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## Spring 1974

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**Authors**

J. L. Williams, M. A. Ross, T. T. Bauman, William Spence, D. S. Ralston, W. H. Daniel, and Rollie Henkes

# TURF BULLETIN

MASSACHUSETTS TURF  
AND LAWN GRASS COUNCIL  
I N C O R P O R A T E D

*Featured in this issue:*  
**Is it Really Herbicide Injury?  
Replenishing our Drinking  
Water Supply**



**SPRING 1974  
CONFERENCE ISSUE**

**BETTER TURF THROUGH RESEARCH AND EDUCATION**

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## Is It Really Herbicide Injury?

By J. L. Williams, M. A. Ross, and T. T. Bauman

Many people, including weed scientists, are often called upon to investigate herbicide injury to plants. Herbicides may or may not be the cause of the injury symptom. The person examining the plants for injury symptoms needs a broad background of knowledge and must keep a number of points in mind.

Don't forget that many things can cause the same gross symptoms on plants. For example, several plant diseases and herbicide injury symptoms are often confused. Tobacco Mosaic Virus, for example, can be confused with leaf abnormalities caused by 2,4-D. Stunted top growth of nematode infested plants can give a similar appearance to several herbicides that also prune plant roots. And why shouldn't they? They are doing the same thing to the roots and therefore causing the same type of stunting condition.

Inefficiency of several essential elements can cause chlorosis very similar in nature to several of the herbicide symptoms. Try to distinguish between manganese deficiency on soybeans and the photosynthetic inhibitors some time. Both give a very similar chlorotic pattern. On the other hand excessive amounts of certain nutrients such as ammonium nitrate will cause burning and necrosis of the leaf tissue and could be confused with the contact herbicides.

Weather plays an important part in evaluation of injury. Extreme low temperatures can damage the plant (frost injury) as well as high temperatures. An extreme moisture condition, either drought or excessive moisture, can cause symptoms, such as leaf curl, which sometimes are confused with herbicides, not to mention other acts of God, such as hail and lightning damage. Air impurities cause more severe injury than one thinks and then don't forget the mechanical injury (Figure 2). This not only includes such things as the cultivator, harrow, rotary hoe but ground hogs, ground squirrels, and insect feeding.

Don't overlook the possibility of other pesticides as well as herbicides causing the plant injury.

### SOME POSSIBLE CAUSES OF HERBICIDE INJURY

Whether soil applied or foliage applied, we can still categorize all the probable causes of herbicide injury into three general divisions.

**1. Incorrect application.** This is generally related to drift to non-target organisms either by ground or aerial applications and misapplication of dosage. This misapplication of dosage can be related to several things such as equipment malfunction, addition of the wrong amount of material to the spray tank, applying the wrong quantity



Figure 2. Mechanical damage to corn.

of water, lapping the spray boom, running the sprayer too slow, having the wrong nozzle, using the wrong pressure, etc.

**2. Intolerance to certain crops.** This can happen even though the material is labeled for use on the specific crop because certain herbicides have narrow margins of crop tolerance and under specific conditions can cause injury. If the margin of tolerance is narrow enough, weather and soil factors within a given field may vary the tolerance enough to cause problems.

**3. Excessive residue present in the soil.** This generally implies a residue present in the soil at the time a sensitive crop is grown in rotation. This usually is related to soil type, rate and time of application, weather conditions, and sensitivity of the crop to the herbicide.

### IF IT IS HERBICIDE INJURY

It is an impossibility to know all the subtle differences of all of the symptoms caused by a particular herbicide; however, an understanding of the more general and prominent characteristics manifested by a herbicide or at least a group of herbicides is well within the realm of possibility.

Probably the best method of classification for purposes of discussion is by toxic effects or symptom expression on the plant. To set forth this type of characterization, we have broken down the herbicides into three general classifications. Do not be, however, misled by this oversimplification of symptom expression.

The first group is the **hormone or growth regulator** effects. This response is very similar to the natural growth regulating substance (auxins) which regulate the growth

The authors are specialists in weed science in Department of Botany and Plant Pathology, Purdue University.

(Continued from Page 3)

by a controlled change in their concentration in the plant. Similar damage, in corn or soybeans, for instance, can also be caused by virus disease (Figure 3). On the other hand, synthetic regulators upset the normal growth patterns at rates of application used in the field. Examples of these herbicides are 2,4-D, 2,4,5-T, 2,4-DB, 2,4-DP, silvex, MCPA, dicamba, and picloram.

Next is the group of **Chlorotic and Necrotic** effects. Here herbicides inhibit the formation of green chlorophyll in plant leaves causing them to be chlorotic or yellow. When the tissue dies, it is said to become necrotic (Figure 4). This group can be divided into three subgroups.

A. Chlorosis and Necrosis with a symptomatic pattern on the foliage. This includes such things as atrazine, simazine, propazine, diuron, linuron, etc.

B. Chlorosis without a distinguishing pattern (general chlorosis). Examples of this would include the organic arsenicals, amitrole, etc. These symptoms could also be caused, for example, by improper application of ammonia (Figure 5).

C. General necrosis (necrosis without a pattern). This would include such things as the borates, chlorates, paraquat, etc.

The third group would be the **herbicides that cause stunting**. This is a fairly general symptom that can be caused by several things. This symptom can be caused by cell-growth inhibitors that upset normal cell division, root inhibitors that prevent the uptake of some nutrient, etc. It includes EPTC, chlorpropham, butylate, trifluralin, nitalin, dalapon etc. However, this type of injury can be caused by cool, wet weather, for instance.

#### COMPLETE ANALYSIS OF YOUR PROBLEM!

Don't go off half cocked! Keep an open mind! Don't stretch your knowledge too far! One has to analyze the total situation. This means look at the roots as well as the tops and analyze all the possible situations that exist in the field. Keep a pocket knife handy. You may need it along with the hand lens. Check the field patterns and

Diagnosis is difficult, but here are some things to keep in mind when checking fields for possible injury from herbicide application.

- Look at roots as well as tops of the plants.
- Keep a pocket knife and hand lens handy.
- Check field patterns and time symptom appeared relative to the farming practice utilized.
- Look at type and position of symptom on the plant.
- Check weeds as well as the crop.
- Look for application errors such as dosage applied, equipment or technique utilized.
- Remember, all facts don't lie on the surface.

time the symptom appeared relative to the farming practices utilized. This may be a key in your determination of how things fit together. Look at the type and position of the symptom on the plant. This includes weeds as well as crops. Don't be partial to any plant, look at them all. If finally you suspect a herbicide, check this out so it can be prevented next time. Look for application errors such as the dosage applied, equipment or technique utilized. Take the back doorway for information if it is necessary. Sometimes all the facts don't lie on the surface.

When you use pesticides, understand all the characteristics for the specific chemical you are using. If one is not willing to read the label and spend some time understanding it, then for heavens sake don't use it. We have to assume some of the responsibility. After all, some benefits must have been derived from its use, otherwise you shouldn't have been using it.

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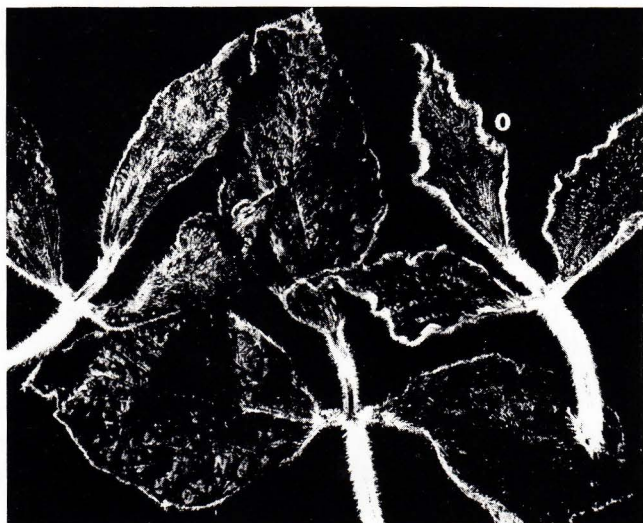


Figure 3. Damage to soybeans from, left, 2,4-D, and right, from Budblight virus.

# Replenishing Our Drinking Water Supply: A Major Step Forward—

By William Spence

With the advent of Rachael Carson's book "Silent Spring" in the early sixties, man has become increasingly aware of his environment. For years he has assumed access to seemingly infinite supplies of resources and land. As a result of an ever increasing rate of population growth, land availability as well as resources have appeared to shrink considerably. In fact, today we are on the verge of seeing the end of our life-sustaining elements.

