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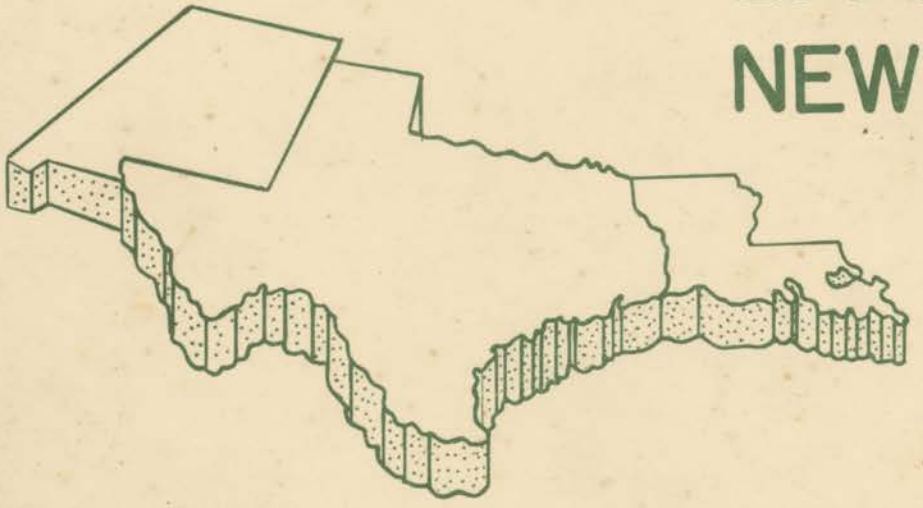

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GRASS

by

John J. Ingalls

Next in importance to the divine profusion of water, light, and air, those three physical facts which render existence possible, may be reckoned the universal beneficence of grass. Lying in the sunshine among the buttercups and dandelions of May, scarcely higher in intelligence than those minute tenants of that mimic wilderness, our earliest recollections are of grass, and when the fitful fever is ended, and the foolish wrangle of the market and the forum is closed, grass heals over the scar which our descent into the bosom of the earth has made, and the carpet of the infant becomes the blanket of the dead.

Grass is the forgiveness of nature--her constant benediction. Fields trampled with battle, saturated with blood, torn with the ruts of cannon, grow green again with grass, and the carnage is forgotten. Streets abandoned by traffic become grassgrown like rural lanes, and are obliterated; forests decay, harvests perish, flowers vanish, but grass is immortal. Beleagured by the sullen hosts of winter, it withdraws into the impregnable fortress of its subterranean vitality and emerges upon solicitation of spring. Sown by the winds, by wandering birds, propagated by the subtle horticulture of the elements, which are its ministers and servants, it softens the rude outline of the world. Its tenacious fibers hold the earth in its place, and prevent its soluble components from washing into the sea. It invades the solitude of the deserts, climbs the inaccessible slopes and forbidding pinnacles of mountains, modifies the climates and determines the history, character and destiny of nations. Unobtrusive and patient, it has immortal vigor and aggression. Banished from the thoroughfares and fields, it bides its time to return, and when vigilance has relaxed, or the dynasty has perished, it silently resumes the throne from which it has been expelled but which it never abdicates. It bears no blazonry of bloom to charm the senses with fragrance or splendor, but its homely hue is more enchanting than the lily or the rose. It yields no fruit in earth or air, and yet should its harvest fail for a single year, famine would depopulate the earth.

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SOILS IN RELATION TO GROWTH OF TURF GRASSES

Luther G. Jones, Professor of Agronomy
A. & M. College of Texas

To be the first speaker on the program is a pleasure and an honor. I shall endeavor to stay within the bounds of practicality and record. I salute the Texas Turf Association and the Texas Golf Association, and I am happy to see the infant now walking under the capable tutelage of Gordon H. Jones.

I am intrigued with the subject handed me, for several reasons. Not the least is the fact that my brand of golf allows for thorough inspection not only of the vegetation on the fairways, greens, and roughs, but also the soil underneath. It is something to be familiar with the cracks that form in the Blackland clays, the sands of the Coast Prairie, and the loams of the northern counties.

The golf fraternity comes closer to knowing humanity than any other profession, unless it is the medical. You can tell about a man on the golf course, although you may not be able to tell him much.

A player who advances his ball or drops a stroke should also be watched in a business deal.

An altered version of Omar Khayam is: "Allah in his benigh omnipotence counts not in the life of man those days spent in golfing". A golfer learns to hold his tongue; he is never profane (without cause); he always has the proper perspective between labor and relaxation. (If his score is under 70 he neglects business; over 100, he neglects the game.) The ideal must be about 75. For an ideal score, what is the ideal course? I suppose it would be one with ideal conditions on green and fairway.

There is the story of the golfer who went to Hades. He found a guide who showed him a perfect golf course with wonderful fairways and greens. "Where are the clubs?" asked the new arrival. "None here", replied the guide, "that's the hell of it."

Pedologically, the soils of the Southwest, Texas, Louisiana, and New Mexico, are legion. In this area we have the Red and Yellow Podzols, the Rendzinas, the Red Prairie, the Half Bog soils, the Reddish Chestnut, the Sierozems, and the Solonetz. We have also the brown, the reddish brown, the red desert, the grey desert, and the lithosols.

Edapologically, we have the Ouachita Highlands, the Forested Coastal Plains, the Black Prairies, the Cross Timbers, the Rolling Plains, the High Plains, the Central Basin, the Edwards Plateau, the Rio Grande Embayment, the Mountains and Basin, the Inter-Mountain Desert soils, and the Upper Mountain Terraces.

The significance of soil classification to a turf specialist consists of management. First comes the physical condition, and second, the organic material. He needs to recognize the earmarks of the soil he is dealing with.

Why is it that the Houston clays of the Blackland Prairie respond for a while to mineral fertility measures, and in a few years tighten up and apparently give no response?

The answer is that you can not manage an average soil without consideration of organic matter and you cannot get proper results from organic matter without drainage and plant food.

Good drainage is the key to the physical condition. A manager tried no top-dressing for twenty-six years on a hill built on rock with excellent sub-drainage. He obtained a perfect stand of grass. The grass had penetrated deeply on the fertile soil of the hill which had good sub-drainage; but a soil may be well drained at the top but the roots limited to an inch or two where the area is water-logged chronically.

The basic causes of poor greens in the Southwest are poor physical soil conditions. The worst of it is that these are permanent conditions which get worse in the absence of corrective treatment. We can list the causes:

1. Lack of a good soil material; depth of soil should be 12 inches and have proper construction.
2. Faulty top-dressing mixtures.
3. Incomplete equipment at the disposal of the keeper.

The keeper, if he is not experienced, may think he can get his remedy from a sack. He might try everything his friend, the banker, advises, but neither may suspect that improvement of physical condition is needed. Often improvement of physical condition is avoided because it (1) may be expensive, (2) may be improperly understood, and (3) may interrupt play temporarily.

With improved grasses available, and nearby such soils as the terrace gravels and sands of the Brazos, Colorado, Red Pecos, and Frio, there is no reason why an ideal soil condition can not be provided for a green anywhere in Texas.

It should be mentioned that fairways can be greatly improved by skillful use of a few tile in depressions.

Drainage Results in Aeration

Drainage is essential to the production of satisfactory putting surfaces. Greens soils when built up on a proper base permit trouble-free maintenance for years. Overwatering with its well-known troubles virtually is impossible where adequate drainage is built into a green. Fertilizers are more effective when the soil is open and porous. The roots penetrate deeper and the plants are healthier and more resistant to disease organisms, grubs, and fungus.

Enemies of porous soils are fine textured materials such as:

1. Clay
2. Very fine sand
3. Sewage sludge

Desirable materials are:

1. Coarse sand or fine gravel
2. Coarse organic material of the sedge or reed type
3. Tile drains
4. Over-head sprinklers

We have named groups of soils that make good greens foundation; now we will list them according to the soil survey according to W. T. Carter and E. H. Templin. Parenthetically, choose for your purpose a sandy soil that is slowly permeable or of good permeability.

Blackland Prairies
- Lewisville clay or loam
- Austin sandy clay
- Catalpa clay loam
- Kaufman clay loam
- Bastrop sand

Grand Prairie
- Denton clay
- Lewisville loam
- Catalpa clay loam
- Bastrop sandy loam

East Texas
- Nacogdoches fine sandy loam
- Bowie fine sandy loam
- Ruston fine sandy loam
- Yahola silt loam
- Miller fine sandy loam
- Sawyer fine sandy loam

Rolling Plains
- Miles fine sandy loam
- Abilene clay loam (this has a permeable subsoil)
- Foard fine sandy loam

High Plains
- Amarillo fine sandy loam
- Portales fine sandy loam
- Lubbock fine sandy loam
- Pullman clay loam

Rio Grande Plain
- Willacy fine sandy loam
- Duval Fine sandy loam
- Laredo silt loam
- Laredo fine sandy loam
- Runge fine sandy loam

Gulf Coast Prairie
- Galveston sand
- Acadia fine sandy loam
- Hockley fine sandy loam
- Lake Charles clay

West Cross Timbers (deep, medium textured, permeable)
- Wolf's peach soil
- Windthorst fine sandy loam

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SOIL AND FERTILIZER CHEMISTRY

Thomas C. Longnecker, Senior Soil Scientist
Texas State Research Foundation
Renner, Texas

Soil and Fertilizer Chemistry is quite a subject and one which it is impossible to do justice to in an hour or two hours for that matter. There have been several books written about the subject and they still haven't really covered it yet. So about all you can do is hit the high spots.

First of all we have broken down the mineral nutrients which are required by plants and when I speak of plants that includes the turf grasses which we are dealing with, into primary and secondary nutrients. The primary ones are those needed in greatest amounts by plants and those which we customarily apply in commercial fertilizer. The secondary ones which we will get to a little later are those which are not needed in such great quantities by plants but which are just as essential for plant growth and plant growth cannot go on without them. There are other names given to these that I call secondary fertilizer elements as they are sometimes called minor elements, sometimes essential trace elements, but I think the term secondary is best. There is no term that puts them in their proper place because they are as important as the primary elements but we usually, or in the past at least, have not needed to apply them as we have commercial fertilizers. We'll take up that a little later.

First of all I have a list here of the important fertilizer materials which are used in making commercial fertilizers. This list I believe is thoroughly inclusive of any which might be placed in any commercial fertilizer and some more than others, so let us briefly go down that list there to get a speaking acquaintance of each one of these. First one there is anhydrous ammonia. That particular product is relatively new. It's been known for quite some time. It is a base product for most of the synthetic nitrogen industry, but as a source of nitrogen on crops it is only in the last few years been used to any extent. On golf courses I don't know whether it will have any practical application or not. It has to be applied as a liquid. I don't know of any occasion where it has been used. If you had proper containers in which to contain it it might be satisfactory. It has to be shipped in tank cars. It has to be stored under special conditions so I think as far as golf courses are concerned and other turf areas we can forget it, at least for the present.

Urea, the second one listed, 45% nitrogen. Well maybe first of all I should explain that table before going any further. In the second column I have noted the effect on soil reaction. By that I mean simply whether it will affect the soil acidity one way or another and if it is listed as acid that means that this particular material will result in the soil becoming more acid If it is listed as alkaline why it will be the reverse of that. It will make the soil more alkaline. There are varying degrees of that, some of these materials have a pronounced effect on the acidity or the alkalinity of the soil, while others have very little or no effect on soil reaction.

Ammonium sulphate will tend to make the soil more acid because the acid part of the fertilizer is not used by the plant. The nitrate part of sodium nitrate is used leaving the sodium which is the alkaline part and then the soil becomes more alkaline. This change is not great and unless used over a long period of time would not be detrimental I don't believe.

Ammonium phosphate, is one in which both parts, the ammonium and the phosphate are used for plant growth. One can see from the phosphate chart down below that it contains about 48% available phosphate as well as 11% nitrogen. It is used to some extent but not generally in complete fertilizer.

Now we get into the organic material which must be broken down by bacterial action in the soil before they are available. Dried Blood is the first and only a limited supply of this material is available. It is not generally used as it is not in great demand.

Animal tankage is the most universally used of the organic materials as a source of nitrogen. Cotton seed meal has been used to some extent but the price has risen so that it is now now used much in the fertilizer industry. Fish scrap, activated sludge--you probably know activated sludge better under the name of milorganite at least if you have been acquainted with O. J. Noer very long you will soon get acquainted with milorganite, steamed bone, tobacco stem, garbage tankage, and all those others are some which are used occasionally but they are available in such small quantities that you will very seldom come in contact with them. They are not the standard source of nitrogen fertilizers.

Now the phosphate fertilizers--the first one, superphosphate, is the one which is most universally used as a source of phosphate. It varies depending on the source and the amount of rock phosphate in the raw materials used in its preparation. The percentage will vary from about 16 to 20%. It is prepared by treating rock phosphate with sulphuric acid. Superphosphate is a mixture of tricalcium, dicalcium, and monacalcium phosphates plus calcium sulphate. The significance of this is that instead of putting on one salt you are applying a number of salts. It may be two, it may be three or it may be more. So the main thing to consider there is the fact that there is some calcium sulphate in it. On acid soils it would be desirable to have the calcium sulphate present since on acid soils that are suffering from deficiencies of calcium it would help correct this deficiency. On soils which are suffering from deficiencies of sulphur the sulphate is desirable in correcting this condition. Thus sulfur and calcium as well as phosphate are being applied when superphosphate is used. The other phosphate materials in this list are not too common. Basic slag is not very well known in this country. In Europe especially in Germany, they make very great use of basic slag, principally because basic slag is a by-product of the steel industry. It is the slag that is taken out when they process iron. In this country our iron ore is so low in phosphorus that the basic slag doesn't contain a very high percentage of phosphate. In Europe the iron ores are higher in phosphate so as a result the basic slag is relatively high in phosphate and relatively valuable. But here we don't get much of it. Before the war there was some shipped in, but not enough to be important.

Colloidal phosphate is something which is becoming advocated to some extent. I have come across a number of cases where it has been recommended, not on golf courses but on farm land. I could go into the details of it, where they get it and so forth, but I don't think it is worthwhile. One thing I will say about it is that I don't believe there is very many cases where it would be worthwhile to use colloidal phosphate. I will qualify that by saying I have only been in Texas a little less than a year now and so I am not too familiar with the soils down here.

Treble superphosphate is the same thing as superphosphate except instead of using sulphuric acid to treat the rock phosphate they use phosphoric acid which naturally increases the content of the phosphate. It's equally as good from the standpoint of a supply of phosphate as the superphosphate but I think you will find there is very little of it on the market now. The main advantage of treble superphosphate is that you get at least twice as much phosphate in a ton, which means less handling and it is usually cheaper per unit of phosphate because of freight rates.

These last few down here, steamed bone, cotton seed meal, and these others are simply organic sources of phosphate primarily used for their nitrogen content but they do have a little phosphate in them.

In potash fertilizers we don't have the many different sources that we do in the others. I have three listed here. Perhaps there are others, but these are about the only ones generally available. Potassium cloride is the most commonly used one in making up commercial fertilizers. Potassium sulphate before the war was used to quite an extent. It was imported from Germany. Another one of those salts which Germany exported but now we get very little if any of is Kanit. Kanit is a mixture of Potash salts and I don't believe we will find that much in the fertilizer trade now.

The secondary fertilizer elements--I have already made some comment concerning these. They are just as important as the primary elements but most of our soils usually have an adequate supply of them. It is only in special cases that we need to apply these secondary fertilizer elements--manganese, calcium, magnesium, iron, boron, zinc, copper, and sulphur. In some soils it is necessary to apply one, maybe two of them, in other soils you might need all of them. However, we are finding, especially in the topsoils that in the older agricultural areas as farming continues over a longer period of time that these minerals are gradually taken up from the soil and there is not enough left to supply the needs of the plant. I would therefore hazard a guess that within the next few years we are going to hear more and see more of these secondary fertilizer elements in the fertilizer trade and being applied on all of our crop land. On turf, principally fairways or other areas where the clippings are not removed it probably wouldn't be such a problem because anything which is once in that soil is simply taken up by the grass into its leaves or its roots and if those clippings are not removed those leaves and those roots revert back to the soil and you have taken nothing away. However, on greens where the clippings are removed, it is a different problem and I think that there is a possibility, a strong possibility that some of our soils may be suffering from a lack of these secondary fertilizer elements. This is more likely to occur on the calcareous soils of which there are quite a number

in Texas. The one I am most familiar with as far down here is the Blackland Prairies and the Grand Prairies and on the basis of the fertilizer research which we have done this year we think that there is a strong possibility that some of these or maybe all of these may be lacking. However, that is something which only more research will give us the answer.

I have a slide which I think will illustrate the effect of soil reaction on all of these primary and secondary elements on the soil. This chart has the lines on it to indicate the pH or the degree of pH acidity. The pH may vary all the way from zero to 14 but in very few of your soils do we find those extreme ranges. In most of our soils we will find our pH varying from about 4 or 5 to about 10 or 11.

This line right here indicates the degree of alkalinity. You can see that it isn't a straight line but a curve. The wider these bands become the greater the degree of acidity or alkalinity. At pH 9.0 the alkalinity is ten times what it is at eight and so on up the same thing on the opposite side. The acidity at 5 is ten times what it is at 6, a pH of 4 is ten times what it is at 5, so on a theoritical basis that would indicate that you should apply perhaps ten times as much lime to change the pH one degree based on 6 down to 5 as you would 7 to 6 but actually it doesn't work out quite that way, but a larger quantity is required. How does all this alkalinity and acidity effect plant growth? First of all they have a direct effect on the availability of plant nutrients. The line that is potash is fairly well available up to a pH of 8 thus the acidity or alkalinity doesn't effect the availability of potash too much in the soil. With nitrate the line becomes very narrow at a pH of about 4.5. This is an indirect effect almost entirely because nitrates are not produced at this low pH. Nitrates are produced by the action of bacteria on organic matter and ammonia fertilizer and these nitrate producing bacteria are not active below a pH of 4.8. Because of this very little response may result from applications of ammonia fertilizers if the soil is strongly acid. It is only when you get the pH up to about 6 that these bacteria become active enough to produce quite a large supply of nitrate for use by the plants because the organic materials which supply this nitrogen are not broken down at lower pH values. On strongly acid soils nitrogen should be supplied, in the form of sodium nitrate or calcium nitrate. Magnesium is not affected greatly by the soil pH. It's merely a question of whether it is in the soil or not. If it is present in the soil to begin with the soil pH will usually have little effect on its absorption by plants.

On the calcium--you can see the calcium line here becomes larger as we go across indicating that more calcium is available as we increase the pH. Thi is more or less indirect, because if a lot of calcium is present the calcium itself would change this pH and make it higher. With the phosphate, this edging here at pH 8.0, that looks like fish bones indicates an interaction between calcium and phosphate. At pH 5.0 and below, aluminum and phosphate combine. There is considerable aluminum in most soils. Most of our normal soils have an unusually high amount of aluminum. But in the pH range from 5.0 to 8.0 none of the aluminum is in soluble form it is all in insoluble chemical compounds which do not effect plant growth. However, when the pH drops below 5, part of that aluminum comes into solution and it will tend to react with the phosphate and tie it up in unavailable form so that it is un-

available to the plant. So if you are attempting to grow grass under those conditions--first of all we wouldn't recommend that you attempt to grow grass under such strongly acid conditions, we would recommend that you apply lime in orger to correct that--but in the meantime you should apply fertilizers that the grass plants are able to utilize. If the usual farm superphosphate is applied, a large part of it will be tied up by this soluble aluminum, however, you can get around that to a certain extent by using the organic phosphate. Such materials as tankage and cotton seed meal, must be broken down by bacteria before they are available and as a result this breakdown even though slow supplies some phosphorus which the plant can use until this harmful degree of acidity is corrected.

Now we get on to the upper end of it up here you can see the calcium in interaction with the phosphate and it is tying it up in an unavailable form. And since many of the Texas soils have a pH of 8.0 or above much of the soil phosphate exists as unavailable calcium phosphate. Very little of tri-calcium phosphate is available to plants. If under these conditions you apply superphosphate the same thing may happen, especially if it had very much clorine in it, because the clorine which was in that original rock phosphate causes it to recombine in its original rock phosphate form which is almost entirely unavailable.

Iron is the next one. When the pH drops below 5 the same thing happens to it as happens to the aluminum. Large amounts of it will come into solution if much is present in the soil and iron in large amounts is toxic to plant growth. So that is another one of the harmful effects of this low acidity. Even though toxic to plant growth in high concentrations iron is required by plants for growth. It is one of the essential elements which all plants require. They must have it in order to produce chlorophyll, the green coloring matter. And in the pH range of 6.0 to 8.0 enough of it is usually available to satisfy the needs of most plants. When the pH goes above 8.0 the iron percipitates as an insoluble compound and plants suffer from iron deficiency. On such soils it will be necessary to apply iron in the fertilizer. Manganese is in the same category as the iron. It is required in small quantities for plants to grow but when large quantities of it are in soluble form in the soil it is also toxic. So when the pH drops below 5 quite large amounts of soluble manganese is present which is harmful to plant growth. It is only in this range (pH 6.0 - 8.0) that manganese is available in desirable quantities.

All of this discussion applies to normal mineral soils, but a lot of our soils are not quite normal or they may not have these elements present to begin with. Or if they have been present, they may have been used up by constant crop removal. Our recommendation would be to keep the soil pH within desirable range of 6 to perhaps 7.5. It is in that range that the lease amount of interaction in the fertilizer nutrients will occur and at the same time the acidity itself is not harmful. However, even though you do have the correct pH let me repeat again that it may be necessary to apply one, or all, of those secondary elements.

QUESTIONS AND ANSWERS

Q. What do you have to say about ammonium nitrate as far as explosive ability is concerned?

A. According to the Chemistry of it I believe that ammonium nitrate is only supposed to be explosive when it is mixed with some kind of an organic material. However, we have mixed pulverized sheep manure with it and had no difficulty. Everyone seems to be careful of it and afraid of it but nobody seems to be too certain about it as yet. I do not believe you will find it in any mixed commercial fertilizers at all, primarily because of this. No, I would not be afraid, however I would use a little caution with it. I wouldn't want to store it where it might get too warm, or be smoking around it or something like that. You are all aware of what might happen. Over in Belgium you couldn't talk any farmer into using any kind of ammonium nitrate they wouldn't even consider it. Ammonium nitrate when exposed to the air picks up moisture and turns to a pasty material which will not go through a fertilizer spreader.

Q. What can I do about chlorosis on greens?

A. Well, that chlorosis which you find on the alkaline soils might be due to different conditions. What I believe you mean is whether you would change the acidity. You can do that by using sulphur, which being oxidized in the soil will produce sulphuric acid which will lower the pH. Where you have these soils which have large quantities of calcium carbonate it will take a lot of sulphur to make much change. Iron is the nutrient usually lacking on alkaline soils and addition of iron sulphate will correct this.

Q. Which is the most important plant nutrient?

A. Why I don't think you can say any of them are most important or that any of them are least important. It would depend entirely on the soil on which you were trying to grow grass. If one of them is absent or is not present in sufficient quantities it would be the most important one. However, nitrogen is the one from which we get the most response because if enough other plant foods are present, nitrogen will give wonderful response. It is the one which causes green coloring and a lot of growth.

Q. What could I do to improve poor fairway turf?

A. Could you make the grass grow on that side hill? Well, based on the response which we had there last summer I would think it would. Applications of 500 to 1000 pounds of ammonium sulfate per acre certainly made the Bermuda grass grow and became good turf in one season.

Q. What is the bent pH range for greens?

A. I think they would fit into that desirable range which I indicated, somewhere about a pH of 6 to 7. Bents will grow at a lower pH, but I think they will probably do better if they raise it to at least 6 or 6.5. If I had 6.0 I wouldn't raise it any higher.

PRACTICAL ASPECTS OF FERTILIZING LAWNS AND FAIRWAYS

Robert C. Dunning, Agronomist
Southwest Turfing Company, Inc.
Tulsa, Oklahoma

A great deal of the information in regard to the use of fertilizer in the Southwest for turf grasses was gained during the war, when it became necessary to establish many thousands of acres of turf at Army installations for intensive use for airplane traffic and for wind and water erosion. The tremendous range in climatic conditions with an average rainfall variance from eight inches or less to higher than sixty inches in Louisiana and rainfall of near this great in Texas, with growing seasons varying from a few months in length to virtually year around growth and elevations from sea level to over nine thousand feet and many geological formations, it is natural to find great variations in soils not only as to physical characteristics, but as to fertility, pH, salts concentrations, and other chemical properties; therefore, it should be understood that parts of the information which follows is of a general nature and a great many factors must be considered before being applied to a specific area.

Those charged with the establishment of turf during this period found that there was little or no concrete data that could be applied for establishment and maintenance programs. In most cases, this was due to lack of turf research, however, in some cases grading and manipulation created a soil conglomerate.

Due to the extreme need for turf and the limited time for establishment, a standard rate of from 40 to 60 pounds of nitrogen from a grade 10-6-4 inorganic fertilizer, or similar grade, was set up for all new plantings, organics were not available.

In some cases, the specifications carrying what was thought to be high rates of nitrogen, were severely criticized. As rapidly as possible, with limited personnel, soil samples were taken for analysis as analytical results would help determine needed plant nutrients, with the exception of nitrogen. In no place were trace elements found deficient, with the exception of Iron, which was shown by the Chlorotic condition in St. Augustine grass around San Antonio and the airdic soils of the Rio Grande Valley. Chlorosis was also noticed in soils of high calcium content in the Great Plains area of Texas and Oklahoma.

Wallace Miller, used a complete fertilizer for the establishment of native grasses at Woodward Army Airfield, Woodward, Oklahoma, that was made possible by moving sand dunes from the north part of the field to the south side. Fertilizer had not been used before in this region for grasses as it was thought that fertilizer on native grasses was not needed, the results were very good. Later, the Bureau of Plant Industry in their fire prevention program treated squares at the Great Plains Experimental Station, Woodward, Oklahoma, with a mixture of Ammonia and Phosphate. These fire prevention test were not successful although they did prevent burning of the grass, but it was

found that a light dew would remove the chemical from the foliage which prevented lasting qualities to the experiment. The rates of the chemical applied for fire prevention were higher than was ordinarily used for fertilization. This work was done in the fall of 1943 and in the spring of 1944, the results on the treated areas in regard to increased foliage and density from the plant nutrients furnished, were unbelievable. Prior to this, Gordon Jones and others were establishing test plots at numerous airfields throughout the Southwestern Division gaining additional data on the need of nitrogen - phosphorus - potassium, and iron and other trace elements, giving further information on need of increased rates of nitrogen.

In the meantime, Howard Goldthwaite had established an excellent turf by the sprigging method and by the use of a vegetative mulch at Matagorda Island and Peninsula on pure marine sand by the use of a complete fertilizer and also organic nitrogen on some areas. Howard later seeded the Galveston Army Airfield, which was constructed by hydraulic fill of Marine sand pumped from the bay, with hulled Bermuda grass seed. I believe that he used 120 pounds of nitrogen per acre of a grade 10-6-4 inorganic fertilizer and in some areas more. I am sure he used all the fertilizer that he could get. Complete coverage of turf was obtained in less than a year.

