NINTH ANNUAL
TURF CONFERENCE

Southeastern Turfgrass Conference

ABRAHAM BALDWIN AGRICULTURAL COLLEGE
AND
GEORGIA COASTAL PLAIN EXPERIMENT STATION

APRIL 5-6, 1955

TIFTON, GEORGIA

F O R E W O R D

You will find bound in this booklet the majority of the talks made at the "Turf" conference held at Abraham Baldwin Agricultural College and the Georgia Coastal Plain Experiment Station on April 5 and 6, 1955. It was impossible for us to include four of the talks in these proceedings. I regret this as I am sure you would have enjoyed reviewing them.

I hope you will find these proceedings useful in your everyday activities in trying to have better turf. Every effort has been made to present this booklet to you in good readable form. I thought the program presented at the last "Turf" conference was the best of any yet held. The members of the turf staff at the Georgia Coastal Plain Experiment Station have the responsibility of working up this program, and I thought they did an excellent job. These gentlemen, composed of Dr. Glenn W. Burton, Dr. B. P. Robinson, and Mr. J. M. Latham, would appreciate any constructive thoughts you may have concerning the "Turf" conference. It is the aim of all of us to improve year by year, and we can best do this with your help.

It is always a pleasure to have the turf leaders of the Southeast on our campus. I hope that you will always find it enjoyable, and at the same time receive information that is useful to you in your everyday turf problems.

T. M. Cordell

T. M. Cordell, Dean
Abraham Baldwin Agricultural College
Tifton, Georgia

C O N T E N T S

DROUGHT RESISTANCE AND ROOTING HABITS OF SEVERAL SOUTHERN GRASSES

Glenn W. Burton, Principal Geneticist
U. S. Department of Agriculture
Tifton, Georgia

This entire morning session will be devoted to a discussion of water, and with 1954 behind us, and we hope we won't know another 1954 right soon again, I don't think we need to emphasize the importance of the topic. It is an important topic, and it is particularly important to those people who are not in a position to turn on faucets to get all the water that they need when they need it. Since our morning is devoted to water, I thought maybe it might be worthwhile to just briefly outline some of the main functions of water.

Plants need water, first of all, to live, and if you deny a plant all of the water that would be in it, it would die. They need water to maintain turgor for growth and shape. When a plant wilts it ceases to grow very much, if any. Plants need water for food. In this case, we have carbon dioxide combining with water in the chloroplasts in the presence of light, to produce sugar, the basic substance in the plant from which all of the plant itself ultimately comes, with the addition, of course, of other elements, and some oxygen. The plants need water for transportation of the nutrients that are in the soil, the fertilizer that is put there, and some other elements that you don't put there must go into solution in water before the plant can take them up. Then these elements move in the plant, from the root on up to the leaves, in the stream of water that is in the plant. The products of photosynthesis also move through the water to the place where it is needed for growth, storage, and other functions. Finally, we list water for transpiration, with a question mark after it. And the question mark is there for a purpose because this process that we call transpiration is one that the specialists have spent several generations studying and yet they are still not sure as to whether it is important or not sofar as the life of the plant is concerned.

How much water does it take for these various functions? I do not know that everyone can answer exactly, and it's going to vary from place to place, but let's just visualize a Bermuda grass plant that would weigh 10 lbs. I do not know exactly what it would look like myself, but let's just imagine that we have a Bermuda grass plant that would weigh 10 pounds. It would probably take a minimum of two or three pounds of water to keep that plant alive, about a quart, if you could keep the plant from losing any water, would be enough to keep it alive. To maintain turgor for growth and shape, you would need about 6½ to 7 pounds of water. It probably took about a pound of water as food to make that plant. If you had enough water to meet the needs for turgor and growth, you would also have enough water for transportation, so certainly less than 10 pounds of water would be about all that you would need for these first four functions which we have pretty well decided are significant and important functions sofar as the life of the plant is concerned. Ten pounds of water or a little less for a 10 pound Bermuda grass plant. The work that we have done, which I will talk about later, indicates that it probably took in the neighborhood of 2500 pounds, some 300 gallons of water, to produce that 10 pound Bermuda grass plant if it was grown in the field. That means about 700 pounds of water for every pound of dry matter. Well, that means that practically all of that water, 2490 pounds of it, was spent in the process of transpiration, plus evaporation losses from the soil, a process that may not be necessary. This process commonly called evapotranspiration does exist and since we haven't learned how to by pass it, we must put up with it and supply plants with great quantities of water to satisfy it.

My topic is "Drought Resistance and the Rooting Habits of Several Southern Grasses", and I am going to talk almost entirely about the work that we have been doing with forage and pasture grasses in the last four or five years. I think what I shall say about them would be equally true about turf grasses. After 1954, it should not be necessary to tell any of you men that there are differences in the drought resistances of different grasses. But just in case some of you still feel that all grasses are all equally susceptible to drought, I want to show you a couple of pictures. This one was taken on the 7th of July, 1952, after we had had an extended drought. These grasses are growing on a deep sand; they had only the water that had come from the sky. Here is a plot of Dallas grass that is rather badly injured. This is a plot of Coastal Bermuda, no injury at all, and beside it is a plot of common Bermuda that is brown, and way back in the corner is a plot of carpet grass, just about as brown as anything can be; injured more than any other grass in this particular test. Over here is a plot of Pensacola Bahia that was not injured at all in 1952. The next slide will give you a picture, the same experimental layout, taken in the summer of 1954, on the 9th day of July after a much more severe drought. The grass over here on the left, that is obviously pretty badly killed out as a result of the drought, is Pensacola Bahia grass that had not been injured at all in 1952; the grass that some people have said is the most drought-resistant pasture grass we have. Right beside it is Suwanee Bermuda, fertilized and managed exactly the same way, showing no injury at all. Right behind it is Coastal Bermuda with practically no injury. Over here is a plot of common Bermuda, seriously injured. Here is another plot of Pensacola bahia browned out. Over in the corner is another plot of common Bermuda. There are differences in drought-resistance. The first two pictures that you looked at were taken of grasses growing on deep sand and you may be saying, "Well, that's all right, but what would happen if you had these grasses on a heavy soil"? Well, you are looking at common Bermuda on the left and Coastal Bermuda on the right, photographed in August, 1954, growing on a heavy soil, and again I think you can see that the common Bermuda has suffered a great deal from drought, and Coastal Bermuda comparatively little.

What relation is there between these drought symptoms that we have observed and root development? We have here some data, (and I hope these figures won't scare you), indicating something of these relationships. In these first two columns that I am pointing to now, we have the firing injury, rated by numbers. A rating of 4, for example, means that we have had quite a lot of injury both in 1952 and 1954. A rating of 1 means no injury at all, grass still green, no evidence of firing. A rating of 5 means severe injury. Well, you can see, as you look at these ratings giving common Bermuda a rating of 4; Coastal Bermuda a rating of 1, Pensacola Bahia a rating of 4;

carpet grass, a rating of 5; Pagola, a rating of 3, that there are differences in grasses. Here we have merely expressed them numerically.

We have said so much about the desirability of increasing grass roots, that I suppose you might think that the grass that did produce the greatest pounds of root would be the most drought-resistant. We have measured the pounds of root under those grasses to a depth of 8 feet; dug out cylinders of soil; washed out the soil; weighed up the roots; and that is the sort of data we get. You will notice that the Pensacola bahia produced more pounds of roots, by a substantial margin, than any other grass. And yet, when the going got tough in 1954 it was injured more by drought than either Coastal Bermuda or Suwanee Bermuda. Thus, drought resistance is dependent on more than root yield. You will also notice that common Bermuda actually produced more pounds of roots than Coastal Bermuda; so the pounds of roots may not be so important after all.

We think that distribution is quite important, and this data, I think, shows that it is. Carpet grass, the grass injured more by drought had 93.6% of its roots in the upper 2 feet. When we got down below 4 feet we found very few roots. Remember, this is on a deep sand, and these roots will go deeper on a deep sand than they will on a heavier soil. Remember also that these grasses were clipped and cut for hay. They will go deeper when you manage them that way than they will when you clip them every day as you do on a green. Common Bermuda had 85 percent of its roots in the upper 2 feet. The two Bermudas that were most drought-resistant had only 65 percent of their roots in the upper 2 feet, and a much higher percent at the lower depths. What does this mean? In this deep sand we have about three-quarters of an inch of available water that can be stored in each foot of soil, so if you have most of your roots in the upper 2 feet you have available, after a good rain, about $1\frac{1}{2}$" of moisture that the plant can draw on, and when that water is gone, if you do not get another rain, that plant begins to suffer. On the other hand, if you have roots down to a depth of 8 feet, instead of having an inch and a half, you have 6" of water that can be drawn upon. Thus distribution and the depth of roots is important, and that is one reason that we have said so much in the past about the value of deep roots.

We still do not have the whole answer however, because Pensacola bahia had just about as good a root distribution as Suwanee Bermuda, actually produced more pounds of roots, and yet was not nearly as drought-resistant under severe conditions. Why the difference? Let's look a little further.

We have done a little calculating, trying to figure out just how much water it takes to produce a pound of dry matter, and we have it listed here for three of the grasses that we have had in this test. The assumptions that we have made to do this, that we have listed below in this table, I think are valid. Let's just look at the three year averages:

For common Bermuda, 1573 lbs of water were required to produce 1 pound of dry matter. For Coastal Bermuda, 678; and for Pensacola bahia, 1075 were needed. That is a much larger figure than you will find in the text books when you start reading about how much water it takes to grow a pound of some particular plant. I would like to point out, however, that the data you read in the textbooks were collected in the North where temperatures don't get as high, and where evaporation and transpiration losses are not so great. There has just been some recent work done in Texas where irrigation water has been applied, indicating that on Coastal Bermuda, at this fertility level, it takes about 700 lbs. of water to produce a pound of dry matter. If they can get such results at College Station, Texas, our data would appear to be reasonably dependable.