Of course, one of our most crucial problems is that of drinkable water. We constantly draw on our water supply, using it, polluting it, and finally diluting it by dumping into the nearest lake, river, or stream. The resulting problem is that we are using it faster than the system can be replenished by natural means i.e. precipitation. In fact in many areas such as Pennsylvania, Massachusetts, and California there have been severe problems involving a declining water table. This can be illustrated easily with the example of a town having a population of 100,000 which relies solely on this groundwater source for water. The water is drawn up in wells, used in homes, sent to a treatment plant, and finally dumped into a body of water that will carry the waste away. It should be noted however that enough minerals do remain in the waste to cause profuse growth of aquatic plants and weeds. This results in eutrophication or the choking out of a stream caused by the respiring plants depleting the oxygen supply. So as this process continues the groundwater source steadily declines and other possible sources are destroyed.

One method of partially correcting this double disturbance of the environment is by recycling the sewage water. This could be accomplished by applying the mineral rich effluent to a crop land or forest and allowing the biological action of the biosphere (soil and vegetation) to purify the water before it reached the groundwater supply. Thus two things are accomplished: (1) the prevention of an otherwise harmful pollutant from reaching additional water supply areas and (2) the replenishment of the groundwater supply system. This, plus the added bonus of an irrigation medium that would contain vital plant nutrients including nitrogen, phosphorous, and potassium, makes this a project that is worth exploring.

### How the System Works

The removal of water polluting constituents from the effluent depends on three factors. They are: (1) the nature of the soil (structure, organic matter, etc.) (2) the type of vegetation (permanent or annual) and (3) the depth of the water table in relation to the soil surface.

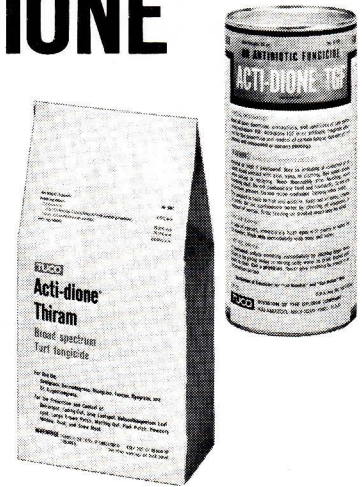
The soil must be a good medium for "fixing" the harmful nitrates, phosphates, and various other constituents within the effluent. This would rely on the ability of negatively charged (-) clay and humus particles to attract and hold a positively charged (+) cation such as an ammonium

(NH<sub>4</sub>) or potassium (K<sup>+</sup>) within the upper soil layers. In addition the microorganisms contribute to this process by consuming nitrates and in effect removing them from the applied waste water. To sum up, the soil by fixing or holding the polluting nitrates, phosphates, or other elements, purifies the waste water before it reaches the groundwater supply.

It is important to note that since surface run-off would be highly undesirable because of the polluting effect of sewage effluent, soil permeability is a crucial factor. The soil structure must be porous enough to allow penetration of sewage effluent at a rate slow enough for the activity of the biosphere to remove harmful minerals but it must also be fast enough to facilitate easy infiltration and minimal surface run-off.

(Continued on Page 6)

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(Continued from Page 5)

The other element of the biosphere essential for removal of pollutants from waste water is the vegetation present at the irrigated site. Simply, this can be thought of as either permanent or annual vegetation.

Permanent vegetation would include trees or a forestland and possibly a perennial grass. The chief advantage of having a perennial vegetation would be that the roots of the trees or grasses are in the soil year round. This allows for absorption of minerals from the soil to continue from early spring to late fall. Problems might occur, however, due to a self-servicing system of recycling nutrients by the forest. For example, the roots absorb nutrients from applied waste water, translocate these to an actively metabolizing area of the tree i.e., the leaves. In the fall the leaves drop to the forest floor, decompose, rendering these same nutrients available for tree use the following spring. So with many years of continued irrigation with nutrient bearing waste water forest sites might become overloaded to a point where trees no longer can utilize the additional nutrients. This situation might lead to considerably more leaching of nitrates into groundwater supplies thus defeating the purpose of the system.

Conversely, annual vegetation such as a crop site presents a different sort of dilemma. Under these conditions, a crop may be in the soil for as short a period as three months. Therefore irrigation would be feasible only during the time the crop was in the soil and actively removing nutrients. Consequently, some method of storage of the waste water would be required.

The advantage of irrigating a crop land is that true recycling can occur. Take for instance, a situation in which waste water is applied to a field of corn. The corn roots extract nitrates, phosphorous, potassium, etc. from the applied effluent and incorporate these elements into the various plant structures. Meanwhile, the now "purified" water reaches the ground supply in a drinkable condition and is thus ready for home use once again. The corn crop is harvested, consumed by cattle, the cattle by man, with the waste materials being sent to the sewage treatment plant and then pumped to the original site to be applied again. So in actuality the system involves a recycling of both the nutrients and water—a very desirable situation in lieu of the present stress on the environment.

The depth of the water table below the soil surface is another important consideration especially in selecting a site for irrigation with sewage effluent. The bulk of the biological activity takes place in the upper four feet of the soil which contains the roots, humus, microorganisms, as well as the best aeration. The distance between soil surface and water table may be thought of as a function of soil permeability. As is noted above, the effluent must be held in the soil long enough to allow for the removal of the pollutants before the waste water can reach the drinking supply. Failure of the biological processes to work adequately results in the polluting of the water table with these harmful constituents. Therefore a sandy soil

would demand a ground water system that is further from the soil surface than would a clay soil.

This has been only a very brief sketch of how the filtering process of the biosphere functions. To summarize: (1) Man draws on the groundwater supply for home use. (2) Addition of human and home waste pollutes this water. (3) The sewage waste is removed to the treatment plant where most of the pollutants are extracted. (4) However, enough ammonium, nitrates, phosphates, potassium, and other minerals do remain and can cause eutrophication of other water supplies if the waste water is dumped there. (5) The alternative to this is to use this effluent to irrigate a crop or forest and allow the biological action of the soil and vegetation to purify this waste so that it will reach the groundwater supply in a drinkable form. (6) Result: Prevention of stream pollution, rejuvenation of the drinking supply, and some fertilization of a crop or forest area.

#### Is This Feasible?

This is by no means a new procedure, only objectives have changed. Ancient civilizations used a similar method by fertilizing their crops with human waste material. Our aim today is not fertilization alone but rather—the rejuvenation of our depleting water supply that can no longer be recharged by natural means only. Pennsylvania, Michigan, New Hampshire, California, and Massachusetts are all turning to this method as a practical way in which to add water to the dwindling ground supply. Many problems do exist, however, and it would be unfair to ignore them.

First, enough land would have to be set aside as a suitable site for irrigation with waste water to occur. An area of one to two hundred acres would be enough to accommodate a town with a population of ten to twenty thousand. The site should be a combination of forest and crop land so that the advantages of both permanent and annual vegetation could be utilized with the greatest efficiency.

Second, the land should have a fairly low topography. Steep sloping hills would cause run-off and any sewage effluent finding its way to a stream or lake would nullify the benefits of the system. The soil at the area would have to meet specifications that were mentioned previously. The two most important being the ability of the minerals and organic matter to remove and fix the elements present in the effluent as well as the amount of pore space to ensure good penetration of the waste water. The distance from soil surface to water table must be adequate for purification to take place.

A third problem might be a method in which the effluent can be stored. There will be times when irrigation would be ineffective or undesirable, possibly after an extended rainy spell. Winter irrigation may be impossible, although a forested area could accommodate some winter applications of the sewage material. The construction of artificial ponds to facilitate storage may supply a solution here. However, consideration would have to be given to the cost of such a venture.



Exploration and experimentation remains to be done in the area of pathogenic organisms that are present in the effluent. Chlorination at the treatment plant is designed to remove 99.9% of the viruses, bacteria, and protozoa from the effluent. However, there is still the .1% that is present at the time of application to crops which could infect the plant and cause disease if consumed. This would be most hazardous in the case where vegetable crops were irrigated. Vegetables or other crops that are consumed raw, if infected, might cause the outbreak of a disease such as typhoid. So, obviously, this is one subject to be inspected very closely.

In this very brief report I have tried to illustrate one small step towards our harmonizing with the environment. I would like to stress that this is only a sketch of a system that is extremely complicated and intricate. To go into any detail on the subject would require much more

space than is allotted here. In fact, today there are volumes written on this subject.

Soon, additional exploration on this biological filtering process of sewage effluent will begin at the University of Massachusetts. Work has been going on at Penn State for some time with favorable results. Many communities already employ this as a way in which to replenish the ground drinking supply. Hopefully I've provided enough information here to present a general view of an attempt by man to bring to a halt the current resource crisis and to inform the reader of a system that may soon become widespread throughout the land.

