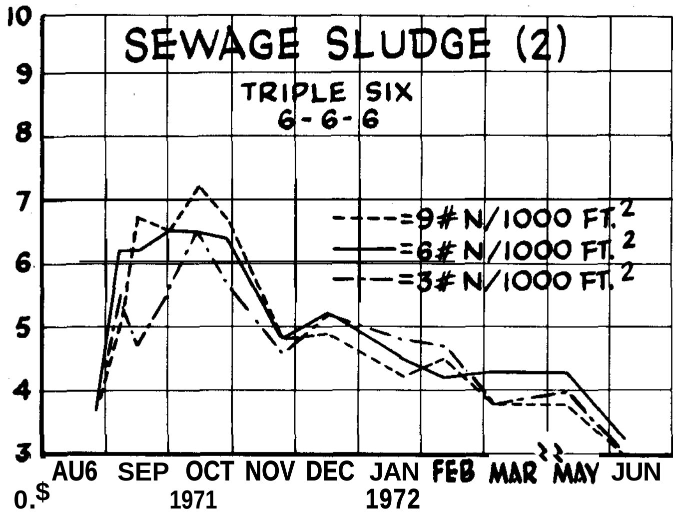

THE ART AND SCIENCE OF NITROGEN USE

By V. B. Youngner *

All turfgrasses display normal fluctuations in growth during the course of a year. These fluctuations are the result, largely, of changes in soil and air temperature, but day length is also a factor of importance. A good nitrogen fertilization program for turf should be designed to minimize these fluctuations while providing the desired turf quality throughout the growing season. Efficient nitrogen utilization must also be a goal since nitrate nitrogen leached below the root zone is not only wasted but may become a dangerous pollutant of ground water as well. A well designed program will attempt to stimulate growth of roots, rhizomes, stolons and tillers without the over-stimulation of leaf growth.

These objectives can be approached in several ways but only if the turf manager understands fully a number of relevant factors as they exist at his facility. The recommendations suggested by a fertilizer salesman or given on a fertilizer bag should be used by the turf manager only as a base from which to formulate his own specific fertilization programs.

Grass Species and Fertilization Practices.

Cool season and warm season grasses differ markedly in their growth behavior, therefore, nitrogen fertilization programs should be developed accordingly. Cool season grasses produce a large flush of growth in late winter or early spring. If nitrogen is applied to coincide with this flush of growth large amounts of soft succulent herbage will result. This may be excellent if the grass is being grown for pasture but it is clearly undesirable for turf. Only small amounts of nitrogen should be applied at this time if turf color indicates a need. Delaying the application until this first flush has subsided will be of greater benefit. The amount of clippings removed will be less while tiller and root initiation which occurs at this time will be stimulated. Removal of large amounts of top growth at one time has been shown to retard both tiller and root development so it should be avoided as much as possible. Thus, providing adequate but not excessive nitrogen through the spring months will develop a strong cool-season-grass turf better able to survive the stresses of the hot summer weather to follow.

During the hot summer period root growth of cool-season grasses slows or stops and often death of existing roots may occur. Tillering is also reduced to a low level. Since respiration and top growth continues during this period, stimulation of additional soft top growth at this time can only be detrimental and may create conditions favorable for the development of some fungous diseases. Therefore, nitrogen application should be held to the minimum needed for acceptable color and growth until the cooler fall weather returns.

With the coming of fall cool-season grasses again produce a flush of growth but leaf growth is generally less than during the spring flush. Root initiation and growth is resumed and continues in most areas of California through the winter. Tiller development may also be strong on most cool-season grasses. Moderate amounts of nitrogen should be applied throughout the fall and winter but care must be exercised to avoid loading the soil with nitrogen that will become suddenly available with the return of warm spring weather.

Bermudagrass and other warm-season grasses begin growth slowly in the spring as the soil warms. Readily available nitrogen applied in late winter or early spring will accelerate their recovery and bring on an early greening. Extensive root growth occurs in the spring even though top growth may be slow. Stolon and rhizome initiation and development is at a high rate during the long days of late spring and early summer. Regular nitrogen feeding throughout this time will contribute to the development of a deep-rooted dense turf.