One of our greenhouse experiments indicates that grasses can live and make about half of their normal growth when only 11.7% of the roots receive water and fertilizer. This study also shows that a higher percentage of the roots are required to supply water than are needed to supply the fertilizer needs for a given amount of growth. In the greenhouse Coastal Bermuda was more efficient than common Bermuda and Pensacola Bahia in water and fertilizer use.

There is much yet to be learned about the drought resistance of plants. We know there are differences in the drought resistance of different grasses. Usually the deeper rooted grasses and those that have a higher percentage of their roots at the lower depths are more drought resistant. There are exceptions, however, that cannot be ignored. Some grasses are more efficient in water use requiring much less water than others to make the same amount of growth. There are other differences that at present can only be explained by saying that there are differences in the protoplasm itself that enable some plants to remain green when others turn brown. We may not be able to explain completely why some grasses remain green while others beside them turn brown, but we do know that farmers and golfers are both looking for green grass. You can rest assured that we, at this station, will continue to do our best to develop such grasses for your needs.

DOWN WITH THE ROOTS

J. C. Harper
Research Agronomist
U.S. Department of Agriculture

Man with all his complex knowledge has given roots the rather dubious distinction of being the most neglected part of any plant. We all know roots play an extremely vital part in the growth of all higher plants. They serve as anchorage organs, food storage organs, nutrient and water absorbing organs, and occasionally as propagating organs. Practically all the water and minerals which the grass plant uses in growth are obtained from the soil solution through absorption by roots and root hairs. Obviously, the plant should be provided with a root system sufficiently deep and extensive to permit absorption of the moisture and nutrients required to support the top growth.

What are the factors affecting root development? Basically, they fall into the two groups - hereditary factors and environmental factors.

The type of growth of root systems is firmly fixed by heredity. Many plants have central tap roots which grow rapidly downward and penetrate deeply while others such as grass have shallow primary roots and extensive rapidly growing lateral roots. With few exceptions root growth types are so firmly fixed by heredity that they never change their basic form, although often modified by environmental conditions. Some trees, such as red maples, have the ability to develop shallow fibrous root systems under moist low land conditions and a deep tap root system under dry upland conditions. Within a given growth type group we have numerous variations. Bermuda grass and Kentucky bluegrass for example can develop extremely deep and extensive root systems under the proper conditions whereas <u>Poa annua</u> develops very shallow roots under the best of conditions. It is to our advantage to use grasses which have the ability to develop deep root systems provided the turf quality of the grass is suited to its intended use.

More important from the turf manager's viewpoint is the environment which he can modify considerably. Among the environmental factors affecting root development and soil characteristics such as texture, structure, and depth; the amount of available water; the kind and concentration of salts; the soil reaction; soil aeration and compaction; and competition with roots of other plants. Factors affecting the top growth such as clipping, disease and insect injury, and shading will also affect root development through their effects upon processes carried on in the tops.

The development of roots and, particularly, the depth of rooting, is closely correlated with the amount of soil moisture available and the depth of wetting of the soil. We all know that frequent light applications of water result in very shallow roots because sufficient moisture can be absorbed by the relatively small amounts of roots near the surface.

There are a few beliefs concerning roots that should be explained. It has long been assumed that roots grow towards moist soil. Research has shown that this is seldom true under field conditions. Most plant roots will grow downward out of moist soil into dry soil where elongation is stopped by desiccation instead of turning at an angle and staying in the moist soil. Many people believe that roots can detect water and grow towards it, based on the observation that large amounts of roots often develop near leaky faucets or in leaking drain pipes. This is readily explained when we realize that roots are continually growing outward in all directions and that when these roots, extending at random, reach an area where there is an abundance of moisture, as well as good aeration, they branch profusely and develop large root masses.

Too much moisture can be as deleterious to root development as too little moisture because of its effect on soil aeration. I am sure you have often seen the yellowing of leaves, reduction of growth, and eventual death of plants when the soil is completely saturated for relatively long periods of time. Injury of this nature is due to the lack of oxygen, the accumulation of carbon dioxide or both. Proof that death is not a result of the water itself is shown by the fact that grass can be grown quite satisfactorily in water culture provided it is well-aerated. Respiration of soil organisms and roots continually depletes the oxygen supply, and under saturated conditions there is little or no gaseus exchange with the atmosphere.

Soil characteristics play an important role in soil aeration and soil moisture. Aeration is largely dependent on texture and structure because it is through the large or non-capillary pores that gaseous exchange takes place. Poor structure and texture will also impede drainage and result in saturated conditions. Hardpans or impermeable layers, particularly those near the soil surface, will seal off the large pore space and impede gaseous exchange.

Roots undergo a seasonal cycle of growth which is controlled largely by temperature. Bermuda grass roots make no growth at a soil temperature of 40° F. and very little at 50° F., but increase in growth up to 100° F. Kentucky bluegrass on the other hand makes its optimum root development at 50° F. Generally speaking, root growth of most grass species slowly increases with increasing temperature over a range of 20 to 25° from minimum to maximum temperature while a further increase of 5-10° may cause complete cessation of growth.

Roots will branch profusely when they penetrate into soil areas containing an abundance of minerals. Providing a continuous phase of nutrients is available, we can expect deeper roots in soils having good nutrient supplies at considerable depth. All essential mineral elements should be supplied in adequate amounts - phosphorus, boron, nitrogen, and calcium being the most likely to be limiting.

Most grasses have a wide tolerance to soil reaction provided there is an adequate supply of nutrients available at a given pH. Most of the effect of pH on growth is indirect either because the availability of certain nutrients is reduced or solubility is increased to such an extent that toxic concentrations occur.

In acid regions salts often accumulate in the soil until the concentration is too high for satisfactory plant growth.

The root-shoot or root-top ratio is another important consideration in the development of the roots. Since roots are dependent on their shoots for the carbohydrates essential to growth, whatever effects photosynthesis will also affect root growth. Shoots, on the other hand, are dependent on roots to supply them with minerals used in food manufacture. Any factor which modifies the development of one will generally modify the development of the other.

Factors of a lesser degree which may affect root development include toxic secretions as a product of root or other organic matter decomposition and mechanical injury by wind or machinery. Root nematodes have, in recent years, caused considerable damage in the Florida area. At the present time Dr. Nutter and his assistants are hard at work in an attempt to solve this problem.

Let's take a quick look at the influence of some of our management practices on root development.

Clipping has a very definite effect on root growth. By the process of photosynthesis food is manufactured in the leaves for the growth and functioning of tops and roots. Clipping, therefore, severely cuts down the size of the manufacturing plant. Any excess food manufactured is stored in the roots as reserve and is drawn upon to start new growth of the stems and leaves following clipping. Frequent clipping materially depletes this supply of reserve material. Fortunately, for you, creeping or prostrate grasses are less injured by repeated top removal than are erect types of grasses.

Water, of course, is vital for plant growth. With too little water a drought condition exists and wilting occurs as the leaves continue to lose water which cannot be replaced by the roots. With too much water the air spaces become filled with water, air is forced out, and the plant turns yellow from lack of oxygen. Even though sufficient amounts of nutrients and moisture are available, the roots cannot function without a supply of oxygen. Some grasses such as marsh grasses and rice can tolerate saturated conditions, but only because these plants are equipped with special parts which enable them to supply oxygen to the roots through the aerial portions of the plant.

You are all familiar with the statements "Water heavily, but infrequently" or "frequent light waterings result in shallow root formation". Good watering practices on the sandy soils of the South are much more difficult to carry out than on the clay soils of Northeastern United States. Nevertheless, every effort should be made to maintain some deep moisture without keeping the surface constantly moist.

Most of us accept fertilization as a standard practice, but how many of us have ever stopped to consider what effect our methods of fertilization have on root growth. Roots, like humans, are lazy. Wherever the optimum fertility exists root growth will be greatest. If all our fertilizer is on the surface our roots will be shallow; if we fertilize in bands, roots will develop in bands. Poor distribution of fertilizer may result in areas of excessive fertility where roots may actually absorb too much fertilizer and be damaged by the high concentration of soluble salts in the root cells. In some instances roots may absorb so much nutrients that they will concentrate in the leaf cells and cause burning of the leaves.

Poor fertilization and poor watering practices go hand in hand and may start a vicious cycle. Suppose our grass is yellow from overwatering. An unthinking turf man assumes he has a nitrogen deficiency so he applies nitrogen. He knows the nitrogen might burn so he waters it in - and the grass becomes more yellow - and gets more nitrogen from our unthinking friend.

Compaction caused by tramping, golf buggies and maintenance equipment poses another management problem. Compaction is one of the best ways to exclude oxygen from the soil. Packing of the soil reduces the air spaces necessary to hold both air and water. A thin compacted surface layer is just as effective a method of excluding air as a plastic coating. This may be overcome by breaking up this layer with some type of aerating or spiking device.

In conclusion, I would like to quote from a similar talk given by George A. Grees, Purdue University, at the 1953 Midwest Turf Conference. Quote "We must remember our grasses are like children. Each one is different and will respond differently under various circumstances. Get acquainted with your grasses. Remember - the most important practice in the proper management of turf grasses is the liberal application of abundant common sense."

RELATION OF SOIL TEXTURE AND STRUCTURE TO TURFGRASS PRODUCTION

Fred V. Grau, Agronomist
West Point Products Corporation
West Point, Pa.