There later arose the question on whether fertilizer was needed in the Blackland area at Ashburn General Hospital at McKinney, Texas, even though good results had been obtained with the use of fertilizer on the Blackland prairie soils of the Houston-Wilson group. It was reported that fertilizer had been used in Collin County on Bermuda grass without results, consequently, fertilizer test plots were established at Ashburn in May and June of 1945.

There were over 100 plots starting at 20 pounds of nitrogen per acre and ranging to 600-900 and 1200 pounds of nitrogen per acre. All tests gave color even including 20 pounds of nitrogen per acre; however, there was very little increase of turf density until 80 pounds of nitrogen was reached. Probably the most practical rate for one application of fertilizer per year was 200 pounds of nitrogen per acre in this particular soil, however, results were good from 120 to 160 pounds of nitrogen per acre and there was a small amount carry-over in regard to increase in color and growth the next year.

It was then decided to establish a test plot to end all controversy, as to whether there could be any particular damage done to establish Bermuda grass with exceedingly high rates of fertilizer on this particular soil type. 43,560 pounds of grade 5-10-5 fertilizer per acre or 1 pound of fertilizer per square foot or 2,178 pounds of nitrogen per acre was applied, none of the plots were watered after application of fertilizer and some were applied when there was dew on the grass.

During the drought that followed in the exceedingly heavy fertilized test plots, the grass showed some tendency to wilt and probably due to the large quantity of unremoved clippings, thinned out very little from its original increase in density; however, this appearance quickly disappeared with rainfall. All plots were more drought resistant, retained color and density than the unfertilized check plots. The results of the fertilization on the test plots receiving low rates of nitrogen disappeared during the first summer.

In the fall of 1947, the only test plot left that showed evidence of color from fertilization was the one given the exceedingly heavy rate. All plots starting at 300 pounds of nitrogen per acre showed increase in density over the unfertilized check plots, but had much less density than they had at the end of the first year. It was later determined that the highest rates of fertilizer, applied in Collin County in previous fertilizer test on Bermuda grass were 20 pounds of nitrogen per acre or exactly the same amount of nitrogen of our lowest test plot.

The existing turf at Ashburn General Hospital before general fertilization was very poor, much of the topsoil had been removed in the building area and the area on which the golf course was built had been subject to erosion. There was one area of undisturbed Bermuda and Buffalo grass turf which was infested with Japanese clover and Black Medic, parts of this area were so badly infested that very little of the Bermuda and Buffalo grass was left. The hospital grounds were fertilized with 1,100 pounds of Sodium Nitrate per acre and on the undisturbed turfed areas, the fertilizer was applied early in the morning when there was a dew on the vegetation. The results of the general fertilization were very good and complete eradication was accomplished of the Black Medic and Japanese clover and within a month the thin turf had improved in density. A second application of 700 pounds of Sodium Nitrate was applied six weeks later and I do not believe that I have ever seen a more beautiful turf than existed on the undisturbed area. The total nitrogen applied in the two applications was approximately 250 pounds per acre.

I do want to point out that good results can be had by fertilization any place in the southwest and so far west as grass grows. Those of you who are fortunate to be in the Bermuda grass area, have the most suitable of all the present day widely used turf grasses for fairways and tees. It's dense foliage, deep green color, rapid recovery from injury makes it the most suitable of all grasses. In fact, Herb Graffis recently named good Bermuda grass turf as one of the reasons for superior golf being played in Texas, and the development of your outstanding players. Bermuda grass however, has it's limitations, it does not do well in shady areas and will not grow at all in deep shade where the soil is infested with roots of trees and shrubbery. It is a ravenous feeder of nitrogen, it goes dormant and off color in the winter of course, needs irrigation in the western part of the state as well as fairways elsewhere and is subject to dry winter kill, or desiccation however, this can be materially reduced by keeping the soil moist in the winter.

Bermuda will grow in almost any type of soil, but if one were constructing a lawn it would be desirable to have a friable soil of a loamy nature with enough porosity of sufficient size space to allow the absorption of moisture and containing 15 to 30 per cent organic matter by volume. A good source of organic matter is Peat or Peat moss.

Soils should be tested for soil reaction by a dependable quick test and the use of lime should be based on soil reaction or whether or not the soil is acid, expressed as pH. Bermuda grass is tolerant to both acidity and alkalinity, however, Bermuda in some cases responds to lime. If the pH of the soil is 5.2 to 5.7 it would be well to establish test plots to determine the need of lime.

If pH of soils are:

pH	Soils	Ground Limestone	Pounds per acre
5.2 - 5.7	Sandy	Ground Limestone	2000 lbs.
	Loam) Clay)	Ground Limestone	3000 lbs.
5.7 - 6.2	Sandy	Ground Limestone	1000 lbs.
	Loam) Clay)	Ground Limestone	1500 lbs.

50 lbs. per 1000 square feet is approximately equivalent to 2000 pounds per acre.

After a survey is made in regard to soil type, drainage, the nearness of large rock to the surface and other factors that might impede growth, it will be found that nitrogen is the major limiting factor in establishment and maintenance of Bermuda grass in open areas. However, soils should be tested for phosphoric acid and potash and if found deficient these nutrients should be added. In test plots established throughout the southwest acid phosphate never gave as satisfactory results as 80 pounds of nitrogen.

For established grasses 100 pounds of available phosphoric acid to the acre is usually sufficient. If grass is to be established for lawns by seeding, it is usually well to use from 400 to 600 pounds of 20% grade superphosphate per acre or from 10 to 15 pounds per 1000 square feet where there is 100 pounds of available P_2O_5 per acre. Where sprigging is to be accomplished, 200 pounds of superphosphate may be applied per acre where there is 100 pounds of available phosphoric acid in the soil, this will aid in root development; however, splendid results can be obtained where there are 100 pounds of phosphoric acid available to the acre from the use of nitrogen alone, so it's use is a doubtful procedure on large scale plantings.

All fertilizers should be incorporated into the soils to a 2 or 3 inch depth in vegetative planting or seeding.

Most soils have enough available potash however, some of the sandy and piney wood soils, blackjack areas and costal plains soils are deficient in potash. Lawns that are deficient should receive 5 to 10 pounds of potash per 1000 square feet or from 200 to 400 pounds per acre.

Due to expenses and other reasons, it is not always feasible to fully construct a Bermuda lawn and as stated, good Bermuda turf can be had on almost all types of soils; of course, it would be difficult to establish and maintain turf on inert shale soils.

What I do want to point out is, that our so called good black dirt, sold commercially, in most cases would be better left where it is rather than bring it to our lawns. The reason for this is, that in most instances, it

comes from low places and is a silty soil and in many cases is taken from hardpans of undesirable texture and the dark color comes from completely depleted organic matter. Be sure that the soil you bring in is better than you already have. Even subsoils are not always undesirable if they are friable soil of good texture, plant nutrients can be added by fertilization at much lower cost than bringing in the so-called black dirt.

It is a pity that in cities where beautiful lawns are desired by so many that there are so few. As has been stated before, nitrogen is the limiting factor and as Bermuda grass is a ravenous feeder of nitrogen, only by it's use can beautiful lawns be had. In a few cases, available phosphoric acid, potash and Lime may be a limiting factor but this can be readily determined by soil tests as analytical results will readily determine deficiencies in plant nutrients. If soil tests indicate that there is 100 pounds of readily available phosphoric acid and from 300 to 400 pounds of available potash, the use of phosphorus and potassium, expressed as phosphoric acid and potash, is a doubtful procedure and many thousands of dollars are wasted each year by the use of grade fertilizers high in phosphoric acid and potash for lawns, besides wasting our national resources.

Good Bermuda turf can be had by heavy applications of nitrogen two or three times a year; however, in the case of lawns it is more desirable to make frequent applications at lower rates of from either organic or inorganic source. Nitrogen from an organic source in some ways is probably more desirable, in that it is slightly longer lasting; and will not burn the turf and tends to build up the organic content of the soil and is not necessary to apply it in split applications, this however, does not mean that good results can not be obtained from an inorganic source of nitrogen at a very much reduced cost. At slightly increased rates over organics, carry over results are very good and inorganic nitrogen has the advantage of rapid results preventing the development of weeds; this is especially true in the spring.

By heavy rates, expressed in terms of nitrogen, it is meant from 120 to 300 pounds of nitrogen per acre or approximate rates of 3 to $7\frac{1}{2}$ pounds of nitrogen per 1,000 square feet. Expressed in terms of complete fertilizer, grade 4-12-4, this means from 3000 to 7000 pounds per acre or from 75 to 187 pounds per 1000 square feet.

If phosphoric acid and potash are not needed, it can easily be determined how much actual waste in regard to dollars and cents and resources there is in such a procedure.

Here, I think we should determine in actual pounds the quantity of grade fertilizer required to make a pound of nitrogen. This may be determined by dividing the first number of a grade fertilizer into 100, in other words; if you were using a 4/12-4 fertilizer, it would require 25 pounds of the mixed fertilizer to equal one pound of nitrogen. Whereas, if the fertilizer was 33% nitrogen it would require approximately 3 pounds of the material to make a pound of nitrogen.

Comparing Ammonium Nitrate to a grade 4-12-4 Fertilizer

To Equal	4-12-4	Ammonium Nitrate	4-12-4 to 1000 sq. ft.	A. N. per 1000 sq. ft.
120 lb. N.	3000 lbs.	360 lbs.	75 lbs.	7 lbs.
300 lb. N.	7500 lbs.	900 lbs.	187½ lbs.	22½ lbs.

If not Deficient in P_2O_5 Not Required

4-12-4 Fertilizer

3000 lbs. rate - - - - - - - - - - - - - - - - - 1800 lbs. waste 20% Superphosphate
7500 lbs. rate - - - - - - - - - - - - - - - - - 4500 lbs. " " " "

Difference of Cost of 300 lbs. Nitrogen

4-12-4	Ammonium Nitrate per acre
$135.00 - - - - - - - - - - - - - - - - - -	$ 27.00
204.00 - - - - - - - - - - - - - - - - - -	27.00

This is a grade 4-12-4 fertilizer and not the type sold for lawns which is more expensive.

Special Grade 4-12-4

Retail price per 100 lbs.	
$ 4.00 - - - - - - - - - - - - - - - - - -	$300.00

If your cities are to be known as cities of beautiful Bermuda grass lawns, there is only one way to do this and that is by adequate and frequent fertilization. Early in the spring or the latter part of February to the first of April, the lawns should receive approximately 160 pounds of nitrogen per acre or 4 pounds per 1000 square feet, this should be supplemented by monthly rates of 40 to 60 pounds of nitrogen per acre in accordance to the particular soil being fertilized.

In the northern part of the Great Plains area fertilizing should be discontinued during the fall months starting in September so as the turf will not go into the winter in a too lush condition making it subject to winter kill.

Mowing should be frequent. Height of mowing on a well-fertilized lawn can be from 1/2 to 1 inch as desired. Root development will be much better and the turf less subject to winter kill as the 1 inch height or heighth of mowing can be raised to increase root development in the fall months.

Frequency of cut should be often enough to prevent unsightly clippings. It is desirable not to remove the clippings as this prevents the loss of phosphoric acid and potash. Phosphorus and potassium are quite stable in the soil and when there is not a deficiency in these elements their use is not necessary for over a several year period.

It may be found necessary to remove clippings part of the time on heavily fertilized turf to prevent too much of an organic mat being formed. However, a certain amount of mat or clippings is desirable as it prevents evaporation of soil moisture.

Lawns and fairways should be watered thoroughly whenever watered. Light watering encourages shallow roots which is one of the causes of poor turf in periods of drought and winter kill. One thorough watering per week should suffice ordinarily. It is useless and wasteful to water unfertilized Bermuda turf, it will create crab grass and other weeds and tends to thin and discourage the existing turf. It also will be found that a well fertilized turf is more drought resistant than unfertilized grass.

Bermuda grass can be encouraged to grow even in medium shade by increasing the height of cut; adequate fertilization, thorough watering and perhaps with the addition of organic matter to the soil.

A dense aggressive turf brought about by proper cultural practice in regard to fertilization, watering etc., with a minimum amount of chemical weed control, will give the best results and discourage weed population.

It is not practical to accomplish fairway fertilization as frequently as for lawns, so necessarily fewer applications at higher rates are required. Soils low in plant nutrients and that have not received fertilizer for several years may require 300 or more pounds of nitrogen per acre. After two or three years of fertilization it will probably be found that less fertilizer will be required to give the desired results. At this time the lowest rate of nitrogen should be determined to retain the improvement gained by fertilization and this rate should be applied yearly.

Applications of Ammonium Nitrate early in the spring a short time after germination of crab grass at the rate of 400 pounds per acre and a second application of 300 pounds around the first of July, followed by a 200 pound application around September first usually gives splendid results, both to desirable turf and decrease in weed population. This is an approximate total of 300 pounds of nitrogen per acre.

Application of 250 to 300 pounds of nitrogen per acre from Ammonium Nitrate in the early spring are very effective, but this quantity of nitrogen used in one application tends to complicate maintenance, because at the time of year when the fairways are apt to be soft from heavy rains the turf will be growing very rapidly, increasing mowing difficulties.

Any one who has seen the fairways at Southern Hills Country Club, Tulsa, in the last two years could not help from being impressed with their wonderful condition; probably without doubt, they are the finest in the country. They have received from 240 to 300 pounds of nitrogen per acre from a combination of Milorganite and Milarsenite, rates of fertilization are now being decreased and only spot treatment with Milarsenite will be used.

If you wish to sell your members and green chairman on fairway fertilization, establish fertilizer test plots in conspicuous areas. The plots can be very simple to determine the need of nitrogen, phosphorus, and potassium.

An area 25 feet long and 4 feet wide or 100 square feet receives 5 pounds of Sodium Nitrate or some other form of nitrogenous fertilizer, the plot is then crossed with three 4-foot strips 25 feet long which will receive respectively 5 pounds Superphosphate and 5 pounds Murate of Potash and the last plot will receive a total of 5 pounds of both Superphosphate and Potash. In this way, determination can be made on the need of phosphorus, and potassium. If they are not required, other nitrogen plots should be established representing from 60 to 250 pounds of nitrogen per acre on 100 square feet plots or less.

In a very short time everyone will want to know what has happened to the grass in those spots and when you tell them that results came from fertilization they will immediately want to know if all the fairways could be made to represent the plots and what the cost will be?

In regard to fertilization of other turf grasses, Carpet, St. Augustine, Buffalo, Mesquite, Centipede and Bahia, they will all respond to fertilizer and nitrogen in particular at lessor rates than for Bermuda grass, especially Centipede and Carpet grass. Zoysia is a heavy feeder of nitrogen. Care should be taken not to over feed grasses in their northern limits in the fall, such as, Carpet, Centipede, St. Augustine, and Bahia.

There are regions in the southwest of over 5000 feet in elevation where Kentucky Blue or Crested Wheat grass should be used. Some of the grasses that will do well in shade are Kentucky Blue, Poa trivialis, St. Augustine, Centipede, and Zoysia.

QUESTIONS AND ANSWERS

Q. Did you say 300 pounds per acre of nitrogen?

A. Yes

Q. Then it would take about 1000 pounds of Milorganite wouldn't it?

A. It takes one ton of Milorganite to make 120 pounds of nitrogen or $2\frac{1}{2}$ tons to equal 300 pounds of nitrogen.

Q. Pretty expensive, isn't it?

A. Well, for organic fertilizer it is not, organics are always more expensive, than inorganics. For organic fertilizer I would say it is rather inexpensive. Of course the cost would be pretty high if you are going into large acreage fertilization but for putting greens I would say it is inexpensive.

Q. You haven't seen them getting away with putting Calcium Cyanamide on?

A. I think you could get away with it, yes, but it isn't generally used and I would not put it in Bent greens. You might use it in Bermuda grass fairways. I would want to do a little testing before using it. It should not be mixed with any other fertilizer as the compound might be poisonous.

Q. What is the difference in cost per pound of nitrogen between Ammonium Sulphate, Milorganite, and Vigoro?

A. Between Ammonium Sulphate and Milorganite? Ammonium Sulphate costs around 18 cents per pound of nitrogen against 30 cents for Milorganite and 65 cents for Vigoro.

Q. Would you use Ammonium Sulphate if you have acid greens?

A. Well, if you have acid soils you could use Sodium Nitrate or Calcium Nitrate, if it were available. I do not think you can get Calcium Nitrate probably be cheaper to use lime, if you thought you needed lime, but on acid soils I would not use Ammonium Sulphate, you probably would find that you would get to the point on Bermuda greens where you will not get results from Ammonium Sulphate if you continue to use it over a long period of time. If you notice that the fertilization is becoming more frequent to get the desired results from Ammonium Sulphate, you had better check to see if the soil is not becoming too acid. You will not get good results from Ammonium Sulphate where the soil is too acid.

Q. Would you use Sodium Nitrate to correct acidity in Bermuda greens?

A. Sodium Nitrate? No, I think the thing to do would be to correct the acidity with ground limestone or perhaps dolmite and then go ahead and use Ammonium Sulphate if you wanted to. Have your soil checked for other plant nutrients and then use Ammonium Sulphate again if you desire. Large quantities of ground limestone might tend to turn Manganese and Iron into unavailable form, this is one of the reasons soil analysis should be made.

Q. Would this mean that you do not need to add phosphorus and potash?

A. No, you will need phosphoric acid and potash if they are deficient as well as so called trace elements. You will need a balanced feeding of all plant nutrients.

Q. Is Vigoro a good fertilizer to use throughout the year on Bermuda grass greens compared with Milorganite?

A. No, it is only necessary to use phosphoric acid and potash twice a year, spring and fall, is all that is necessary. Then you can use a nitrogenous form of fertilizer through the rest of the year as you desire. The more phosphoric acid you apply to your greens the stubbier the greens are going to be. They are going to mature earlier and go to seed and be hard to handle. You want to keep Bermuda greens vegetative. Milorganite is very good on Bermuda greens, it is easy to handle, can be mixed with other things, you can also use Milarsenite for control of crab grass and other weeds along with your Milorganite program. I do not think a constant feeding of a grade 4-12-4 fertilizer is the fertilizer at all for Bermuda grass greens. Milorganite has the advantage of containing about the right amount of phosphoric acid that is needed.

WHAT'S NEW IN TURF

Fred V. Grau, Director
U. S. G. A. Green Section
Washington, D. C.

I have thoroughly enjoyed getting down here, getting to know you better, and helping in a small way with some of your problems. We don't know all the answers, but we would like to make it possible so that you and others can find those answers. That's the big part of our job. I don't know of anything I would rather do. I was in New York day before yesterday (Saturday) at the U. S. G. A. Annual Meeting. My program for the next three months was being discussed and somebody said that I had better keep my health. Somebody else in the back of the room said that I had better try to keep my wife. I think he had something because it makes it just a little bit difficult to have a home life when you are on the road as much as I am. I do love this work and I do want to see it developed. Then I am sure there will be some time for other things.

I really gave this talk in Golfdom's Planning Issue. Most of you read that I guess. It comes to most golf clubs. In that article, "Turf Roundup of 1947", we discussed a few things of what is happening in the turf field. But I want to be just a little bit more personal tonight than I could be in those columns. "What's New in Turf" raises a fundamental question. It depends on who you are talking to as to what is new in turf and also where you are at the time. Just before Christmas I was out in Portland, Oregon. There was a lot new in turf out there but it depended again on whether you were talking to the seed grower or the seed user. I was meeting with the Oregon Seed Growers League at that time. Even though I don't know a lot of the answers I do get around and see a few people over the country. It is part of the whole picture and if I didn't try to see all sides of this turf picture I would not be qualified to be helping you with your problems.

The first thing that comes to my mind in "What's New in Turf" is the development of the Turf Associations, particularly your own Texas Turf Association. One of the outstanding developments in the country today is the gathering together and the meeting of the minds of all of the turf interests for a common goal--Better Turf--regardless of the purpose for which it is used. The Oklahoma Turf Association, I believe, was organized just prior to yours. There is now a Southern Turf Association embracing quite a few of the Southeastern States. The New York-Connecticut Turf Association is made up mostly of greenkeeping superintendents who are looking into the future to broaden to the point where all turf interests could be included even though golf, as usual, led the way. The problems in golf are so much more highly specialized that that is only natural.

Second, one of the outstanding developments is the increase in interest and the development of turf research and educational programs at the State Agricultural Experiment Stations in various parts of the country. Not too many years ago there were only a few stations interested in turf. You have down here in your midst now two of the men that have helped to write some of

that turf history--Dr. Sprague and Dr. Longnecker. When they were at the New Jersey Experiment Station they helped to write some of that turf history and developed turf research work at the State Experiment Station. Rhode Island has been in the picture for a long time. Pennsylvania's program is well-founded, but you name those three and, until recently, you just about had it. Today, however, you can count a dozen or fifteen that are actively engaged in developing a turf program. That truly is progress.

The third thing that comes to my mind is the development of the turf program in the American Society of Agronomy. Perhaps that doesn't mean so much to many of you but to us in the scientific field it means a great deal. This is the outstanding scientific agricultural organization in the country. Until two years ago they had never considered turf as part of their obligation or their province. Last fall at Cincinnati we had our second annual meeting of the turf section in the Society of Agronomy and it was quite highly successful. From all indications it will be a permanent part of the American Society of Agronomy. It has far-reaching implications. It is difficult to tell you just what they are but it is going to have its effect, in encouraging more experiment stations to develop turf as part of their agricultural program.

Another very interesting new development, and it is not a year old yet, is the organization of the American Society of Golf Course Architects. Until a year ago I think every architect in the country was going his own sweet merry way. Many of us know to our sorrow of a lot of the mistakes that have been made in golf course architecture because it was not in harmony with sound maintenance practices. I think today, even though that society is only a year old, we have made remarkable progress in harmonizing our thinking on architecture in relation to maintenance. The architects, through the society, are being asked to speak at many turf programs. This is going to have only one effect, and that is a good one.

To all of us the spirit of cooperation pervades everything. You can't accomplish anything without cooperation. It is essential in almost every single thing we do. Coming down to home plate now, I mentioned the annual meeting of the U. S. G. A. on Saturday. Some rather significant things happened up there. In the first place they passed an amendment to the constitution changing the status of member clubs. Until last Saturday, a great many golf clubs in the United States were not eligible for membership in the U. S. G. A. That is now changed. Today there is not one single golf club that is not eligible to apply for membership. All of them can be affiliated with the U. S. G. A. That is a truly remarkable advance. Along with that there was a slight raise in dues to take care of increased expenses. It was not much and an 18-hole golf course paying $30. a year now pays $35. That is not much of an increase, certainly not as much as the increase in some of the things we buy. There are two classes of membership now, regular member clubs, and associate members. The public links class of membership has been abolished. There were only 80 members and it didn't justify that classification. This now permits every club to receive Green Section service and our publications. Before that the public links members were denied that service. I am very glad to see the change and I think it is all for the good.

Two years ago we started something else that has been very significant and has been pretty much the foundation of our experimental work. We've never had the size budget that would enable us to do much research work other than at Beltsville, Maryland, and you and I both know that it is impossible for us to do any considerable amount of research work at Beltsville that would apply in too many places in the United States except right around Beltsville. Therefore we developed the policy of a decentralized program of which this is a part here; meeting the problem where it exists and studying it in its natural habitat. In order to do that we had to have some funds over and above our regular budget which is pretty cramped because there weren't enough U. S. G. A. member clubs. All of the money from the U. S. G. A. membership goes to support our office and there is none left over for research. There just isn't enough to go around. We opened a class of subscribers in the Green Section to commercial firms including seedsmen, fertilizer dealers, golf course equipment dealers, nurserymen, cemeteries, parks, and many other classifications in types of turf other than golf. It has been a very fine thing. We have received a lot of support from that, and every cent of those $30 annual subscriptions goes into research. The $300 that we used to establish the Research Grant here at A. & M. last November came out of that Green Section Subscription fund. The Research Grant that we established at Florida came out of it. The same fund was used to establish the Turf Research Fellowship at Pennsylvania State College in recognition of their many years of devotion to this cause. We had over $5,000 in that fund and it will continue to grow year by year.

The other thing that has been very significant has been the voluntary contributions from golf associations and interested individuals, but primarily from the golf associations. A total of almost $15,000 has accrued to our treasury in the last two years, every bit of which has been earmarked and is going into research programs in the area from which that money was contributed. That is very significant and it is giving us a great deal of support which is what we have needed to develop a research program. True, we are still working on "peanuts" in relation to the size and the value of our industry. Golf is worth well over a billion dollars and that is big business. Much of the work we are doing in golf applies to lawns, parks, cemeteries, and other types of turf. Some of the lessons learned from the work that has been done on golf money have very broad applications.

At the present time we have about 1125 members. The most we have ever had is 1154, so we are pretty close to the top. I'm a bit proud of that and you fellows have helped to make that record possible by raising the number of members in Texas from about 17 to about 50. That is a very good record and I want to express my appreciation to you right now for the fine support that you have given us.

At the present time there is a Turf Research Fellowship at Pennsylvania, one at Purdue, one at Michigan, one is being established at Georgia, still another will be established at Maryland. That will be a total of six (6) research fellowships in turf scattered well over the country that are going to have a lot of weight in the next two or three years. You won't get the data out of those fellowships for another three years. We have to wait. It takes time to do research work, but we are going to be developing six good

men while we are getting a lot of valuable data. That money is going to be very well spent and it isn't too much at that, but we want to see more of those. We would like to see one here as soon as money is available. There will be another one set up in Southern California and probably another one in Oregon or Washington, and so it goes.

Most of you are familiar with a Turf Research Fellowship, I believe. Usually we set it up on the basis of $1500 a year. It probably ought to be $1800 but that is better than it used to be. It usually runs for about three years. A man who has graduated from an agricultural college is selected and he has got to have a pretty good record and a good background for this specialized type of work. You will recall that a year ago we took Jim Watson from here and put him on that fellowship at Pennsylvania. A little while later John Stanford, also from here, went up to Pennsylvania on a Highway Research Fellowship. Now those two boys are working together on two entirely different types of turf and yet they are working together there at the same school, and both are going to benefit from it. We are going to benefit from that highway research work that is being done on Pennsylvania highway research funds. We will get a lot of good out of that and so will you. And so it goes. There's pretty much the picture as it is today. The decentralized program is working. It is set up on a sound basis. I don't see how it can go wrong. It's got sound backing, and when I look into the faces of you fellows, see the interest that you show, and see how you are going after these things, and raising money to get this work started here at Texas A. & M. brother, it just can't fail. You have the determination that it takes to put it across and you know that we are with you 100 percent. We can give you a lot of moral support but only so much financial support, limited as we are in funds.