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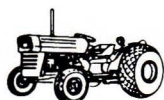
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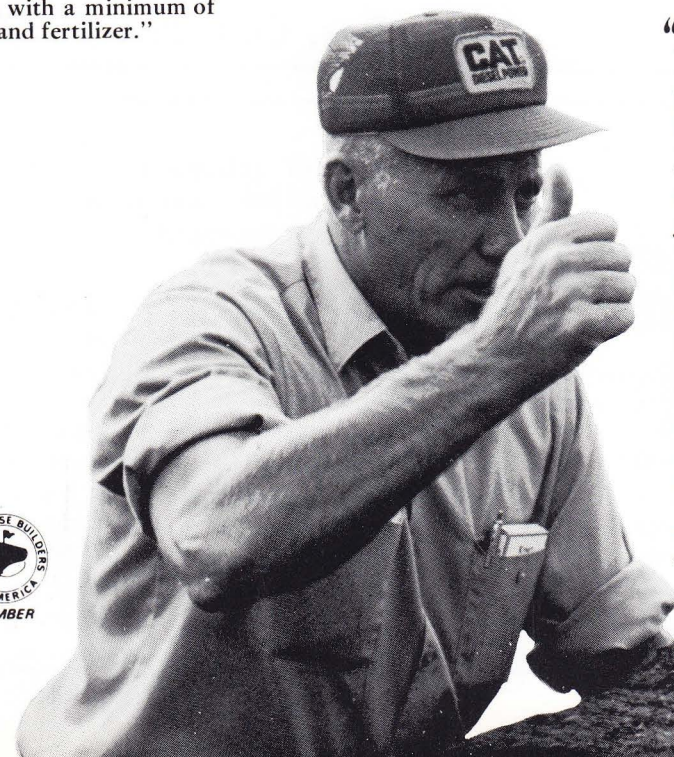
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## Nitrogen Supplies Are Going to Be Tight

That's the word from the TVA Bulk Blending Conference as experts warn bulk blenders will face some tough supply problems in future.

It was "Standing Room Only" at the TVA Bulk Blending conference held in conjunction with The Fertilizer Institute Trade Fair in Louisville last month. More than 800 attended the conference, with an estimated 1400 people at the Trade Fair.

John Mahan of USDA and Edwin A. Harre of TVA combined to present a detailed look at the supply situation for blending materials.

### THE NITROGEN OUTLOOK

They pegged ammonia production today at 14 million tons, reaching 14.7 million tons by 1975, if plants operate at 85% of capacity. Clouding the supply picture is the uncertainty of natural gas supplies for ammonia production. Other materials can be used for production of ammonia, such as partial oxidation of heavy oils and gasification of coal, "but cost of ammonia would increase."

Nitrogen supplies are going to be very tight, according to Mahan and Harre:

"Indications are that a 90% operating rate will not meet domestic demand after this year and that increased imports will be needed. With no new plant construction after 1975 and the 90% rate, by 1980 a trade deficit of over 4 million tons is indicated . . . Any future curtailment of production as low as the 80% level would mean sharp increases in imports if the demand projections are realized. By 1975 imports would be almost 18% of demand and could reach almost 50% by 1980."

There are strong arguments, these experts believe, for not allowing the U.S. to reach these levels of dependency for ammonia. "The potential trade deficits are shown to indicate the need for additional ammonia capacity beyond that which has been announced. Certainly, clarification of our future natural gas position and projected price

levels would allow these investment decisions—domestic vs. offshore production to be finalized."

### THE PHOSPHATE OUTLOOK

There could be real problems in the phosphate market, Mahan and Harre pointed out, problems of oversupply. They predict total  $P_2O_5$  use at 6.8 million tons by 1980. This could bring an oversupply situation if large-scale increases in capacity come into production as scheduled.

"If plants are to continue to operate at 90% of capacity or better, the U.S. will need to double its trade balance between now and 1975," they warned. "Or, without the increased trade level, reductions in operating rates or plant closures will occur."

There are several conditions that could prevent a repeat of the 1960's, Mahan and Harre believe: 1) Stricter pollution controls may force closures of older plants; 2) Phosphate rock mining capacity is not now adequate to supply all of the new phosphate plants and expand exports. About 10 million tons of new mining capacity would be needed to supply new units announced; and 3) Rock prices are up and the price at which phosphate rock is available has a direct bearing on the number of  $P_2O_5$  producers and their level of production.

While the figures indicate pending market chaos for the phosphate industry, "forces are at work which could make this an orderly expansion," Mahan and Harre noted. "This is especially true if more attention is paid to construction scheduling and if the forces of supply, demand, and price are allowed to function properly."

### THE POTASH OUTLOOK

The key to potash supplies is what happens in production controls. With total North American capacity more than twice the domestic demand it appears that some form of control will be needed for some time until domestic demand can catch up and orderly expansion of export markets can take place.

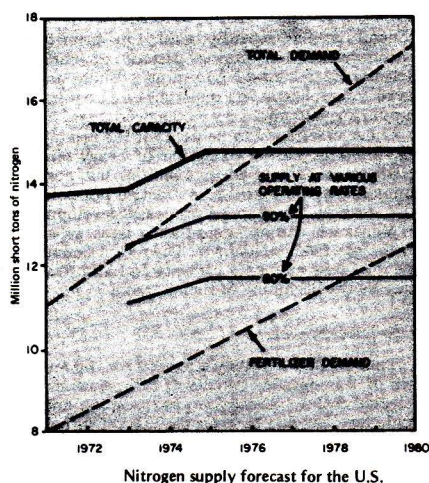
"It is apparent that there should be constant review of the quota system if supplies are to remain adequate," Mahan and Harre pointed out. "If the quota system remained at 50% of capacity trade would decline steadily and supply and demand would be equal by 1980. But, presently, North America exports about 1.5 million tons of  $K_2O$  each year; in order to continue this level, the operating rate will need adjusting upward, reaching 60% by 1976.

### PROSPECTS FOR BULK BLENDERS

Summing up future prospects for bulk blenders; Mahan and Harre said:

"From the supply side, it appears that blenders will have problems with nitrogen supplies while phosphate materials should be ample to meet future market growth.

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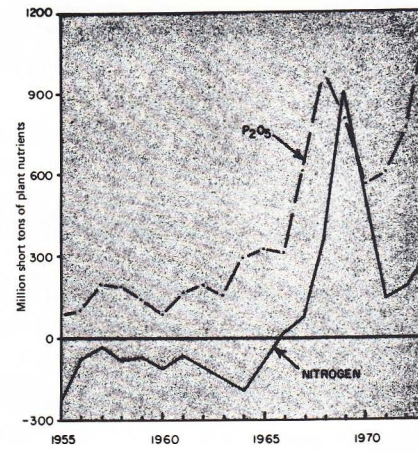
"The blender's major concern will be competition from other distribution systems. The large supplies of phosphoric acid scheduled for the market can end up in a blend plant, an ammoniation-granulation plant, or liquid mixed fertilizer operations. With little change in the level of production of ammoniation-granulation plants and the decline of low-analysis normal superphosphate grades almost complete, it all boils down to the relative merits of liquid mixed fertilizer production and handling versus dry bulk mixing and handling."

**NEW MATERIALS COMING**

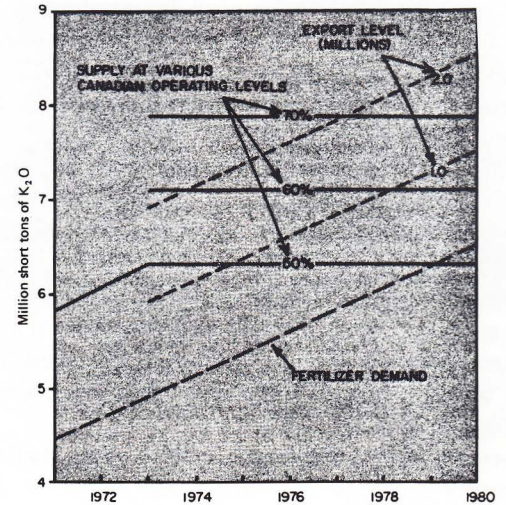
New materials for bulk blending soon to be available include granular urea, now being introduced by Agrico Chemical Co., according to a report by A. B. Phillips of TVA. Another related product is urea ammonia sulfate, being produced on a pilot-plant scale and scheduled for demonstration-scale production at TVA soon. Urea ammonium phosphates also have considerable potential for bulk blending; the 28-28-0 grade can be blended with urea, diammonium phosphate, triple superphosphate, and potash.