I think there may be some misunderstanding on the concept of soil because we may tend to confuse texture and structure. Texture refers to the size of the particle. When rock materials are broken down different sizes come out; some are very fine, some you can hardly see with the naked eye; some are quite large. The very finest are called clay, very floury, and when you rub them between your thumb and finger they are so smooth there is no gritty feeling at all. That is the clay fraction that gives character to the soil. Silt is the next size larger. Silt does not add much character to the soil, it doesn't hold much fertility, it doesn't hold much moisture, and surely does not do much of anything, it's just there. And in putting green, in many cases, the silt fraction is the one that gives us the trouble. Then from there we work up to the very fine sands, the fine sands, and on up to the coarse sand and gravel. This gives you a very rough idea of the range of soil particle size.

The growing of a putting green is the highest form of agriculture in the world today. I think it even exceeds orchid growing, because orchids grow in a protected atmosphere. A putting green has to grow in many unfavorable circumstances, under constant traffic and use, under every kind of weather, and I salute the golf course superintendents who are able to maintain putting greens under those conditions. This highest form of agriculture deserves a little better understanding. It's the structure of the soil, then, that is extremely important in helping the growth of the roots of these grasses. Structure refers to the arrangement of these particles. How are they arranged? In a silt, in most cases, these particles are single-grained, just like a bunch of grapes that have been pulled off the stem and are rolling around in the bottom of the dishpan. You put them in a smaller container and they are all just individual particles, but when they were on the bunch still on the stem, there you had a granule. All those little individual particles were grouped together in a granule, or a mass. It is that kind of granular structure that we are looking for in a good soil, and that is achieved by several different ways. The black snows and the black dust storms that we are having now on the Great Plains are the result of destruction of soil structure. Those particles have broken down to single grained particles, and the wind is picking them out and blowing them away. When those particles are laid down and are again brought into action of roots and fertilizers, then they again begin to gain structure and form granules. Much of this is done through, what is called, colloids. Colloids is a technical term. You don't have to be worried about that technical term, because in the Greek from which it came, colloid means glue; and the colloid glues or cements the soil particles together, into granules, and these colloids largely come from organic matter, and most of that organic matter is developed from roots. The roots of plants are largely responsible for the development of colloids, which give the soil structure. In the mid-West, the greatest grass soils of the world were developed into wonderful agricultural soils of excellent structure because of the action of those roots. I am going to turn to the slides now, because I find myself repeating a number of things, and I would rather show them to you because I believe they will carry a stronger message. We are all familiar with the term top soil, but top soil does not always mean the same everywhere, because in the construction of a home, when the grading has been finished, and the contractor brings top soil onto the site, it probably came from somebody's basement, but here is one honest contractor who pushed aside the top soil and then did the excavation, and after regrading the subsoil, the top soil actually will be replaced. We still have some of those honest contractors, and you see this occasionally as you go around the country. We need to see more of that.

Tom Mascaro has done a lot of work in this respect, and here are some of his pictures showing a simple way of determining what kind of texture you have, that is, how much sand, silt, and clay in your soils. This is a simple thing that can be done at home. You simply take 1-pint jars and fill #1 three-fourths full of water. Put 2 tablespoonsful of fine soil in jar #1. Shake for 2 minutes; allow to stand for a minute and then pour it into jar #2; allow to stand 5 minutes, pour it into #3. Add more water, shake, allow to stand 2 to 3 hours and then pour off the water. We have sand, we have silt, and we have clay. This is a rough approximation of the texture of your soil, and if you dried it, then you would come up with little piles of material that would look like this: sand, silt, and clay. In some of the studies in Oklahoma we found that 8% of clay was about the maximum that would give us best results in a putting green. Now that can go considerably higher with different types of grasses, especially the Bermudas.

Now, the fact that you may have a sandy soil does not preclude the possibility that you will have soil compaction that Jack Harper spoke of. Here is a clay loam; here is a sandy loam; these are Dr. Alderfer's figures, and we find that they are about equal in porosity, about equal in run-off of water, and they are about equal in the water intake. So, whether you have a sandy soil or a clay soil you are going to have compaction, whether you like it or not. Here is a soil in good crumb structure. You add water, and you add traffic or movement, and the water, acting as a lubricant, causes those particles to run together; you lose the crumb structure, and you have compaction. Here is a photomicrograph of a compacted soil, practically no air spaces, very difficult for air or nutrients to move in the soil. By contrast, here is a soil in good crumb structure, and you see many air spaces which are capable of holding water and air and allowing for the growth of roots that Dr. Burton spoke of. At the surface, as Dr. Harper pointed out, you have compaction. Those soil particles have been squeezed together and the air between them has been squeezed out, giving you a very poor condition for the growth of grass. Here is a picture that we took of Dr. Harper working on those plots at Penn. State. He followed Dr. Watson who initiated the work on the study of water and compaction. I think that roller was filled with concrete, and that was really heavy. He was trying to effect compaction at different levels. This is compaction that I thought we were through with, this is a street roller in actual use on a small golf course where they are desparately trying to grow grass, but they had the mistaken idea that they had to put the street roller on it to get it smooth enough to play golf. Just so long as we have situations of this kind I hope that none of us feel smug about how far we have come in this game. Until we raise the level of these poor devils and teach them a little bit about the fundamentals of soil and grass we haven't progressed quite far enough.

This is a tee on a golf course. They water it every night whether it needs it or not. The water cannot penetrate the soil because of compaction and single-grained structure, and you see the foot marks and marks of the caddy carts. That is a horrible situation. There is no grass, so there is no use putting on any water except to keep the soil just soft enough so the golfer can press a peg tee in and play his tee shot. Let's see what the effect of compaction is on porosity, infiltration, and runoff. This is a very compact soil, it weighs 112 lbs. per cu. ft. This is a very porous, well aerated soil; the porosity 6.1 as against 33 percent. That's a terrific difference. But look at the run off. When you apply water, or when nature gives us rain, on the compact soil - 88 percent run off, on the well aerated soil - zero run off. Is not that about what we want to know? Water can enter this soil at the rate of only one-quarter inch an hour, and here nearly an inch and a half an hour, that's going to affect the rate at which you apply water and the rate at which water can enter the soil. We are in the age of machinery, and men and machines working together are going to accomplish a great deal that we have not been able to accomplish in the past. Nature tries desparately to help us in creating good soil structure by freezing and thawing. This is honeycomber soil, and you had temperatures low enough recently to have some honeycomber soil. You did not like it too well because some of the plants you are growing were not in the condition to take it, and there is going to be a terrific amount of economic damage as a result of those low temperatures, but further north we get those regularly, the benefit is short lived. For a few weeks the freezing and thawing tends to create good soil structure, and then in a matter of two or three weeks afterwards, as Dr. Alderfer tells us, the effect of that is gone and our soils again become compact and unable to absorb water. Lime is one of those chemicals or materials that help soil structure by helping to aggregate the particles. That is one of the chemical means that Dr. Harper spoke of; fertilizer is another.

This happens to be Merion Blue Grass. It might have been any other good grass, well fertilized and starved, and the effect on the root growth and the effect on the soils temperature is marked, because with the added heavy root growth there are going to be more colloids; there is going to be more organic matter, which will help to create good soil structure. Roots are so important, and I was so thankful to hear Glenn's talk this morning on the depth of roots in relation to drought resistance. That's the information that we have needed for a long time. This simply illustrates that we need to spend more time thinking about and looking at the roots of our grasses. And if most of you will keep those little soil probes shining that you got at registration this morning I think you will know a little more about your root systems in the days ahead.

Here are some more of Tom Mascaro's pictures. Taken from Dr. Alderfer's work, some of the demonstrations that he has showed us at

Penn State, here are two samples of soil. Here is a clod of soil from an area on which grass has not been growing; very low organic matter, very few roots. And here is this clod of soil, the same kind of soil under good turf. Now, let's put those into those little baskets, in these beakers of water, and almost immediately, as the water begins to penetrate into this clod, the air that is trapped inside of those soil granules begins to explode and this begins to slack, and you might call it melting. This one is remaining clear because those are water-stable aggregates created by the root growth and the colloids from the roots. In a few minutes this clod of soil has broken down into single-grained structure, has melted and dropped to the bottom of the beaker. This is still perfectly intact. This is what we are looking for, so that when water is applied the structure remains the same so that roots can grow. It develops resilience in the soil, and in the turf that will enable us to use it better for golf or any other purpose. When soils are wet they tend to expand. When soils dry they tend to shrink. In shrinking they crack, and many times you have seen cracks in the soil where a golf ball would drop down, you could even get your foot down in there and wrench an ankle the cracks are so large. That is one of nature's ways of aerating soil. We do not like it too well because it interferes with many of the things we would like to do. But remember, it is one way of getting air into the soil. Wetting and drying is probably the greatest force in the world in creating good soil structure. Modern machines designed to cultivate and aerify soils, bring soil to the surface where it can wet and dry and gain structure.

SOIL MOISTURE RELATIONS UNDER TURFGRASS

J. R. Watson, Jr., Chief Agronomist
Toro Manufacturing Corporation
Minneapolis 6, Minn.

In a discussion of soil moisture, one must include other very closely related topics; namely, physical properties of soil and soil air. These three subjects are inter-related and actually cannot be discussed independently. Consideration also must be given to the utilization of water by the plant and the role of water in the soil.

WATER IN PLANTS AND SOIL

The fact that plants require water for their existence and development and that most plants require it in considerable quantities is commonplace knowledge. It is not generally realized that a very large proportion of the water absorbed from the soil is lost by the plant into the atmosphere and plays no permanent part in its development or in its metabolic processes. Water is supplied to and absorbed by the plant in a liquid form while the greater part of the water lost by plants is in the invisible form of water-vapor. This probably accounts for the failure to recognize the tremendous quantities of water needed for plant growth. The loss of water vapor from any part of a plant exposed to air is known as transpiration.