Now let us get down to a few fundamentals of some of the technical phases in this turf field. There is quite a bit new going on. For instance, this is not going to affect too many of you here, but it will affect a lot of people where bluegrass is grown, that is this new B-27 bluegrass. Bluegrass is a very useful turf grass, except on fairways and tees, over a large part of the country, but it is subject to leafspot disease which knocks it out and lets crabgrass come in. B-27, which was a Green Section selection made in 1936, has been almost entirely free of leaf spot. It has been the best bluegrass we have been able to get seed from. Our next interest is to get more tests made so that we are absolutely sure of our ground, and to get seed increased so that it will become a commercial commodity.

In the bentgrass there is quite a little new going on. One of the fellowships, the one at Maryland, is to be set up for the study of breeding, testing, and selecting new strains of bent and fescues. The bents are coming into their own over a large part of the golfing world in the north because bent can stand close cutting. For that reason it is being favored for fairways because golfers like to have the ball sit up so they can hit it and get the proper type of a shot. Bent is giving that to us in fairways where bluegrass did not. I have had a number of letters recently in which the green chairman or the superintendent almost says in so many words that bluegrass is one of the worst weeds they have in the fairways. That is pretty strong language and I want you to know that I am just repeating their words.

There are some good bluegrass fairways but most of them are not especially if they are irrigated. That is not true in Denver and other arid regions because there the bluegrass must be irrigated. They have the advantage, because they don't have the disease that knocks the bluegrass out.

I'll show you in the pictures a hundred new bents at Beltsville under test. Some are from Memphis, Tennessee, that have grown in association with Bermuda grass. Nobody knows how long but these bentgrasses were covering large areas. The Bermuda grass dominated in the summer and the bentgrass dominated in the winter and it seemed to be a pretty good combination. Whether we can repeat that we don't know, but those bents from Memphis are in this collection. There are bents in that collection from fairways that have never been watered or fertilized. They will have some value in a breeding program. What we want to do is to collect just as many of those types as possible so that we can blend them into something superior.

In the Bermuda grass field, which is the one in which you are most interested, by the time you have your research and testing program set up here at Texas A. & M., you had better have plenty of space because Dr. Burton of Tifton, Georgia has over a hundred Bermuda strains in test. Many of these appear to be greatly superior to common Bermuda in drought tolerance, in holding green color, in disease resistance, in turf-forming qualities, and other things. He has some there that make putting greens so beautiful that only the most skilled can tell them from bent. We saw a picture that he showed to the group at Knoxville. It's too bad that he couldn't be here; I understand that he was asked and it was impossible for him to come. He gave the talk and showed the pictures at Knoxville, Tennessee at the Southern Turf Association Conference and they are absolutely outstanding. He showed a golf ball sitting on these different selections of Bermuda mowed down to putting green height. There were great differences in texture and disease resistance. Some of those Bermudas that we sent to him from the north, from Pennsylvania and from Michigan (believe it or not, Bermuda thrives in Pennsylvania and Michigan) just completely went to pieces with disease. Apparently you can move these grasses from the South to the North better than you can move them from the North to the South. That seems to hold true throughout the range of grasses.

We are encouraging the use of Bermuda grass in the Washington and Baltimore areas because where Bermuda grass grows there are no weeds. It provides perfect golf turf and why shouldn't we turn to Bermuda, especially since 75 to 90 per cent of the golf is played during the time when Bermuda grass is excellent. And it isn't something that we have to push either because Bermuda grass itself is doing the pushing. It is coming in without anybody encouraging it. It is taking over large areas on fairways and tees and it is producing superior turf up there in that climate. So, so far as Bermuda grass is concerned, we have a lot in common. We are going to be doing a lot of research there at Beltsville, Maryland, and in Baltimore, on Bermuda turf. Maybe some of the things we learn up there might help you in some way down here, and vice versa.

Another thing that is new is our 7,000-plant Zoysia nursery at Beltsville. At the present time we are the only ones, I believe, doing any serious

breeding and testing work on Zoysia. We have a full scale breeding, testing, and selection program on Zoysia including both Z. japonica and Z. matrella. Our goal is to produce seed because vegetative planting is slow, rather expensive, and not too popular, especially in large areas unless you have specialized equipment such as that which the engineers developed during the war. I believe that Bob Dunning had quite a bit to do with that development. Many of those machines were used in through here but they have not as yet been adapted to golf courses and to other types of turf where the areas are smaller. To date some of our selections of Zoysia japonica at Beltsville have produced at the rate of 900 pounds of seed to the acre. That is rather encouraging especially since some of these selections creep almost as rapidly as Bermuda grass and stay green much longer in the fall. One selection stayed green until football season was over. That is good, especially this year when we had heavy early frosts. We are rather encouraged about the Zoysia japonica but a great deal of work still has to be done with it. One strain never yet has produced a seed head.

Another new thing is the development of seed from centipede grass. I think we mentioned that here last year but we didn't say too much about it. Those of us who were at the American Society of Agronomy meetings in Cincinnati again heard Dr. Burton describe the part of the research work that he is doing in developing seed of centipede grass. Heretofore it has been reproduced entirely by vegetative means. He has harvested yields of two hundred pounds of seed or more to the acre with fertilization and clipping treatments. That is all to the good because centipede grass, from what I understand, may cover a large part of the South. Alabama and Georgia both say it is the ideal lawn and fairway grass. It thrives under a low level of fertility and requires the minimum of maintenance. In a lot of turf areas low cost maintenance is a factor, so we think we have accomplished something there.

Another grass which we might say is new, because it is new to many people and it was new to me when I first heard about it, is Alta fescue. We don't know yet just where it will be used but we do know that it is widely adapted. The main place that we don't know about it is in the areas of low rainfall. It is being used on lawns in a limited experimental way. It is also being used on golf course tees. It has actually been seeded into golf course fairways. It is being used in increasing amounts on air fields, on roadsides, and on athletic fields. It seems to be quite a good all-round grass. It was developed as a hay and pasture grass but through management and fertilization (and it really responds to nitrogen) it certainly makes a nice turf. It's coarse, but it is much better than weeds and it will keep weeds out. I don't believe there is another northern grass of its type that is so resistant to the invasion of weeds. I'll show you some pictures of it a little later.

We have some new things in the red fescues. That doesn't interest you very much because they are not adapted down here so we will pass that for the moment.

You are interested in insecticides. DDT has had a lot of publicity. I don't know how much of it has been used. There has been a lot of it used on

turf in other sections. But now here comes a newcomer and that is CHLORDANE. No sooner do we have CHLORDANE than here comes thiophos 3422 which is ten times more toxic than CHLORDANE and 20 times more toxic than DDT. Heaven knows where we are going to stop with those powerful insecticides. A report from Florida says that one pound of CHLORDANE to the acre controls mole crickets in turf. That is certainly an advance if true and if it can be authonticated and verified. There is a lot new happing in the chemical field and when we say insecticides we must include the fungicides. Some of you already are using the new CRAG fungicide which last year was experimental 531 or Puratized 177, both of dmium which are complexes. The dmium complexes proved superior for dollarspot control to any other fungicides tested. But along with the new things Tersan is still good for brownpatch in the hot weather. We still have a long way to go to beat a light application of hydrated lime on acid soils for picking up turf in the middle of the summer.

In the herbicide field there are many new things developing. Rhode Island reported on P M A S which is Phenyl Mercury Acetate. It is sold under the name of TAT-C-LECT and TAT SOILICIDE. I don't know if any of you have used it. We have not done much with it yet. It has not been tested sufficiently to warrant large scale useage as yet. On the cost basis it is very expensive compared to some other herbicides. I can't help but think about what Bob Dunning said this afternoon concerning Southern Hills at Tulsa. That same process was repeated at the Memphis Country Club where the U. S. G. A. amateur will be played this year. In half a season from June to the end of the season they completely cleaned all of the weeds out of the fairways and changed their population from about 80% crabgrass to nearly 100% Bermuda with three applications of fertilizer and sodium arsenite mixed. It is no secret, it was Milarsenite that was used. Additional fertilizer was used to thicken the turf. It certainly seems as though we had better try some of the old proven things first before we go to a lot of these new things. Sodium arsenite has a big place in your turf maintenance field in the Bermuda grass areas. 2,4-D is pretty much taken for granted in a lot of areas and it's been a wonderful thing. It has taken out a lot of weeds that we have not been able to touch before. Books are being written on it and I don't think any one of us could read all of the literature on 2,4-D even though we were given an entire year in which to do it. The volume of papers and writings on 2,4-D is tremendous. The turf field represents only one small part of the use of 2,4-D. It has gone into agriculture in a big way as you all know. You know too that there are lawsuits when they get it on cotton when they intended to get it only on rice. We won't go into that.

Another new thing that, well it is new in a way and again it isn't new, but we are going to find out about is the use of sawdust as a possible supplement for topdressing material. At least throughout the southeast sawdust is is in abundance all through the piney woods and apparently, when properly treated, it is going to make a very acceptable topdressing material. That should help a lot of the little fellows who don't have the cash in the bank to go out and buy more expensive material and there are a lot of those golf clubs that need help in more economical maintenance. That will be reported on shortly from Tifton, Georgia, which is part of our co-ordinated program.

We are seeking now for sturdier and better grasses for tees. You have got the ideal grass down here for your open tees (Bermuda) but there still is a problem on tees in the shade. I don't believe you have satisfactorily solved that, and tee grasses are just as important as grasses any place else. One of the interesting things on tees in the crabgrass belt at Louisville is where they have been using Zoysia matrella and cutting very close. In the fall when it grows dormant Poa annua comes in and fills up those tees and provides perfect green turf all through the year. In the spring the Zoysia starts to come back with warm weather. This gives them nearly trouble-free tees all summer. I am not saying that Zoysia is the answer but it certainly solved something for them there at Louisville. We can't leave this subject unless we mention those which are not new but still seem to be new to a lot of people. The Big Three in turf management are drainage, aeration, and water management. Those of you who got Timely Turf Topics realize that we are continually punching those subjects. Part of our responsibility in this educational field is to drive home those fundamental points which mean so much to the production of good turf.

Lastly, the newest thing in turf is the decision by the U. S. G. A. to publish a Turf Manual which will be in the form of a primer or a beginner's book on Turf Management. Written in the simplest kind of language, it will be understood by anyone including a green chairman. If we can accomplish that I think we will have done something. I didn't mean that viciciously at all because you know there are a lot of green chairmen and a lot of greenkeepers, some of whom are not here, who could use a book like that. In fact, one of the top-notch greenkeeping superintendents in the country told me the other day, "I go back to my notes that I have taken at the turf conferences where they have discussed these fundamentals and I get more good out of going over my notes than I do out of reading the latest book in the best type of scientific language." We continually have to stress those fundamentals. And I didn't mean that in any degree of disrespect to the green chairmen whatsoever. For the most part they are business men, they are bankers, they are doctors and lawyers, and they do not know the language that we know as scientific men in the turf field. So, we have to write it in simple language.

Someone asked a famous man how long it would take him to prepare a talk. He asked, "How long will I have to talk." "An hour, he was told." He said, "I'm ready now." "But", he said, "If you had asked me to talk for five minutes I would have said I needed a week to prepare my talk." Well, that is the difference between making something simple and in making it to cover the whole field. Our manual or primer will be a possibility within another year, we hope. It is going to be published by the U. S. G. A. and it may be available only to U. S. G. A. member clubs and to Green Section subscribers.

(At this point a series of Kodachrome slides were shown)

1. Gathered at the first annual meeting and Turf Field Day at Tifton, Georgia, is about the same size group as was here last year and is here again now. All are men with the common interest of Better Turf. This is the start of those Bermuda plots. The streaks were caused by applications of various herbicides trying to get at some of the answers to grass susceptibility. The

success of a program like this depends upon one man being so thoroughly sold on turf that he can't think, eat, drink, or sleep anything else but turf. He is going to push it and make it go. We've got to have a man like that at the college which is the seat of a program like this. Graham, would you say that that looks like a fairly good piece of fairway turf? (Well, I'd certainly like to have 18 fairways of it.) A ball hit on this turf can be controlled in almost any way you want to control it. There is a real cushion to protect your shot. That happens to be Zoysia japonica turf, the Z-9 strain which does not produce any seed, and it is only a year old. That was fertilized at the terrific rate of 1,600 pounds of 10-6-4 to the acre in July. I want to tell you gentlemen that nitrogen really grows grass. You will have many evidences of that. This is not a good soil, in fact it is a very poor soil. It bakes hard as brick in the summer and, in the spring when the frost is going out, you go knee deep in it. So when you can grow a fairway turf like that it takes a pretty good grass.

Here are some of the Zoysias that we have in our breeding nursery. These plants in these two rows, and each plant came from a single seed, are from one of the strains of Zoysia japonica. These Zoysias have gone badly off color with the frost. The plants in these two rows are staying green and they did stay green even after the others had turned white. We think there is a good possibility in breeding Zoysia for lasting color and cold tolerance.

This is our U-3 Bermuda grass. We are pushing the U-3 strain of Bermuda grass in the Washington area because it is perfectly winter hardy and has been for some 15 years. It is fine-bladed and with us it is disease resistant. It produces either a good putting turf or a good tee or fairway turf and a good lawn. This turf was produced in four weeks from sprigs, but we used lots of nitrogen. We used four pounds of nitrogen to a thousand square feet at the first application when it was sprigged and then we gave it another four pounds about three weeks later. We produced solid fairway turf in a little over four weeks. It is a little on the blue side but it is a very good golf course grass.

This shows relative speed of establishment. This is the U-3 and this is the Zoysia japonica all around. The Zoysia japonica will take two to three years to fill to a solid turf under ordinary conditions. The Bermuda grass will fill in one season or less.

We jump from Washington to Miami, Florida and the picture is exactly the same. Wherever you use nitrogen and lots of it you get good grass. Here the fertilizer hopper spilled and dumped fertilizer on that new Bermuda grass turf and that is the only place where it filled in right.

Here is part of our bent nursery at Beltsville. You see one here that is eaten up with dollarspot. Some 25 of these selections came from Southern Hills at Tulsa. I have a wonderful collection from their 12-year old seaside greens at Southern Hills.

Now we jump from Washington down to the Everglades in Florida. This is creeping bent. They are growing a creeping bent in the nursery down there

in the Everglades, and believe you me it gets hot and musty, and yet the bent seems to pull through. This is the third summer that the bent has gone through. It has not yet been mowed down to putting green turf, but they are trying to make selections with greater southern adaptation.

I think quite a few of you will recognize that picture. Those are the new bent greens at River Crest and I understand they are looking pretty good. They certainly look good there.

Here is something we continually have to work for and that is natural disease resistance in our grass. Here we have Washington bent which for a long time was one of the standard putting green grasses. Half of the plot is treated regularly for disease. This half of the plot is not treated for disease at all and you see that the bent is ruined.

Here is an Arlington bent (C-1). This half of the plot never has been treated for disease control, this half has been treated regularly. For the life of me I can't see the difference between them. Those are the kind of grasses we are looking for, the ones that are naturally disease resistant. The same thing holds true from the standpoint of insects, weeds, and other pests.

This is the type of a condition that makes golf no fun. Anyway the putter dragging across that putting surface and scuffing up loose grass means that it is not a satisfactory putting turf. We are maintaining our golf courses for one thing only and that is to play golf on, and we want to provide the best possible conditions. We are continually stressing closer and more frequent cutting in order to get away from these messy matted conditions.

Here is another trick that is a good one and it saves man hours. It is a steel doormat hooked to a power machine to drag the top-dressing in mechanically. There it is in operation. Here are rakes mounted on fairway mowing units for scratching up crabgrass. I understand that the West Point Lawn Products firm is coming on the market with a rake of that type for bent fairways, Bermuda fairways, for crabgrass, or for anything that requires scratching.

Here is the result of the use of one of the new cadmium fungicides. That is dollarspot on Toronto bent and it can be pretty serious.

Now we are right at home. Any time you grow bent greens in Bermuda territory you are faced with a problem of Bermuda grass being your worst weed. Where water and plant food are available Bermuda is very aggressive and it is going to invade your bent putting greens unless caution is taken. We are hoping to study that problem under the research setup at Oklahoma A. & M. Of course it will be studied in other places too.

Here is the result of poor architectural work where not enough attention had been paid to surface drainage. The turf became unsatisfactory because the architect failed to allow the water to be removed from that corner of the green but rather ponded it there. Naturally, the turf died and so it had to be lifted and regraded so the water could drain off that corner of the green.

This is another view of that job. It cost several hundred dollars and yet could have been avoided if it had been laid out properly in the first place.

Here is what we mean by deep root systems. You can take that Noer Soil Sampler and lift a sample of soil and have it hanging together for the full seven inches just by the roots in the soil. You don't do that by keeping the greens saturated. When they get dry occasionally then you begin to get roots down. This was on a green in Ohio where they didn't have quite enough pump capacity to get the water to all the greens and it got dry once in a while, yet it was a blessing in disguise. They had roots and the grass came through the summer in flying condition. A few miles away where they had plenty of water they had plenty of trouble.

Now we are back at Fairfax C. C. near Washington, D. C. Here is a square of turf and the roots are those that went down into the tublar-tine fork holes. I know Graham Ross is grinning because we have a picture of that on his course. Another view of the same thing. You can just see them sticking out all over there. Those fork holes were made over a year ago. When this picture was taken the fork holes had been made a year previous and they were still there and still being filled with white roots.

Here we are out at Glen Lakes and here again you see that long bunch of roots that follow down those tublar fork holes. Plant roots need air whether they are in Texas, Maine, California, Nebraska, or Florida. That is one of the basic principles that applies to every grass and to every part of the country or the world. Plant roots need air.

This is a Texas view of a layered putting green. I hope we will never see any of that stuff again. The layered condition and especially the layer of sludge which is death to grass. The dairy loam fertilizer (so-called) has had its place but where it has been used in excess and especially with sludge it is a very bad thing.

Now we are looking at Alta fescue. I want to show you just a few views and share with you a little bit of my enthusiasm for that grass. I suppose a man in my position should not be enthusiastic about anything but I'll be switched if I can help it. When you see a grass that will cover so many situations and come through with flying colors you have got to have admiration for it. This is bluegrass or it was at one time; at least it was seeded to blue grass. Since then clover and crabgrass have come in. You notice the clover didn't go into the Alta fescue. It couldn't because the Alta fescue was so dense, so aggressive, and so vigrous, that the clover didn't have much chance. We are going to feed that grass with pretty much straight nitrogen until it begins to develop an actual need for phosphorus and potash.

This demonstrates that Alta fescue, like Bermuda grass, will respond to nitrogen. We are using Alta fescue in our borders and paths in our turf gardens at Beltsville because it will respond to treatment, it is weed free, it will take almost any kind of mowing that we want to give it, and it stays green without irrigation through our worst droughts. When I was appointed on the station committee at Beltsville to help develop the turf areas at the

Plant Industry Station, the first thing to decide was "where could we start". Everybody looks at our front lawn which is our show window. Therefore we started on the front lawn. We have tried for years and years to grow bluegrass and red fescue and usually wound up with nothing but crabgrass and a little patch of clover here and there. We ripped the whole thing up with a disk, plowed it down, and leveled the surface. It is nothing but a gravel bed and there is no topsoil at all in any shape, form, or description. It is all pure gravel and sand. We disked it and plowed it, limed it at two tons to the acre because it has a pH of 4.5, applied a thousand pounds of 5-10-5 fertilizer to the acre as a starter, and seeded 75 pounds of Alta fescue to the acre on September 12, 1947. It was seeded with a Cyclone seeder in two directions and cultipacked in. It came up in rows afterwe had about an inch of rain. Then we had 32 days of drought and that grass remained green during the entire period without irrigation. This shows how it looked. Here's the administration building and you can see the thin spots all through there. In the gravel spots the seed didn't come quite so well or so quickly as where there was some soil. That shows it coming in rows because it was cultipacked in and it gives the effect of being drilled.

I have been criticized for encouraging research on Alta fescue for turf. It was developed as a hay and pasture grass but it is giving better results for turf than almost anything we have used to date so I say why not give it a thorough trial. A lot of people are watching it because they want to see what is going to happen. Don't you think that we are not watching it too. That's why we planted it because we wanted to find out. We are going to develop the rest of our 123 acres there in different types of turf grasses for scientific study, for observation, and for the benefit of visiting groups.

Here is an Alta fescue on an airfield in Indiana. These are the runways and I will certify that it is a very satisfactory airport runway turf. The letters were written with two pounds of nitrogen to a thousand square feet using ammonium nitrate, spelling out the name HALSMER which is the name of the boys who run this airport. This is a closeup of the runway turf seeded at 20 pounds to the acre which is just a little on the light side. Here is a seeding at 10 pounds to the acre which admittedly is thin but eventually it will develop although it may take a long time. This grass has a very high load supporting value. It is amazing how much weight it will support even when the ground is soft.

There is Alta fescue being mowed at 1½ inches and here is being mowed at 1/2 inch. It has withstood 1/2 inch mowing for two years at Purdue University and it is doing the same with us at Beltsville. It is not entirely satisfactory for some purposes but it is interesting that the grass will adapt itself to even that type of treatment and stay green through our droughts. Here is Alta fescue on roadsides in Oregon. Here is Alta fescue growing in the Everglades in Florida. It has a tremendously wide adaptation, and is nearly disease-free. You look at that huge plant and you wonder how in the world it would ever make a turf. A lot of people wondered that and so did I. It does it but don't ask me how.

Another thing that is new is the Aerifier. We couldn't tell you much about it a year ago but we can tell you a lot more about it now. We still

don't have too much actual data but a lot of fellows have used this machine and have used it successfully. This is the Aerifier and this is a view of the back of it showing the spoons and the way in which it is transported. I understand that the cost is somewhere between 500 and 600 dollars. This is a little closer view of those spoons which bring up plugs of soil after they have cultivated the soil. It is being used on greens, tees, fairways, athletic fields, and even on pastures. It seems to have a broad application. You notice how the term "broad application" and "broad program" pervades almost everything.

They have added a rack which rides on the turf and if the turf is shallow rooted it prevents it from rolling up on the spoons. It has been a very good addition to the machine. You can see many of the plugs of soil on the ground in this picture.

Here they are aerifying the fairways in the Cleveland district. In fact, they did everything on the golf course with the Aerifier; tees, greens, and fairways. It gives you a pretty good idea of how it opens the soil, aerates it and allows moisture, lime, fertilizer, or anything else you put on to penetrate into the soil. That might at first glance look pretty rough on your greens, and yet it is exactly what a lot of greens need. Jimmy Hammner at Memphis is using the machine regularly on his Bermuda greens. He doesn't hesitate to go into his Bermuda greens any time during the summer while they are in play and aerate his greens because in an hour or two they are back in putting condition and nobody ever knows the difference.

Here is a steel doormat being dragged after the Aerifier has been used, breaking and smoothing those plugs. An old mower run over them will chew them all to pieces. Here at Beltsville we are using it with a big section of chain-link fence dragging right behind it. We use up to 1,500 pounds of sand on it to make it penetrate our soil which gets awfully hard. We are using it prior to every fertilization because we want our phosphate as deep in the soil as we can get it. We don't want it on the surface. Apparently it is giving us excellent results. I believe that is the last slide. I hope I have brought you a few new things in turf, at least I hope they are new to some of you. If there are any questions I will be glad to try to answer them.

DIAGNOSING TURF TROUBLES

Thomas C. Longnecker, Senior Soil Scientist
Texas State Research Foundation
Renner, Texas

There are many different factors that can affect turf and cause it to fail. That failure may be in varying degrees of severity all the way from complete turf failure to simply a loss of part of the turf or thinning of the turf. There are so many different factors which are responsible or can be responsible for this turf loss that I have listed here some of those which are most likely to be responsible. There are others which I haven't listed which might contribute to turf failure. Once you have poor turf you must follow the same procedure as the doctor does when he has a patient who is sick. Before that doctor can do anything towards getting the patient on the road to recovery he must first of all determine what is wrong. Quite often in attempting to diagnose turf failure we are in the same position as some of the M.D.'s are, but if we have an understanding of what might cause the turf failure we are in a better position to find out what caused the damage and to take the proper steps to remedy that condition. So let us go down this list of causes of turf failure and take up those as I have them listed.

First of all, disease--there are many different kind of diseases which affect turf and they are going to be discussed a little later more in detail so I won't go into any details on turf diseases, other than some characteristics of them which may be helpful in determining whether it is a disease or not. When a disease strikes it usually produces characteristic symptoms. I have some slides which you can see later and you could also observe from those Dr. Grau showed last night that the disease usually kills almost all the grass in an area. There will be one area with rather definite lines between the injured area and the uninjured area, which is very characteristic of most kinds of diseases. That is particularly true of the brown patch diseases which affect bent grasses. On some of the other grasses the disease is a little more difficult to see because it may just be a thinning out. However, if you are not at all certain that it is a disease responsible one sure way of finding out is to get a plug of the sod, the injured sod, as soon as it happens and take it to a plant pathology laboratory. Your state institution here has the facilities. The piece of sod should be incubated under proper moisture and temperature conditions for 24 to 48 hours and if a disease was present, the organism responsible will grow and multiply under those conditions. It can then be examined under a microscope and if you can positively find and identify a disease organism then you are quite certain it was a disease which was causing the trouble. If no disease organism comes out in incubation then you can rest assured that it was something else that caused the damage. One precaution in finding out whether it was a disease or not is that you can't wait for four or five days or a week and then take that plug of sod and incubate it because by that time those organisms which caused the disease are probably not there, at least not in a condition where they would come out under incubation. So unless that plug of sod is taken for incubation immediately, at least during its active stage or immediately after, nothing will probably be found with a detailed laboratory examination.

Of the maintenance and cultural practices which effect disease outbreaks watering is one of the most important. If there is any one good time to water I would say that it is early morning. Early morning is the time when most disease organisms attack. During the night the moisture is collected on the blades of grass from the dew, so when the sun first comes up and warms up the grass it is ideal for development of disease. It has the proper temperature, if it is a warm day, and it has the proper moisture from the dew. So if you water at night or the evening before you make that condition more desirable for disease to develop, because it leaves the grass even more moist than it would have been otherwise. When water is applied during the early morning the droplets of water from the sprinkler will tend to wash this moisture film off the grass blades and we think the blades of the grass will dry quicker under those conditions than they would if you did not water and permitted the dew to evaporate. So if there is any one good time to water in order to avoid disease I believe that morning is the time to do it. I know of numerous golf courses where they do practice night watering and get along alright so that doesn't mean that it can't be done. That is something that will have to be worked out according to your own course conditions.

Fertilizing also effects disease operations. Excessive nitrogen fertilizer applications during hot weather produces a rapid succulent growth of grass and that watery succulent growth is more easily attacked by disease. So during hot weather it is a good idea to keep your grass slightly on the hungry side, so to speak. We believe that if you do this there will be a little less likelihood of disease attacks. Mowing can effect disease. Mowing too closely will weaken the grass so that it would be more susceptible to the disease attacks.