A new phosphate material soon to be available for bulk blending is ammonium polyphosphate made from merchant-grade wet-process phosphoric acid. Also, new technology in potassium phosphates may lead to early availability of a series of very high analysis P-K materials for bulk blending.

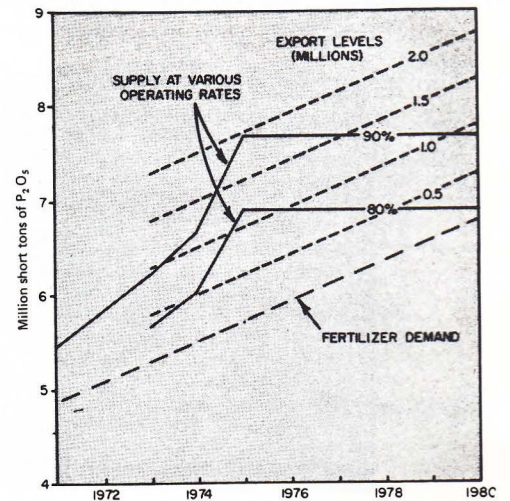
# Fertilizer Supply Outlook



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# Effect of Porous Rootzone Materials Underlined with Plastic on the Growth of Creeping Bentgrass (*Agrostis palustris* Huds)<sup>1</sup>

D. S. Ralston and W. H. Daniel<sup>2</sup>

## ABSTRACT

Recent developments in plastic barrier placement under compacted sand for regulated availability and retention of water (PURR-WICK Rootzone) raises questions of duration of availability. Creeping bentgrass (*Agrostis palustris* Huds) was studied under putting green conditions when grown on replicated 1-m<sup>2</sup> plastic-lined plots containing dune sand, mortar sand, calcined clay, diatomaceous earth, and peat. Soil was not included in any of the rootzone mixtures because of its inherent structural instability. In 1968 and 1969, some infiltration rates exceeded 150 cm/hr and all were greater than 7 cm/hr, therefore, water movement was considered ample.

The relative ability of the material in plots to retain moisture was measured by allowing the plots to dry-down for 15 days between rains during August 1968 and for 17 days during July 1969. No irrigation was added to any plot until turf showed severe wilt. Bentgrass on plots containing the finer fractions of the dune sand, diatomaceous earth, various mixtures of sand, calcined aggregates, and peat did not require water for either period.

Comparison of the dune sand treatments with and without subsurface irrigation showed that a constant moisture level could be maintained in the subirrigated plots. Depth ranged from 20 to 50 cm with 40 cm proving ample.

**Additional key words:** Perched water tables, Plastic barrier, Dew pattern, Zero tension, Pore space.

Effective methods of handling excess water on golf greens and tees have always been desired by those concerned with design and construction, but have not always been achieved. The problem arises when soil near the surface becomes so compacted that the movement of air and water into the rootzone is restricted. Compaction makes management difficult because excess wetness weakens the turf and makes it more susceptible to disease. Standing water also interferes with play.

Rootzones in athletic areas should permit rapid internal drainage yet have adequate moisture retention. Porous materials such as sand and calcined aggregate can be used to provide fast internal drainage; thus, the primary problem is one of retaining enough water so that a droughty condition is not created.

One way of accomplishing this retention is to place a plastic barrier at a desired depth to stop downward movement of water. A drain line above the plastic can be used to drain or regulate the water retention depth. Mois-

ture above the plastic can then become available to grass roots through capillary or wick action toward the surface. This type of rootzone is referred to as the PURR-Wick rootzone (2).

The objective was to determine what additives, if any, are needed with sand to provide a suitable rootzone material for turf. If soil, with its inherent fine silt and clay particles, is not included in the mix, the rootzone material can be firmed during construction and further compaction by traffic will not become the limiting factor to water movement into and through the rootzone. Therefore, the two parameters considered most important to this study were infiltration rate and moisture-holding capacity for the plastic-lined rootzone plots.

## LITERATURE REVIEW

The inability of most soils to withstand compaction due to traffic has stimulated much research on determining the approximate quantities of sand and peat to add to different soils to achieve a suitable rootzone material. Kunze, Ferguson, and Page (4) concluded that 85 to 90% of a uniform coarse sand should be added to a Houston black clay to reduce the effects of compaction. Swartz and Kardos (6) concluded that 70% of a medium sand should be added to a Chester silt loam soil, found in Pennsylvania, to achieve a suitable percolation rate under laboratory tests. After finding that soil mixtures with 80% sand could be compacted, Lunt (5) concluded that at least 85% sand is necessary for sand to form a stable framework in soil mixtures.

Waddington (7) provides an in-depth review of the literature concerned with the properties of soil and related problems that must be considered in soil modification work.

Bingaman and Kohnke (1) established criteria for sand selection for a structurally stable rootzone for athletic turf, concluding that the porous properties of a compacted sand can be predicted with reasonable accuracy from mechanical analysis data.

## METHODS AND MATERIALS

The experiments were conducted on a series of plastic-lined rootzone plots along the north side of the Purdue experimental putting green. The basic plot area was 1 m<sup>2</sup>; the plot profile was a 20-cm layer of test material over a 20-cm layer of local mortar sand over a double layer of 6-mil plastic sheeting extended to the surface on all sides of the individual plots. About half of the plots were provided with subsurface irrigation by connection

(Continued on Page 14)

<sup>1</sup>Journal Paper No. 4674, Purdue University Agricultural Experiment Station, Lafayette, Ind. 47907. Received March 3, 1972.

<sup>2</sup>Formerly Research Assistant (now Agronomist with Miller, Whiry & Brooks, Louisville, Kentucky) and Professor of Agronomy, Purdue University, Lafayette, Ind. 47907, respectively.

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### WEDNESDAY, MARCH 6

—Morning—

11:00 Registration—Lobby

—Afternoon—

### GENERAL SESSION Hall of Fame

Chairman: Mr. John O'Connell, Superintendent  
 Blue Rock Golf Club

1:00 Welcome  
 Dr. Joseph Troll  
 University of Massachusetts/Amherst

1:15 1973 Turf Problems in Review—  
 1974 Possible Remedies  
 Mr. Alexander M. Radko, Eastern Director  
 USGA Green Section

Panel—  
 Mr. George Thompson, Superintendent  
 Columbia Country Club  
 (Transition area)  
 Mr. John Martin, Superintendent  
 Shackamaxon Golf & Country Club  
 (New Jersey New York area)  
 Mr. Robert Grant, Superintendent  
 Brae Burn Country Club  
 (New England area)  
 Mr. William Burdick, Superintendent  
 Canterbury Golf Club  
 (Midwest area)

2:45 Break

3:00 Movement of Water to a Holding Pond  
 Mr. Anthony Caranci, Superintendent  
 Ledgemont Country Club

3:45 Maintenance of Low Budget, Short Season  
 Golf Courses  
 Dr. Vaughn Holyoke,  
 University of Maine

4:30 Massachusetts Turf and Lawn Grass Council  
 Membership Meeting

4:45 UMass Turf Alumni Meeting

—Evening—

Free—A good time to look up old friends.

### THURSDAY, MARCH 7

—Morning—

### GOLF COURSE SESSION Hall of Fame

Chairman: Mr. Tom Curran, Superintendent  
 Eastman Golf Courses

9:30 Turfgrass Fertilization  
 Dr. J. C. Harper II  
 Pennsylvania State University

10:15 Determining Turfgrass Fertilization Needs  
 Dr. F. M. Wray  
 Nova Scotia Agricultural College

11:00 Shortage of Plant Food and How to Adjust  
 to Supply and Cost  
 Mr. William Fines  
 Corenco

11:45 Lunch

—Afternoon—

1:00 Tri-Calcium Arsenate—Use and Abuse  
 Dr. Robert C. Carrow  
 University of Massachusetts/Amherst

## Panel—

## —Afternoon—

- |      |   |      |  |
|------|---|------|--|
|      | Mr. Thomas Rewinski, Superintendent<br>National Golf Links of America   | 1:00 | Transition from Natural to Artificial Turf<br>Mr. George Toma, Director of Field and<br>Landscaping, Arrowhead and Royal<br>Stadiums |
|      | Mr. Leon St. Pierre, Superintendent<br>Longmeadow Country Club  |      |  |
|      | Mr. Melvin B. Lucas, Jr., Superintendent<br>Garden City Golf Club   |      |  |
|      | Mr. Joseph Flaherty, Superintendent<br>Baltusrol Golf Club  | 1:45 | Plant Materials for Outlying Areas<br>Prof. John M. Zak<br>University of Massachusetts/Amherst                                       |
|      | Mr. J. R. Bone, Manager Field Develop-<br>ment<br>Rhodia  | 2:30 | Break  |
| 2:30 | Operating and Maintaining Municipal Golf<br>Courses<br>Mr. Gregg Deegan, Superintendent<br>Unicorn Golf & Recreation Area | 2:45 | Maintenance of University Grounds<br>Mr. Jack Moodie, Superintendent<br>Springfield College  |
| 3:15 | Break   |      |  |
| 3:30 | Maintenance of High Budget Course<br>Mr. Edward C. Horton, Superintendent<br>Winged Foot Golf Club                        | 3:30 | Maintenance of Industrial Sites<br>Mr. George Moore, Manager, Grounds<br>Massachusetts Mutual Life Insurance Co.                     |
| 4:15 | Maintenance of Multiple Golf Courses<br>Mr. Richard Silvar, Superintendent<br>Pinehurst Golf Club                         |      |  |