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These grasses produce their greatest top-growth during the warmest period of summer, Nitrogen applications at this time will usually lead to excessive clippings and a rapid accumulation of thatch so should be avoided. If nitrogen fertilization has been performed during the spring as described above. additional nitrogen should not be needed during this period.

In the fall. the period of good color can be prolonged by providing readily available nitrogen until such time that cold weather induces dormancy. This will be especially successful if thatch has been controlled or removed. Dormancy always develops earlier and appears more complete if the thatch is thick.

Several studies involving analyses of grass clippings indicate that turfgrasses use nitrogen, phosphorus and potassium in ratios varying from 3-1-3 to 5-l-2 (expressed as P_2O_5, and K_2O. This does not mean, however, that fertilizers conforming to these analyses should be used consistantly. Phosphorus and potassium needs are best determined by soil tests because large amounts of these elements may be retained in the soil for long periods of time. When these nutrients are required either spring or fall are excellent times for their application on cool-season grasses. However, a spring application is best for warm-season grasses since it coincides with or immediately precedes the period of maximum root and shoot growth.

That species and even varieties of a species differ in their nitrogen requirements is well established. A suggested ranking of common turfgrasses in this respect is shown in table 1.

TABLE 1

Comparative Nitrogen Fertility Requirements of Common Turfgrasses

Requirement	Turfgrass
Low	Zoysia
	Red fescue
	Tall fescue
	Meadow fescue
	St. Augustine grass
	Perennial ryegrass
	Kentucky bluegrass
	Common bermudagrass
	Improved bermudagrass
	Colonial bentgrasses
High	Creeping bentgrasses

Turf Use and Fertilization Practices.

That turf use determines to a great degree the nitrogen fertilization program is obvious, Greens, tees, fairways and decorative lawns will not be fertilized alike even if they are of the same grass variety in the same locality.

In California bentgrass greens will require 12 to 18 lbs. of nitrogen per 1,000 sq. ft. annually while a hybrid bermudagrass green may require even more. Bermudagrass fairways can be maintained in good condition with four to six lbs. of nitrogen per 1,000 sq. ft. annually. Bermudagrass tees may need six to ten lbs. per 1,000 sq. ft. while decorative lawns may be satisfactory with only four.

The principal reasons for these variations are the differences in intensity of use and management and the quality required by use. Golf greens for example must have a high shoot density to provide a good playing surface. High density requires high nitrogen levels. The close mowing with removal of clippings and the heavy traffic to which the putting green turf is subjected put additional stress on the grass plant increasing the demand for nitrogcn even further.

At the same time the combination of these factors has caused the root system to be shallow limiting the turf's ability to take up nutrients to that which it can obtain from the top two to four inches or possibly six inches of soil. Therefore, it is not only necessary to provide higher rates of nitrogen on greens but to provide the nitrogen in such a way that it is always available in proper amounts in this relatively shallow root zone. However, if too much is applied at one time injury will be more sever than it would be on a more vigorous fairway turf. An error which might go unnoticed on a fairway could be disastrous on a green.

Soils and Irrigation.

Soil characteristics and irrigation programs interact intimately to affect fertilization practices so they are best considered together. Efficient nitrogen utilization requires that lcaching be held to a minimum. At the same time if the soil lacks permeability salt accumulation may soon become a problem. Nitrogen loss through leaching is principally a product of soil texture, soil structure, precipitation (rainfall and irrigation water), solubility of the nitrogen carrier and the amount of fertilizer applied at one time.