TRANSPIRATION

The importance of transpiration and its effect on soil moisture is apparent when we consider that the 60 to 90 percent of the plant body which is water actually represents only a very small proportion of the water used by the plant. There is a constant stream of water passing in through the roots and being transpired by the leaves. From 300 to

500 pounds of water are required for every one pound of dry matter produced by the plant. Many plants transpire an amount of water equal to their weight every twenty-four hours.

The actual amount of water required by plants is, therefore, far in excess of the amount used by the plant in its growth and development processes and is dependent upon the amount transpired. The amount of water transpired by a given plant is governed by several factors such as:

(1) Temperature - High temperature increases and low temperature retards transpiration.

(2) Air Movement - Air movement increases transpiration from the plant. The movement of the plant itself aids in circulation of water within the plant and so increases transpiration.

(3) Humidity - Low humidity increases transpiration.

(4) Soil Fertility - More transpiration takes place on poor soil than on a fertile one.

(5) Light intensity - Transpiration is greater in bright sunshine.

(6) Soil Moisture - The more moisture contained in a soil, the greater is the transpiration rate.

In this discussion we are not concerned with the fundamental controversy of whether the transpiration phenomenon is beneficial or just a necessary evil. Rather, our interest is simply to point up the fact that very large quantities of water are transpired by plants and, hence, it behooves us to adjust our management practices so as to alleviate excessive transpiration whenever possible.

Watering practices that are based directly on transpiration phenomena are "syringing" of golf greens during hot, windy summer days, and the watering of turf areas during winter or early spring when atmospheric temperatures are considerably higher than soil temperatures. In both cases, transpiration is likely to exceed water absorption. This results in wilting or dessication. On high areas not covered by snow and exposed to drying winds during winter and spring months, winter killing is often observed. The plant roots are relatively inactive and cannot take up sufficient water to offset transpiration.

SOIL WATER

Water is a universal component of soils and in addition to its direct usage by plants, it also acts as a solvent for the various minerals within the soil and is a means by which nutrients are made available to the plant. Water serves as a regulator of certain physical phenomena and is utilized by soil micro-organisms. We do not have sufficient time to discuss these functions of water.

SOIL AND MOISTURE RELATIONSHIPS

The nature of the soil is intimately associated with water and air relationships. The capacity of the soil to hold water and air, as well as the movement of water and air, are primarily functions of soil structure (the arrangement of soil particles).

In the true sense, the structural unit known as an aggregate does not include individual soil particles, such as grains of sand, silt, or clay; nevertheless, these individual particles play an important role in a discussion of soil moisture under turf because of their influence on the porosity of the soil. The amount and nature of soil pores is determined by the arrangement of the soil particles (structure); hence, porosity is a property of soil that is dependent on soil structure.

POROSITY

Porosity may be defined as that percentage of the soil volume not occupied by solid particles. In a soil containing no moisture, the pore space will be filled with air. In a moist soil the pores are filled with both air and water. The relative amounts of water and air present will depend largely upon the size of the pores. Two types of pores are recognized -- the capillary and the non-capillary. For convenience, these may be designated as the small (capillary) and the large (non-capillary) pores. The small pores hold water by capillarity and are responsible for the water holding capacity of soils. The sum of the volumes of the small pores is called "capillary porosity". The large pores will not hold water tightly by capillarity. They are normally filled with air and are responsible for aeration and drainage. The sum of the volumes of the large pores is called "non-capillary porosity".

The total porosity of a soil is not as important as the relative distribution of the pore sizes. Total porosity is inversely related to the size of the particles and increases with their irregularity of form. Porosity also varies directly with the amount of organic matter present in a soil. Clays, for example, have a higher total porosity than sands. Clays have a large number of small pores which contribute to a high water-holding capacity and slow drainage. Sands, on the other hand, have a small number of large pores which are responsible for a low water-holding capacity and rapid drainage. Under field conditions, the total pore space is seldom less than 30 percent (coarse, clean sand has about this amount of total pore space.) In silt loams the total pore space amounts to about 50 percent or one-half the volume of the soil. The ideal soil for plant growth should have about 50 percent total porosity, equally divided between small and large pores, or in other words, contain 25 percent water space and 25 percent air space.

CLASSIFICATION OF SOIL WATER

Soil particles are wetted by water and have considerable attraction for water; consequently, soils exhibit a capacity to take up and retain water. This water is distributed through the small pore system of the soil and over the surface of the soil aggregates and soil particles.

The capacity of soils to absorb water and retain moisture provides a reserve which enables plants to grow during periods when soil moisture is not frequently replenished. The moisture retaining properties of soil have been studied in great detail. Various soil moisture constants have been defined and used as an index of moisture retention by soils. Most of the terms are concerned with hypothetical concepts or measurements made in accordance with standardized laboratory procedures.

Soil water was classified as early as 1897 by Briggs into Hygroscopic water, capillary water and gravitational water. These terms may be defined as follows:

(1) Hygroscopic water - The very thin non-liquid film surrounding the micro-aggregate.

(2) Capillary water - The liquid stage which is held in the small pores and as a continuous film around the soil particles and the micro-aggregates. It is held by the molecular forces of cohesion. Sometimes this water is divided into the inner and outer capillary water.

(3) Gravitational Water - That water which exists in the large pores and is free to respond to the pull of gravity. It drains, or percolates through the soil column.

From the standpoint of utilization by plants, water may be classified as (1) unavailable, (2) available, and (3) excess (superfluous). These forms correspond closely to the three forms of water classified by Briggs. From a practical standpoint we are primarily concerned with the available water in a soil. It should be pointed out, however, that many turf problems can be traced to the excess or superfluous water which is not removed from the soil.

Soil moisture constants associated with the upper and lower limits of the available water in the field take on a special and practical significance. For our purposes, we may use the terms "field capacity" and "wilting point" to indicate the upper and lower limits respectively of available water. These terms may be defined as:

(1) Field Capacity - that percentage of moisture that remains after the gravitational or excess water has drained from the soil. It should be noted that field capacity can be attained only in a well-drained soil. Field capacity represents a level of moisture quite close to the "moisture equivalent" -- a level of moisture readily determined in a laboratory.

(2) Wilting point -- That percentage of moisture found in a soil after plants wilt permanently. Contrary to popular belief, it has been established that all plants will wilt at about the same level of soil moisture. In other words, in spite of inherent differences between plants, they are unable to extract water beyond a given level from the same soil.

WATER INFILTRATION AND MOVEMENT

So far, we have attempted to point out the tremendous amounts of water necessary for plant growth and that the number, size, shape and arrangement of the soil pores will determine the ability of a given soil to absorb water and remove excess water from the soil. We have also briefly classified the forms of soil water and discussed the range of available water. Let us now turn our attention to the infiltration and movement of soil water and see how these factors influence the moisture relationships under turf.

INFILTRATION

The process of the downward entry of water into soil is referred to as infiltration. For any given soil or soil condition, there exists a maximum entry or infiltration rate. When application rates, whether from rainfall or irrigation, exceed the infiltration rate, runoff or ponding occurs. In other words, when water is applied to soil at a rate faster than it can be taken in, the excess water is lost for all practical purposes.

MOVEMENT

The downward movement of water through the soil is spoken of as percolation. When rainfall or irrigation stops the moisture moves gradually out of the larger pores in a downward direction. This amount takes place primarily under the influence of gravity. According to Baver, a summary of experimental investigations on the downward movement of water by gravitational forces in natural soils is related to (1) the amount and continuity of the large pores as determined by soil structure, texture, volume changes and biological channels; (2) the hydration of the pores; and (3) the resistance of entrapped air. Concomitant with the recession of water in the large pores, air is drawn into these pores. The large pores are seldom, if ever, entirely voided of water because of the molecular attraction of the soil particles for water. As the soil approaches field capacity, there is a reasonably continuous gaseous phase throughout the soil, but the moisture films covering the soil particles become so thin that additional moisture movement in these films is considerably restricted. Movement of this water (capillary) takes place very slowly as a liquid from the thicker to thinner films. Such movement is spoken of as capillary or film adjustment and plays a vital part in supplying plants with water.

WATER AND NUTRIENT ABSORPTION BY ROOTS

In order to bring some of these seemingly unrelated factors which we have been discussing together and see just how they influence the moisture relations under turfgrass, let us examine a soil in which a grass plant is actively growing.

One of the characteristics of an actively growing root system that is performing its function of absorbing water and nutrients is that it has a relatively extensive area of growing tissue permeating the soil. Only a very small part of this extensive system is actually engaged in absorbing water and nutrients from the soil. Absorption of water and nutrients takes place in the root hairs found near the tip of the actively growing root. Roots must have water and air, as well as nutrients, to grow and develop; hence, the growing tip of the root follows or grown through voids where these materials are found.

We have mentioned earlier that water moves into soils through the large pores and that as the excess water is drained away, these pores are filled with air. It is within the large or non-capillary pores that the capillary water absorbs oxygen so that the moisture which the plants use contains a sufficient amount of this essential element. We might also assume that this water, charged with oxygen, contains the necessary nutrients required by the plant for growth. As a result, we will find plant root growing around and within the large pores and utilizing the capillary water charged with oxygen and nutrients within a restricted area. Until quite recently, it was thought that capillary movement or film adjustment would cause available water in adjacent areas to move into the root absorption zone and replenish the supply. Thus, it was felt that the plant roots could more or less remain within a given area and extract practically all of the available water. It has now been established, however, that such is not the case and that although capillary or film adjustment does occur, it is not rapid enough to provide plants with the required amount of water and nutrients.