—Evening—  
Room ABC

- 7:00 Banquet  
Astrology & Humanism  
Frances Sakoian

## FRIDAY, MARCH 8

GOLF COURSE SESSION  
Hall of Fame

## —Morning—

Chairman: Mr. John O'Connell, Superintendent  
Blue Rock Golf Club

- |       |  |
|-------|--|
| 9:30  | Turfgrass Diseases and Systemic Fungicides<br>Dr. Houston B. Couch<br>Virginia Polytechnic Institute and State<br>University |
| 10:15 | A Look at the Future<br>Mr. Mike Sheridan, Facility Development<br>Consultant<br>National Golf Foundation                    |
| 11:00 | Watering of Golf Course Turf<br>Mr. William H. Bengueyfield, Western Di-<br>rector<br>USGA Green Section                     |
| 11:45 | Cost of Living Is Going Up—and So Is Grass<br>Seed<br>Mr. Robert J. Peterson<br>E. F. Burlingham & Sons                      |

## ALTERNATE SESSION—

Those not interested in golf course maintenance can  
attend the Alternate Session on general turf management.

## THURSDAY, MARCH 7

## —Morning—

ALTERNATE SESSION  
Room ABC

Chairman: Mr. Charles Mruk  
Hercules Inc.

- |       |  |
|-------|--|
| 9:30  | Trends in Agricultural Education and Where<br>Are the Emphases<br>Dr. John Denison, Dean<br>Stockbridge School of Agriculture                        |
| 10:15 | Maintenance of Municipal Parks and Recrea-<br>tion Areas<br>Mr. Baldwin Lee, Superintendent<br>Springfield Department Public Parks and<br>Recreation |
| 11:00 | Maintenance Grass Tennis Courts<br>Mr. Joseph Leander, Superintendent<br>Newport Casino  |
| 11:45 | Lunch  |

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(Continued from Page 13)

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(Continued from Page 11)

of the drain lines to float chambers outside the plots so that the level of water stored above the plastic sheeting could be regulated.

The materials studied can be divided into sand and calcined aggregate plots. The Lake Michigan dune sand was wind separated into three fractions (Table 1) to study the effect of particle size on moisture retention.

**Table 1. Source and mechanical analysis data for materials studied.**

Material and source	Particle size, mm						
	<0.053	0.053-0.125	0.125-0.250	0.25-0.50	0.5-1.0	1.0-2.0	2.0-4.0
<b>Calcined aggregates</b>							
a) Calcined clay (C. C.) "Terra-green Oil Dri Co., Chicago, Ill.	0.1	0.2	0.4	0.9	19.0	67.6	12.1
b) Diatomaceous earth, "Dialoam" Eagle-Picher Co., Cincinnati, O.	0.1	0.2	0.4	0.9	19.0	67.6	12.1
	0.2	0.2	0.3	1.6	29.3	48.0	20.3
<b>Mixtures, %</b>							
Calcined aggr.	Sand	Peat*					
80	0	20	0.4	0.6	1.1	3.0	18.0
60	20 Dune	20	0.4	0.6	31.2	22.8	15.4
40	40 Local	20	0.8	2.4	13.2	19.3	38.3
<b>Sand</b>							
a) Local mortar (I.S.) Lafayette, Ind.	0.6	1.1	8.8	34.6	34.8	18.4	1.7
b) Dune (D.S.) Michigan City, Ind.	0.0	0.4	38.9	59.5	1.2	0.0	0.0
<b>Dune sand fractions†</b>							
	Particle size, mm						
	.12-.15	.15-.21	.21-.30	.30-.42	.42-.71		
	% by weight						
Course	--	13	30	46	11		
Medium	--	34	56	10	--		
Fine	3	73	24	--	--		

\* Furnished by Milburn Peat Co., Otterbein, Ind., then air dried and ground.  
† As separated by wind.

All plots were seeded with 'Penncross' bentgrass, and all were managed alike except during the dry-down experiments. All were mowed about four times a week at a height of 1 cm, fertilized as needed with complete turf fertilizer, and sprayed for disease and insects in a preventative program. The amount of putting on the green would be considered average, consisting mainly of physical education classes during the day and students during the evening hours.

Infiltration rate was measured on selected plots using the double-ring infiltrometer with rings of 20- and 40-cm diameter. Plots to be measured were watered heavily prior to measurement to establish uniform conditions. Before each measurement was started, at least 5 cm of water was added to the plot through the center ring. The infiltration rate for each of two 30-min time periods was determined for each plot. Water was maintained at approximately 3 cm head by addition of water at a controlled rate.

The ability of the plots to retain water after drainage was determined by permitting the plots to dry-down between rains in August 1968 and July 1969. The plots were rated each afternoon for degree of wilting on a scale of 1 to 9 in which 1 to 2 was normal growth, 3 to 5 showed foot-printing, 6 to 8 was blue wilt, and 9 was severe wilt. As each plot reached 9, it was individually watered to prevent turf failure. In addition to visual ratings, the experiment conducted in July 1969 included moisture content measurements with the Troxler Surface Neutron Gauge, Model 105-217, in conjunction with a Troxler Portable Scaler, Model 200 B.

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RESULTS AND DISCUSSION

General Observations

The general condition of the plastic-lined test plots during the summer months with regard to maintenance and playability was satisfactory. Little difference in appearance between plots was apparent when all were managed for top performance. The test pilots were fertilized about every 3 weeks with a complete turf fertilizer, so that a total of about 3.8 kg/100 m<sup>2</sup> (8 lbs/1000 sq. ft) was applied during the growing season. The fertilizer rate needed to maintain a good color for Penncross on the sand and calcined aggregate plots was higher than the 2.9 KgS/100m<sup>2</sup> rate needed for turf grown in silt loam soil in the center of the green. The significant factor here is that the fertility level in the test plots could be adjusted to obtain the desired growth and color of bentgrass, but the physical structure of the silt loam soil could not easily be altered to improve water movement into and through the rootzone.

The disease susceptibility of Penncross on the test plots was about the same as on the rest of the green. Cup cutting in the porous materials was not a problem if the material was in a moist condition. The vigorous root system in the surface 20 cm for moist plots tended to hold the loose material together, aiding in cup cutting.

Winter frost heave varied from near 0 for the 100% dune sand plots to as much as 15 cm for the 100% Dialoam plots. The dialoam in high percentages over plastic showed severe frost heave due to low bulk density, which reduces heat transfer, and high moisture transfer rate within the material. Moisture moved from pores deep in the rootzone to the surface, where it would freeze and form long ice crystals. The ice would lift the turf off the plot as much as 10 to 15 cm by late winter, resulting in an uneven surface after thaw. Slight frost heave was noted for the calcined clay plots.

An infiltration rate of 2.5 cm/hr is considered adequate by many persons working with turf (3). Higher infiltration rates have been discouraged by some because they are synonymous with droughty conditions.

Water movement into the through the coarse-textured rootzone materials appeared adequate for all test plots. Infiltration rates for the plots, as measured in both 1968 and 1969, were all greater than 7 cm/hr. Even with the high infiltration rates of between 7 and 50 cm/hr found for the materials used in this study, the moisture reserve was good for most of the plots, as shown by the dry-down experiments.

Dry-down I — 1968

The first dry-down experiment was initiated following a 5.7-cm rain on August 16, 1968 that saturated all plots. The experiment was terminated on August 31 due to rain after 15 days of hot, dry weather as shown in the weather data presented in Table 2. The data show that the first 9 days of the experiment were considerably warmer, with temperatures in the high 20's and low 30's, than the last 6 days in which the maximum daily temper-

Table 2. Weather data during dry-down experiments.