Although sandy soils such as those manufactured for golf greens resist compaction they have poor nutrient retention properties. The addition of organic matter to the sand will improve the retention of some nutrients but the nitrogen leaching potential will remain high. Heavy applications of water to these soils will quickly carry soluble nitrogen out of the root zone except that which may be retained on the soil colloids as the ammonium ion. However, light frequent irrigations may lead to a salinity problem even on sands. Efficient and effective nitrogen fertilization of sandy soils can be achieved only through good water management and by following fertilization techniques which will approximate as closely as possible the nitrogen needs at any given time.

On clay soils the leaching problem is less severe but salt accumulation will be a greater danger simply because leaching is more difficult and capillary water movement to the soil surface is greater. Compaction of clay soils will lead to poor aeration characteristics which in turn will affect the grass roots reducing their ability to take up nutrients. Nitrogen fertility management on clay soils thus involves frequent aerification and occasional long slow irrigations. Of course, if subsoil drainage is poor even these practices will be ineffective.

Modifications necessitated by microclimate.

In planning fertilization programs the turf manager must consider the specific climate of each individual block of turf. A golf green located in a depression may have a much different climate from one on a knoll. Air drainage in the low spot will be poorer, huimidity may be higher, frosts may be earlier and more frequent. As a result the grass growth cycle will be modified and the disease hazard may be greater. Evapo-transpiration rates may be lower and dew formation may be more frequent, heavier and persist longer in low-lying areas. As a result the fertilization program must be changed from those areas on higher ground. On a golf course built on rolling terrain (as many are) each green, tee and fairway must be considered as a separate entity.

Nitrogen Carriers and Fertilization Programs.

Satisfactory nitrogen fertilization can be achieved with any of the common nitrogen fertilizer materials in most instances. However? it is necessary to understand the characteristics of each material and to use them accordinly. No material or formulation will work magic despite frequent claims to that effect. However, one may be easier to apply, safer, less expensive to use or more effective than another in anv given situation. For the consideration of program variations nitrogen carriers may be divided into three groups; immediately soluble, natural organic and synthetic organic.

Immediately soluble nitrogen carriers.

Included in this group are ammonium sulfate, ammonium nitrate, calcium nitrate and urea which is a highly soluble synthetic organic compound. These compounds provide the turf with readily available nitrogen, for the most part regardless of soil temperature. Hence, they are especially valuable for late fall, winter and spring fertilization.

Because of their high solubility these materials'have an especially high salinity potential; the danger of fertilizer burn is great. and they may contribute to later salinity problems. For the same reason the potential loss of nitrogen from leaching is greater than with other materials. Thcreforc, safe efficient nitrogen use requires that the soluble materials be applied in small amounts at rather frequent intervals. No more than one lb. of actual nitrogen per 1,000 sq. ft. of area should be applied in a single application. In many instances even lower rates are desirable. As a result labor costs may be high, but they will be at least partially offset by the lower cost per unit of nitrogen of the soluble carriers.

Labor costs can be practically eliminated if soluble materials are applied through an irrigation system. For this method to be successful the irrigation system must be well designed to give uniform coverage without runoff, and it should be constructed of corrosion resistant materials.

A turf manager can achieve maximum control of his nitrogen fertilization program through the use of soluble materials. Since the nitrogen is immediately available he can apply just the amount needed at any given time. There will not be large amounts of residual nitrogen in the soil stimulating growth at a time when it is not desired, for example during a long period of high temperatures. In this way nitrogen fertilization may be timed with the growth phases of the grass to help achieve a particular result. Fall applications of soluble materials are especially good for prolonging color of warm-season grasses since they are unaffected by the gradual reduction of soil temperature.

Natural organic nitrogen carriers.

The principal natural organic materials are the activated and digested sewage sludges although certain animal by-products may be used occasionally. Practically all the nitrogen in these carriers is unavailable until nitrification by soil microorganisms takes place. Since all the nitrification does not occur at one time the nitrogen becomes available to the turf slowly. This characteristic makes it possible to apply larger amounts of nitrogen in one application without burning than is possible with the soluble materials. Thus labor costs are lower.

The natural organic provide varying amounts of phosphorus, ,potash and micronutrients as well as nitrogen. However, the total amount of nutrients may be rather low necessitating the handling of a fairly large volume of material to provide the desired level of nitrogen.