We now know that most of the water and nutrients which plant roots are able to take up are made available to those plant roots by the growth or extension of the roots into parts of the soil which have a sufficient amount of available moisture and a new supply of nutrient elements. In other words, the plant root must seek out new supplies of moisture and nutrients instead of these materials seeking the root; otherwise, it would soon utilize all the nutrients and water in a given area. This is one very good reason for developing and maintaining as desirable physical soil condition as possible under turfgrass. It also points out the importance of an extensive well-developed root system.

It goes without saying, that the soil which permits extensive and deep root development is one that displays good tilth, has good structure, has desirable pore space distribution, is abundantly supplied with available nutrients, is periodically replenished with water and is sufficiently permeable to permit good drainage. In such a media, which obviously would be well aerated, the roots in general are long, light colored and well supplied with root hairs. In the absence of adequate amounts of oxygen, the roots are thickened, shorter, darker and have less than a normal number of root hairs.

Inadequate soil aeration, or in line with the terminology we have been using -- insufficient large pores, decreases the intake of water by plants directly through its effect on absorption and indirectly by reducing root growth. In water-logged soils, or where sufficient anaerobic biological activity occurs, the accumulation of such products as methane, carbon monoxide, and hydrogen sulfide may result. Also, reduced forms such as nitrites, ammonia, ferrous compounds and manganous compounds will build up in soils. These products are quite toxic to plant roots and if the situation is prolonged, death of the plants occurs.

AERATION AND DISEASE

In addition to the more or less direct influence of soil aeration on plant growth, soil aeration exerts an important indirect effect as a factor in the occurrence and severity of certain plant diseases. Such effects are of two kinds; (1) the lack of oxygen and/or excess of carbon dioxide on the growth and longevity of the pathogen, and (2) the increased susceptibility of the host plant when grown in poorly aerated soils. Pathogens that attack plant roots are the ones that are most influenced by soil conditions. The importance of temperature, pH and moisture content are widely recognized as factors affecting root attacking organisms. It is assumed by some that the principal effect of high moisture content arises from the attendant poor aeration.

SUMMARY

In this paper an effort has been made to point out that plants require a great deal more water than the amount actually used in their metabolic processes.

The physical properties of soils govern the air and water movement and retention within the soil. The relative distribution of pore sizes is of greater importance under turfgrass than the total porosity of the soil. In order for turfgrasses to function properly, there should be an approximate equal distribution of large (non-capillary) and small (capillary) pores. The two classes of pores should occupy approximately 50 percent of the soil volumes; the solid or mineral fraction should make up the remaining 50 percent of the soil mass.

Water and nutrients which plant roots are able to take up are made available to those roots by the growth or extension of the roots into parts of the soil which have a sufficient amount of available moisture and a new supply of nutrient elements.

Inadequate soil aeration decreases the intake of water by plants directly through its effect on absorption and indirectly by reducing root growth. Soil aeration may exert an indirect effect as a factor in the occurrence and severity of certain plant diseases.

THE CONTROL OF BERMUDA AND RHODES GRASS SCALES

Elmer W. Beck, Entomologist
U. S. Department of Agriculture
Tifton, Georgia

I have been mainly concerned with cereal and forage crops insects, but have made some observation on three of these insects which are serious pests of turf. Dr. Robinson asked me to discuss these insects for you today, but I didn't know that he was going to use the word "control" in the title. I wish that he had left it out because we are going to talk about three tough customers. We have done a lot of work on them and made a lot of observation, but we haven't yet succeeded in bringing them under control. These three insects are Rhodes grass scale, Bermuda grass scale, which is sometimes called Ruth scale, and ground pearl. The Rhodes grass scale is probably your worst pest. We haven't made many observations on it in the Tifton area because it isn't found here. We have seen it on some grass in the green-house, and made some observation on it in that way; however, it is in North Florida. Its distribution extends across the Coastal Plain states, Alabama, Mississippi, and into Texas where, of course, it is a serious pest. It was first found in 1942 on the Kings Ranch by an agronomist, and since that time it has either spread or built up in numbers until it has been found in all of the states that I mentioned. We have a sub-station at Denton, Texas, Dr. H. L. Chada in charge, and he has worked on the Rhodes grass scale for three or four years without too much success. I have obtained his paper and all the information he has on it, and that's the source of the information I will give you.

Slide - This, of course, is a scale insect; it secretes a waxy covering which protects it from most of our sprays and other materials. It produces parthenogenetically, that is, there are no mates. The egg is held in the insect until it hatches and the young scale is born alive. It is known as the crawler in this stage. This is the first stage of Rhodes grass scale, and it is in this stage in which it is most easily killed, if we can get the materials on, keep them on, and use a material which has a long lasting residual effect. The females continue to produce young right straight throughout the season, and we have to make repeated applications in order to kill all of the crawlers. The crawlers remain on the females a short time, crawling over the body of the mother and then they take off and wander all over the plants, and finally settle down behind a leaf sheaf. They have long thread-like mouth parts which they insert in the grass, sucking up the juices, and from that point on they no longer move but remain immovable the rest of their life. The crawler is very minute but you probably could see it with the naked eye. This is the mother or adult of the Rhodes grass scale. The long thread-like part that you see is the mouth parts, which is inserted into the plants. Often one will see this protuberance, which is a waxy secretion. It is really excretionary in nature, the same as the over-all coating or wax by which they protect themselves.

Next slide - When we remove the wax covering and look at the dorsal side of the insect this is what you see, except it is pinkish in color. It's more or less formless since you don't see any legs or other structures.

Next slide - This is the ventral side of the scale. One can see four scars of the legs, which, of course, are not functional and again we see the mouth parts.

Next slide - This is the Rhodes grass scale on some Bermuda grass. Notice where they are located. Most of them will be found in the crown just above the surface of the soil, but here we have them along the nodes. The small young insect fastens itself to the plant just under a sheath, and as the insect grows it grows out of that sheath.

Next slide - This is the Rhodes grass scale as it grew in the greenhouse. Here is a good example of what you can see in the field where the insect becomes abundant.

Next slide - On the right we have the Rhodes grass scale and on the left, the Bermuda grass scale. I brought this picture to give you some idea of the difference between the two. The Rhodes grass scale is found on the upper part of the plant, whereas the Bermuda grass scale will be found in the crown or on the stolons or on the roots in the mat. Actually, most of them are in the mat which explains why it is difficult to control the Bermuda grass scale. The insecticide must penetrate that mat and in quantities.

Next slide - This is a little better picture of the Rhodes grass scale, and on the right we have the Ruth scale. In the case of the Ruth scale we often get a cluster of them around the stem like that shown and they injure the stem so severely it dies.

On the Bermuda grass scale. I believe it was last May or June, one of the large plantations near Albany, Georgia, called in and said they were having some difficulty with their pastures, particularly the

Bermuda grass. A pathologist and I examined the pastures but the only thing we could find abundant there was this Ruth scale. We set up an experiment to see if we could determine whether or not the scale was actually causing the damage.

We used three materials, parathion, systox, and summeroil. Summer-oil was one of those long shot chances. We thought that perhaps we could get the oil to penetrate the sheaves and kill the scale. As it turned out we got no results with the oil. There was no difference in the increase in yield in the oil over systox. We had high hopes that systox would do a pretty good job, but the parathion gave the results that you see here. The plot on the right is a check, and the plot on the left is where we applied parathion at the rate of eight ounces to the acre, using 100 gallons of water. We had to use a high gallonage spray in order to get the material down into the crown of the grass. We are not yet ready to recommend this as an efficient control, but we think that eventually we will be able to recommend it under similar conditions. Whether or not that is going to be satis-factory on golf course turf is doubtful. In the case of the Rhodes grass scale, Dr. Chada tried various materials, and he ran into the same thing, of course, that we have found here. We have to hit those fellows and have to penetrate the waxy covering that they have or the material isn't going to be effective. Dr. Chada found Dematon (systox), which is a systemic, would do a fairly good job. He used 1 gram per 1 square yard in 1/2 gallon of water, which would mean, if I have figured it correctly, 19 pounds to the acre in 2400 gallons of water. This application rate is impractical so far as being able to recommend it for farm use, but that is the only material that gave them a high degree of control.

The ground pearl overwinters in what we call the pre-adult stage. Along in the spring of the year the pre-adult leaves the pearl, which again is a waxy covering and a difficult thing to penetrate with insecticides. We have a female this time, which is able to move about and crawl through the soil though as far as we know she doesn't move very far. As she moves she secretes a waxy material, which I imagine assists her in moving through the soil. When she settles down she continues to secrete these waxy filaments but her motions in the soil break up the filaments. If you will look in the soil where you have an infestation of ground pearl you will find these little pockets which seem to be lined with a powdery material, the waxy secretion. After the female stops moving she exhausts herself in producing eggs. The eggs have a very long incubation period in the laboratory. We held some for five to six weeks before we got any to hatch. The little crawler comes from the egg and is very similar to the crawler of the Rhodes grass scale, pictures of which I have shown you, except that it is elongated and has club-like rather than a filiform antenna. Crawlers move, we think, just short distances but we haven't any information on that either. It is a difficult thing to observe. The crawlers settle down on the roots and their long filament-like mouth parts are inserted into roots to suck up the sap. The pearl completes its development in this position. We have tried a number of soil applications but we haven't obtained any results. We are planning this year to make soil injections. That, of course, would be impractical from the standpoint of a pasture, but we are hoping that it may be a help in controlling this insect in lawns and grasses on golf courses. I have a few specimens here if anyone would like to see the three scales. Thank you.

ESTABLISHMENT AND MANAGEMENT OF BENTGRASS GREENS FOR THE SOUTH

Charlie Danner, Superintendent
Richland Golf Club
Nashville, Tenn.