Days	Dry-down I					Dry-down II				
	Date	Air temp,* C		Precip†, cm	E-T‡, cm	Date	Air temp,* C		Precip†, cm	E-T, cm
		Max	Min				Max	Min		
	August, 1968					July, 1969				
0	16	30	20	5.69	--	8	25	17	5.33‡	--
1	17	32	18	0.0	0.41	9	23	16	0.0	0.10
2	18	29	17	0.0	0.36	10	28	19	0.0	0.18
3	19	31	20	0.0	0.36	11	31	20	0.66	0.36
4	20	32	23	0.0	0.53	12	31	18	0.0	0.46
5	21	33	22	0.0	0.46	13	31	18	0.0	0.58
6	22	34	23	0.0	0.41	14	30	17	0.0	0.51
7	23	30	22	0.0	0.41	15	30	17	0.0	0.46
8	24	33	23	0.0	0.46	16	30	18	0.0	0.53
9	25	32	16	0.0	0.66	17	34	20	0.0	0.51
10	26	25	10	0.0	0.41	18	32	22	0.0	0.43
11	27	21	6	0.0	0.33	19	33	19	0.32	0.56
12	28	21	7	0.0	0.53	20	30	21	0.0	0.36
13	29	23	9	0.0	0.33	21	28	17	0.0	0.28
14	30	24	9	0.0	0.30	22	30	19	0.0	0.33
15	31	26	13	0.13	0.25	23	30	17	0.0	0.41
	September, 1968					24	31	18	0.0	0.41
16	1	--	--	0.56	--	25	29	15	0.0	0.30
17	--	--	--	--	--	Avg	30	18	--	0.40
18	--	--	--	--	--					
Avg		28	16		0.40					

\* Data from Agronomy Farm weather station (6 miles NW of plots). † E-T values reported are 0.80 pan evaporation. ‡ Data from rain gauge on experimental green. § Total precip. for 4-day period of July 4 to 8, 1969.

atures were 20 to 30 C. The hot weather during the first 9 days resulted in high daily evapotranspiration (E-T) rates of between 0.36 and 0.66 cm/day, and the total E-T for the 15-day period was 5.99 cm (2.36") or 4 mm/day.

Comparison of the daily wilt ratings for the separates of Lake Michigan dune sand treatments in Fig. 1 shows the difference in water storage for the different size fractions. The smaller pores in the finer sand retained sufficient water after drainage stopped to supply the turf needs for the entire 15-day period. In contrast, the coarser/medium plots showed blue wilt and had to be watered by the 13th day to prevent death. The medium dune sand plots showed no moisture stress during the 15-day period. However, where 10 cm of medium sand was placed over 10 cm of finer sand, the plots showed severe wilt by the end of the test period, indicating reduced moisture movement into upper coarser sand, where most roots tend to be.

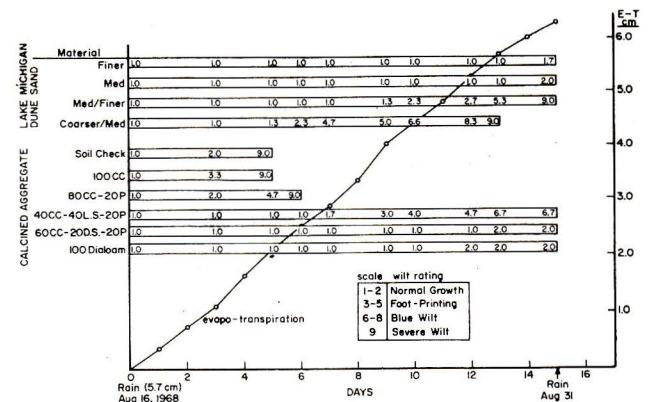


Fig. 1. Cumulative evapotranspiration curve and wilt rating for dry-down I, 1968.

The bentgrass on the silt loam soil in the center of the green showed foot-printing on the 3rd day after the rain. By the 5th day nearly all of the soil areas required watering to prevent complete loss of turf.

The plastic-line calcined aggregate plots showed striking differences in the number of days to severe wilt.

(Continued on Page 17)

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(Continued from Page 15)

The 100% calcined clay plots showed wilt by the 3rd day and severe wilt by the 5th day. Where 20% peat by volume was added to the calcined clay in the surface 20 cm, the plots did not show severe wilt until the 6th day. Where either dune or local mortar sand was added to the calcined clay and peat, the plots showed no severe wilt during the entire 2-week test period. It is interesting to note that the plots that contained 20% dune sand had lower wilt rating averages than did the plots that contained 40% of the somewhat coarser, less uniformly graded local mortar sand. All the plots that contained Dialoam showed good moisture-storage throughout the test period, as indicated by their turgid growth.

During the first dry-down experiment, it soon became evident that the morning dew and guttation pattern was a good indicator of moisture stress. Plots that did not have dew in the morning were the ones that showed wilt stress in the afternoon. Thus, soil water availability to the roots could be correlated to morning dew and guttation pattern.

Figure 2 shows the dew pattern for the test plots on the 5th day of the 1968 experiment. The three plots without dew at the bottom of the picture are the 100% calcined clay plots. In the afternoon of the day the picture was taken, these plots showed severe moisture stress and were watered. The three plots with the light dew patterns immediately above the dry plots are the 80% calcined clay-20% peat plots; they required watering the day after the picture was taken (6th day). Those plots with the heavy dew patterns including the 100% Dialoam, 80% Dialoam-20% peat, dune sand, or local mortar sand with calcined aggregate and peat did not require water for the entire 15-day test period.

The turf grown on soil in the center of the green (right-hand side of photograph) had only a very light dew pattern. The area showed severe wilt later in the same day and required irrigation.



Fig. 2. Morning dew and guttation pattern on the 5th day of dry-down I, 1968.

#### Dry-down II — 1969

During a second dry-down experiment in July 1969, the plots were rated visually; in addition, the decrease in moisture content with time was measured with the surface neutron meter.

The weather data in Table 2 show that the rain that saturated the plots came over a 4-day period, so there was no quick change from wet to dry conditions. The evapotranspiration rates for the first 2 days were low (0.10 and 0.18 cm) due to overcast conditions; they then varied from 0.28 to 0.58 cm per day for a total of 6.76 cm for the 17-day period.

Showers on July 11th of 0.66 cm and on July 19th of 0.32 cm increased the total number of days to wilt for the plots.

The length of the horizontal bar graph and the average wilt ratings in Fig. 3 show the relative differences for the various treatments. Data for the dune sand plots show that the moisture reserve was greater for the finer frac-

(Continued on Page 18)

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(Continued from Page 17)

tion than for the medium or coarser fractions. The finer fraction showed foot-printing by the 15th day and blue wilt by the 17th day. Both the medium and medium/finer treatments had approximately the same wilt ratings and both had to be watered on the 15th day. By comparison, the coarser fraction showed foot-printing on the 9th day, and needed water by the 11th day to prevent complete loss of turf.

Moisture data, as measured by the surface neutron meter, for the unwatered dune sand plots is presented in the bottom four curves in Fig. 4. The F test for the unwatered dune sand plots was highly significant (0.01 level of confidence), with an LSD of 3.67%.

The volume moisture content range was 14 to 2% for coarser/medium treatment, 17 to 3% for medium, 23 to 5% for the medium/finer. The difference between medium and finer sands was significant on all days.

**Subsurface Irrigation**

The water table of the subsurface irrigated plots was maintained at approximately 30 cm below the turf surface by means of a float control chamber outside the plots. Moisture data presented in Fig. 4 show that moisture remained rather constant throughout the 17-day period. The bentgrass turf showed adequate turgidity at all times.

The moisture content at 0- to 5-cm depth for the subirrigated plots remained within the range of 21 to 30%, com-

pared to the steady decrease for the unwatered plots. The data show that subsurface irrigation can provide a means of supplying the evapotranspiration needs of putting green turf for an extended period of time.

In 1969, bentgrass on the soil area in the center of the green showed stress after 7 days and was watered on the 9th day, as shown in Fig. 3. The moisture content for the soil varied from 22.4 to 10.3% (Fig. 5). The bentgrass on soil

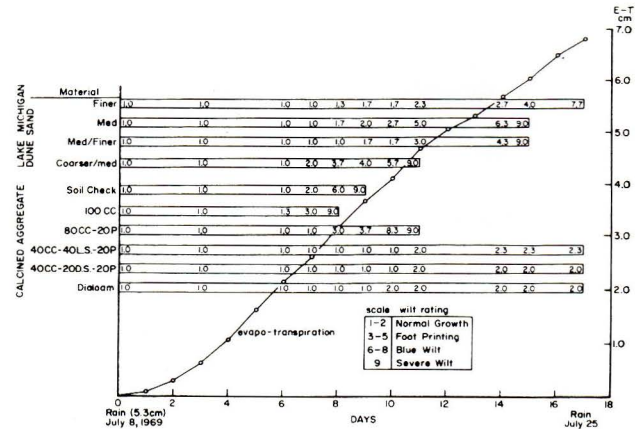


Fig. 3. Cumulative evapotranspiration curve and wilt ratings for dry-down II, 1969.