The safety in application may be partially offset by the fact that the manager loses some of his nutritional control as a result of the slower release of nitrogen. This may not be too serious if the amount of material applied in a single application is not excessive. Natural organics function best when soils are warm with high microbial activity.

Synthetic organic nitrogen carriers.

Two types of carriers fall into this group, urea formaldehyde and I B D U (isobutylidine durea) . Ureaformaldehyde (commonly called ureaform or U F) is manufactured by reacting synthetic urea with formaldehyde to produce a plactic-like substance which must be nitrified by soil microorganisms for the nitrogen to be made available to plants. The rate of nitrogen release can be regulated to some degree in the manufacturing process. The total nitrogen in a U F fertilizer is approximately 38% a part of which may be as simple immediately available urea.

Since U F fertilizers are high analyses, light weight, slow release materials they combine easy handling, safety in addplication and low application labor costs. However, the cost per unit of nitrogen is much higher than that for the soluble carriers.

As with the natural organics the turf manager must sacrifice part of the control of his fertilization program when he chooses to use a U F fertilizer . Hs is less able to manipulate his nitrogen applications to achieve specific results as with the solubles. Mineralization (nitrification) of most U F occurs at the rate of only about 6% per month, therefore, it is necessary to maintain a fairly high residual level in the soil to have satisfactory turf fertilization. The need for this residual reduces further the manager's control of the nitrogen level at a given time. Microbial activity increases with soil temperature to an optimum, thus very little nitrogen is mineralized in a cold soil while too much could be released under some conditions in a warm soil. With experience a turf manager can learn how much U F to use and when to apply it for good results, but he must look ahead several months to the conditions which will then exist and the level of available nitrogen desired at that time.

Some of these problems mav less with I B D U since this material depends upon its solubility and the soil moisture content for release of its nitrogen. As long as soil moisture is maintained at the proper level for good turf growth adequate amounts of nitrogen will be released regardless of temperature. Thus a satisfactory fertilization program with this material will bc dependent upon a good irrigation program. Heavy winter rains may release fairly large amounts of nitrogen at a time when the turf's need may be low. Excellent results, nevertheless, have been obtained in fall and winter fertilization. The cost per unit is approximately that of U F which may eliminate much of the savings in handling and labor.

Other slow release nitrogen sources such as the resin and sulfur coated soluble materials and magnesium ammonium phosphate are available. These have been used with excellent results in other landscape plantings and in nursery production but have had only limited use in turf management.

Summary.

An exact recipe for turf fertilization cannot be provided nor is it desirable. A turf manager must formulate an individual fertilization program for each different area of turf under his care. This program must be based upon a careful study of all the factors that determine nitrogen requirements and nitrogen utilization and the characteristics of the various fertilizer materials available to him. This information must then be related to costs per unit of nitrogen, labor costs for application and storage and handling problems.

REFERENCES

Beard, Jame B. 1973. Turfgrass Science and Culture. Prentice Hall, Englewood Cliffs, N. J.

Madison, John H. 1971. Principles of Turfgrass Culture. Van Norstrand Reinhold, New York.

Madisdn, John H. 1971. Practical Turfgrass Management. Van Norstrand Reinhold, New York.

Hanson, A. A. and F. V. Juska (Ed.) 1968. Turfgrass Science. American Society of Agronomy. Madison. Wisc.

Shaw, E. J. (Ed.) 1968. Western Fertilizer Handbook. Soil Improvement Committee, California Fertilizer Association, Sacramento.

Youngner, V. B. and C. M. McKell (Ed.) 1972. The Biology and Utilization of Grasses.

CALIFORNIA TURFGRASS CULTURE

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CALIFORNIA TURFGRASS CULTURE is sponsored and financed by the regional Turfgrass Councils and other turf/landscape organizations. Subscription to this publication is through membership in one of the councils listed below.

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Secretary .... James Papulas

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