The second cause of turf failure I have listed here is insects. Insects and their control are going to be taken up more in detail later so I won't go into any detail on that. But insects more or less also produce characteristic injuries. They are a little different than the characteristics associated with turf diseases. I don't believe that there would be much danger of confusing insect attacks with disease attacks, especially the brown patch. Some of the leafspot diseases which effect our grasses might be confused with chinch bug damage, but one sure way of finding out whether it is insect damage or not is to make a very careful, close search for the insect, if one is suspected. If an insect is found which you suspect might be causing the trouble then follow the safety treatment which I outlined before for disease. If you don't recognize it yourself as being an insect which causes turf damage take it to somebody who can tell you that, who can give you a positive identification on the insect and also indicate whether it is parasitic on grass. There are numerous insects that live in grass and which you will find in among the grass blades but they are not parasitic. They do not damage the turf. So simply because you find insects present this is no indication that they are responsible for the damage. If you cannot positively identify them as a parasitic insect on grass, take them to an entomologist who can identify them for you and tell you if they did any damage and also recommend control measures.

Chemical burns--golf courses now are using enormous quantities of all different kinds of chemicals, fertilizers, herbicides, fungicides, insecticides, and most of these chemicals are chemical salts and they will all burn if they are not properly used. So in using all these different chemical salts

I can't emphasize too much how necessary it is to be very careful. Chemicals can ruin excellent turf by improper application. I know of one occasion at the West Side Tennis Club on Long Island where the National Singles Tennis matches and the Davis Cup matches are played, they have turf tennis courts. They have about 25 turf courts altogether but three of them are located inside the stadium where the big matches are played and those courts are used only for the big matches so it is quite common for those courts to be maintained for five months in a year without a game of tennis being played on them. One year just before the Davis Cup Matches were to be held there they made an application of a fungicide which is a combination of mercury salts and they got it a little too heavy, didn't get quite a uniform application, and ended up with brown streaks all over the turf on those tennis courts. It was quite a blow to their pride of always haveing good turf tennis courts. So be very careful in applying all those materials.

Fertilizers which contain ammonium sulphate or any of the chemical salts will burn. Make certain the application is uniform and that it is not too heavy. Don't apply them when the grass is wet. Any of these chemicals applied when the grass is wet will stick to the blades of the grass, and when they stick to the blades of the grass they are going to burn that grass blade and it will turn brown. You can apply them when the grass is wet if water is used to wash it off the grass blades. The best practice to follow for dry applications is to apply fertilizer only when the grass blades are completely dry then there is much less danger of burning. Many places apply these materials by spraying them on wet in water solutions and there is very little danger of burning, but if they are not properly watered-in they will cause burning even then.

Herbicides--the main precaution to follow here is to keep the herbicide on the areas affected. 2-4D will not damage the grass and will take out the weeds but it is very damaging to shrubbery and flowers which might be growing along the borders of your grass areas. So keep the spray nozzles close to the ground and spray only on quiet days and in cleaning out spray equipment in which 2-4D is used and which you expect to use in spraying greens greens make certain that the spray equipment is clean. Otherwise valuable shrubs and flowers may be damaged. I know of one occasion where it was thought that the spray equipment was cleaned thoroughly and when the sprayer was used to apply insecticides on tomatoes they were all killed. However, if you should use some 2-4D and find that some has gone on other plants where it might cause damage about the only thing you can do is to clip off those parts of the plant which received the 2,4-D because it is absorbed down through the leaves and stems to the roots but if you clip off the sprayed parts of the plants immediately you will prevent it from going down to the roots and the plant may be saved.

Malnutrition--It is usually fairly simple to recognize turf which is not being properly maintained with respect to the feeding and proper amounts of plant nutrients. Improperly fed turf doesn't have a good healthy color and it doesn't grow very fast. It is easy to recognize immediately turf which has not been properly supplied with plant nutrients. However, sometimes on grass, in the greens which you think is well supplied with nutrients you may come up with some yellowing of the grass which wouldn't quite come under those characteristics and where plenty of nitrogen, phosphorus, and potash are applied.

Some of the minor elements which are necessary for plant growth may be needed on the acid soils. There have been some pretty good tests worked out which will indicate whether those elements are present in the soil in available form and in sufficient quantities to supply the needs of the plant. However, in the alkaline soils the tests have not been too satisfactory so far. There are lots of tests being used but they have not been correlated too well with response from application of these different elements. So in many of those cases, especially on alkaline soil it is simply necessary to go by trial and error method, that is, make small applications of these different minor elements or essential trace elements, whatever you want to call them, and see what happens. Do not put on heavy excessive applications and cause damage because all of them are toxic if applied in large quantities. Copper, boron, manganese, iron, are all toxic if applied in large quantities.

Over Fertilization--I have already mentioned something about over-fertilization in connection with disease. Even though you may not damage turf by over-fertilization, it is uneconomic. There is no point in putting on 1000 pounds of fertilizer if 500 pounds will do the job. You are spending twice as much money without getting proper returns for it and at the same time if you put on too much fertilizer trouble may result. So keep fertilization well within the limits of safety. Make certain that you are not puttin on too much and instead of putting it on if there is a question of putting on too much at once, and you have the fertilizer and want to get it all on, put it on in split applications. In this way there will be much less danger of causing damage.

Drought Injuries--This is something that in quite a large part of this State of Texas that is apt to be a limiting factor especially during the summer months. On greens it is not at all uncommon to find localized dry spots in greens which get the same amount of moisture as other sections of the green do, but for one reason or another the water does not penetrate in that particular spot. Unless you take out a plug in that area and examine it you probably won't know that the moisture is not penetrating until it shows up as an off-colored spot and dies. Some of the bent grasses have the property of causing a thatch over the top of the soil and if that thatch or mat of turf becomes bad enough moisture will not penetrate. All applied water runs off into other areas, and does the surrounding grass absolutely no good. These spots usually show up in a bent green as a somewhat bluish tinge and thi is especially true if root system is shallow. If you have a good deep root system of 4, 5, or 6 inches this is much less apt to occur. When you begin to see some of those bluish tinted spots showing up it is a good idea to examine the soil below them and see if there is enough moisture present. I have exaamined a number of those and found that the soil below those was powder dry. Then it is necessary to make fork holes with tubular tines or use some means of getting water down into that soil and usually when this is done the spot will recover unless it has the turf too much damaged to recover at all. Also if you have a shallow root system it may be necessary to water, especially on hot days, more than you otherwise think necessary. With a shallow root system on a hot day the grass may loose moisture faster than it can take it up out of the soil, so it may be necessary on certain days when this is happening to water the greens as much as twice a day if you have a shallow root system, in order to keep the grass alive. Of course, the goal to work for would be to get a good deep root system so that you know you are

not handicapped by that shallow root system which makes this twice-daily watering necessary.

Over-watering -- Many golfers have the peculiar property of wanting their greens soft. If the greens are soft it is much easier to hold a pitched shot on the green for that reason you may have a lot of your members complaining about the hard greens. They want the greens soft and giving them more water is their remedy for doing this. So in the event that you were forced into putting on more water in order to keep the greens soft so that any kind of a pitched shot will stick on, then you are inviting trouble. Over-watering seals off the soil so that no air can penetrate and you will end up with a shallow root system. Golfers, caddies, workmen, and equipment running over the green will further restrict the root system and you will end up with a puddled soil which is almost like concrete. You may have a scrap on your hands with your membership in order to keep them from insisting on more water but by all means if possible avoid over-watering. Make certain that the soil is dry and needs water each time before it is applied. You saw the picture last night of the root system where they permitted the soil to dry out so that the roots went down in order to get water. Develop a deep root system and try to avoid too much water.

Acid soil--A too acid soil may in itself directly and indirectly result in the soil becoming an improper medium in which to grow grass. In addition to having a chemical effect on the soil it may also effect the physical nature of the soil. An acid soil in a green is characterized by being hard and unyielding. In walking across the green it feels like walking on concrete. There is no give to it. Soil doesn't exist in the proper structure when it is extremely acid. So if the soil is acid remedy this by applications of lime and in this way the soil will become more loose and friable, since the soil in the greens takes enough punishment as it is even though we have ideal conditions. Try to make the soil as nearly ideal as possible because you are still going to have enough trouble. When you do have an acid soil it may be characterized by not getting enough response from fertilizer, especially ammonium sulphate. That is characteristic of a strongly acid soil If the pH is down to about 4 or 5 you can put on ammonium sulphate and you will never know it. The ammonium sulphate which you put on must be changed to nitrate before the plants can absorb it. But at low pH values the bacteria which cause this change are not active so no transfer of ammonia to nitrate takes place and when this happens the fertilizer does the plants no good. If that happens and you do have an acid soil make certain you have your soil tested to find out. If you are doing your own testing and have one of the test kits which have the four different indicators in it make certain you use the right color chart because out of the four indicators two are green and change through blue to yellow. The other two go from red to yellow. The color change are identical but of the two green ones, one covers a pH range of about 4 to 5, the other the same color change covers a pH range of about 6 to 7. So if you make the test with one indicator and read it off the other chart you will be very much in error. I know of one golf course that did that and thought they had the proper soil acidity when actually it was down to about 4.5 and they couldn't understand why they were loosing the greens. So if you do your own testing be very careful about it. In regard to these soil tests it is also important that you do the proper job of sampling because no soil test is more accurate than the sample taken. I would recommend in testing the soil

you take at least 4 or 5 cores of soil as deep as the roots penetrate and 1 inch in diameter. Usually about 4 inches deep from different sections of the greens is adequate. Make a composite of these after the top half inch of each core is removed. The reason for cutting off that top part is that it may have certain things in it that may affect your soil test but which will not affect grass growth. There is no reason for going deeper than 4 or 5 inches unless you have a deeper root system because if you go down say to 8 inches and you test that soil it won't mean anything because you have nothing growing in it. It may be worthwhile to examine the soil below 5 inches as its physical condition may affect grass growth. We have found in our soil tests that in any particular soil you get extreme variations. In a clod of soil about 4 or 5 inches in diameter we have run pH tests on different soil particles taken from that clod and we found that there would be a variation of as much as .8 to 1 pH in different sections of it. So unless you do make a composite of these different cores then you cannot obtain a clear picture of the entire green. All you have is a picture of one isolated spot. We think however, that from the standpoint of plant growth it is best that the soil does not have a uniform sod. A variation in different parts of the soil, say from a pH of 5 to 7 results in different nutrients being available at pH 5.0 than at pH 7 and each grass plant will have roots going into each kind of area. Each plant will have roots where the pH is 5, it will have roots at a pH of 6 and all variations in between. So don't be alarmed if the pH is not the same uniformally over the entire green.

Mowing too closely--Now Dr. Talley covered the subject of mowing quite well. There is not much point saying anything about that except that I would like to bring up this point. One golf course superintendent will say that, well I cut my greens 3/16 and another says I cut mine at 1/4 or whatever it may be. Even though two golf courses have mowers adjusted at what they consider 3/16 I think they are not cutting at exactly the same because each has different methods, their own individual method of adjusting that mower to whatever he wants. Also the growth of grass on the green will affect the height it is cut. If you have a thin turf your front rollers and your rear rollers on the mower will penetrate much deeper and sink farther into the grass, so the 3/16 on that kind of turf is not the same 3/16 that you get where you have dense mat of turf where the rollers are supported by a heavy growth of green. Keep this in mind in adjusting your mower. If you have a heavy healthy growth of grass you can adjust your mower much closer than you can if you have a thin turf.

Washboard effect on fairways--Everybody's opinion isn't quite the same as to what causes this. The two reasons which are commonly given are the mowers are operated too fast, and secondly, improperly adjusted mowers or maybe a combination of the two. Some places may mow their fairways at high speed and still get away with not having this washboard effect. Others claim they cut down on their speed and they still have it. However, I think that it would be a good idea to point out that the adjustment between the bed knife and the reel is at least a factor. Because if the reel is in too tight adjustment against the bed knife, as the mower goes along the rotation of the reel tends to lift the rear roller off the ground, especially where the surface is rough and if the mower is moving at a rapid rate. When the roller comes back down again it hits the ground again pretty hard and if you are mowing when the soil

is somewhat damp it will tend to make a depression there and with continuous operation of that going up and down in the same spot you will probably end up with this washboard effect. So I believe if you watch those two things, not going too fast and keep your mowers in proper adjustment, there will be little danger of having this condition arise. In the dry part of summer where you don't have irrigated fairways you don't have to worry about that because the ground is so hard it makes no difference if the mower bounces. Once you have washboards in the fairways the only way they have been able to correct it is by cross-mowing the fairway which is a lot of trouble because there is so much turning that it takes about twice as long to mow them. So try to avoid this condition, in the first place.

Matted turf--It is a good idea to have a certain amount of mat but when it goes beyond that amount it is not so good. The heavy matted turf, if it gets too heavy, stays damp for longer periods of time which makes good opportunities for disease outbreaks to occur. It makes a good hiding place for insects and between the two of them you may run into trouble. In order to provide a proper cushion on the green it is a good idea to have a certain amount of this mat but don't let it go to extremes. In addition to the difficulty you might run into from disease and insect attacks, if it occurs on fairways it may prevent the penetration of fertilizer and other applied materials.

You haven't had to worry about Japanese Beetle grubs yet, but in the East they have had them for years and they cause severe damage. It was not at all uncommon on unprotected turf areas to find the fairways entirely gone. The Japanese Beetle grub lives below the surface of the turf and it feeds on the grass roots and it will cut off all the grass roots and sometimes the grass will still be green on top and you could pick it up like a rug. All the roots had been cut off. Lead arsenate at 400 lbs. per acre is the control but with the heavy mat of turf the arsenate remained on top of the mat and never penetrated to where the Japanese Beetle grubs **were** feeding. This may also happen to applied fertilizer. If you have this heavy mat and the fertilizer will remain right on the surface and you may wonder why you get no response from the fertilizer. The rakes which Dr. Grau showed in the pictures last night are an excellent way of helping to remove that mat. Some have even gone as far as to use disks in the fairways which just cut through the mat and let fertilizer and other surface applied materials go on through. On the greens if you get this matting you will also probably run into a "grainy" condition. In other words, the grass stems will run along in one direction in one area and another direction a few feet away. You may find these stems running along as much as 18 inches to 2 feet long all going in one direction and the golfer doesn't like this. When the golfer attempts to putt, if he is putting with the grain the ball goes like the devil, but if he is putting against the grain the ball doesn't go at all. Using a rake is the best method of correcting this condition once it develops, but mowing practices may affect its development. It is a good idea to mow greens in a different direction each time. If this is done it will tend to prevent that matting, and also the "graining". You may also use brushes on mowers to help keep the mat from forming and the grass becoming "grainy". Once it forms all you can do is to go in and give it a severe raking job, you may think you are tearing the green all to pieces and you may. I have seen cases where they would rake it then mow it then rake it again then mow it again, each time they would get enormous

quantities of grass clippings. Following this with a top-dressing and proper fertilization you would never know that anything had ever happened to the green.

Mower out of Adjustment--An improperly adjusted mower can cause a lot of trouble. Even though you have your green surface as level as it is possible to make it, if your mower is not properly adjusted you still get a lousy putting surface. I would guess half of your putting surface which you obtain is produced by good clean mowing and unless the mower is properly adjusted so that it will cut properly you are not going to get that. When you adjust your mower, unless you adjust each side to cut exactly the same, you are going to get closer mowing on one side than the other, and you will again run into trouble. So make certain that you have a good tool to adjust your mower with and secondly make certain that the mower has the proper adjustment between the reel and the bed knife. I have seen instances where the reel was so far away from the bed knife it was rusty. It wasn't even wearing the rust off of it. With a mower adjusted like that you can't do a good job of cutting. It chews off part of it, and when it chews it off the end of that grass blade which it chews off will certainly turn brown, especially in hot weather so that you may have some brown tips showing up if you don't have your mower properly adjusted.

Poor Surface Aeration--You may have greens located back in the edge of the woods where they are completely surrounded by trees so that there is no possibility for proper circulation of air around that green. The main difficulty which will usually arise if you have a green like that is that you will have more brown patch there than on the others. This is because the moisture and temperature conditions make it more ideal for their development. Or secondly that green, will take much longer to dry out than your other greens do because air blowing across tends to remove the moisture much faster, so a green under these conditions will be overwatered even though you put the same amount of water on that as you do the other. This will tend to result in a puddled compact soil because it doesn't dry out fast after rains and watering. The players and equipment in going over it will pack the soil. There are two things you can do in order to eliminate this condition. Usually if you have all those trees the best thing you can do is to thin them out. Take out some of the trees, and those you leave cut off all the limbs up to a height of 15 feet. But if you thin out the trees and clean out the underbrush so that the air can get in and dry out the green and keep it under the same moisture conditions as the greens that are out in the open it will be much easier to maintain. I know of one case where they couldn't cut out the trees so to get air in they brought in an airplane propeller on a motor and placed it so that it would circulate air over the green. Although this was rather expensive it accomplished the job.

Poor Surface or Underground Drainage--Grass can't grow if it has its feet in water. Dr. Grau talked last night about the need of grass plants for oxygen and aeration. All the grass roots carry on respiration, the same as we do. They take in oxygen and exhale carbon dioxide. It is not the same mechanism as we have but the same thing happens to those grass roots that happens to us if we don't get the necessary amount of air and oxygen, they die. They come up to the upper layers or upper regions of the soil where they can get the oxygen and a shallow root system results. If you do have such a con-

dition as this all you can do is install either surface or subsurface drainage or both but get the water off the green one way or another. Make the grade so that the water runs off the surface and also you may need to put in tile drains so that you can take it off below. Originally we only had the plans to do as the farmer did in installing tile drains. He puts his tile drains 18 inches or more below the surface so that all his tillage equipment would not interfere with the tile. We have found in all of our greens where we put in tile drains this deep that it was useless, just a waste of time, because the water never got down to the tile. The best way to put in this tile drains so that they perform their function is to keep them as close to the surface as possible and still not interfere with placing the cup. I would put them in just deep enough that when I made a cup hole the cup cutter would not touch the tile. Place gravel of some kind, pea gravel is the best, around the tile drain so that the water can get to it and keep it as close enough to the surface to take the water.

Layering--I want to go into this subject tomorrow more in detail when I discuss application of top-dressing material, but I would like to say this about it now. When putting top-dressing on do not put on anything which you do not consider an ideal medium in which to grow grass. In the East we could take a plug out of a green in most of the golf courses down to a depth of 8 or 10 inches and by looking at that plug, the layers of it, we could trace the history of our knowledge in greenkeeping because back in the late 20's when peat moss was first used there was a lot of straight peat used. You can still find these layers of peat. They have been covered up now, and some of them are down to a depth of 8 to 10 inches by continual top-dressing but those layers of peat are still there. Likewise a lot of our greenkeepers that came to the United States got their early training in Scotland and England. England has a peculiar climate which is very good for growing grass. It is ideal. The most ideal that we have in the world for growing grass. Over there you can do most anything with the grass and it still grows. We can't do that over here. So when those greenkeepers came here from Scotland and England they started the practice of sanding the greens each fall. On greens where that was done we can take those plugs out and still find those layers of sand. These layers of sand and peat are interfering with deep root penetration, and they are interfering with water movement both up and down in the soil. If you have a layer of sand in the greens you will very seldom find that the roots will go through it. You take a plug out and it will break right where that sand layer is. Your peat layers prevent water from going down. In other words, if you have a layer of peat in the greens, even tho it is only a quarter of an inch or half and inch in thickness, water won't penetrate at all, so it may be a limiting factor in grass growth.

With a layered condition you can tear up the green and remake it, but if that isn't possible and it usually isn't for after all a golfer has to have a green to play on, what you can do is use some kind of a tool for breaking it up. These tubular tine forks are a hand instrument for doing this job but now they have a machine which will do the same job, and do it much easier and much quicker. The aerifier, which you saw pictures of last night will do that same job. It will make holes through those layers, and you can work a small amount of good top-dressing into those holes and if you continue that over several years eventually you will have that condition corrected. Not entirely perhaps

but you should be able to maintain satisfactory turf.

Black Scum--This black scum is nothing more than an algae growth. It starts out as a green scum which comes in hot rainy weather and it is usually found where drainage is bad and where water stands. After the spot dries the green scum turns black and becomes dry and crusted which kills the grass. When the fertility is quite high on the greens and moisture is plentiful it makes ideal conditions for these small plants to grow. They grow and develop in the water with the fertilizer which you have applied to the grass. So first of all if you want to eliminate black scum don't have the conditions which bring it on, have good drainage, and keep your grass growing well.

TURF GRASSES OF THE SOUTHWEST AND THEIR MANAGEMENT

Gordon H. Jones
Chief, Turfing Section
Civil Aeronautics Administration, Region IV

The choice of turf grasses to be used under different conditions depends upon a number of factors. Among these factors are; type of soil, the use to be made of the grass, the amount of care that is to be spent in the maintenance of the grass and the type of area to be planted.

In the Southwest there are approximately 1,000 different species of grasses. While many of these species have potentialities as turf grasses, they have never been fully tested and are not available commercially. Such a large number of grasses has had the effect of causing considerable confusion in the naming of grasses and before going into a discussion of the more important turf species of the Southwest, I would like to discuss briefly how grasses are named.

As most of you know, plants usually have two names, the botanical name and the common name. The botanical name is in Latin and serves to identify the plant no matter what the native tongue of the writer or reader may be. Common names cannot be universal, since they naturally vary with the language spoken. Also there are often several different common names in one language. As, for example, the grass which we commonly refer to as Bermuda grass, is known in English speaking countries under great variety of names. In Australia it is known as couch or Indian couch, doob and kweek, in Africa, it is called doob or dub, couch, kweek, quick or fine quick and Scotch grass; in India the names given it are doob or dhoob, durba or durva, creeping panic grass and hariali; in Cuba it is known as Cana maza and yerba fina; in Egypt it is called Neguil; in Hawaii, it is referred to as manienie; in Malaya, it is known as serangoon. In our country we have often heard Bermuda grass referred to as devil's grass and wire grass. It is also called Bahama, dogstooth, reed, Scotch and scutch grass. Accordingly, it may be easily seen why botanical names for plants are necessary and why they should be used in ordering seed or planting stock.

The botanists, in attempting to make the names of plants universal, have given the plants two (2) names. The first of these is the genus which is comprised of closely related species and the second, the name of the particular species being described. This system is comparable to listing the names of individuals in a telephone directory with the family name first. For example, Smith, John and Smith, Bill. The problem involved in pigeon-holing every species is a complex one and one that will not be discussed here.

As previously stated, the number of desirable turf species in the Southwest is limited. For our discussion today, I am going to limit my remarks entirely to those grasses which are considered as true turf species and that are available on the market. They will be discussed in accordance with their area of adaptation working from Louisiana to New Mexico.

Carpet Grass (Axonopus affinis): There are two carpet grasses in the U. S., broadleaved carpet grass (A. compressus) and the narrow-leaved form (A. affinis). While the broad-leaved form is found in Louisiana, we are principally concerned with the latter.

Narrow-leaved carpet grass is a perennial, creeping grass forming a dense close turf, the stolons or runners rooting at each joint. It is found throughout the state of Louisiana and extends into southern Arkansas, East Texas and along the Gulf. It is especially adapted to areas where the moisture is near the surface most of the year and under these conditions will produce a dense turf even on an infertile soil. It is not drouth resistant and therefore, it is not well suited to dry uplands. In areas in which it is well adapted, it often appears voluntarily as soon as the soil is disturbed. It will withstand very close and continuous mowing and this fact combined with the fact that it has a very low fertility requirement, makes it one of the better turf grasses to use when little or no maintenance other than mowing is performed. Carpet grass does respond to nitrogen, however, despite its low fertility requirement. Its principal objectionable feature is its prolific production of seed heads from mid-summer to fall. The stems of these seed heads are wiry and flexuous and therefore difficult to mow.

Carpet grass is usually propagated by sowing seed during late winter or early spring using a rate of 25 to 50 pounds per acre for large areas and 1 to 3 pounds per 1000 square feet for lawns. Seed should not be covered to a depth of more than 1/2 inch. It may also be planted by spot sodding or sprigging but care must be taken that the sod does not dry out due to the fact that it has no underground root stocks or rhizomes.

Bermuda Grass (Cynodon dactylon): Bermuda grass, although a native of India, is undoubtedly the most widely adapted turf grass in the Southwest. It has the added advantage over other species as to availability of seed and planting material. It may be found throughout the State of Louisiana, Texas and the southern half of New Mexico where watered and below elevations of 5,000 feet. A description of this species is certainly not necessary before this group, except to possibly point out the fact that it is one of the turf species having both underground runners (rhizomes) and above ground runners (stolons). The fact that it has rhizomes is one of the major factors which makes it so capable of withstanding intensive traffic and healing rapidly where scarred. The strains of Bermuda grass are tremendously variable, varying from low growing, fine-leaved types to erect coarse-leaved ones. This has been well demonstrated by Dr. Burton of Tifton, Georgia who has studied over 5,000 individual strains of Bermuda grass. Without a doubt, tailor-made strains of Bermuda grass could be developed for almost any turf need in the Southwest.

Bermuda grass has often been called the "poor man's" grass, but this is not entirely true. It is true that it will survive under the most adverse conditions, but when a dense, wear-resistant turf is desired, this grass requires a high fertility level and plenty of moisture. The nitrogen requirement of Bermuda grass is particularly high and on most soils applications of at least 80 pounds of nitrogen (245 pounds of ammonium nitrate, 500 pounds of nitrate of soda or 400 pounds of sulphate of ammonia) are virtually "musts"

if a dense turf is to be maintained. This rate should be applied early in the spring and if necessary repeated in late spring and again in early fall. These rates are for lawns or fairways, of course, not greens.

Bermuda grass may be propagated either vegetatively or by seeding. While seeding is more economical, first year stands are more likely to winter-kill in the northern sections than areas planted by sodding or sprigging. It has been demonstrated by numerous instances, however, that considerably less liklihood of winter-killing results if a dense turf is obtained during the first growing season. Seed should be sown in the spring when danger of frost is past, using a rate of 10 to 20 pounds of hulled seed or 15 to 30 pounds of unhulled seed per acre for large areas, 1 to 2 pounds per 1000 square feet for lawns and 3 to 5 pounds per 1000 square feet for greens. Since unhulled seed germinates quite a little slower than hulled seed, it probably should be sown somewhat earlier than hulled seed. Seed should not be covered more than 1/2 inch in depth.

Germiston grass (Cynodon transvaalensis): Otherwise known as African Bermuda grass is similar to ordinary Bermuda except that it is very fine-leaved and is light green in color. It has one undesirable characteristic and that is the fact that the stems and lower leaves are brown in color. Consequently the turf has a brownish appearance after mowing it it is not mowed often and regularly. Germiston grass is planted by spot sodding or sprigging.

Centipede grass (Eremochloa ophiuroides): Centipede grass is a low-growing, perennial grass which spreads rapidly by stolons. It is light green in color and produces a dense sod that crowds out most other plants. The leaves grow to a height of only 3 to 4 inches and the turf formed does not have to be mowed regularly to maintain a good appearance. Its region of adaptation in the Southwest is not definitely known but is probably similar to that of carpet grass with perhaps a little more tolerance of dry conditions. It has a very low fertility requirement and can even be thinned out by heavy applications of nitrogen. This is not caused by burn but by the grass forming such a dense sod that it tends to crowd itself out. Where adapted, it is an excellent turf grass.

There are no large quantities of centipede grass seed available, and it must be planted vegetatively. As is the case with St. Augustine grass, the leaves should not be covered with soil.