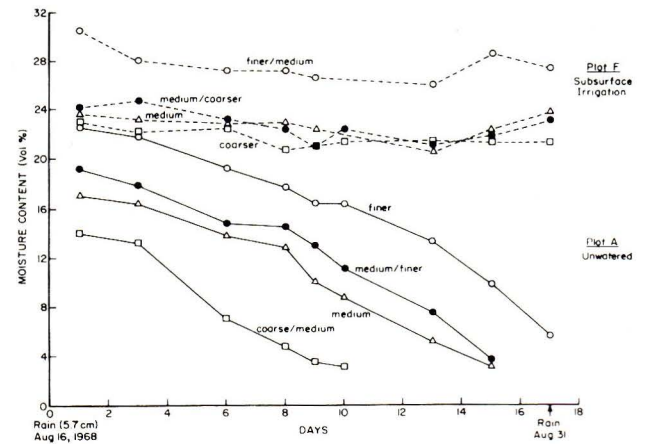


Fig. 4. Comparison of moisture contents for dune sand treatments during dry-down II, 1969.

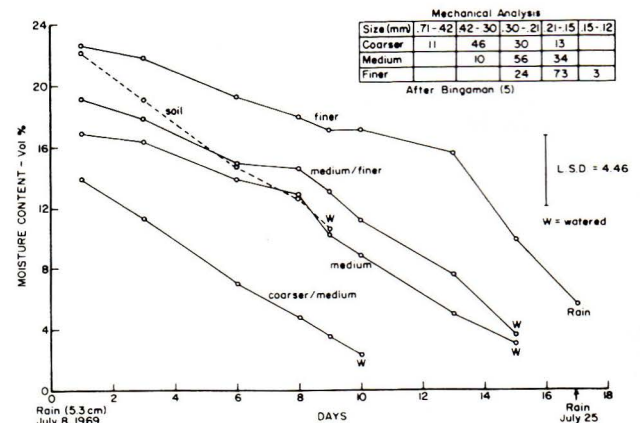


Fig. 5. Moisture content for calcined aggregate treatments and soil check during dry-down II, 1969.



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showed severe wilt when the moisture content by volume was 10.3%, while that on dune sand did not wilt until the moisture content by volume was 10.3%, while that on dune sand did not wilt until the moisture content dropped as low as 3%, a difference of 7%.

The calcined aggregate plots showed marked differences in water storage ability (Fig 3 and 5), depending on the nature of the calcined material and the presence of sand and peat in the rootzone mixture. The 100% calcined clay plots showed little sign of wilt until the 7th day, but by late afternoon of the 8th day they showed severe wilt and were watered. The plots in which 20% peat was added to calcined clay showed wilt on the 8th day, but wilt was not severe until the 10th day. Where sand and peat were added to the calcined clay and peat, the plots retained sufficient moisture to supply the turf's moisture requirements throughout the 17-day period. As in the 1968 experiment, none of the plastic-lined plots that contained diatomaceous earth in the rootzone mixture required watering during the test period.

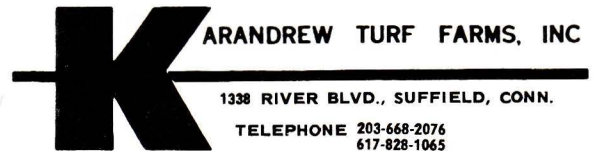
In Fig. 5 the F value for the treatments and soil check was significant (0.05 level of probability), and the LSD between treatments at any single time period was 4.46%. Note the steady decrease in moisture content with time for the soil. The 100% calcined clay, and the 80% calcined clay-20% peat had a similar moisture loss pattern.

For all days measured, the calcined aggregate plots that contained 20% dune sand and 20% peat had a significantly higher moisture content than those that contained 40% of the somewhat coarser, less uniformly graded mortar sand and 20% peat. Both curves tended to level out after the gradual decrease in moisture content during the first 10 days. After 17 days, the plots with 60-20-20 (calcined clay-dune sand-peat) had 22.5% moisture and the 40-40-20 plots had an average of 18.4% moisture. Sufficient capillary moisture was retained in the plots containing dune sand and mortar sand to supply the daily average evapotranspiration demand of 6.76 cm moisture over the 17-day period.

Other than requiring more fertilization during the first 2 years, the management and putting on high sand rootzones above a plastic barrier was found to be very similar to that followed for most greens. The conservation of water and infrequent irrigation needed offer unique savings in management.

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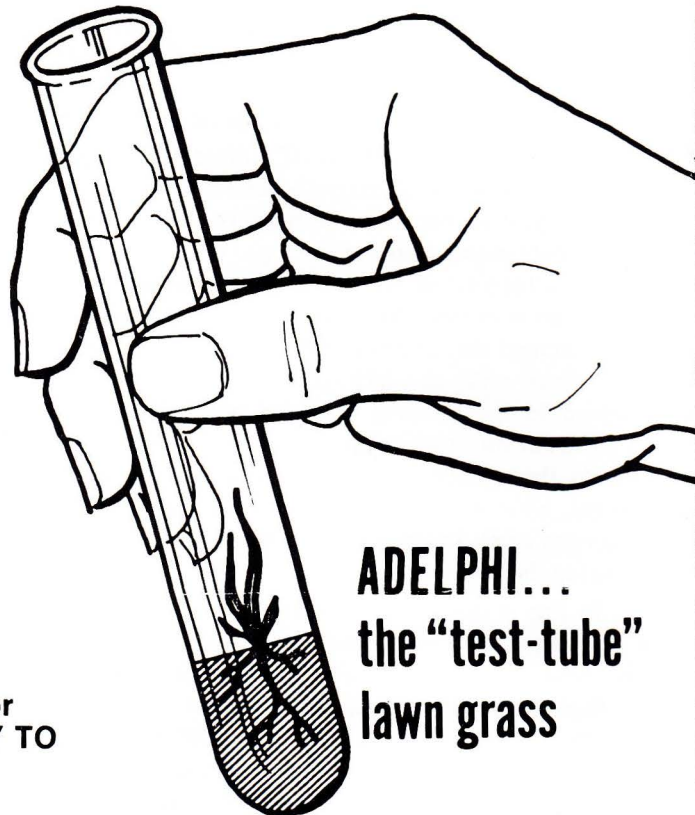
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Reprinted from the *Furrow*, Vol. 79

## Fertilizer: Have rates peaked?

By Rollie Henkes/Regional Editor

### SOME FARMERS LEVEL OFF AS DWINDLING RESPONSE, HIGHER COSTS, AND IMBALANCES CALL FOR PINPOINT APPLICATIONS.

Evidence mounts that top farmers are leveling off on fertilizer rates.

Percentage of corn fields receiving more than 200 pounds N per acre peaked at 4 percent in 1969 and declined in 1970 and 1971, according to a USDA Corn Belt survey. Average rates of fertilizer applied by all farmers continue to rise, but more slowly as those below optimum catch up (charts at left).

Iowa State University agronomists seldom advise more than 200 pounds N on corn anymore. General phosphorus recommendations were recently rolled back by Michigan State University. In California, rates in many crops started to level off three to five years ago, reports Roy Rauschkolb, soils specialist at the University of California.

Why are some farmers backing off? A yield plateau of sorts has been reached in many crops and areas as farmers wring all they can out of current technologies. As the response curve flattens, they are taking a harder look at ever-higher production costs, fertilizer included.

The price of nitrogen fertilizer is being driven up by suddenly-short supplies of natural gas, the basic raw material for ammonia production. Phosphate rock and potash reserves appear adequate, but U.S. farmers currently compete with overseas farmers for phosphate and potash fertilizers in a buoyant world market.

**Guesswork.** Pressures for more precise rates are on

a collision course with an opposite trend—misapplication of fertilizer. To be blunt, there's a lot of sloppy fertilizing being done. That's how we see it after talking with agronomists coast to coast. While some farmers are indeed leveling off and zeroing in on optimum rates, many others are flying blind without benefit of a soil test or other facts. Typical tendencies: applying the same old rates year after year without realizing soil nutrient status has changed; putting on plenty of everything in the mistaken notion that this will insure the crop has enough.

Guessing at rates could get increasingly expensive as the price of fertilizer goes up, and there's the added penalty of pollution if enough unused nutrients, particularly nitrogen, find their way into streams and aquifers. Also, years of indiscriminate fertilizing are causing yield-depressing imbalances in some soils which aren't easy to unravel—phosphorus-induced zinc deficiencies, for example.