After working with Bentgrass greens at Richland Country Club at Nashville for the past seven years, observing the Bent greens at Knoxville and Chattanooga, I am convinced that with good management, and I just have to stress that word "management", good Bent grass greens can be grown in the South. I would like to review what we consider to be the advantages of Bentgrass in our area. First, it is a year-round grass. That is something we have all been seeking for a good many years. In Knoxville a few years ago, with O.J. Noer and Fred Grau present, we had a turf conference, and it wound up with a round table discussion, and we were crying to them about our problems with our two-green system, and Fred Grau suggested that we try Bent, just fool around with it to see what we could do. O. J. helped out with it, and between the two of them, along with some plants that Fred sent down from the green section of Washington, we started to work with it at Nashville, and planted a little nursery. I got so sold on the results of the nursery that I put in one green, and the grass sold me. Bent will stay green the year round in our climate. Best way to avoid spring and fall transition period associated with Bermuda and rye greens.

Second, it makes a better putting surface the year round. Everyone will agree that Bent makes a better putting surface than any of the Bermudas, and it is as good or better than the best rye greens.

Third, Maintenance. Now here was a surprise to me. The cost was actually lower. This may be contrary to the general belief; however, we find this to be true, because we save on top dressing. Bent needs very little top dressing as required for Bermuda, and the occasional top dressings needed for rye greens.

We save on fertilizer. With Bent you are fertilizing one grass as compared with fertilizing two grasses with Bermuda and rye combinations, and both of those grasses are heavy feeders.

We save on labor. This last is a substantial saving. Less labor will be needed for top dressing, mixing and applying top dressing, weed control, and mowing. Bent will require mowing only about three times a week compared with mowing Bermuda seven days a week, and rye four to six days a week.

We save on water. Even with occasional syringing during the day during the summer months we find that we use less water watering the Bent greens than we use watering the rye greens, hence we not only save on the water itself, but again on the labor involved.

For construction, we removed the old surface down to a depth of 14"; installed tile lines down to a depth of 5" to provide for sub-surface drainage. On the top 9" we mixed 50% coarse sand, 40% loam, and 10% peat. These materials were mixed off site in a concrete mixer and then put on the green. We tried to build the top so as not to leave any pockets or depressions, and to provide for a good run-off of surface water. We firmly believe that surface drainage is more important than sub-surface drainage.

The next step was to sterilize the soil. We used methylbromide, sold commercially as Dowfume MC-2. We then planted Arlington C-1 stolons at the rate of 1 bu. per each 100 sq. ft. The stolons were spread, then covered with a top dressing and kept moist until they started to grow. The greens were put in during the fall and opened for play the following May.

Maintenance. We mow, aerofy, vertacut, and fertilize as needed.

Fungicides. PMAS, Tersan, Calocure, Actidione, and Cadminate, are used to combat diseases. We find PMAS is a good chemical for preventative fungicide treatments as well as being a good chemical to prevent crabgrass. We find Tersan and Calocure a good cure for brown patch. Actidione, a good cure for curvularia, and Cadminate, a cure for dollar spot. You know this sounds like a lot of chemicals, but we rarely ever have to use them on the Bent greens except in June, July, and August, three months out of the year. The cost of chemicals used during the three summer months runs to around $25.00 a week. I am sure a lot of you have had these diseases in your rye greens during the winter months, and I am told that your Bermudas also are susceptible to disease, so I don't believe chemicals needed for control of disease would be any more expensive than those used on Bermuda and rye.

Fertilizer. We usually use Milorganite, and add 60% muriate of potash, then a complete fertilizer as needed. At first we set up a regular fertilizer schedule, but today we are applying fertilizer as needed.

Watering. Early morning appears to be the best time for watering. During the hot, windy days we check for wilt, and this is very important. If wilting occurs we water the green lightly during the day to supply moisture to the leaves of the grass, and this cools the grass and soil.

I have got to stress management. That really enters into the keeping Bent or any other kind of a grass. Management is really the most important factor in keeping Bent greens, and it enters into all phases of the golf course operations. A fungicide treatment as soon as disease appears will usually stop the disease, whereas if permitted to go unchecked for a day or two, or if allowed to get a good start, will result in a seriously damaged green. The golf course superintendent must be on the job seven days a week during the summer months, June, July, and August, to watch for wilting. A little water at the right time will stop wilt quickly, and to wait can be disastrous. I know all of this sounds like a lot of work, but you will have far less labor costs keeping Bent greens as compared with Bermuda and rye greens. Remember, there is no maintenance, except mowing and fertilizing, from September to June.

In conclusion, we know Bent grass can be grown in the South. With the newer strains of Bent grass such as Penlu, which is more disease resistant, and with better fungicides now coming into the picture, I firmly believe that good year round Bent greens can become a reality almost anywhere in the South.

ESTABLISHMENT AND MANAGEMENT OF NEW BERMUDAS FOR THE BORDER LINE AREAS

E. E. "Bubber" Johnson
Bluegrass Country Club
Hendersonville, Tenn.

I am a newcomer in the turf business, but Dr. Robinson asked me to come and relate to you some of my experiences with the strain of grass that we use at our Club which is known as Tiffine or Tifton 127. But first of all, since Charlie Danner and I are both in Nashville, you might think that we would be in competition, but I am growing Bermuda and Charlie is using Bent. I have seen Charlie's greens and played them; and they are some of the finest Bent greens that I have seen anywhere -- and I've played on some in different sections of the United States. If Bent grass can be grown successfully in the South, Charlie can certainly do it.

Would also like to say a word about the many things I have learned from attending these turf meetings in Tifton. The writer wasn't fortunate enough to be here each time, but in coming down I learned a lot. Since I am so new in this turf business I feel out of place talking to a group of people that know so much more about it than I; but it has been very wonderful to meet such informed men and discuss our problems concerning turf.

My topic is ESTABLISHMENT AND MANAGEMENT OF NEW BERMUDAS FOR THE BORDERLINE AREAS. Now, first of all, I would like to tell you where our Club is located. We are right on the Kentucky line, just above Nashville, and are known as the Bluegrass Country Club. I went up there shortly after the site was selected. They had obtained an architect and he had already given them the specifications, blueprints for building the course, etc.; and in making his selection of grasses for our fairways, he either got the wrong book or the wrong page when he selected Bluegrass for our part of the Country. We are close to the Bluegrass Country, but definitely not where we can grow Bluegrass on fairways with any degree of success; now, particularly, during the Summer, when the Bluegrass would not stand close clipping. So, in order to carry out the name of Bluegrass, we found a thicket reasonably close by and obtained some sod and managed to sod around the Club; so at least we have a little of the grass around to bear out the name of the Club.

I would like to illustrate to you, as clearly as I can, some of the things that we have done and maybe it will be of some help to you. Our first step was to locate each green. After this, with the aid of an instrument, we set our stakes which outlined the green and also gave us the amount of fill necessary for our finish grades on the outside of the putting surface. The architect's plans called for a 12" fill under the entire putting surface. Before putting in the fill however, we decided to use the herringbone type of sub-drainage which was our next step. This was done by digging trenches 15" deep and 8" wide, 15 feet apart over the entire subsurface of the green. We used 4" open drain tile partially covering each joint with a heavy paper. Next, we back-filled the trenches with approximately size 2" rock to top of the trench. Now we were ready to apply the 12" fill which consisted of 50% top soil and 50% coarse sand. This mixture was mixed in a very large concrete mixer and then placed on the greens by motor buggies. When the entire putting surface was filled with this mixture we applied 1" peat moss over putting surface. With hand rakes we worked the peat down into the soil and sand so that our top 3" consisted of 1/3 soil, 1/3 sand and 1/3 peat. We had the soil tested and found that a few of our greens needed potash. This work was completed in the Fall.

By March we had very few weeds, so we did not use Methol Bromide. In fact I didn't use anything to treat the soil -- we were undecided at the time. Even though the weather became bad about that time we came out very fortunate. Very little weeding by hand and hoe had to be done. In fact, I do not recommend that at all; the safest thing to do is use Methol Bromide.

In the Spring we used an application of 10-8-6 fertilizer at the rate of 35 lbs. to 1000 sq. ft. then we were ready to get our grass. We felt so lucky to have Tifton 127 available for use at that time. So I made arrangements with a local nursery here in Tifton to get enough grass to satisfy our needs. All of the grass was shipped parcel post through the mail in waterproof bags. We ordered well over 100 yards of Tiffine Bermuda. Out of the 100 yards that we bought, we did not lose one sprig from wilt or from drying out. The grass came in in excellent shape; it was pretty and green and I believe it was as green as when it was taken out of the nursery. Just as soon as it came in to the postoffice we immediately put it in a bed of loose soil and watered it thoroughly until ready to be used. Another thing we noticed is that this certified Bermuda is a very pure strain and you would get good protection by using certified grass.

The grass started spreading about the middle of April, and by the middle of June the greens were covered. They could have played on them by June 15. I think in the sprigging method that was pretty fast coverage. Then we kept working the mower down until we finally got it down to 3/16". We found at 3/16" that maybe we got it down a little too quickly, and possibly shocked it; so we raised the mower back to a quarter for awhile and then back to 3/16" and were able to maintain a 3/16" cutting height.

Now, when we went into Winter we had only one set of greens, and no place for a temporary green, so we decided to put half of our greens in rye grass. We played on these the first year, but in the Spring we started the transition. We had trouble with about five greens. We lost some grass and I think that it was particularly due to a mistake by the writer. Because the greens were new we failed to aerofy them enough and therefore we failed to get enough root depth out of the grass that was lost. By having a nursery we were able to obtain enough sprigs to replant and it covered rapidly.