St. Augustine grass (Stenotaphrum secundatum): St. Augustine grass is a perennial, low growing, coarse-leaved grass. It is yellowish green in color, except when growing on fertile soils or fertilized heavily with a nitrogenous fertilizer. It produces a dense sod which tends to crowd out all other plants and it grows well in the shade. For the latter reason, it is the principal shady lawn grass of the South. It is well adapted throughout Louisiana and the south half of Texas but is quite susceptible to winter injury and is seldom grown north of the Oklahoma-Texas and Arkansas-Louisiana line. It has a high water requirement and must be watered regularly during the summer months in sections receiving less than 40 to 45 inches of rainfall. St. Augustine responds readily to applications of nitrogenous fertilizers;

although, like carpet grass, it produces a dense turf on infertile soils when there is plenty of moisture. Its actual fertility requirement probably is somewhat higher than that of carpet grass, but not as high as that of Bermuda grass. St. Augustine grass produces little or no seed and must be propagated vegetatively.

The pieces of sod or runners should not be completely covered with soil, but should be planted with the leaves or one end of the runner uncovered.

Manila grass (Zoysia matrella): Manila grass or Zoysia, as it is commonly called, is a grass introduced from the Philippines which produces a very dense low growing turf. It is sometimes sold under the Trade name of "Flawn". It is a fine-leaved grass, dark green in color which grows only to a height of 4 to 6 inches. Like St. Augustine, it will grow very satisfactorily in the shade or in the sun. At the Alabama Agricultural Experiment Station, this grass has proven the most shade tolerant of any species tested. It thrives best on heavy, fertile soils and is found growing in Louisiana, Arkansas and the eastern half of Oklahoma and Texas. It spreads by means of rhizomes and stolons but grows very slowly and as the outer limits of its range of adaptation are reached, two growing seasons may be required to obtain a dense turf. Dr. Sturkie of Alabama, classes Zoysia with Bermuda grass when it comes to fertility requirements, but it will make a dense sod on an infertile soil if given time.

While some seed is produced in Porto Rico, it is generally not commercially available and accordingly, this species must be planted vegetatively. This is usually done either by spot sodding or sprigging in early spring. There is some evidence that better growth is obtained initially if it is planted by sprigging rather than spot sodding, leaving the ends of the runners uncovered.

Korean lawn grass (Zoysia japonica): Korean or Japanese lawngrass is similar to Manila grass or Zoysia, but is coarse-leaved and grows to a height of 6 to 9 inches. It is a native of Korea and Manchuria and is very cold tolerant. It will thrive either in the shade or sun, grows well in sandy soils and appears to have a lower fertility requirement and a higher rate of spread than Manila grass. While it may be used satisfactorily for lawns or fairways, it does not produce as fine a turf as the narrow-leafed Zoysia.

Some seed has been available commercially in the past, but at the present time there is none on the market and accordingly, it must be planted vegetatively.

Bahia grass (Paspalum notatum): Bahia grass is another introduced grass which has coarse leaves and spreads by heavy rhizomes. While the common Bahia grass forms a rather coarse, open turf, there are several strains which do produce a turf that is dense, and low-growing. Perhaps the one best suited to lawns and fairways is the Pensacola strain, which, as the name implies was first observed in Florida. However, we have a strain which was introduced into south Texas in the Bay City area some years ago that also produces a dense turf. This strain is thought to have originated in Paraguay and accordingly, is called the Paraguay strain. Small amounts of seed of both

these strains are available commercially. The Bahia grasses require considerable moisture and are, therefore, of value only in sections receiving annual rainfalls of 40 inches or more. This grass has a low fertility requirement and is probably best suited to athletic areas, airports and similar areas receiving heavy traffic.

Bahia grass may be planted either vegetatively or by seeding. Seed should be scarified and planted in early spring at the rates of 25 to 50 pounds per acre. It should not be covered to a depth of more than 1/2 inch.

Bent grass: There are three important species of Bent grass, velvet bent (Agrostis canina), Colonial Bent (Agrostis tenuis) and Creeping Bent (Agrostis palustris). There are many strains or varieties of bents within each species. For example, Creeping Bent, is also called Coos Bay, or Coos County Bent, seaside and carpet bent. Since we are concerned primarily with creeping or seaside bent, my remarks will be confined to that species.

Creeping Bent is generally thought of as a northern rather than a southern grass. There is increasing evidence, however, which points to the fact that it will withstand very intensive heat and will grow well in the south, so long as adequate drainage and aeration is provided and the diseases are controlled. This is one grass which is definitely susceptible to diseases. As most of you know, it has been grown very successfully on greens throughout West Texas, the Panhandle and New Mexico. It has also proven successful in Fort Worth and Dallas. Without a doubt, strains of bent grass can be developed by selection and breeding that will grow successfully in areas much further south than this. Under conditions of high humidity, bent grass will probably always be a grass that requires considerable "Know-how" when it comes to maintenance, due to its susceptibility to disease and physiological injury. Nevertheless, it is one of the finest, if not the finest of turf grasses and well worthy of some extra study and work when the best in turf is desired.

Bent grass may be propagated either vegetatively or by seed. Seed should be sown in the fall, late winter, or very early spring, using one to two pounds of seed per 1,000 square feet for general purposes and 3 to 5 pounds per 1,000 square feet for greens. Seed should be covered to a depth not exceeding 1/4 inch by raking or top-dressing.

Buffalo grass (Buchloe dactyloides): Buffalo grass is a low-growing, drouth-resistant, native species which forms a dense sod. It is found growing throughout central and West Texas and Oklahoma and extends throughout the lower altitudes of eastern New Mexico. This grass, although growing extensively throughout these areas, has been somewhat neglected as a turf grass. Nevertheless, it is a grass which is of real value due to its low fertility and moisture requirements as well as to its low growth habit. Buffalo grass responds to applications of nitrogen and to a limited amount of watering. It may be planted either by spot sodding or by seeding. If sod is used, it must be planted, so that the leaves are not covered with soil. Seed of Buffalo grass is available commercially, although somewhat high in price. For best results, treated seed i.e., seed which has had its percentage of germination increased by freezing or other means, should be used. While relatively light rates of seeding will produce good stands over a period of time, a rate of

15 to 25 pounds of seed per acre should be used for large areas and 1 to 2 pounds per 1,000 square feet for lawns. Seed should be sown during early spring and covered to an average depth of 1/2 inch on a well compacted seed bed. In windy areas, the seed should be sown into a protective stubble or mulch.

Blue grama grass (Bouteloua gracilis): Blue grama is another native grass which is found throughout most of New Mexico and extends eastward throughout the northern and western half of Texas and the western half of Oklahoma with scattered stands much further east. It is a low-growing bunch grass which forms a fairly dense sod when seeded at heavy rates either alone or with Buffalo grass. For turf purposes it is probably best suited for use with Buffalo grass, comprising half to two-thirds of the mixture.

Blue grama is propagated by seed using a rate of 25 to 50 pounds per acre alone. Seed should be sown during early spring and covered to an average depth of 1/2 inch on a well compacted seedbed. If water is not available, it should be sown into a stubble or mulch for protection against wind erosion while it is becoming established.

Lehmann lovegrass (Eragrostis lehmannia): Lehmann lovegrass is a perennial grass producing runner-like stems that root at the joints to form a fair turf. It is adapted to the southern portions of New Mexico and the southwestern portion of Texas, south of Midland and Odessa. Its principal virtue lies in its ability to grow in sections of very low rainfall and high temperatures. It will withstand regular mowing and under this treatment produces a turf that looks surprisingly like Bermuda grass. It is planted by means of seed, using 1 to 3 pounds of seed per acre for large areas.

The seed is very fine and should be covered to an average depth of 1/4 inch. Rolling the seeded areas with a cultipacker or flat wheel roller will aid in securing a good stand. Spring plantings are preferable.

Yellow Bluestem (Andropogon ischaemum): Yellow bluestem is a perennial low-growing bunchgrass and is a native of India. It is very drough resistant and tends to spread in pure stands by reproduction from its own seed. The principal strain is the Kings Ranch strain which was selected from a volunteer stand found growing near Kingsville, Texas. While this strain is relatively new, it appears to be well adapted throughout Louisiana and Texas to approximately the 20 inch rainfall line. This grass is not a true turf grass in the usual sense but forms a dense sod under continuous mowing. Its seed stems grow to a height of 18 - 36 inches and are very flexuous, making it hard to mow "clean".

Seed of the Kings Ranch bluestem is available commercially. While somewhat high in price at present ($3.00 to $4.00 per pound), large quantities of seed are not required, 12 to 20 pounds per acre providing good stands which thicken rapidly. Seed should be sown during the spring or early fall to a depth of 0 - 1/4 inch, never over 1/2 inch, on a firm seed bed.

Kentucky bluegrass (Poa pratensis): Kentucky bluegrass is a dense, durable turf grass which grows in the higher altitudes of Oklahoma, Texas and New

Mexico. In Texas it may be grown throughout the Panhandle approximately as far south as Lubbock, doing better in the shade than direct sunlight. It requires considerable watering in this section and must be fertilized regularly with a nitrogenous fertilizer for best results. Fertilizer should be applied in early fall or late winter. Due to the high lime content of the soils in much of this section, this grass often shows symptoms of iron deficiency by a yellowed, chlorotic appearance in early spring. This may be readily corrected by the application of two to five pounds of iron sulphate per 1,000 square feet.

Kentucky bluegrass is planted by means of seed. On lawns and similar areas, it should be seeded at the rate of three to five pounds per 1,000 square feet and at the rate of 50 to 100 pounds per acre for larger areas. Seeding should be performed in early fall or late winter. Fall seedings are preferable. Seed should be sown to a depth of 1/4 to 1/2 inch.

Crested Wheatgrass (Agropyron cristatum): Crested Wheatgrass is a dry land grass introduced from Russia and is noted primarily for its drouth resistance and winter hardiness. It grows best during the cool weather of the spring and fall months and is adapted primarily to the higher elevations of New Mexico and the Texas Panhandle. Not all strains of crested wheatgrass are suitable for turf purposes, since most of them contain a high proportion of plants which are of the bunch grass type. The best one for turf purposes is the "fairway strain" which produces fairly fine stems and leaves and has the ability to thicken into a relatively dense turf.

Crested wheatgrass should be sown at a rate of 2 to 4 pounds per 1,000 square feet for lawns or similar areas and covered to a depth of 1/4 to 1/2 inch.

Italian ryegrass (Lolium multiflorum): Italian ryegrass, often called winter rye or simply ryegrass, is a winter annual which will produce a dense temporary turf when planted at heavy rates. It usually dies out during May or June but in a cool climate may act as a short lived perennial. It is a native of the Mediterranean region and may be grown throughout the Southwest westward without supplemental watering to approximately the 25 inch rainfall belt. From there on west it will usually require watering for satisfactory results. Ryegrass grows very slowly initially, not making any great amount of growth until late winter and early spring. Accordingly, it must be planted in early fall at heavy rates if a winter turf is desired. It responds readily to application of nitrogen, and in fact on infertile soils, it will be yellowish or even reddish in color during late fall and winter unless it is fertilized. When it is used for overseeding of lawns or greens, however, nitrogen applications should not be too generous as this increases its smothering effect on the summer grasses. Likewise, heavy applications of nitrogen in early fall tend to make it too lush and therefore, more susceptible to the disease commonly called "damping off".

Italian ryegrass should be planted during early fall at rates varying from 50 to 100 pounds per acre for large areas, 2 to 5 pounds per 1,000 square feet for lawns and 15 to 25 pounds per 1,000 square feet for greens.

There are other grasses which could be mentioned, such as Rhodes Grass, slender grama, alta fescue and rescue grass, but they are of minor importance at the present time and accordingly will be omitted from this discussion. Even so it may be seen that we have plenty of good turf grasses for use in the Southwest and our principal problem is one of properly managing what we have.

In the process of learning more and more about proper turf management there are two approaches that can be made. One is by trial and error and the other by experimentation or research. Much has been learned by trial and error but it is costly and time-consuming at best and controlled research is certainly preferable. Research may be broken down into two phases, 1 - fundamental research to be carried on at a research center such as Texas A. & M. College, and 2 - Field trials to be carried on throughout the area in question to test the veracity of the results obtained at the central research station. This is where you come in. I have discussed one grass after another, some of them new to you and you have immediately wondered how this or that particular grass would work under your conditions. There is only one way to find out for sure and that is to actually give it a trial. Instead of followers, we should be leaders in the trial and use of new grasses as well as other turf management practices which appear to have promise. This doesn't mean that you should plow up a fairway or one corner of a park and plant it with every new grass that comes along but it certainly is suggested that you plant at least two plots - one under the best condition that you have and the other under adverse conditions. For example, you might plant one plot in a moist, fertile area and the other on a dry hillside. A minimum size plot of 10' x 10' is suggested. Be sure to treat the plot in the manner in which you hope to use the grass i.e., under close, continuous mowing or no mowing, etc.

This same analogy can be applied to almost any management practice. If you think you need to apply more nitrogen or lime or iron sulfate for example, get all the information you can and then if there is still a question in your mind, give it a try - not on the whole area involved but on a smaller area representative of the whole. Apply the rate you think you should use on one plot, half that rate on another and twice that rate on a third. Be sure to leave a check plot or strip adjacent to each treatment so that the results may be readily observed. In this way you will make steady progress in the solution of your turf management problems and the lessons you learn will not be the costly ones of mistake through trial and error.

INSECT CONTROL

H. G. Johnston, Head
Department of Entomology
A. & M. College of Texas

That title, although it sounds very simple, covers a tremendous territory and I am going to attempt to cover only a small part of it this afternoon. In so far as insects affecting turf or sod land is concerned, I don't think we will find a more favorable place for the development of insect pests than a luxuriant well-kept turf. In preparing an ideal turf or a well-kept turf you are at the same time preparing a very nearly ideal breeding place for insects. With a luxuriant growth of grasses and the fact that so many of our insects naturally feed upon grasses as food plants then you are actually preparing an excellent pasture land for insect pests and they have an excellent ability to locate the greenest, most luxuriant part of your turf in searching for a place to feed. Now in attempting to select the most important pests that we might discuss this afternoon I have not attempted to single them out as individual posts so much as I have attempted to select groups of insect pests that are very similar in their life cycle and development, very similar in their habits, similar in the nature of damage that they cause to turf land and consequently representing groups of insect pests rather than single individuals. I hope that by doing so I will be able to give you much more information and a broader scope of the damage and control of insect pests on turf than I would be able to do by attempting to select individual pests.

Of all insects attacking turf I don't believe that there is a more important group in this part of the country, or any other part of the country, than a group of beetles, the immature stages of which are commonly called white grubs. This particular group of grubs represent more than a hundred different species of beetles of one kind or another, although their habits are very similar, the damage that they do to turf is very similar, and consequently we will be able to cover a considerable territory here in one discussion.

The white grubs are the immature stages of a group of beetles that are commonly known as May beetles, or June bugs, including the Japanese beetle which is such an important factor in the northern and eastern part of the United States. These beetles vary considerably in size but so far as their feeding habits are concerned they are rather uniform. The adult beetles themselves feed primarily on the foliage of shade trees of one kind or another and almost all of our commonly used shade trees serve as hosts for the adult beetles. They feed primarily at night, and consequently the damage done by the beetle may be easily overlooked.

They lay their eggs however, on or about the roots of grasses, or grass crops principally on a good thick, turf of grasses. Consequently, in areas near where there are shade trees the turf is most likely to suffer from the attacks of these grubs. The eggs are laid in the soil and usually hatch within three to four weeks, producing a tiny little grub with which I am sure

you are all familiar. They are whitish in color, a rather stout grub that curl themselves together in a semicircle. These eggs are usually laid during late spring and early summer and throughout the remainder of the summer these grubs, which are small at that time, feed primarily on the decaying organic matter in the soil. With the coming of cold weather in the fall they go deeper into the soil and in this part of the country usually not more than four or five inches down. Further north they go deeper and deeper to get below the frost line, to protect themselves from cold during the winter. The following spring they come back to the surface or near the surface and begin to feed on the roots of grasses and it is during that second summer of their development that they do their most damage to sod land or to turf.

In the vicinity of shade trees in many parts of the country it isn't at all uncommon to find turf completely killed out by the attack of these white grubs. I have in any number of cases seen turf over considerable areas, half as large as this room that could be rolled up like a carpet where the roots had been completely cut off underneath the surface. That, of course, is an extreme case. You very often will find, however, spots three or four feet in diameter where you will find a similar condition, or where the sod is being killed out in patches by these grubs which are feeding on roots of the plants.

The life cycle of these different species vary considerably but in general it requires two to three years for these grubs to reach maturity which means that in many cases not only the second summer but even a third summer these grubs are going to continue feeding on the roots of grasses before they have completed their life cycle. Further north you will find that many of the same species that require only three years down here to complete their cycle will require four years in the northern or middle western states. But the damage regardless of how long it lasts is the same summer after summer. So at the end of the third summer or the fourth summer, as the case may be, the grubs complete their life cycle, and change to the beetle stage again.

In regard to this particular group of insects, they are not at all easy to control. In the first place, in view of the fact that they spend two or three summers, at least, in the soil feeding altogether below the surface of the soil, it is not easy to get at them with insecticides or any other method of control. The most satisfactory control used at the present time is the use of lead arsenate applied to the soil, at the rate of about 10 pounds per thousand square feet of space. In applying this material, the 10 pounds of lead arsenate should be thoroughly mixed with about a bushel of sand or garden soil and then evenly distributed over the surface. After it has been spread over the surface, the soil should be thoroughly wed-down with a hose so as to soak the lead arsenate thoroughly into the soil. Each rain then will continue to carry this lead arsenate into the soil, the roots in the soil, and the organic matter on which the young grubs feed, to be poisoned and in this way satisfactory control for the grub is obtained.

A second group of pests that are very common in almost all parts of the country, on sod land of almost any kind, including turf, is a group of larvae or caterpillars known as sod web worms. These insects inhabit the soil primarily. There are several differnet species, some 15 or 20 of them at

least, but again in this particular case they all have very similar habits so far as their life cycle and damage to turf is concerned, and can be discussed as a uniform group. This particular group of insects live on the surface of the soil or just beneath the surface in loosely woven silken tunnels. These insects are comparatively small, measuring about one-half to three-quarters of an inch when full grown. They are easily recognized by shinny, glossy, black spots that are usually arranged in definite rows or definite patterns over the body of the caterpillar. In feeding on the plants there are some few of them that vary a little in their habits to the extent that they feed primarily on the stems of the plants. These simply cut the plant off just above the surface of the ground and consume only that part of the plant that they eat as they chew off the stem. The big majority of them, however, feed on the foliage of the grass plant and completely denude the plants, leaving nothing but the stems after they have finished their feeding.

The adult moths emerge principally during the late spring or early summer months, lay their eggs which hatch in a very short time, and the young worms begin to feed on the grasses. The first evidence that you will notice of the feeding of these insects will be a pale grayish appearance of the grass itself, because the young worms when they first start to feed do not consume the entire leaf but only eat the upper surface of the leaf, leaving more or less the skeleton of the leaf intact. Then later on they begin to consume the entire plant, and by the time they are about half-grown of course they are very noticeable. With most of the species there is only one generation during the season. Some of the species, however, have two or three generations, and this same thing will be repeated during the summer months. At any rate regardless of whether there is only one or several generations during the season, in late summer or early fall the larvae which are about half grown at this time dig in just below the surface of the soil and spin a silken tunnel in which they spend the winter. They remain there until the following spring and then begin to feed on the grasses as already outlined. In regard to the control of this particular group of pests one of our new insecticides, DDT, which you have heard a great deal about during the last two or three years has proven to be an excellent control. A 5% DDT dust applied to the surface of turf at the rate of about 15 to 20 pounds per acre will give you almost perfect control. It is a very quick control, stopping the feeding of these worms within thirty to forty-five minutes after it is applied, and in two or three hours you have almost a complete clean-up.

Another group of pests that are extremely variable in their habit but very common on grasses is a group of larvae commonly known as cutworms. The term cutworm covers a very large group of insects and a rather variable group so far as their feeding habits and nature of damage is concerned. However, the group that is most injurious to grasses and the group that we will confine our discussion to almost entirely are night feeders, they hide away during the day time, either just below the surface of the soil or in debris on the surface of the soil, and come out to feed only at night. They do not feed on the leaves as most other insects do but simply chew off the stems. So consequently this group of insects can do a lot more damage per individual than most other insects will do because of the fact that they

destroy a complete plant with one feeding. Here again the insects spend the winter as partially mature larvae, usually about half-grown, beneath the surface of the soil. The following spring, as soon as the soil begins to warm up, they come out and begin to feed. There are several generations of most of these species during the summer. In regard to the control of this particular group, so far as turf is concerned, the use of poison baits is about the only satisfactory control that we have. This poison bait consists of 100 pounds of wheat bran, about 4 pounds of either sodium arsenite, white arsenic, or sodium fluosilicate, and some 7 or 8 gallons of water. The poison, whether you use sodium arsenite, white arsenic, or sodium fluosilicate, should be thoroughly mixed with the dry bran, then the water slowly added to it and stirred in so as to make what we commonly speak of as a dry mash. In other words you want just about as much water into this bait as you can get so that you don't make a dough out of it or make it too sticky. When you start to scatter it, you still want it to crumble so that you can scatter it uniformly. In view of the fact that these worms feed only at night the bait should be applied late in the afternoon, so that it stays moist and is attractive to these worms when they come out and begin to feed just about dusk. By applying it at the rate of about 10 pounds per acre you will get a very satisfactory control of practically all cutworms.

The fall army-worm belongs in the same group with cutworms but it has a very different feeding habit and different method of control, so we must discuss it separately. This particular insect is a tropical pest, but is widely distributed throughout North, South, and Central America, and particularly in the Gulf Coast Area of North America. It is not able to spend the winter in any stage whatsoever in the United States except in the Gulf Coast area and extreme southwestern regions. Here it spends the winter in immature stages, usually down around the roots of the grasses where it is protected from cold weather. As soon as it begins to warm up in the spring they begin to feed, and by early summer we begin to get tremendous numbers of these moths emerging which have a definite migratory instinct. These moths, when they emerge, usually do not lay their eggs in the immediate vicinity where they have been reared, but begin to move northward and very often will go several hundred miles before they start to lay eggs. Each adult moth will lay some thousand eggs or more during a lifetime. These are layed in several batches of some 150 to 200 eggs each so that wherever they stop to lay their eggs you have a mass of young worms coming on very soon afterwards. The first evidence of the presence of the fall army-worm that you will notice is a grayish appearance of the turf in the area where they are feeding, because they feed primarily on the surface of the leaf in the early stages and do not consume the whole leaf. As they become a little larger though, they consume the whole plant and begin to move. The group of 150 or more larvae that have been feeding very closely together in the early stages of course soon consume all of the grasses in the small area in which they were feeding. They begin to move then to greener pastures and this is what gives them the common name army-worms. The first generation usually will mature in about four to six weeks after the eggs were laid and we get a second generation coming on. The adult moths that emerge from this first generation do the same things that the previous ones have done, they begin to move northward. That brings up a very interesting fact in the development of this pest, that is, you may have a tremendous infestation on your lawn and in a very few days time they completely disappear as if by magic. This is an extremely interesting and destructive

group of insect pests. Fortunately, DDT is an excellent control for the fall army-worm. A 5% DDT dust applied at the rate of about 15 to 20 pounds per acre early in the morning, when the grass is wet with dew, will give you almost perfect control. It stops them from feeding almost immediately after the dust is applied, and within 3 or 4 hours you have almost a complete kill, provided you have done a uniform job of covering the grasses with this dust.

Another group of insects that are very general, both in distribution and in their feeding habits, is the grasshopper. Grasshoppers breed as a general rule on waste land. However, a good luxuriant growing turf almost anyplace is an inviting place for grasshoppers to lay their eggs. They deposit their eggs in the fall. The eggs are laid in the soil just below the surface in clusters and usually tremendous numbers of eggs are laid in some favorable location. Consequently we have in those favorable places what we speak of as "egg beds". The following spring when these eggs begin to hatch you will find tremendous numbers of these young grasshoppers in a comparatively small area. They feed on practically all kinds of vegetation and particularly on grasses. They are very destructive and destroy tremendous areas of grasses in a short length of time when they become abundant, and are always a serious threat to grass crops wherever they are found. By far the most important factor in connection with the control of grasshoppers is to search for these egg beds early in the spring when the grasshoppers first begin to hatch. A small grasshopper, a young grasshopper is very easy to kill. A half-grown or fully mature grasshopper is extremely difficult to kill with almost anything that you want to use. By locating these egg beds early in the season when grasshoppers are small, a poison bait as mentioned for cutworms is an excellent and by far the most economical method of control. In this particular case however, the bait should be applied in the early morning rather than afternoon as for cutworms.

In addition to the use of a poison bait, three of our new organic insecticides have proven to be very effective for the control of grasshoppers. In many cases on golf greens or turf land these insecticides would be preferable to the use of the poison bait. These include 10% chlordane, 3% gamma benzene hexachloride, and 20% chlorinated camphene used as a dust. Each of these materials should be applied at the rate of 12 to 15 pounds per acre. These three materials are also more effective if used early in the season when the grasshoppers are small and when they are concentrated on a comparatively small area. One precaution should definitely be observed with each of these three materials and that is they are not safe to use in areas where livestock are being grazed.

Now only one other group of insects that I want to mention just hurriedly and then I am through. This is a group of ants that we find almost everywhere. So far as turf land is concerned there is one ant that we are particularly interested in, the so-called agricultural ant which builds up tremendous mounds around the entrance to its nest. It has a still worse habit of clearing away the vegetation for a considerable area around its nest and collecting seed and carrying into the nest upon which they feed. This pest is best controlled by a treatment of the individual nests. This can readily be done by using carbon disulphide or highlife. One of the best ways of applying the material is to take about a gallon of water or even more

during dry periods and pour it into the entrance of the nest, letting it run all the way down into the nest. This is done for two reasons, first, to open up the tunnel so as to give the carbon disulphide a chance to go in and at the same time, soak the soil on the sides of the tunnels to more or less seal them. This confines the fumes of the carbon disulphide or highlife to those tunnels so that it doesn't diffuse out through the soil. After the water has been poured into the nest about two tablespoons of carbon disulphide should be poured into the entrance to the nest, then completely close the entrance to the nest by throwing a shovel full of dirt over it or by kicking the dirt over and packing it down with the foot to confine the fumes in the tunnels. The fumes of carbon disulphide are about 4½ times as heavy as air, consequently it goes downward and follows these tunnels right on in to the breeding chambers of the ants and kills out the entire colony. Usually one treatment is all that is necessary, although in some cases you will find that a second application 20 to 30 days later may be required.