Booming farm commodity prices may set back precision fertilization. Nevertheless, agronomists we've contacted think it's high time many farmers reevaluate their fertilizer programs.

**What's happening.** A University of Illinois survey of 1,700 corn and soybean fields showed that over 40 percent exceeded levels of phosphorus at which a response could be expected, and of those, 16 percent had unrealistic

(Continued on Page 22)

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(Continued from Page 21)

tically high levels. A fifth of the fields were unnecessarily high in potassium.

As soil-test levels of phosphorus and potassium rise in Ontario, farmers are being advised to set out demonstration plots to see if fertilizer rates could be cut without yield loss. For the last seven years, Iowa farmers, as a group, have applied more phosphorus than they removed in harvested crops. Phosphorus has built up to very high levels in some Michigan soils.

Soil acidity is sneaking up on many farmers.

"In parts of the Corn Belt, high rates of nitrogen without liming are dropping soil pH to the point where you just don't get maximum utilization of phosphorus," warns R. D. Curley, chief agronomist, Farmland Industries, Inc., Kansas City, Mo. "Instead of applying lime to increase phosphorus efficiency, too many growers simply apply more phosphorus, which in turn can induce a zinc deficiency."

Environmental pollution, real or imagined, will also apply pressure for rational fertilizer use. In noting the worsening condition of many of North America's waters, some of it due to nitrates, certain environmentalists point out that farmers applied over 8 million tons of nitrogen in 1973 and only 1/3 million tons in 1940. But when it gets down to specific cases, the connection seems flimsy at best. Industrial and domestic sewage is a far more likely source of wayward nitrates. "Much more research is needed on effects of fertilizer before rushing into any restrictions," says S. R. Aldrich, University of Illinois agronomist.

There are pockets of potential pollution from fertilizer, such as on some sandy soils in Nebraska where intensive irrigation is leaching fertilizer nitrogen into the groundwater. But for the most part, pollution shouldn't be a problem if farmers apply optimum rates, properly timed, backed up by weed control, erosion control, and other solid supporting practices.

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There is far greater concern over farmers losing profits through under-application and improper ratios, especially during a time of food shortages. About half of the corn tissue samples sent into Ohio State University the last seven years have been low or deficient in nitrogen, reports Roy H. Follett, Ohio State University soil scientist.

Armand Bauer, soil scientist at North Dakota State University, says farmers are still mining the inherent fertility of North Dakota soils. Some soils in Montana are responding to potassium for the first time. Fallow wheat in parts of western Nebraska is showing deficiencies of nitrogen and phosphorus. South Dakota farmers apply about 300,000 tons of fertilizer a year as against an estimated potential of 1 million tons.

Many farmers, then, should still be applying build-up rates of phosphorus and potassium so that optimum amounts are available to crops. Others could be throttling down to maintenance. Many are in both phases, depending on the field.

Agronomists agree that all farmers, whether accelerating or cruising, should soil-test routinely to tailor rates to each field and crop.

J. B. Jones, extension agronomist at the University of Georgia, thinks a good New Year's resolution would be to abstain from general recommendations. This would eliminate the wall-chart "expert" who comes up with instant and often erroneous advice.

**Custom testing.** Soil testing may come out of its apparent slump with the growing realization that farmers are willing to pay for a professional job. Soil Science, Inc. of Fargo, N. D., sells farmers a package of soil sampling, testing, and a complete set of fertilizer recommendations—and not an ounce of fertilizer. A fleet of Soil Science Jeeps criss-cross the Red River Valley (of the North) pulling samples in seconds with a hydraulic probe invented by Soil Science president Eddy G. Johnston. You'll be seeing more power sampling tools.

"We look for a big increase in soil testing as farmers choose rates more carefully," says Robert Harris of Harris Laboratories, Inc., Lincoln, Neb. Harris also sees a trend toward more complete analyses, which include seven or eight different elements plus pH.

Other progress brewing is a move by the Council on Soil Testing and Plant Analysis to standardize testing procedures and reporting to improve accuracy and end confusion in comparing results of one laboratory with another.

You can also expect increased emphasis on the crucial step of translating test results into profitable recommendations.

Tissue testing will at least inch ahead as farmers fine-tune fertilizer rates. Such testing is good at spotting pockets of micronutrient deficiencies. Many farmers tissue-test to monitor their overall fertilizer program, but only as an adjunct to soil testing. "A plant test doesn't mean much unless you know the nutrient status of the soil," says Jim Cox of NuAg, a commercial lab in Rochelle, Ill.

**New approach.** "You can measure nutrients in the soil and plant tissue, but that doesn't necessarily

mean they're being utilized," says C. A. Stutte, plant physiologist at the University of Arkansas. "For instance, too much calcium in a plant can suppress enzymes associated with utilization of magnesium or potassium." Stutte and his associate, J. T. Cothren, are studying interplay of nutrients by way of enzyme assay of leaf tissue. Someday, their work might help farmers select better fertilizer rates. They also analyze plant sap (xylem flow) for ionic balance of nutrients. That tells them what nutrients are coming into the plant while enzyme assay tells them what the plant is doing with those nutrients. Stutte has designed an apparatus for collecting plant sap in the field.

In an era of more rational rates, "in" practices will be those that put on nitrogen closer to point of crop use. On that score, few things beat applying fertilizer through irrigation water ("fertigation"), which spoon-feeds a crop three or four times a year with hardly a lick of extra labor. Slow-release nitrogens such as sulfur-coated urea might also find a place.

But don't wait for new "break-throughs" to solve present problems. As one soils man put it, "Farmers already have all the tools they need for accurate fertilizing."

Maybe dusting off a few old slogans would help. Such as, "Don't guess; soil test."



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## University of Massachusetts Turfgrass Research Fund

It has been brought to our attention that a number of Golf Course Superintendents still misunderstand the funding of turf research at the University of Massachusetts. Because the University is a State Institution it would appear that monies would be appropriated by the State or agencies of the State for research. They do no such thing. Money for turfgrass research often comes from private grants from commercial companies often interested in pest control or related product development. The GCSAA, U.S.G.A. and O.J. Noer Foundation also sponsor turfgrass research.

Two years ago with the foresight and help of Golf Course Superintendent Paul O'Leary, a University of Massachusetts alumnus, the Turfgrass Research Fund was initiated. The alumni have been most generous in contributing to the fund. In addition, we have asked each Massachusetts Superintendent and his Chairman to get into their budgets annually fifty or one-hundred dollars, depending whether the club is a 9 or 18 hole course to be contributed to the Massachusetts Turf Research Fund.

Last year a number of Massachusetts golf courses contributed. A list of contributions was published in the Turf Bulletin. This year we again appealed to Massachusetts Clubs for money and the following contributed:

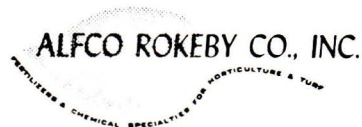
Green Harbor Golf Club, Marshfield, MA.	\$ 50.00
Pleasant Valley Country Club, Sutton, MA.	\$150.00
Juniper Hill Golf Course, Inc., Northboro, MA.	\$100.00
Ledgemont Country Club, Seekonk, MA.	\$100.00
Nashawtuc Country Club, Inc., Concord, MA.	\$100.00
Oakley Country Club, Watertown, MA.	\$100.00
Hemlock Ridge Golf Course, Fiskdale, MA.	\$ 50.00
Winchester Country Club, Winchester, MA.	\$100.00
Worcester Country Club, Worcester, MA.	\$100.00
The International Golf Club, Inc., Bolton, MA.	\$100.00
Middleton Golf Course, Inc., Middleton, MA.	\$100.00
New Meadows Golf Club, Inc., Topsfield, MA.	\$ 50.00
Longmeadow Country Club, Longmeadow, MA.	\$100.00
Cohasse Country Club, Southbridge, MA.	\$ 50.00
Quaboag Country Club, Inc., Palmer, MA.	\$ 50.00
St. Marks School Golf Association, Southborough, MA.	\$ 50.00
Charles River Country Club, Newton Centre, MA.	\$100.00
Wellesley Country Club, Wellesley, MA.	\$100.00
Up John Company, Kalamazoo, MICH.	\$500.00
Loft Seed Company, Arlington, MA.	\$500.00
GCSAA, Lawrence, KANS.	\$750.00

The above list also contains this years grants.

We have a number of research projects underway. All of them have been explained in previous issues of the Turf Bulletin. Questions pertaining to any of these projects and for the funds will be answered upon request. Our books are open to our supporters. We again appeal to both the Massachusetts Superintendents and their Green Chairmen to budget monies annually for the support of Turfgrass Research at the University of Massachusetts.

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