Actually, the first green was started about the middle of April and we were ready to seed rye in September. So you can readily see that this is not long enough to have established a turf with deep enough roots that you could over seed with rye without some loss. Personally, I believe that when the greens are older that they will take an over seeding of rye grass. This past Fall we covered our greens with wheat straw and played on temporary greens. We have removed the straw already this year and the greens have a lot of color and seem to be covered real well.

There are two characteristics that we have found in the Tiffine Bermuda - one is seeding and the other is a tendency to mat slightly.

We have been able to control the seeding partially by brushing, cross mowing, and liberal feeding of nitrogen and less feeding of phosphate. The matting has been controlled very successfully by use of the verticut.

In conclusion, let me say that our members are very happy with our greens and we feel fortunate in having Tiffine Bermuda on our greens.

SUMMARY

J. M. Latham, Asst. Turf Specialist
Georgia Coastal Plain Experiment Station
Tifton, Georgia

Moderator

I would like to bring out a few things that you men have said. The variety of grass does not seem to matter too much in the long run. It does help, of course, but it does not make too much difference as long as the management will fit the grass. The grass will vary from place to place as other crops will. They don't say that variety of corn for Georgia will do the same thing for upper South--the Tennessee or Kentucky area, or for southern Florida. I don't think we should expect the grasses which we have to do the same thing. Management and establishment of turf areas will be the same.

As has been pointed out, we have several good Bermudas which have looked very good in some places, but they are not worth a darn in others. The one that we are looking at down here now is the 328 Bermuda. It has good leaf width and color, fairly good habit of growth, and it does spread rapidly. It has looked good the first few years we have had it, but what it is going to look like in later years when it has more age on the planting is going to make a lot of difference. Also how well it is going to take traffic. Our plots don't get as much traffic as your greens do, of course, and that might also change the picture considerably.

The grasses we do have: Ormond, Everglades, Gene Tift, Tiflawn, Tiffine, and what else we might find, all have a place somewhere. The thing that we have to do now is to find it. That is one reason why Robbie and Dr. Burton have been trying to get the superintendents to establish a little nursery of their own, to handle the grasses that we have in the manner that they would handle them and see what they will do under their conditions. We don't have too much trouble with the 127 here, but other places they do; several other places, in fact. Until we know about such things we do not know what the grasses will do and whether they should be released or not.

This genetics business can carry us only so far in getting good turf. The rest of it is going to stay in the management field which will also vary from place to place. Everybody has a different problem; either there is too much clay or too much sand, it's too hard, or too soft. It's always going to vary from one course to the next even within the same town. That is something that you are going to have to fight, and which will have to be worked out with you.

To summarize these remarks--there is no better combination than a well adapted grass and a management program that takes into account the local conditions under which turf must be produced.

THE USE OF SODIUM ARSENITE ON FAIRWAYS AND GREENS

Dan Hall, Superintendent
Peachtree Golf Club
Atlanta, Georgia

TEST FOR PROPER HERBECIDE:

We tested the following for general weed control: 2,4,D; Potassium Cyanate; Sodium Arsenite; Nitrate Solutions; PMAS; M,H,40.

REASON FOR CHOOSING SODIUM ARSENITE:

1. Gave us the best results on most types of undesirable plants that we had.

2. Little effect on desirable plants if used properly.

3. Was most economical.

PROPER APPLICATION METHODS:

We experimented for three years before arriving at the proper methods of application. They are:

1. Climatic Conditions: We stake a thermometer at a 1 foot height above green or fairway to be treated. From our test we found that temperature was nearly as important as the rate to be used. We found that the best results followed when the temperature was 75° and higher. We found 1-3/4 oz. of Sodium Arsenite in 5 gals. of water per thousand square feet down to $\frac{1}{2}$ oz. per thousand square feet are the best rates. The 1-3/4 oz. solution is used when the temperature is 25°, and we decrease the amount $\frac{1}{4}$ oz. per 5° increase in temperature. For example: the first green treated in 1953 had the heavier rate while the last green had $\frac{1}{4}$ oz. per thousand square feet at a temperature of 105° one foot above the putting surface. The results were the same. We were only interested in killing rye and poa annua and any other plants such as crabgrass and crowfoot that were beginning to germinate in the surface soil.

2. Grass and Soil Condition Prior to Application: We let the grass on the half to be treated go uncut for 3 days. No plant food is applied for 10 to 14 days. We try to have the top one inch of soil dry so that the grass and soil will be receptive to the solution of Sodium Arsenite.

3. Method Used: We use a four foot hand operated boom with a course nozzle at 60 lb. pressure at the pump outlet. We just want to wet the grass thoroughly. Enough run-off occurs to reach the seeds in the surface layer of soil. We use a method of three strings to guide the operator and prevent skips and double dosing. This speeds up the operation and eliminates doubling to get good results. We can treat 72,000 feet of putting surface in three to four hours this way.

RESULTS:

In 2 to 4 hours the grass wilts. After 24 hours it has a bluish color, appearing oily and slick; it also begins to curl at the ends. The second day it begins to turn brown and by the third day is brown all over. After four or five days it is thoroughly dead; we then brush and mow the greens to remove the dead matter. This allows sunlight to thoroughly get to the soil and the underlying Bermuda grass. After the fifth day we water by hand. When the Bermuda again becomes active on the sixth or seventh day, we fertilize at the same rate as we do the area in play.

RESIDUAL EFFECTS:

The first year this was done the same rate of 1-3/4 oz. per thousand square feet was applied to all the treated area. The Bermuda on the greens treated after temperature reached 85° was greatly affected.

Since that time, we have seen no effects on the Bermuda or the soil. We did notice that on the treated area we had little or no crabgrass and crowfoot, while in the untreated area these plants were beginning to appear in the latter part of May. We give ourselves about one month to put the treated area of each green in play. We then treat the unburned area of all greens. Each spring we alternate areas to be burned. The area treated last, last year, will be first treated this spring, and so on. With this rotation of application we find that we have had little or no poa annua in four years. We also secure a fine control of crabgrass and crowfoot throughout the year.

FAIRWAY WEED CONTROL:

We found in our test plots that Sodium Arsenite will kill poa, crab, crowfoot, chickweed, plantain, dandelion, and carpet grass. We treated seven fairways in 1953 in middle June, using 1 gal. of Sodium Arsenite solution or 5 lbs. of Sodium Arsenite per acre in 50 gallons of water. This gave us a wonderful kill on all weeds, except Dallis grass. We did notice that the Dallis on treated fairways failed to develop stems and seed spikes, even though it was little affected on the surface. We applied 66 lbs. of nitrogen per acre 30 days prior to burning and 66 lbs. more 7 days after. In two weeks these fairways were good Bermuda. We expect to treat all fairways and tees this spring in the same manner.

COST: (includes labor, materials such as gas, oil and water)

Labor to treat 18 half greens	$18.00
1 gal. Sodium Arsenite solution @ 5# per gal.	.75
Water - 350 gals.	.25
Gas and oil in pump	.30
	$19.30

This breaks down to:

2.7 cents per thousand square feet, or 21 cents per 8,000 square feet of greens for one year, or about $1.30 per acre.

Dates of Burning on Bermuda	Dates of Mowing on Bermuda
April 28, 1952	May 24, 1952
May 4, 1953	May 22, 1953
May 19, 1954	June 18, 1954
May 10, 1954 burned aprons	
Recovered completely on May 29, 1954	

THE CONTROL OF WEEDS AND USE OF SOLUBLE FERTILIZER

Fred C. Galle
Ida Cason Gardens
Chipley, Ga.

I really should be sitting down hearing a talk on this problem of weed control, for I feel I need more information than I can possibly pass out. We do have a problem of Dallis grass. Many of our fairways were former pastures, where they had, for a period of 10 years, been trying to establish Dallis grass. Now we are going in reverse and trying to get rid of it. We have had some of the same experiences as Don Hall. Sodium arsenite will kill Dallis grass, but if not used carefully can give you very definite burned areas. The normal rate for commercial sodium arsenite is 1 to 10, however, as the temperature increases, one can use a rate of 1 to 20 parts of water. We also use a soap or "sticker agent" in with the spray. Moisture is necessary to remove the sodium arsenite residue from the soil. We did find that areas treated late in the Summer are difficult to establish with rye grass during the Fall.

We also tried using ammonium nitrate in a concentrated liquid form. This material needs further testing to obtain the correct concentration. We did find that sometimes we could kill Dallis grass and after a rain or after irrigation Bermuda would come back over the area rather fast. However, if insufficient material was applied, you may burn some of the Dallis grass leaves, but it would "jump" back into vigorous growth.

We also used spot treatment with ammonium nitrate fertilizer, applying a handful to individual clumps of grass. It is a good method, but can be mighty expensive over a large area.

Dr. John Monteith, our former consultant, suggested making a knife tamp. We made a tamp with a base approximately 8 x 8" and used old mower blades welded on the bottom about $1\frac{1}{2}$" apart. This tamp was used around the approaches and on tees, and primarily on individual clumps of Dallis grass. The tamp is dropped twice on each clump and given a half turn after the first tamp. The knives cut and reduce the leaf surface of the Dallis grass and the Bermuda comes in and crowds it. We do not believe this will eliminate the Dallis grass, but it reduces the large tufts and you have no burned areas, such as with poisons. We are encouraged with its use and have made up three such tamps, after having made just one to experiment with.

We have been working on a method of lifting up the leaves of Dallis grass so that they can be cut off and enable the Bermuda to crowd it out. We made a rake, from the old tines of a rototiller, to go on the front of a Whirlwind mower. This is not one of our golf course mowers, but used this machine for trial purposes. I realize that there are commercial rakes available, but they are generally not heavy enough for Dallis grass. We used this mower around the greens and approaches and are so encouraged by its treatment that we hope to build a similar unit for our fairway gang mowers.