One other thing I want to mention for treating golf greens, lawns, and other small areas of turf is a material commonly sold as carbon disulphide emulsion which is nothing more nor less than carbon disulphide that has been emulsified in water. For almost any sort of insect inhabiting the soil are found on the surface of the soil this carbon disulphide emulsion will kill them to a depth of two to six inches. Carbon disulphide emulsion is prepared commercially and can be bought on the market in various strengths of carbon disulphide in the solution. Manufacturers directions should be followed in using this material. It is however, very expensive and for most purposes, certainly for large areas, it would not be practical to use, but if you have an infestation of some sort of insect pest on golf greens or a small area on the lawn that you want to get rid of very quickly, carbon disulphide emulsion is usually your best bet.

I certainly thank you for this opportunity to have discussed the few insect pests that we have time to cover.

QUESTIONS AND ANSWERS

Q. How can grasshopper "egg beds" be located?

A. Early in the spring when these grasshoppers first begin to hatch there will be concentrations of them. By watching the waste land on golf courses, particularly you should watch the roughs, the waste land areas around your golf courses, and in some cases you may find that your fairways are very excellent places for grasshoppers to lay eggs. They can very easily be located early in the spring when they begin to hatch and that is soon enough for control.

Q. Why not use DDT in the soil for white grub control?

A. The reason for not mentioning that is the fact that some of the work that has been done in recent years with DDT has shown that there has been no deterioration whatsoever of DDT put in the soil several years ago. It

has also been shown that something like 25 to 50 pounds of DDT per acre is about all that many crops will withstand without causing serious damage to the crop itself. So we are getting very much afraid already of the accumulation of DDT in the soil as being definitely injurious to the growth of grasses as well as many other cultivated crops.

(From Audience)
As much as 800 pounds per acre of DDT has been used on golf greens without damage.

A. Well then if it is safe to use it is by far the best thing to use. We are not too sure about those recommendations yet because they have not been used long enough to be definitely sure about the safety of them in the soil in different areas at least.

Q. We have had quite good success with using the same treatment for cutworms as we have had for sod webworms.

A. In many cases it works out equally as well. It depends entirely upon the type of cutworms. There are some of the cutworms where the sod webworm treatment would be less effective than it would be for others. I probably should have mentioned that for cutworms 5% DDT in many cases or for many cutworms will give you very satisfactory results.

(Audience)
At Knoxville we have the first reports on some recent tests on the fall army-worm in Georgia, and the new 3422 or thiophos was the most effective material used. That's quite new.

A. That is very new and it is another one of those materials that is extremely dangerous to handle for many purposes. I'm just wondering whether we should include it for any purpose until we know more about it.

RODENT CONTROL

Walter P. Taylor, Leader
Texas Cooperative Wildlife Unit
A. & M. College of Texas

A few days ago I was wandering about on an otherwise beautiful golf course when my eyes were attracted by some of the unsightly mounds of the pocket gopher. In some instances these fresh mounds of earth had been raked out smooth to render them less inconspicuous. I can sympathize very much with the harassed green keeper who finds himself all hot and bothered by these particular rodent nuisances, but it is obvious that smoothing out the mounds would do him very little good indeed.

First let me give you a little information regarding the pocket gophers of this section and their habits in relation to turf. Of the pocket gophers we have in Texas no fewer than half a dozen different kinds. All of them are burrowers. They are found in soils ranging from the stony mesas of West Texas to the sandy regions of the extreme southern part of the State, eastward through the piney woods into Louisiana, and south to the Gulf Coast, as well as northward to the Red River, and into Oklahoma.

If there is one key to the distribution of these pocket gophers it is a sandy soil. Indeed one can take a map of texas showing the soils, and if he plots the sandy soils of the State, he will have pretty well enclosed the geographic range of the various pocket gophers. These rodents are absent from heavy black clay soils, but they dearly love the deep sandy surface soils which are so conspicuous over a great deal of Texas. If the soil is thinner than 4 inches down to the clay sub-soil, pocket gophers do not occur.

As you will see from these specimens, the pocket gopher is a chunky beast with a short neck and small eyes and ears. The front teeth project permanently outside of the mouth. There is a fur-lined pouch on each side of the mouth. In length they vary, as you can see, from about 6 or 7 inches up to 12 or 13 inches. It is comforting that we do not have in Texas a kind of gopher which lives in Mexico and of which I have a specimen here.

The food of the pocket gopher consists entirely of vegetable matter, principally tubers, roots, and bulbs.

Over much of its range the pocket gopher, in relation to the soils in which it works, is neutral or beneficial, being a natural soil cultivator and builder. But in cultivated areas where maintenance of a smooth green turf is important the pocket gopher is an exasperating nuisance. Orchardists, farmers, and gardeners also report serious damage done by the pocket gopher to fruit trees, valuable forest plants, potatoes, and garden crops. The pocket gopher is reported to scatter the tubers of that serious garden pest in East Texas, the nutgrass. In irrigated regions pocket gophers cause breaks in dams and ditch banks. Unfortunately these rodents are particularly fond of the roots of some of the grasses that make up the best turf. The characteristic habit of the pocket gopher in throwing up mounds of earth ranging from

3 to 6 inches in height and up to 18 inches or more in diameter is what makes him peculiarly obnoxious to the turf specialist. One cannot run a lawn mower over these gopher mounds with safety to the blades.

Fortunately the pocket gopher is easily controlled and there is no excuse whatever for having any of these pests on a lawn or green.

In eastern Texas generally the mole is common in some places. While the mole is not a rodent, it nevertheless deserves consideration here, as it may do a lot of damage to turf. Like the pocket gopher, it throws up mounds of earth on the surface of the soil. Probably 90 per cent of the life of the mole is spent below the surface of the ground. Its movement through the soil is almost like that of a swimmer through the water, pushing up miniature ridges wherever it goes and occasionally throwing up larger hills. If any of you here are from west of the hundredth meridian you won't have any trouble with moles, although you still may have to cope with the pocket gopher. As you can see from this specimen, the mole, like the pocket gopher, is a small robust animal with a pointed nose, a short nearly hairless tail, and soft, brownish velvety fur. Its front feet are specialized for its subterranean existence They are broadened and shovel-like with webs between the toes extending to the base of the claws. The eyes and ears are probably very little functional and so have been reduced to a very small size. The total length of the mole is about 5 to 6 inches. Like gophers, moles like moist sandy soil, but they are likely to be absent from dry sandy or heavy clay soil.

In marked contrast to the habits of the vegetarian pocket gopher, moles feed largely on animal matter, although they do eat vegetation to some extent. Larval stages of June beetles and of certain moths that pupate in the ground have been found in the stomachs of Texas moles.

Mole burrows are of two types--one deep built for nesting, the other shallow for subsurface feeding. Burrows of the mole and associated mounds of earth tend to disturb both the soil and the vegetation. While part of the activity is beneficial in that it allows air and water to enter the soil, when the mole throws up ridges or mounds of earth which interfere with mowing and make a turf unsightly, they become a decided nuisance.

The mole is not as easy to control as the pocket gopher, but it can be controlled as Mr. Poore will demonatrate in a moment.

There are a lot of other small mammals beside the mole and the pocket gopher which use the tunnels of the mole and the pocket gopher. These include some of the white-footed mice, some of the shrews, and in some instances doubtless other kinds of small rodents as well as some insects and lesser creatures.

In the western part of Texas other rodents are found doing at least some damage to grassy surfaces. Among these are the little ground squirrel, the thirteen-lined ground squirrel, the Mexican ground squirrel, and the spotted ground squirrel. These are not nearly so detrimental as the others. They just burrow up to the surface where they can come out and look around some-

times during the daytime. All one has to contend with in this case is the small round opening of the burrow. Control is fairly easy whether by drowning, the use of poisoned gas, or poisoned grain.

At the Turf Conference last year we found considerable interest in the crayfish, crawfish or crawdad, another animal which sometimes gives trouble in turf. While, of course, the crayfish is not a rodent, it nevertheless interferes with the turf in all areas where it occurs in abundance. For the most part these are the deep soiled moist areas along the well-watered portion of the southeastern Gulf Coast. Indeed crayfish "chimneys" may be found widely in the more humid parts of the State of Texas.

Like the pocket gopher, the crawdad or crawfish can be controlled with relative ease.

Studies by the Fish and Wildlife Service and others have shown that crawfish are extremely susceptible to the new poison DDT. A 5 per cent solution of this insecticide has been found to be effective. An application used in one instance (sprayed from a B-25 Mitchell Bomber) used No. 2 fuel oil as a spreader in a 5 per cent DDT solution and put out 210 gallons a minute on strips from 300 to 400 feet wide, the plane traveling at the rate of 200 miles an hour. This was on a marsh area. In the case of turf it probably would be necessary to make such a wholesale application, but the fact that DDT is a highly effective poison for crawfish will, I am sure, be of interest to all of you who live in crawfish country.

We have had a great deal of complaint also about the armadillo from time to time, although we have never been able to pin very much serious damage upon this unique and interesting Texas animal. While the armadillo is not a rodent, it occasionally gives some concern because of its unpleasant habit of running its nose around over the surface of the ground and making unsightly rooted-up places in the turf which otherwise would be smooth, green, and attractive. The armadillo moves dirt about sometimes like a little pig, and, as a matter of fact, the armadillo is actually doing the job for the same purpose the pig does, namely, trying to find some termites or other bugs or insects in the surface layers of the soil.

The armadillo is notably difficult to control. Last year I told the folks that a .22 caliber rifle used in the twilight of the evening might prove to be the best way of getting rid of nuisance armadillos in places where they were interfering with the turf, but now we feel that the use of cyanide flakes under proper conditions in the armadillo dens or possibly DDT may constitute a better way of controlling armadillos. I will ask Mr. Poore to refer to this also when he discusses specific control measures.

May I leave this thought with you, that a proper combination of trapping and poisoning or drowning or gassing will take care of all these pests. There is really no excuse for having any of them in a well kept turf. Now I am going to ask Mr. Poore, who is Extension Specialist of the Fish and Wildlife Service and the Texas Extension Service with headquarters here at A. & M. College, College Station, to show you some of the types of traps which can be used and to further discuss the specific methods of control best suited to

the different kinds of rodents and other animals I have been discussing.

I should also like to list the following bulletins which may be helpful. These can usually be secured from your County Agricultural Agent or from the local Rodent and Predatory Animal Control man representing the Fish and Wildlife Service. Otherwise you may write direct to the Agricultural Extension Service, College Station, Texas, or to the Fish and Wildlife Service, U. S. Department of the Interior, Washington 25, D. C., for these bulletins.

USEFUL BULLETINS

Directions for Destroying Crawfishes, Wildlife leaflet 190, processed, Fish and Wildlife Service, U. S. Dept. of the Interior. May 1941.

Mole Control. By James Silver and A. W. Moore, Farmers' Bull. No. 1716, November 1933.

Pocket Gopher Control. By W. E. Crouch, Conservation Bull. 23, Fish and Wildlife Service, U. S. Dept. of the Interior, 1942.

Distribution and Variation of Pocket Gophers (gemis geonup) in the Southwestern U. S. By William B. Davis. Tex. Agri. Exp. Sta. Bull. No. 590, August 1940.

RODENT CONTROL

Mr. J. E. Poore, Specialist
Fish and Wildlife Service and the Texas
Extension Service, A. and M. College
College Station, Texas

I believe Dr. Taylor pretty well covered the species of rodents that you have on your turf and so I am not going to take but a very very little bit of your time.

On pocket gopher control we are not going into the species of that at all. The pocket gopher control that is carried on all over the state. In San Antonio we prepare a poison grain. It is treated with strychnine. It is mixed there in large quantities and is distributed for use on farm land. The way that it is used, we just put it down in the gopher runways, I won't even take time to explain how that is done, if you care for more information contact Mr. C. R. Landon, Box 1941, San Antonio, Texas.

About crayfish, I don't know anything about DDT I'm sure it is good, I haven't used it but down on the Gulf Coast around Beaumont in that area in there, they are using quite a bit of copper sulphate. It is in lumps, about two lumps of that dropped into the opening of the burrow will absolutely kill out your crayfish. Another means of killing them that is very effective is carbon disulphide. Take an oil can and get in there, if you put 10 drops of carbon disulphide into a burrow and then just taking your heel and close the opening why that will usually do away with your crayfish too. The best time of the year to do that is in anywhere from the first of March to the later part of July, in other words when there is water in their openings.

Now on the armadillo, I'm going to answer that question and maybe some others and quit and sit down. On the armadillo, as Dr. Taylor told you, it is not considered a rodent and we do not ordinarily work after armadillos. Calcium cynide flakes have been used with very good results and were these calcium cynide flakes are used put about 2 tablespoons of the flakes in the burrow and close the opening. That produces a gas and gasses the armadillo. I have seen some poisonous gas bombs where you could light them and drop them into the burrow but they are not available so far as I know--not on the market. Those two means are about all I know of for the control of the armadillo.

Ground squirrel--poison grain is very good for the ground squirrel control. That may be obtained from our San Antonio mixing plant at $14.00 per hundred, delivered any place in Texas (Address on first page, obtain same place as gopher poison). Where there are county agents they often keep the poison grain. Now another thing on your ground squirrel--carbon disulphide will also kill them.

Another thing I might mention is that the grain mixed at our service's plant has a bright yellow color, in mixing our grains down there we are adding yellow dye to it so that it can be put out on top of the ground for

ground squirrels, prairie dogs--it has been found that birds, domestic birds that is your doves and song birds will not often eat a grain with dye on it.

Moles--well the mole is about one of the hardest rodents to control. About the only success that I have had with the mole is by trapping them. There are repellants that drive them away, but won't kill them. Trapping is successful. Poisoned earthworms placed in runways have been used with some degree of success.

DISEASES OF TURF GRASSES AND THEIR CONTROL

Fred V. Grau, Director, U. S. G. A. Green Section
Beltsville, Maryland

I could take some of the notes from the previous speakers, reproduce them, and have a very good basis for this talk on Diseases of Turf Grasses and Their Control, so I am not going to spend a great deal of time up here before you this afternoon. In the first place you are tired of sitting. I'm in a little better position because I can get up here and exercise a little bit and you can't.

There are two sorts of diseases; one is caused by organisms and the other is the result of physiological conditions. Don't get scared of that word because it simply means the conditions under which the grasses are growing. For instance, I can be sick from flu or a cold and my sickness will have been caused by an organism. But I could drink too much highlife and I'll be sick but it will not have been caused by an organism; it will be caused by some physiological condition because I wasn't quite smart. Turf grasses can be diseased from those two causes; organisms, and the conditions under which they are forced to grow.

You can go right down the list of many of the things that Dr. Longnecker told you this morning, factors affecting the growth of turf grasses, and you can pick out a lot of the reasons why turf is sick. Some of the things we saw on our trip a year ago last August were diseases, but we saw a lot of grass that was sick but not from any organisms so far as we could tell. We won't spend a great deal of time on that because that has already been so thoroughly covered from another standpoint and yet it is fundamental to the health of turf grasses. Naturally, in discussing diseases of turf grasses and their control we are going to spend most of our time on the putting green because that is the only place anybody is doing anything about disease control from the standpoint of controlling organisms with fungicides. It isn't practicable at the present time, with the price of fungicides the way they are, to go out and treat any larger areas such as fairways. It just isn't being done, and I doubt if it ever will be done because in our search for better grasses one of the standards that we are using in selecting those grasses is the capacity of that grass to resist disease.

Last night I showed you a picture that illustrated exactly the direction in which we are going. A grass that can naturally resist disease or be immune to it, (we hope we can develop immunity) is the kind of grass we want provided it has the other characteristics we are looking for. And again we spend most of our time on the putting greens in relation to those diseases because the grasses on the putting greens are the most intensively-managed grass of any that we know. We are growing that grass under highly artificial conditions and thereby we bring out the inherent weakness in the grass. I have felt, and I have stated myself clearly on this point, that a great many of the forage crops workers could very well devote part of their time to studying those same grasses under closely-clipped conditions. I believe that the weaknesses of those forage grasses from the disease standpoint would come

out a lot faster under closely-clipped conditions which simulate close-grazing, than they will in the nursery rows growing to maturity. There is a very good tie-up between those two phases of grass work.

I could save a lot of time by simply telling you that we have available, in our office, a Bulletin on Turf Diseases and Their Control which is available at 85¢ per copy, available to anybody connected with a U. S. G. A. member club or to Green Section subscribers. We still have a supply of them and they are not very much out of date. They are still quite standard and I think most of you could get a great deal out of reading that Bulletin if you do not already have it.

A common disease on putting greens, and one of the worst from the standpoint of impairing the putting surface, is dollarspot. It can be controlled in several different ways. One of the ways is with a fungicide. Work of the past two years clearly indicated that the most effective chemicals for dollarspot control are the dmium fungicides. They are new. One of them is the experimental 531, an inorganic cadmium preparation now sold as CRAG. Directions are complete on the packages. Another one is Puratized 177, an organic cadmium fungicide. From all the evidence it is unanimous that the cadmiums hold the spotlight for dollarspot control. They have not been satisfactory for brownpatch control.

The development of resistant varieties is still our goal from the agronomic standpoint and there is a world of difference in strains of grasses and their resistance to dollarspot. An attack of dollarspot can quite readily be overcome by an application of fertilizer, especailly nitrogen. That has been demonstrated time and time again. Dollarspot usually is worse in turf that is improperly managed. We can stand pretty squarely on that premise. Properly fertilized turf is not subject to dollarspot attacks. You don't get a great deal of it here and you fellows from West Texas don't have to worry very much about any kind of diseases on your bents because you just don't know what these diseases are yet. You can sit back and relax at least for a time. You fellows who are growing bents in the more humid areas of the state like Dallas, Fort Worth, and now Austin and other places, are going to have to watch brownpatch control in the middle of the summer very closely.

Brownpatch is a fungus disease which usually responds to treatment but when you have high temperatures, high relative humidity, and a water soaked soil, you are going to have recurring attacks of brownpatch that may wipe out large areas of turf. You can check attacks of brownpatch quickly with a light dusting of hydrated lime. It is not a permanent control. It's sort of a crutch to lean on, but it is a very strong one. It is not a fungicide necessarily but it does temporarily dry the surface of that green and changes the pH in the immediate area where the fungus is working and stops its growth. We have been relying principally upon Tersan for brownpatch control in the middle of the summer because it does not check the growth of the grasses like the mercury compounds do. Mercury will check the growth of the grass to the point where it can't recover quickly from the injury that it has had from the disease. With the two together, I have seen greens practically wiped out, not from the disease but actually from the fungicide applied to

control the disease. Therefore mercury is being used less and less in the heat of the summer for brownpatch control even though it was one of the standard treatments. We simply have found better materials since that time.

Water management in the summer time is very important from the standpoint of disease control. The type of water management that keeps the soil saturated will greatly increase the incidence of disease. There again I want to repeat what Dr. Longnecker said this morning about watering. Early morning watering is designed to give you the least incidence of brownpatch during the summer. Water in the evening and you increase your disease because the grass is kept wet during the night and greatly favors the growth of the fungus.

Helminthosporium, commonly known as leafspot, is a serious disease throughout the south. It is not confined to bluegrass, it is not confined to bent, but it is prevalent also on Bermuda grass. Some of the Northern strains of Bermuda grass, as I told you last night, when brought south to Tifton, Georgia, went completely to pieces on account of leafspot, I am sure that a lot of leafspot occurs on your Bermuda putting greens and on your Bermuda fairways here. How damaging it is I do not know, but I do know that it is there, and in certain seasons it may be very prevalent. This last fall at Tifton, Georgia, two diseases gave them an opportunity to throw away a lot of Bermuda grass strains because they were so highly susceptible to leafspot and to another disease known as curvularia. I don't know anything about curvularia except that I know how to spell it, I think. So far as we know there is no chemical control for either leafspot or curvularia or even for pythium and perhaps some other diseases. The approach to those is through resistant varieties which means breeding and selection and testing to find out those strains which are resistant. We had a very severe attack of pythium in the Washington area this summer during a period of prolonged rainfall, high temperatures, and high humidity. Some of our finest bent greens looked pretty sick after pythium hit. There is no known control. You simply have to wait it out, do the best you can, keep the greens as dry as possible and give the grass a chance to recover. Eventually the grass will recover but it is pretty sickening while it lasts. I don't know how much pythium may exist down in this area. It may be considerable. Most of these diseases are very well described in words and pictures in the Disease Bulletin of the U. S. G. A. Green Section.

Copperspot need not concern you very much here. It is a factor in the Northeast. There is no satisfactory control for copperspot but Puraturf has been promising. Pink patch is in the same category, not wide-spread, doesn't do much damage, but occasionally it occurs. Snowmold may be mentioned and it, too, can be controlled with mercurials but you are not affected by it here except at high altitudes and where there would be snow cover through the winter. There again, seaside bent, which you find so very good especially in the Panhandle and in the more arid regions of Texas, is difficult to use in the northern bent regions because of its high susceptibility to snowmold.

Damping-off was mentioned and discussed, I needn't go in to it further here. There are conflicting reports on it and there isn't very much to recommend in the way of treatment for the control of damping-off. You may get some relief from mixing Arasan and Tersan with seeds before planting.

There were some experiments being carried on in Georgia and Florida this winter. I do not yet know the results of that work. There was some relief by using some of the newer fungicides. 531 or CRAG was one of those which seemed to give some relief.

There is not a great deal of use in discussing the diseases of fairways and lawns, even though in some cases it is important, because there is no control. Fungicides at present are simply not practicable from the standpoint of cost on large areas and I don't know that we would want to encourage that anyway because the development of the resistant strains is so much more important and so much more practicable. I mentioned last night B-27 bluegrass which is highly resistant to leafspot which is one of the worst enemies of bluegrass wherever it is grown. We think that, through the development of that grass, we can overcome a lot of these troubles on bluegrass. It is going to be some time before adequate seed supplies of that particular grass are available.

For the next few minutes let's throw it wide open for you to bring up some of your problems so we can discuss them briefly.

QUESTIONS AND ANSWERS

Q. Does it help to use some mercury in connection with Tersan?

A. The use of Tersan through the summer is increasingly less effective unless mercury is used at some time during the year. It is a very good point. Mercury can be used to excellent advantage in the cool season of the year and by building up a backlog of mercury apparently the Tersan is very much more effective.

AERATION OF FINE TURF

Howard B Sprague, Head,
Agricultural Research Division
Texas State Research Foundation
Renner, Texas

I am serving in lieu of Dr. Noer who gave such a nice lot of information last year, but I assure you that I am very much interested in this subject, "The Aeration of Fine Turf". I believe we ought to remember that fine turf not only includes greens on golf courses, which is of course a very important type of turf, but it includes all other turf that is cut about the same length where fine texture is desired and is obtained. Fine turf would include all grass tennis courts and all private lawns, where they are attempting to maintain fine turf, and any other particular areas that are maintained in about the same fashion as greens.

The first thing we should consider is that aeration of the soil is necessary because of the occupation by grass roots. In general, the shorter the grass, the shorter will be the root system, but not necessarily directly proportionate. Fine turf may have a relative extensive root system or a very scanty root system depending on the soil conditions, both the natural soil condition and what we have done to the soil. Dr. Longnecker showed you some pictures where oxygen had been provided in great or less amount demonstrating the great effect oxygen supply has on root development of grasses. Similar studies have been made where the sod has actually been taken out and the soil washed away to see how much root system was left, and there is a tremendous difference in root development of grasses depending on management and on the character of the soil. The ideal would be to have a live root system of at least 6-inches in depth, thoroughly permeating the soil; a root system that is alive and functioning and not a mass of dead roots. We should think in terms of a soil at least 6 or 7 inches deep in condition for roots to occupy, and if it is possible to provide a soil profile deeper than 6-inches with conditions favorable for occupation of roots, that is to be desired.

You may have examined some of your green sod and found that the roots did not go down six inches but I assure you that if you make soil conditions suitable the roots will go down six inches and sometimes considerably more. Aeration is completely tied up with the moisture supply in the soil. Or I had better put it this way, that in a soil of good tilth there is a connecting system of pore spaces that are irregular in shape and size, which constitute an aerating system in the soil. That system may either be completely occupied by water or it may be partially occupied with water and partially occupied by air. The joint occupation by water and by air is the condition to be desired.

The statement has already been made in this conference that grass roots must have air. I would like to emphasize that. None of the grasses that we are growing do well unless there is an ample supply of oxygen in fairly close contact with every tiny root hair and rootlet. It isn't sufficient to have oxygen in part of the soil, you must have it pretty well distributed all

the way through the soil mass, and we would like to be assured also that there is plenty opportunity for an exchange of air between the soil and the atmosphere above the soil. The oxygen in the soil air is the part we are concerned with, and if there is not a ready exchange of air between the pore spaces of the soil and the atmosphere above, it may be that all oxygen has been exhausted in poorly ventilated layers of soil.

There are several factors that determine the character of the ventilating system in the soil. One is soil texture. With extremely sandy soils, there is too much aeration. Very heavy textured soils are inclined to be very poorly ventilated. The soil texture then can have a profound influence. However, I believe that there are two other things that are of equal importance, and sometimes more important than the texture of the soil, whether it is a sand, or clay, or loam. One of those things is the profile, or the stratification of the soil itself. Natural stratification or zoning of the profile hardly ever needs to concern us on the putting greens. Nearly all putting greens are made artificially, so I am speaking about the profile that you have produced in the construction of the putting green.

Any layer of sand or peat or clay, any layering of any kind is going to be undesirable, as far as growing grass is concerned. If you examine the well-built green you will find a homogenous soil mixture, no artificial barriers to the movement of air or to the movement of water. Air and Water must be considered together because one can be exchanged for the other, and one can be excluded by the other. The layering of soil must be avoided at the time of constructing or you will be fighting it until you rebuild that green, because any layer of sand, peat, or clay will stay right there for a long, long time, certainly longer than any man will be around. Efforts to work those materials into the soil with a disk-harrow are usually not successful; instead of having horizontal layers you may find strips of materials at all angles and they will stay there for a long time. Any layering is undesirable because of the interference with the movement of water and the movement of air within that soil, and between the soil and the atmosphere about it.

The other factor that is even more important than the texture of the soil is the structure or the organization of these materials into aggregates. The soil scientists use that word "aggregate" to describe soil granules. A certain amount of aggregation is highly desired. As a matter of fact we hardly ever get too much aggregation from the standpoint of growing grasses. When we remember that all of these grasses like plenty of air, it is clear that we seldom get too much soil granulation. You can go in the other direction very easily. The ideal situation is to have all of the soil particles organized into granules. If the soil is poorly aggregated you may find an undesirable amount of compaction caused by tramping in wet weather or the use of heavy machinery in wet weather. When soils are compacted the movement of air and water will be very inadequate from the standpoint of the grass roots.

How may we produce good aggregation? First, that will depend very largely on the character of the soil that you have to work with. There are no set rules that I can mention, I will discuss some of the things to consider. First of all there is texture, it is much harder to get good aggregation if the soil is sandy or too clayey than if the soil texture is loam, silt loam,

or sandy loamy soils; particularly sandy loamy soils since they are very much easier to handle. Second, organic matter well mixed with the soil is one of the most effective ways of getting good gramulation or good aggregation of the soil particles. Third, root action of grasses growing in well aerated soils produces a good condition of aggregation.

There isn't time for me to go into the details on organic matter, but you may remember that there are two general types: We can use fresh organic matter which will more or less completely decompose, in which case the effect is going to be temporary. However, if it is fresh organic matter, in the process of decomposition there will be some redistribution of it in the soil. This redistribution is not very extensive, but there is much more than occurs with such forms of organic matter as peat. The types of organic matter that decompose very slowly include all of the peats. There are many different types of peat. Both fresh organic matter and peats intimately mixed with the soil to produce good soil structure, because they will not be redistributed or mixed in the soil to any extent by microorganisms which cause decay. They are going to stay in the soil about where you put them, and it is desirable to have them well mixed with the soil.

A further factor in soil aggregation is the quantity of lime. Lime is a very beneficial substance if the soil is acid. Now if there already is an excess of lime as we have in Blackland soils and in many other calcareous soils in central and western Texas, adding lime certainly will be of no value. On such soils we have the problem of excess alkalinity or alkali. Alkali also is an enemy of aggregation, and a good way to break down soil aggregation is to permit the accumulation of excess alkali by poor drainage. Excess acidity destroys aggregation in a different way but both alkali and strong acidity are to be avoided.

There are some natural forces working in the direction of giving us the type of soil structure that is desired by grasses. First, I may mention to those of you who are in the northern area where it freezes to a depth of four or five inches, that you have a very powerful force working in the direction of good grass. Please do not undo all of the good that nature does in the winter through freezing and thawing by heavy rolling in the spring when the soil is soggy. Freezing of the soil is a very effective natural force where it occurs. Another natural force which is very effective in developing granulation is wetting and drying of the soil. If putting greens are kept continuously wet all year round, there will be little benefit in gramulation by the drying process. If you can permit some drying periodically, perhaps not to the extent of hurting the grass, you will derive some natural benefit in the form of gramulation and better aeration.

The one natural force that always is functioning is root action. Grasses are probably the most effective forms of plant life in producing granulation in soils. If you will give the grass roots an opportunity, they will go a long way toward developing in the soil the very conditions that they like for further growth. If the grass roots are penetrating only two inches because of poor management or some other conditions, the gramulating effect will be just 2-inches, the depth of the root system. If you are managing the grass so the roots are going down to 6 or 8 inches on greens, or two or three feet on some other kinds of turf, you can expect to have some benefits in gramulation to the full depth that the grass roots are able to penetrate.

I might mention now two or three of the things commonly done that destroy the type of structure required for aeration, for rapid drainage, and the proper root development. One of these is unavoidable; and that is tramping by man on these fine turf areas when the soil is wet. We shall not be too critical of that type of injury, because I must confess that when I am ready to play golf, a rainstorm is not going to be very much of a deterrent. And certainly as soon as the rain is over, I am ready to play, and so is every other golfer. They are going out and play whether the soil is going to be puddled by tramping or whether it isn't. We must put up with that because that is the reason the turf was developed in the first place. However, I think we should remember that it is a very bad thing as far as grass is concerned, and we should not add to that injury or handicap in any way by any of our management practices. I have been horrified a few times by seeing some well-meaning individual actual renting a 10-ton roller and going out to roll the turf because it was rough and he wanted to smooth it out. Unfortunately those who use heavy rollers do not understand the damage they do to the soil structure and soil aeration. We should remember that any rolling or any form of compaction with any implement, done when the soil is soggy should be avoided because of the interference with water movement and good air movement.

As indicated in my earlier comments, aeration must be considered in conjunction with drainage. Three aspects of drainage: Surface drainage, which is getting water off the soil sample is perfectly obvious. Anybody knows that should be done although it is not always accomplished where the design of the turfed area is faulty. We must get water off the surface because if the water is standing on the grass, both the leaves and the roots are deprived of air. The only oxygen that grass can get during the period it is submerged in water will be the very small amount that is dissolved in the water; and in warm weather that is a very, very small amount. There may be quite a lot of oxygen dissolved in water when it is cold. The higher the temperature, the less oxygen will be dissolved in the water and the sooner the grasses will suffocate. Fortunately the grasses can die by degrees, but it is possible to kill the lower part of a root system by prolonged water-logging. The part of the root system that is in a layer of soil which is where there is too little oxygen, particularly in warm weather, will die and if most of the root system is completely submerged, most of it will die. If the conditions later become favorable, the grass root system may be regenerated. However, grass root formation occurs in cycles. The replacement of the grass root system more or less on an annual basis, roots are being formed to some extent in all seasons when the grass is growing, with much more rapid re-generation at some seasons than others. The grasses I have worked with produced most of the roots in the spring or in fall. If that is the case you can see what situations might occur. Suppose the grass had produced its crop of spring roots and then water-logging occurs. Most of that crop of roots is lost. The sod then must function with just a part of a root system until the next season comes around for the formation of a new root system again. In other words, a short period of unfavorable soil condition may deprive you of a large percentage of the working root system for a long period. Therefore it is necessary to get rid of excess water within the soil as well as on top of the soil in order that enough oxygen be supplied for all of the plant to function normally. Movement of the water within the soil is some-times very greatly handicapped by impervious soil layers. Even though these

layers are below the depth of the root system, they may still impede water movements. Those barriers to water movement must be corrected if there is to be proper aeration for the root system.

Now I come to the correction of soil during construction. When we are dealing with greens that is usually possible. In order to correct any soil deficiencies we must first make an estimate of what the soil will do. This estimate should be based on experience under similar conditions on some other location. If the soil that you have at hand is considered inferior on the basis of its known properties and known performances, the time to make the decision to get some that is good, is before construction begins. I agree with some of the earlier speakers that it may be quite practical to improve the soil at hand. It may not be necessary to import another soil. But in any event that is the time to correct those conditions that are unfavorable to grass. If you have an unfavorable condition either because the character of the soil or because of an impervious subsoil, it will be necessary to consider whether or not to put in a tile drain system.

If the local soil that you are using is well known to be difficult to handle from the standpoint of drainage, you can be sure it is going to be difficult to handle from the standpoint of aeration for fine turf, and you might as well accept the probability that a little more money spent on a tile drain system at the beginning will save a lot later on. After that decision has been made then you still have the decision of how much organic matter to incorporate, what quantity, and how to incorporate it. It has been my experience that disking and harrowing will not give a uniform mixture of peat or sand with soil of the type that we must have to produce a good putting green. It takes more than that to produce a mixture that would approximate the kind of soil that you get under ideal conditions. It is not easy to get those materials mixed into the soil. There are several types of rotary tilling machines that do a pretty good job of mixing materials into soil, if they are properly handled. Most of these machines will not operate effectively more than four inches deep. If you are preparing an 8-inch seed bed you will have to prepare the lower four inches first, and then prepare the upper four inches. The only alternate to that procedure that I know of is to put your soil, organic matter, sand, if you are using sand, all through a shredder or screener simultaneously so as to produce a uniform mixture. I think you can see for yourself whether the mixture is good or bad. After you think you have the green ready, just take a spade, cut down through it in a number of places, then examine it and see what you have. You will find that if you have used a disk and a harrow only, the desired uniform mixture of materials has not been accomplished.

Another thing that should be considered is what is to be done with regard to lime if it is an acid soil, or in regard to gypsum or sulphur if it is an alkaline soil. Those materials in order to be fully effective, should be mixed throughout the soil mass. The time to mix them through the soil mass is the very same time that you are putting in the sand or the organic matter. This outline of what is to be done indicates that much work is involved. This work might stop some of you from undertaking soil improvement. However, you are dealing with some very critical areas, on golf course greens. A golf course must have good greens, and if the work must be done at any time, the time is during construction.

Now let us suppose that you are dealing with greens that are already established. Suppose you find from examination that you have a scanty root system, and have determined that it is caused, at least in large part by poor aeration and poor drainage. What can we do about it? One of the earliest things that was done historically, was to use an ordinary spading fork, to lift the turf. The spading fork is put down to a depth of 6-inches, and the turf lifted slightly. The fork is moved about 4-inches and the process is repeated. This old system was used a long while until turf men devised other means of aerating turf. I can remember in my short experience with turf, the transition from just ordinary hand forking of that type to some of these other types of aeration. The use of a solid-tine fork like the spading fork has mostly passed out of the picture, although it still is used in some places. The hollow-tine fork was a tremendous improvement over the solid type forks because the hollow-tine forks actually took out plugs and you could let those holes stay open, or gradually fill them with improved top-dressing material. In any event, the hollow-tined fork gives postive improvement in aeration to the depth the fork will go. Machines are now in use like the "aerifier", do it by power, and cover great areas. Aeration of an old green is good but not as good as having built the green right in the first place. Methods of aerating old greens are useful when it is too expensive to rebuild, and they may always be helpful on large areas where it is impractical to rebuild the soil.

Another thing that can be done to correct poor aeration on established greens is to control irrigation. Excess water naturally excludes air. Controlled watering means never using so much water that you completely fill the soil pores. That does require considerable control, because as water moves down through the soil it must saturate the top layer in order to get down to the next layer. In watering it is necessary to carefully guage how much water can be put on, so that when it is all percolated down into the soil the top layer is no longer saturated. That takes considerable judgment and practice, but it pays off very well in soils that are inclined to be waterlogged and produces a strong turf capable of enduring much wear. In that connection, I might suggest that rolling be passed out of the picture completely. Lawn rollers are still handled by hardware stores and lawn supply companies, and people still buy them, but I advise against using them unless you absolutely have to. On a poorly aerated soil there is no more effective implement to cause grief.

Again I might emphasize what Dr. Longnecker said briefly in top-dressing, and what he is going to discuss in more detail later; the character of the top-dressing can be quite important in handling those difficult areas where there is poor aeration. That subject will be developed in more detail, later.

We have then this final problem--when to decide to rebuild a green and when to decide to try to keep it going by aeration and top-dressing. That is an individual decision and it will have to be made on each green, in the light of the soil conditions at hand, in the light of the kind of play expected, and most particularly in the light of budget limitations. I will not attempt to make that decision for you, but I suggest that you look ahead and make the decision on the basis of whether you would like to have the job of nursing a sick green over a long period, or whether you would like to

rebuild it now, and get rid of that perennial headache with greens that you know are in bad physical condition.

QUESTIONS AND ANSWERS

Q. How would you mix peat and sand with soil in rebuilding a green?

A. I would rent one of the rotary tilling machines to do the job. It will do it almost as fast as disking and harrowing, and do a satisfactory job. They will go only about 4-inches deep but they will do a very much better job.

Q. Would you roll a green that has a clay soil, to make it smooth?

A. In a black clay soil that is saturated with calcium you can get away with quite a lot of abuse; as it drys it tends to crumble and flake and the structure is more or less re-established by wetting and drying. However, I would say that rolling is undesirable as a rule. The only conditions that I can think of where it would be desirable would be in very loose sand. If the surface is rough there are other ways of achieving a smooth surface. Top-dressing probably is the most effective of all.

CONTROL OF WEEDS IN LAWNS, FAIRWAYS, AND PUTTING GREENS

Fred V. Grau, Director, U. S. G. A. Green Section
Beltsville, Maryland

It appears that you have had a most successful conference. I am sorry that this is the last time that I will appear before you and sorry in a way that it is over so soon. It is surprising how quickly the time goes when one is profitably and pleasurably occupied as we have been here these last two days. It has been a source of considerable gratification to me to see the growth of this group, The Texas Turf Association, and to see the desire to learn more about better turf in Texas. True we don't have a great deal to offer you but we bring you what we can, what we know, and we hope what we give you can be applied in your work. I am glad to see that the program is so broad, covering so many phases of turf because, we above all people, interested as we are in golf, do not want it confined to golf because that is restrictive and we want it broad in the broadest sense.

In the subject that is assigned to me this morning, "The Control of Weeds in Lawns, Fairways, and Putting Greens," I could make one statement and sit down, and that is this: "The first principle of weed control is to grow good grass." Most of the weeds we have are there because we haven't grown good grass and we worry more about the weeds than the reasons why we don't have good grass. I just can't impress that upon you too strongly. It comes out every time I talk about weeds--grow good grass first and then worry about controlling the weeds. The weeds are there for some good reason. You can take Tom Longnecker's talk that he gave yesterday, the outline of which you have in your pocket. If you will go through that outline and analyze it very carefully and then go back home and analyze your own conditions on the basis of those reasons you will know then why you have weeds. Until then there is not much use of getting rid of the weeds until you correct the conditions that caused the poor grass.

If there are weeds in good turf it is so much easier to control them because the grass is more vigorous, it snaps back more quickly after it receives a temporary injury, and the scars from taking out the weeds heal up so much faster. Ferguson talked last year on the same subject and I believe that one of his statements was, "Prevention is better than cure". In most cases weeds largely can be prevented. I can't help but think of the large quantities of nutgrass that you see in putting greens, not only in Texas but in Louisiana and Florida. In almost every case that nutgrass is there because the soil is poorly drained. It is so poorly drained, so packed, so water-logged, so everything that is wrong, that nutgrass is about the only plant that can grow successfully. Even Bermuda grass can't grow successfully under those conditions. So why worry about the weeds until you have corrected the conditions that invited them to enter. Grow good grass and then I don't believe that you will have too much trouble from weeds.

Graham Ross made a very significant statement yesterday when he said when he had Bermuda greens, with the soil just thrown up with a slip scraper, black mud, or whatever was there, he was continually beset with crabgrass.

Then he put in bent with improved soil conditions. Somebody asked him how much crabgrass he has had, thinking perhaps he had a lot, but his statement was that he hasn't had any since. He's growing good grass.

I remember the time in putting greens, in Pennsylvania, New York, New Jersey, and Tom Longnecker knows this, they had crews of women, women and children, anybody they could get, out there on those greens and they might spend $3000 or more a season picking the crabgrass out of the greens. Since then we have learned how to grow better grass and today they don't spend 30¢ a year picking out crab grass from the greens. It is in the same climate, they've still got much the same grass but they have learned how to grow it better. And you go right on down the line and it is pretty much the same with almost any grass you want to mention, in almost any part of the country. Our big trouble with blue grass lawns in Washington and clear across to St. Louis and Kansas City is crab grass. We know the reason but we haven't been able to do too much about it as yet because our common bluegrass gets leaf-spot, gets thin, and crab grass is just the natural consequence under ordinary management. There are some grasses however, that won't let crab grass invade them.

I think perhaps we can make classification of weeds into broad groups rather than considering individual weeds. The broad-leaf weeds is one group which includes the dandelions, plawtains, and similar weeds, and, generally speaking, the broad-leaf weeds respond to certain types of treatment. Then we have the mat weeds, the flat weeds, and clover, as my friend Bruce Levy in New Zealand classified them. I saw him 10 years ago in England at the International Grasslands Congress. The mat weeds and clover group includes Dichondra repens. You may know that is used as a grass substitute in California where it is difficult to grow grass. Included also is the pennywort which has been quite a pest in New Jersey, in Washington, Florida, and other places where there is quite a bit of moisture. In addition to the clovers, in Florida they have match weed, a Pihyla species. We also have chick weed, knot weed and similar ones in that class. Usually these are the weeds of either watered fairways or areas where there is plenty of moisture. And then we have the grassy weeds. Among the whole group the grassy weeds are the most difficult to control. They have presented the greatest problem because it is more difficult to get selectivity between two grasses than it is between a broad-leafed weed or a mat weed and the grasses. Among the grassy weeds we have Dallis grass and you all know what a problem that is under your own conditions. We have crabgrass, goose grass, or silver crab. Nut grass here is bad. Although it is not a grass but we include it here, it is a sedge. In Florida one of the bad weeds is sandbur or sandspur and you probably have it here too. It is especially bad in the roughs.

The first decision to make is, what is the proper control method for the weeds that you have. That really isn't first because the first is to find out why the weeds are there and why you don't have good grass. You are still most fortunate in Texas and throughout the South where Bermuda grass is so well adapted. You can do things down here that people in the North couldn't think of attempting. You can make Bermuda grass grow with liberal applications of nitrogen fertilizer so that it will crowd out almost any weed in its path. I have seen that done and with just a little bit of help from

sodium arsenite or 2,4-D the problem is even simpler. You should plan the treatment in relation to the turf grasses present. It isn't quite as simple as that because in some cases you have centipede or carpet or St. Augustine. I don't want to go out on a limb on this because I don't remember what Dr. Burton said exactly, at Knoxville last week, but he showed a picture of a combination of Bermuda grass, centipede grass, and carpet grass. 2,4-D had been applied at rather a heavy rate and lo and behold the carpet grass completely disappeared and the Bermuda and the centipede grass weren't even injured. They had been studying for years to try to find a way to separate these two grasses and just stumbled on to it. The data has not been published as yet but will be soon. So you will have to plan the treatment in relation to the grasses that you have present.

A turf that is perfectly adapted to its environment, a turf that is healthy and deep rooted can stand a lot more punishment and shock from a chemical treatment than a grass that is shallow rooted and narrowly adjusted to its environment and just holding on. There was quite a little discussion when 2,4-D came out as to its use and advisability on Bermuda grass. Some said that you can't hurt Bermuda grass with 2,4-D. You will remember that when we were here last year both Noer and I gave examples of where Bermuda grass on putting greens had been killed with normal applications of 2,4-D. There was a reason for that of course because the Bermuda grass was just holding on and it was sick to begin with. It didn't have any root structure because of the soil conditions and under those conditions it dropped out of the picture.

There is a great deal of difference in susceptibility in different grasses to these chemical treatments. We find it in the bents, we find it in the bluegrasses, in fact we believe that it occurs in almost every species of grass. I'd hesitate to make any flat recommendations based on what we have learned in other sections of the country because through these weed control conferences and different meetings we learn that you just can't pick up a treatment in one place and set it down in another part of the country and expect it to work just like it did in the other place. It doesn't do it. Climatic conditions, character of the grass, moisture conditions, and many other factors affect that. It just about has to be worked out in detail in every section of the country.

I am speaking of chemical control this morning mostly because the other factors of plant growth have been discussed so thoroughly here this week. And there is just no use of repeating them so often because you can look at your notes and get the whole story. I want to insist however that the agronomic approach to weed control, that is, to grow better grass, is the best in the long run. The chemical control of weeds is simply a crutch or a prop to lean on until we know more of the answers on how to grow good grasses, or at least to apply them.

We have been quite outspoken in our support of dry applications of chemicals mixed with fertilizer. You might say it is a device, in a way, for a little better education because a lot of the weed troubles of turf are caused by malnutrition or lack of adequate plant food. If you can combine a weed treatment with a fertilizer treatment you are killing two birds with one

stone and we know that it works. The two chemicals that I would suggest for any large scale trials down here would be 2,4-D and sodium arsenite. There hasn't been nearly enough sodium arsenite used in this part of the country according to my way of looking at it. Wherever it has been used it has been remarkable successful. Now you can put it on as a spray, yes, but considering that the grass usually is weedy because it is starved, I would much rather see it go on in combination with a fertilizer. I think sodium arsenite is a common enough chemical that you won't have too much trouble getting it and it isn't too expensive. Seldom has it ever gone over 8 or 10 cents a pound, today perhaps it may be double that, but I don't know. Does anybody have any recent quotations on sodium arsenite? (Gordon Jones said that it is very difficult to get sodium arsenite except in the liquid form).

Sodium arsenite has so many advantages in the dry form. It takes very little more of it than as a spray. We have been in touch with Chipman Chemical Co. too and they indicated to us that they weren't too much interested in making it dry but they are continuing to supply us with it. I think that if pressure were put on they would continue to make it in the dry form and, having had 10 years of experience with sodium arsenite in various treatments in Pennsylvania and over a wider scale since then, I have a great deal of faith in it as an agent for helping to control weeds, particularly in your southern grasses. Two of the most recent experiences that I have been connected with are the fairways at Southern Hills at Tulsa, and the fairways at the Memphis, Tennessee Country Club. The problem in both cases was crabgrass, which I believe has been mentioned most frequently in this conference. The applications were made in the latter part of the summer, during the best growing period of Bermuda grass before the crabgrass had had a chance to produce seed. The sodium arsenite in both cases was purchased in a form already mixed with fertilizer. I don't think we have to mince any words here, so I'll tell you that it was Milarsenite, the only commercially prepared fertilizer-sodium arsenite mixture that we know of.

We have used sodium arsenite mixed with every type of fertilizer and it has worked equally as well so if you are of a mind to purchase it and mix it with a brand of fertilizer you are using now, it will work just as well. Three applications of 400 pounds of Milarsenite to the acre at each application was made after the end of June and in both cases the results have been outstanding. Extra plant food in addition to that contained in the fertilizer-sodium arsenite mixture was applied to force the Bermuda to still stronger growth. At Tulsa there was no additional treatment made, but at Memphis the soils were acid and the fairways were aerified several times in the spring and limed to bring the pH up to about 6.5. It is a heavy, sticky, clay soil, and the results of that, I think, prepared the ground for the fertilizer-sodium arsenite treatment later in the summer.

At Knoxville last week the boys from the Memphis area were saying nice things about the fairways at Memphis. So it was a combination of taking the weeds out and fertilizing the grass; in other words, growing good grass. Probably quite a few of you will be at Memphis the end of August this year for the U. S. G. A. Amateur and the reason for the launching of that program was to have the course in the best possible condition for the tournament.

From our experience 2,4-D can be used in a fertilizer mixture just as effectively as sodium arsenite. Since there are so many 2,4-D preparations on the market in the liquid form which must be applied as a spray, a great many of them cannot be used dry with fertilizer. It is only the salts that come in powder form that can be used that way. There again though, unless fertilizer is used to thicken the grass and the other factors of plant growth are carefully followed, the use of 2,4-D isn't of much avail unless you grow good grass along with it.

There may be some place down here for the use of the di-nitro compounds. The dinitros are very useful in some sections. They are a little difficult to use on account of the fact that they are yellow dyes. I remember quite vividly the story that was told about a venerable old gentleman who was interested in this procedure of spraying some putting greens with a di-nitro compound and he was so interested that he was following the spray truck a little bit too closely. A hose broke and the white haired old man very quickly was a yellow-haired old man and the yellow dye stayed until his hair grew out. It is a very fast dye and it doesn't wash off very easily. That's minor however. We don't yet know how to use the di-nitros in our turf work nearly as well as we do 2,4-D and sodium arsenite.

There is another chemical that has been used for years and it is unfortunate that the price is so high now that it discourages many from using it and that is lead arsenate. Of all the chemicals in use it is the only one that we can unreservedly recommend for the control of weeds on putting greens. We never have recommended any other chemical for weed control on putting greens, except lead arsenate. There is going to have to be a lot of work done before we can recommend any of these other materials. Sodium arsenite has been used on putting greens, but they have been individual recommendations based on the man's ability to use that material wisely and safely. We cannot make a general recommendation to use anything like sodium arsenite or 2,4-D on putting greens. Lead arsenate is safe. It acts as a worm control and on a putting green where good putting is the business, we cannot tolerate anything that interfers with good putting so the worms have to go regardless of whether we may consider them beneficial or not. We can use mechanical earthworms or machines that aerate the soil without destroying the turf. It is an advantage because we can control the operation. The lead arsenate kills worms, and many of the other insect pests and also controls weeds. Those of you who get Timely Turf Topics, I wish more of you would send in the answers to the surveys in Timely Turf Topics. We have gotten about 100 returns from the lead arsenate survey and the results are very illuminating. Some people have used lead arsenate continuously for 20 years on their putting greens and whenever a blade of clover shows up, or chick weed or crabgrass appears, they immediately put on another application of lead arsenate because they are using the weeds as a guide for the next application. So far we have not seen any damage to the growth of grass even from the continued applications of lead arsenate if the soil conditions are good and if the grass is healthy and if you have the good drainage and aeration and all of the rest of the things we have been talking about all week.

Weed control in lawns probably is important to more people than anything else we have been talking about. There are about 16 million lawns in

the United States which cover over a million acres. When you consider the size and the scope of that business it is no wonder there are so many people in the lawn supply business. We know from experience that the most common reason for poor lawns is lack of fertilizer. Most of the grass is poor because it is starved. There hasn't been enough nitrogen used to make that grass grow and crowd the weeds out. We think on lawns the best approach is through a fertilizer mixed with a weed control chemical because you are doing two things in one application without having to do too much education of the home owner. When you try to educate 16 million home owners you have got a real job on your hands, considering that very few state extension services yet recognize the problems of turf and have qualified men and women dealing in that subject. And so you have to get at it some other way and if you can combine them in a treatment that is attractive to the home-owner, that is safe to use, you've really got something.

It has been very difficult to use sodium arsenite in any home lawn mixture because of its poisonous character and from the fact that some people get skin rash from it. 2,4-D is a different proposition and most of the weeds on home lawns can be controlled with 2,4-D. Already several fertilizer manufacturers are preparing fertilizer-2,4-D mixtures for home use. There is one in Pittsburgh, one in Philadelphia and one in New York and others are taking it up. Usually it is prepared so that the average rate of application of fertilizer is considered. We will say it is 500 pounds to the acre of a 10% nitrogen goods. Enough 2,4-D is added to that to give the home owner the proper rate of 2,4-D per acre at that rate of application of the entire mixture. In the dry form from 2 to 3 pounds of actual 2,4-D to the acre usually does the job. It takes a little more in the dry form than it does as a spray. About 1½ pounds is usually considered a maximum as a spray for turf and between 2 and 3 pounds in the dry form.

In the last year we have seen some articles on PMAS for crabgrass control. As yet we do not know enough about it to say much about it. We have seen some good results and we have seen some bad results. We want to see a lot more work with it before we make any flat recommendations. It has worked very well in Rhode Island. It has not worked so well in places in New York. We have seen a lot of grass killed with it at the recommended applications and yet we don't know the reasons why that was so. We have got to study it a little longer.

Now I haven't given you a great deal of specific recommendations for weed control and I hope that I am not called upon to do that because it is difficult in the first place, and, in the second place, if you are growing good grass you wouldn't have so many weeds, and in the third place, almost every area is an individual problem and has to be studied as such. I can only hope that I have given you enough of the principles of weed control that it will help your thinking a little bit more. Now I realize I haven't covered the subject as fully as I might, I haven't shown you any pictures but then there is a lot of time for that. Data like that from your own conditions here will mean a great deal more than if I were to give you a lot of data and pictures from other areas which wouldn't mean much in the final analysis.

QUESTIONS AND ANSWERS

Q. What is the recommended rate for using lead arsenate on putting greens?

A. About 10 pounds of lead arsenate to a thousand square feet applied as often as necessary is a good rate to use. Some use it as low as 5 pounds but they apply it more frequently. If the grass is inclined to be tender the lower rate would be preferable. If the grass is sturdy, past experience has shown you can get away with 10 pounds. I have known in some cases where they have used even 15 pounds in one application but that is a little on the heavy side. The last quotation I heard was 32¢ a pound. We used to get it for 8 and 10 cents.

Q. Do you use this rate before planting a green?

A. No, I was thinking of the established greens, in fact, we are not even recommending that the arsenate of lead be worked into the seed bed when the green is planted because so many times if the green is seeded it may retard the germination of the seed. Where mole cricket is bad perhaps that would be justified because it would discourage the activity of the mole cricket long enough to get the seed established. But, generally speaking, the insect and weed pests that the lead arsenate will control don't become too serious until after the green is established, and there is plenty of time to start working it in. Some of the greenkeepers that I know who have used it for many years mix it right in with their top-dressing and make it an integral part of their top-dressing material. In that way it never burns.