I would like to close the Dallis grass discussion by saying that a weed is often described as a plant out of place. Another classification of a weed is a plant for which we have found no use. Now if we could find a real good use for Dallis grass on a golf course, we might then stop referring to it as a weed.

We have 2500 acres in the Gardens and have other weed problems that may interest you. For honeysuckle control, we use a commercial mixture of 2-4-D (1-1/3 lbs.) and 2-4-5-T (2/3 lb) acid equivalent per gallon. Our rate of application is three pints to sixty gallons of water, again adding a soap or wetting agent. Follow-up spraying is often required to get complete control.

Another one of our problems is tree stumps. We are doing an extensive amount of thinning, such as might be done around fairways. Unless the stumps are poisoned when removing hardwood trees, such as oak and sweet gum, the sucker growth comes back and you have the same problem. We are using a mixture of 2-4-5-T (4 lbs. acid equivalent per gal.) and diesel oil 1 to 20. The stumps are painted with this material and we find it better than ammate or other materials. Often stumps are missed in the painting and it is difficult to tell several days later if all have been treated, so an oil soluble dye is now added to our painting mixture and eliminates another problem.

For our greenhouse and nursery area, we have a Rough Brothers steam sterilizer and have now started using this machine to treat our top-dressing soil for the golf course. Steam sterilizing of soil is a common practice in greenhouse operations and you do not "kill the soil" as is often believed. The top soil mixture is prepared and thrown into a large enclosed frame. Two lines of perforated pipe are inside the frame and, after filling with soil, a steam cloth is placed over the top. The soil is heated to a temperature of 150 degrees for thirty minutes and then stored in covered storage bins. The major advantage of this treatment is that we can sterilize our soil during the winter season and store it until Spring or when it is needed.

Among our general horticultural equipment, we have a large Hardie Mist Sprayer. Last fall, we mounted this unit on a trailer and used the blower to blow leaves off the golf course. We thought we were pretty smart, using this machine in this way - and then read in a copy of Tree Magazine of the same operation being done in Michigan.

The leaves still offered a problem, for we could use them for mulching of plants and composting for additional organic matter, but it takes a lot of man hours to pick them up. We have several portable irrigation pumps that we use during the summer season and which sit idle during the fall and winter. We removed the water pump from one smaller unit and mounted a 25" suction fan. This suction machine is pulled by a dump truck; leaves are sucked up through a 6" flexible hose and blown into the closed truck body. The leaves are then utilized in mulching or composting. With our large water pump unit, we have mounted an Asplundh Chipper. During the summer, we are irrigating, but by simply changing the V-belts, we can use the chipper to dispose of brush from our thinning program.

Another piece of labor-saving equipment is our soil auger, which mounts on the rear of our tractor. We have augers from 6", 9", 12", 18" to 24", and we use these for digging planting holes. We have been planting over 10,000 plants each year in the Gardens and the auger has really payed off. For planting holes over 24" in diameter, we use the auger to bore several holes in the same area and then shovel out the loose soil.

Now to the problem of liquid fertilizers. We have been using liquid fertilizers in our greenhouse and nursery, but haven't used it on the golf course because we haven't felt that we have the right kind of applicator to get an even distribution of material. We have a water wagon, spray tanks and such, but still cannot govern the flow of material with pressure to know just exactly the rate of fertilizer used at a given time or area.

For our greenhouse, we make up our own liquid fertilizer. No, we don't feel it is better than commercial products, but it is cheaper. For example, our 20-20-20 fertilizer costs approximately 10 to 12 cents a pound.

The following examples of mixed fertilizers will show how you can make up your own material and change it to suit your own need.

Approximate analysis: 20 N 20 P 20 K

40# Ammo. Phosphate (21% - 53% - 0)
25# Urea (46% N.)
33# Muriate of Potash (60% K)

Approximate analysis: 25 N 22 P 10 K

41# Ammo. Phos. (21% - 53% - 0)
35# Urea (46% N.)
16# Muriate of Potash (60% K)

If the material is to be used entirely as a foliar fertilizer, I would suggest adding a wetting agent, such as Santomerse S made by Monsanto Chemical Company or an equivalent material.

I believe too, that foliar fertilizers have only a temporary effect or as a "shot in the arm". Longlasting effect of fertilizer is had from material in the ground.

I hope that this material has been of general interest. The Ida Cason Callaway Gardens have been open only three years and, while we have made progress, there is still a great deal of work to be done. We invite you to visit us at any time.

QUESTIONS AND ANSWERS

B. P. Robinson, Regional Director
U. S. Golf Association Green Section
Tifton, Georgia

The following is a summarization of the questions and answers which occurred during the annual "superintendents' question box" of the conference. Mr. T. M. Baumgardner, Sea Island, Georgia was discussion leader. Most of the people in attendance took part in the discussion.

Q. What is a good control for sod webworms?

A. Because of its residual effect D-D-T, when applied at 3 to 5 lbs. of actual per acre, is one of the best materials which has been used. One-half pound actual parathion per acre has also given good control. Other materials which have been used successfully are malathion, chlordane, dieldrin, aldrin, etc.

Q. What is the latest information on chinch bug control?

A. Parathion heads the list for control with 10 lbs. of D-D-T per acre as second. Thatch often prevents good control. To overcome effect of thatch - wet turf before applying insecticides, use low to medium pressure on sprayer and enough water to penetrate the thatch, and use the emulsion forms of insecticides.

Q. Has an insecticide been found which will control ground pearls?

A. No material is being recommended as a control

Q. Has anyone used the verticut for Rhodesgrass scale control on greens as they have in Texas?

A. No one had used the machine for this purpose possibly because of little damage to greens by this insect in the Southeast.

Q. Will methyl di sodium arsenate or lead arsenate injure St. Augustine grass?

A. St. Augustine grass seems to be quite sensitive to herbicides. Be careful therefore, when using these materials.

Q. How can we keep from getting crowfoot and crabgrass tees every year?

A. (a) If tees are small, enlarge during longrange program
(b) Remove competition from trees.
(c) Practice heavy fertilization each spring especially with nitrogen.
(d) Use vertical cutting equipment in control program
(e) Use spiking equipment, etc. to soften tees and not water.
(f) Consider the use of improved grasses.
(g) Try the pre-emergence herbicides to prevent germination of seed.

Q. How can Dallisgrass be removed from large areas?

A. The following methods have been used for control:

(a) Where Dallisgrass infests Bermuda lawns some homeowners have covered the areas for several hours with heavy paper, cloth, etc. Bermuda will survive this treatment.
(b) Encourage base grass (usually Bermuda) by fertilization while thinning Dallisgrass with rakes attached to mowers or using vertical cutting equipment.
(c) Repeated spraying with at least 5 lbs. sodium arsenite per acre plus 1 lb. of 2-4-D and a wetting agent.
(d) Applying heavy applications of inorganic sources of nitrogen (ammonium sulfate, ammonium nitrate, sodium nitrate, etc.) to produce a burning action.
(e) Spraying with light oils.

Q. Should one remove shade trees for more sun, or plant a different grass other than Bermuda?

A. If possible, grow a different grass. This can be accomplished on lawns, parks, etc. Sometimes root pruning or removal of branches will help Bermudagrass putting greens.

Q. Can Bermudagrass be grown from seed?

A. Only common Bermudagrass can be grown from seed. There are no seed available of the improved Bermudas.

Q. Has anyone used dye on dormant grass in this area?

A. Two superintendents reported the use of dye on Bermudagrass. In one case the club members did not know the difference, but thought the turf was wonderful. In the other they stated, "Look he has to dye the grass, he can't even grow it anymore".

Q. How often should vertical mowing equipment be used?

A. Vertical mowing equipment is designed to prevent the formation of thatch, grain, etc. It should be used often enough to keep these conditions from occuring. This may mean once every 10 days or once a month.

Q. What is the best preventive spray for disease control?

A. The first step in a disease control program is to know the organisms which may or are causing damage. No one material is effective against all organisms which cause disease on grasses. Send samples of diseased turf to a qualified person for identification. Spray programs for the Southeast which include such materials as Captan, Tersan, etc. plus one of the mercurier (PMAS, Calocure, etc.) or anti-biotic (Acti-dione) have been quite effective.

Q. It is difficult to work rye grass into some Bermudagrass putting greens. What other smaller seeded grasses may be used or can ryegrass be hulled?

A. (a) Bentgrass seeded at 4 to 6 lbs. per 1000 sq. ft. has produced good winter greens. Other grasses which may be used are blue grasses, red top, and fescues (especially meadow and red fescue).

(b) Further processing of ryegrass seed would probably destroy its germination.

Q. Have the improved Bermudas been planted into old Bermuda-grass greens without destroying the turf?

A. This has been tried with some success. Conversion, however, is slow. Because of two different grasses, putting quality is not good until the planted grass crowds out the old. Plugs in this case seem to be superior to sprigs.

Q. What has been the procedure for planting improved Bermuda on greens when the old turf was destroyed?

A. (a) Methyl bromide (Dow Chemical Company's Dowfume) has been used extensively to kill the old grass. New materials (Dow's, Dalapon, and American Cyanamid's, amino triazol) may find future use.

(b) Greens have been planted by using plugs, sprigging in holes made by spiking equipment, sprigging solid in rows, broadcasting sprigs and disking lightly, and broadcasting sprigs and topdressing lightly.

(c) One club (Forest Hills, of Columbia, S. C.) liked making the change during its slack maintenance period. One-half of each green was treated in the fall with Dowfume, all the green seeded with rye, and the treated half planted with plugs of an improved Bermuda in early spring.