Q. Have we ever found anything to control dandelions?

A. Yes, 2,4-D is the answer to a maiden's prayer for dandelions. It is the most efficient chemical we have ever found for controlling the weed.

Q. Is there any good control for nutgrass?

A. I have not found any nutgrass where drainage is perfect, where soil conditions are ideal, and where the grass is very dense and healthy. Nutgrass usually comes in those areas where the soil is soggy, saturated, and the grass is thin, because it is so well adapted to those conditions and the grass is not. As far as chemical control is concerned there has been no satisfactory control worked out. 2,4-D has offered promise but I don't think it is the answer.

Q. Do you know of any specific instance where sandbur have been controlled?

A. Yes, on some courses in Florida. When the sandburs were blooming and before any burs or seed were produced, the roughs were sprayed with sodium arsenite which is a very effective chemical for controlling grassy weeds.

Q. Can you use sodium arsenite on a playground?

A. We have used sodium arsenite widely on athletic fields and playgrounds throughout Pennsylvania and have yet to find an instance of any unfavorable incidents. They used 4 to 6 ounces of sodium arsenite to a thousand square feet. It might be used even heavier if you aren't too afraid of damaging other vegetation. The timing of that is important to kill those plants before they are through flowering or have a chance to produce seed. One application would not be enough and it would have to be repeated probably several years in succession because of the habit of some grass species of germinating their seeds over a long period of time.

Q. Do you have to continue to treat with chemicals?

A. That is right. With almost any of these weed control methods there will be recurrence of the weeds unless the turf is thick enough to resist them because the seed is in the soil. They continue to come year after year.

Q. What was the rate you gave us for sodium arsenite?

A. From 4 to 6 ounces of sodium arsenite to a thousand square feet. That's about 11 to 15 pounds per acre.

Q. How much sodium arsenite would you mix in a ton of fertilizer?

A. We don't look at it that way usually unless we know what kind of fertilizer and how much normally they would apply to the acre. Let me put it this way very simply. If you are using a 10-6-4 fertilizer, for example, and your normal rate of application is 400 pounds to the acre and you wanted to use 15 pounds of sodium arsenite to the acre it's just simple addition. But it is most important to get the correct rate of application of the chemical per acre regardless of the amount of fertilizer. You might need very little fertilizer in some cases so you just use 100 or 200 pounds to act as a carrier.

Q. In our good fairways we don't have any trouble with weeds. In our poor fairways there are plenty of them.

A. Well, what kind of grass, Bermuda? What kind of weeds? Wouldn't it be better to build those fairways up with fertilizer because by your own admission you don't have them where the grass is good. And wouldn't the grass crowd them out? With the present difficulty of getting arsenite and mixing it, you might do a good job of weed control with just fertilizer.

Q. How much arsenite would you use for crabgrass in Bermuda turf?

A. I would probably use in the neighborhood of 6 to 8 ounces in the dry form of sodium arsenite per thousand square feet. That would be a half pound to the thousand or about 22 pounds to the acre mixed with the normal rate of application of your fertilizer.

Q. Would you use that rate when using Milarsenite?

A. Oh, no, I was just putting it on the basis of sodium arsenite. With Milarsenite, if you are using that, I don't know just how much sodium arsenite is contained in a hundred pounds. You probably would want to use about 400 pounds to the acre.

Q. Is 2,4-D successful on puncture vine?

A. I do not know. Do you know Sydney? Has 2,4-D been successful on the puncture vine? Does anyone have anything to offer on that? (Sydney Watson said that 2,4-D had done a good job on puncture vine).

PREPARATION AND APPLICATION OF TOP-DRESSING

Thomas C. Longnecker, Senior Soil Scientist
Texas State Research Foundation
Renner, Texas

Preparation and Application of Top-dressing. That title could mean preparation and application of top-dressing most anywhere. However, the general principles would apply to any kind of turfed area where you are going to apply top-dressing material. The main emphasis which I will make will be its use on golf greens, and other fine turf areas, perhaps tennis courts, bowling greens, and such places as that.

I wonder if I asked the group what your reasons were for applying top-dressing what kind of reasons I would get. I wonder if you ask yourself when you are putting on top-dressing, why am I doing this? What is the purpose for it? After all top-dressing is an expensive proposition. Whether you make your own material or whether you buy it commercially it is costing you money, and over a period of years or even one year it will run in to quite a bit of money on an 18-hole course if you top-dress all of your greens. So maybe you have considered it sometimes, why not do away with top-dressing? Why put it on? I know of golf courses in the East who in attempting to answer that question didn't put on any top-dressing and some of them were able to get good results with using almost no top-dressing or in some cases none for a year or two at a time. But I believe the two most important reasons for using top-dressing are the two I have listed. First of all to procure a level surface and give a more desirable putting surface. After all the only reason for the existance of a golf course is for the pleasure of the golfer and in maintaining the golf courses it is our duty to give him as near as possible what he wants within reason. So I believe the main reason for top-dressing is to provide that level putting surface. In the event you already have a good level surface on your greens perhaps you are throwing money away when you do put on top-dressing. However, I wouldn't tell you not to because it is an individual case on each golf course and I think that each case should be analyzed, then on the basis of the conditions which you find in that analysis decide whether you do or do not need top-dressing, and how much. I think it is a waste of money to put on more top-dressing than you need because it is bad economics. There's no point in using twice as much as you need if you can get results with half that quantity.

The second reason for putting on top-dressing is to cover the creeping rootstalks and prevent matting. Most of our grasses which we use on greens produce these above ground creeping stems. If you permit those to grow unrestricted without proper raking and mowing, no top-dressing, you will end up with a dense heavy mat of turf on the surface which is what I think some of them were describing yesterday in what happens to edges of the greens where the grass is not cut at the same height as it is on the other. You've got such a heavy mat there that it eventually will kill itself out, either directly because the roots can't support the top growth or indirectly since that mat on top provides a good place, hiding place for disease and insects to get started. So that if you do follow good cultural practices with regard to mowing and raking you can get by with much less top-dressing material. Once you have

obtained that level surface which the golfer wants, then after you have decided whether you do or you don't need top-dressing and if so how much you need, then the problem arises as to where am I going to get it. I don't know how much of a problem that is in this particular area, but I know in the area I am most familiar it is becoming quite a problem both from the standpoint of getting a desirable soil and a good source of organic matter or humus to include in it.

I have listed here what I consider the characteristics of good top-dressing material. I would like to repeat what I have already said that a good top-dressing material is one which is an ideal medium in which to grow grass. When you put on any kind of material on top of a green I think you should ask yourself where is this material going to be 5 years from now or a ten years from now and how is it going to affect the growth of grass on the green. If you will ask yourself that question I think you will get a little better idea as to what is going to happen if you put on an improper top-dressing material, such as, perhaps straight sand or straight peat, which brings on the layering condition which I described yesterday. I would also like to repeat again what I said yesterday that in the East we can trace the history of our knowledge of green keeping by taking the plug out of our greens. This is characteristic of many of the golf courses in the metropolitan New York area, and of all of the different kinds of material that have been applied, we can tell from how deep it is about how many years ago it was put on. We can tell from which went on first as to which came on to the market first and which got the most publicity and which was used. Many of these materials are causing trouble and I hope that this area does not make the same mistake that the other sections of the country have already made.

The three characteristics which I have listed here are purely general. What I consider an ideal medium in which to grow grass. First of all it should be a sandy loam in texture, and to classify as a sandy loam in texture it should contain from 50 to 80% sand, 20 to 50% silt, and from 0 to 20% clay. All these textural classifications which we have for soil (whether it is a sandy loam, a loamy sand, loam, or clay) are based entirely on the amounts or proportions of three different soil separates which we have in soil and those are sand, silt, and clay. Their classification is based on the size of soil particles, beginning with clay which is the smallest, silt which is intermediate, and sand which is the largest. It is the proportion in which those three are present in any soil which determines its textural classification.

A sandy loam has a rather wide range in content of these three soil seperates. From 50 to 80% sand, covers a 30 per cent range and from 20 to 50% silt also covers a 30% range. So all sandy loams, even though they would all classify as sandy loams would not look exactly alike. First of all the sand particles might vary in size or they may be fine sand or coarse sand. From the standpoint of growing grass I believe that the coarser sand is to be desired and if at all possible I would obtain a coarser sand. Something which would run probably in the neighborhood of around 1/6 of an inch in diameter. Fine sand even though it classifies as sand and from a textural standpoint would make the soil a sandy loam will pack almost as hard as some of the clays will under certain conditions, so if you can get a coarse sharp sand I think it will be much better. So when you are making up a mixture obtain if possible

one of coarser sand. On the silt and clay there won't be much variation in that. You can always get plenty of that to put in. From an organic matter standpoint I believe it should contain from 12 to 15% organic matter by weight which would make it about 25 to 30% by volume.

The source of organic matter is going to have quite an effect on the top-dressing material that you prepare. There is many different sources that you can use, if they are properly handled, I think they are all probably satisfactory but they must be in proper condition otherwise they will not make a good top-dressing material.

Now from the standpoint of soil reaction I consider a pH of between 6.0 and 7.0 the most ideal and that is what I would recommend that you have your top-dressing material test. It may be necessary to apply lime in order to obtain that pH. If you have an alkaline soil then it may be necessary to mix in sulphur in order to bring that pH down. Now under those conditions I don't believe that I would recommend that you apply enough sulphur to bring it down to a pH as low as 6.0. I believe you can get by with bringing it down to about 7.5. Lower pH values offer no advantage and other problems might arise in alkaline soils.

A fourth characteristic of a good top-dressing material is one in which all these materials will not tend to separate out. In other words, once you put the sand, soil, and organic matter together in the proper proportion and mix them thoroughly, it is no benefit to put them that way unless they remain in those proportions and stay where you have placed them. On some of the synthetic mixtures which are necessary sometimes and which some people are using, these materials are simply mixed together, placed on the green. When water is applied the sand and peat (if that is the source of your organic matter) will tend to separate out in layers. The sand will settle out and go to the bottom, the organic matter will come to the surface because it is lighter. So you will still end up with layering conditions. That is why I believe that the best way to prepare a top-dressing material is to compost it.

If you compost top-dressing it makes it a more natural material and one in which there will be much less tendency to separate out when you spread it on your green. Now there is different methods of composting. One which I have outlined here consists of spreading alternate layers of soil and humus in proportions of one part soil to two parts humus, in four to six inch layers. In order to stimulate decomposition the compost pile is going to need some fertilizing. For this use I would recommend a complete fertilizer such as a 5-10-5 or anything similar in order to supply the necessary nutrients or food which the bacteria need in order to decompose the organic matter in the compost pile. Also if your material is acid it is an advantage to put in some lime in order to hasten decomposition because these bacteria will not thrive in an acid medium. The bacteria which causes breakdown of organic matter must have a nearly neutral soil or neutral medium in which to function properly. If you build a humus compost pile simply by using nothing but organic matter the products of decomposition are naturally acid and may stop that decomposition process unless lime is applied. So whether lime is needed or not will depend on the conditions under which you are decomposing it. Perhaps you are using an alkaline soil and if so no lime would be required but if you are making purely an organic compost pile with no soil in it then I believe some lime

would be necessary.

In composting I think the easiest way is to compost the organic materials and then mix it with the soil and sand later. If the organic matter is well decomposed there is not so much tendency for it to separate out when mixed with soil and sand. Make certain it is well decomposed. I believe you can get a better physical mixture if both the soil and the humus are composted at the same time together in the same pile but this requires more labor in handling. There has been some interest in the last few years on the use of earth worms in order to stimulate and hasten the decomposition in compost piles. In some of the greenhouses the standard practice in the preparation of their materials is to buy the earthworms on the market and innoculate the pile with these worms. The earthworms grow and multiply and the claim has been made that composting is completed in about half the time required if the worms are not included. The worms obtain energy for life by passing organic matter and soil through their digestive systems and in that process it is thoroughly mixed and decomposed. The organic matter is a source of food for the worms and this produces a better mixture and it will be decomposed much quicker. I have heard the claim made that they could use it within two months after it was piled up simply by adding these worms. Only a few worms are needed as they grow and multiply many times and go through the entire compost pile and I suppose you could use them for fishing when you finished.

Now after the compost heap is finished, in other words, after it has been turned over and cooked the required length of time in order to give you the decomposition desired, then it should be shredded and screened. This is to remove all the large chunks of organic matter which are not thoroughly decomposed, and any large stones that may have been present. The shredding will tend to tear up the organic matter and the screen will tend to take out all of those which are not torn up and at the same time take out the larger stones and you should end up with a very fine material which can be used for top-dressing. Some greenkeepers even go to the point of including the sand in their compost heap. It can be done, but it makes more work and if you have sand and soil and everything present it is three times as much trouble to turn over and handle as it would be if you only have just the humus itself, so that decision as to what to include in your compost heap will probably be based on how much time and how much labor you have.

Another method of composting which utilizes a little less hand labor and which can be used if you have satisfactory material is field composting. In other words, pick out a spot on your golf course or wherever it might be that has the desirable soil textural classification and then spread the organic matter on the surface, use a rototiller or disc or any kind of implement which will get it mixed in with the soil and put on enough fertilizer to lime that is needed to hasten decomposition. Then you can even drill some cover crops on it, plow it under and further increase the organic matter content. The advantage of that method is that you can do most of that work with machinery rather than labor, and since labor is quite a problem now and quite expensive I think that is quite a factor to consider. Most of the tools which you would need for such an operation are available on most golf courses. However, it takes about twice as long to produce this top-dressing material by that method as it does for regular composting, so if you use the field method you will have to start in with that area perhaps this year which you are going to use

two years hence. Then have an area becoming available each year to take care of your annual needs. Then if you have an area such as that it can be worked at odd times when you don't have other work to do and have it screened and placed in under cover so that it is available for use any time you need it.

Last of all I have synthetic mixtures. If you need a top-dressing material and need it in a hurry, you don't have a great deal of choice as to what you are going to use, it may be necessary to use synthetic mixtures. If you are going to do that I would be very careful to make certain that they are well-mixed, and guard against the possibility of their separating out after they are applied. If you put them on in smaller applications I don't believe there will be as much tendency for them to separate out as it would if you made heavy applications. Slight separation of sand and organic matter in light applications would not cause enough layering to be of any consequence. You can make these synthetic mixtures in sufficient quantity to last for perhaps two or three years. Incorporate some fertilizer and lime if necessary and leave it inside your shed until required. It will be in much better condition to use the following year.

Now the kind of humus that you can use to prepare top-dressing material. First of all, Manure--well rotted manure if it is in an advanced stage of decomposition I believe is a good source of organic matter for use in top-dressing material. It is a more active organic matter than that you will find in peat, so that when you do apply it it will, after a few years, probably be broken down a hundred per cent. After four or five years there will probably be very little or none of it left. So from that standpoint if you want organic matter to remain in the soil for any length of time it might be a good idea to use manure to incorporate along with it some peat so that the manure decomposes first and later you will have the peat which will give the spongy character to the soil which you want. At the same time you will be getting some active organic matter which will cause some decomposition and produce some release of the plant food which is present in the manure.

Probably the greatest source of organic matter used in top-dressing material is peat. That is universally used I think over large sections of the country. It contains very little available plant food. It contains some nitrogen but it is locked up so that it is not immediately available. You get very little of those plant nutrients out of it. It is very resistant to decomposition so that when you put it into the soil it will remain for fairly long periods and still be undecomposed. But peat if it is properly handled is one of the best sources of organic matter which we have in use for top-dressing. But remember if you do use it, and this would also apply to other organic materials, make certain that it is thoroughly mixed with the top-dressing material.

There are listed a number of materials which might be locally available. Some golf courses make a practice of collecting all their grass clippings, their leaves, everything they have in the way of organic matter and incorporating it into a compost heap which they use as a source of organic matter. Grass clippings have to be handled anyhow so it is probably very little additional labor to simply collect them and put them in a pile and use them. Here in the cotton growing areas you might have these cotton hulls and cotton burrs, if they are properly decomposed I see no reason why they wouldn't make a satis-

factory source of organic matter for top-dressing. There again make certain that they are in an advanced stage of decomposition. We don't want any raw materials applied in top-dressing material.

Lastly, after you have prepared your top-dressing material one of the things which should receive consideration, perhaps it should be considered even before, and that is the weed seeds that it might contain. When you select the soil and also the sand which you are going to use in preparation of this top-dressing material it is always a good idea to select it in some areas where there are the smallest amounts of weeds of different kinds which might cause trouble on the greens. Much of the soil now being used may be seeding your greens with all different kinds of weeds which you don't want. So if it is not possible to get a soil which you are certain will be free of weed seed then some measures may be necessary in order to sterilize it and kill those seed. There is some methods you can use--you can use steaming that used to be a favorite practice and is still practiced I believe quite a little in greenhouses. It takes quite a bit of equipment and it is kind of a nuisance to use. So they have more or less gone to the chemical methods now, calcium cyanamide is one of them, the materials which has been used for this purpose. This calcium cyanamide is very toxic and if you mix it in with the top-dressing material it is so toxic it will kill all of the weed seed that are there. However, there again you must leave it long enough so that there is no danger of burning the grass on the green when you apply that top-dressing.

There is another chemical method which has been used, chloropicrin gas. In the East there was a company which either did it on a contract basis or loaned the applicators. The applicator that they used was like a huge hypodermic needle. Using a three or four yard pile of the top-dressing material give it a hypodermic in a number of different places and cover it over with a canvas and permit it to stay there for about 48 to 72 hours and the gas will kill the weed seed. This method has given satisfactory results.

Now on rates of application--I would let the rate of application be governed entirely by the uneveness I had to correct. If you have a fairly new green which naturally is uneven because it is almost impossible to start a green and have it any other way you are going to need some fairly heavy top-dressing applications. But don't try to correct all that uneveness in one application, if you do, you will simply bury a lot of the grass and it will never come through. I have seen golf greens where that was actually done. I thought the grass was dead but when you dug underneath that soil on top you could find green grass or grass that had been green at one time. So don't put on any more than what you can conveniently work into the turf. Simply repeat the application a little later. Don't try to correct it all at once. Heavier applications should be made in the spring and fall when the grass is most vigorous. Don't make any heavy applications in the summer months when the grass is having a most difficult time anyhow with the weather. You can make light applications during the summer but be sure they are light.

Now I have a little table worked out there. The amount of top-dressing material to cover 5000 sq. ft. of greens. On that type green any time you put 1/16 of an inch it is going to take about a year of material and as you go up from that each 1/16 of an inch you can add another year, so that it runs into

a lot of material if you make very heavy applications. That is another reason for not putting on any more than you can at any one time when the grass will take it.

In the method of application--there are two methods. I recommend the spreader myself, but on golf courses where they have men who have had experience over a period of years putting it on by hand they can do just as good a job as you can with the spreader. So it is more or less an individual matter that will have to be worked out on each golf course. If you have inexperienced workmen your spreader is by far the best method and there is one spreader which is universally used in the east, I don't know what you use here, the root spreader, the one which I particularly refer to and that can be adjusted to put on most any size application that you want and it does it uniformly and evenly. After the material is applied it must be worked into the grass. I believe the best method of doing that is one which you saw being applied, Dr. Grau showed the other evening, is where you use a heavy steel door mat. That is most generally used and I believe will give the most satisfactory results. Not only does it work the material down into the grass but it doesn't bruise the grass to any great extent unless you weight it down and at the same time it will tend to drag off all the pebbles of any size which might interfere with the putting surface on the green and also with your mower. The mowers pick up those small pebbles, they don't do your bed knife or the blades of your reel any good.

Now that is somewhat brief coverage on the subject of preparation and application of top-dressing.

FERTILIZING BENT GRASS PUTTING GREENS

Robert C. Dunning, Agronomist
Southwest Turfing Company, Inc.
Tulsa, Oklahoma

To think that the proper fertilizing program for Bent grass greens is the answer to good greens is like asking the doctor to give you a pill that will immediately cure all your ailments. There are so many important factors that come before fertilization can be considered and that are related to fertilizing that it would be impossible to give a fertilization program without going into a few of these problems, some of which have been discussed by others. A fertilizing program must be adapted to existing climatic and weather conditions.

Bent grasses do very well in New England and in the Northwest where the climate is usually cool and moist. They need only to be prepared for changes in weather when it becomes hot and humid. Bent grasses will withstand a great deal of hot weather if nights are cool and there is not a great amount of humidity, therefore it is not a serious problem to grow Bent on the Great Plains, and Bent can even be grown in the desert, but where you combine hot and humid weather, it is possible to reach a point where the species will not survive, or at least, it will become more difficult to maintain with increasing humidity and extreme heat. It is in the latter region that we are most interested with, as it covers parts of Texas, all of Louisiana and Arkansas, as well as parts of Oklahoma and other southern states.

There is nothing that will take the place of fundamentally sound maintenance practice and it is in this region that one must be fundamentally sound. The greens must be fundamentally sound in regard to construction covering three phases: 1. Surface runoff is most important and water must escape from the green in several directions. 2. Internal drainage. Any water within the green other than capillary water is excess, filling the voids that should contain air. The optimum condition to work towards is a soil that is not excessively wet during periods of heavy rains but with enough water-holding capacity to support the turf during extreme heat, with a suitable top soil containing from 20% to 30% organic matter by volume. This soil should contain a certain amount of clay, as colloidal clay particles will aid in base exchange which is most important for retaining plant nutrients and of course, the top soil should be friable, with enough porosity of sufficient size space to insure absorption and aeration. 3. Air drainage. It is very important that greens are not surrounded by trees or shrubbery or sharp bunkers that keep the movement of air from the putting surface and above all, the proper fertilizing program will have to be correlated with the proper watering program as well as other important functions in regard to mowing, top-dressing, preventing and eliminating matted condition and thatched layers in the green, disease control and others.

In no way is the following program intended to take the place of other important maintenance functions, with the possible exception of the control of dollarspot or at least make the attacks of this disease less intense. Soil samples should be taken of the greens, as analytical results will help determine if there is any deficiency in plant nutrient elements with the exception of nitrogen.

Phosphoric acid and potash are important plant food nutrients, and as clippings are removed from the greens and adequate supply of these compounds should be insured. However, as they are quite stable in the soil, their use is necessary only twice a year, during the spring and fall.

I know that you are going to think I am not being very consistant as potash will be recommended in this program, for summer, under certain conditions.

The use of lime must be taken into consideration. Greens should be tested for soil reaction by dependable quick test and the use of lime should be based on soil reaction, expressed in terms of pH. Recommended rates of lime in regar to pH are as follows:

4.0 to 4.6 pH	60 to 80 pounds per 1000 sq. ft.
4.6 to 5.0 pH	40 to 60 pounds per 1000 sq. ft.
5.1 to 5.5 pH	20 to 40 pounds per 1000 sq. ft.
5.6 to 6.0 pH	10 to 20 pounds per 1000 sq. ft.
6.1 to 6.5 pH	0 to 10 pounds per 1000 sq. ft.

In regions where lime is needed, make one application each year, preferably in the late fall, use finely ground limestone but apply dolomite containing not less than 20 to 30 per cent magnesium, reported as magnesium oxide, whenever available magnesium is low (500 pounds per acre, or less, by the Hellige-Truog Method).

Greens that have ample available lime are more disease resistant; more able to withstand drought and are less susceptible to scald.

Slightly alkaline soils are all right for Bent grass and phosphoric acid is more readily available where the soils are not too acid.

The use of Hydrated lime in periods of scald is recommended and is used irregardless of pH. Some use it as a preventative for scald and also believe that it makes turf more resistant to disease. But it should be used with care and experience, so try it out on the nursery first over a period of time. There are possibilities that Hydrated lime will cause chlorosis.

Potash is used after periods of scald, also to make the grass more resistant to disease. In periods of trouble or hot humid weather, care should be taken with all chemicals, whether they are applied in the morning or late afternoon is important, also time of watering.

Last summer many of the greenkeepers were mowing in the cool of the evening. A practice that we think is of very little importance, may turn green off in hot humid weather. Everything possible should be done to develop deep healthy roots.

Bent grass needs a uniform and continuous supply of nitrogen and a fertilizer program must furnish enough of all the nutrients needed by the grass and they must be replaced with enough leeway to take care of leaching and fixation. A balanced feeding of a ratio approximately 3-1-2 is desirable. Nitrogen is the key to good putting greens. It gives deep green color, plant foliage, increases turf density, which helps control weeds. It promotes leaf-

iness in Bent grasses and influences the amount and severity of turf diseases. Organic nitrogen is best for Bent grass greens and is all right for summer use. Troubles that have been attributed to organic nitrogen have been intensified by other factors such as fertilizing into a deep mat in very hot humid weather which may cause decay. Fertilizer should probably not have been applied at all and most certainly, the matted condition should not exist. Develop a tight turf, without mat or thatch by raking, combing, brushing and correct mowing practice, along with proper fertilization. Too little nitrogen causes steminess and poor putting surface.

The following part of my talk on Bent grass greens is part of the general information used by some greenkeepers in Oklahoma and has not been re-written.

A good top-dressing is one that has enough placticity to hold together after wetting and drying naturally but one that will readily crumble upon dropping or striking with a stick. This type of top-dressing usually consists of sharp sand, such as concrete sand or even a more coarse sand, soil and organic matter. A good source of organic matter, which should be 25% to 30% of the mixture by volume, is a fibrous reed and sedge peat. The use of manure is not recommended, always have your fertilizing program for greens under control and it will not be if you use manure. Top-dressing should never be applied into a deep mat of grass as this may cause thatched layers in the green interfering with the movement of the soil moisture and in many cases causing poor root development. Top-dressing is not recommended in hot humid weather and it should contain clay as the colodial clay particles will aid in base exchange. Clay content should approximate 8 to 10 per cent of the mixture.

Rates of fertilizer applied are heavier in the spring and fall and decreased and sometimes discontinued in hot weather all together. When the grass becomes too lush or is growing too fast, rates of fertilizer should be decreased or fertilizing discontinued. Fertilizing should not be accomplished during hot humid weather and it will be found necessary to increase or decrease rates under certain conditions.

Very light rates of Ammonium Nitrate or Ammonium Sulphate or Sodium Nitrate may be used early in the spring or during cool weather in the fall to give the grass a boost if desired. These rates should approximate the following: Ammonium Nitrate ½ to 1 pound per 1000 sq. ft., Ammonium Sulphate 3/4 to 1 3/4 pounds per 1000 sq. ft., Sodium Nitrate 1 to 2 pounds per 1000 sq. ft., one or two applications should be sufficient for each, spring and fall, if required at all. There should be at least a ten day period between the application of Ammonium Sulphate, Ammonium Nitrate and Hydrated Lime.

Greens should never be mowed in the morning when there has been a heavy rain or an excess of moisture during hot weather. It would be much better to delay mowing until the cool of the evening. In any case, do not over-fertiliz in hot and humid weather or any other time.

In hot and very humid weather if fertilizing is necessary Ammonium Sulphate may be used at the rate of 1/2 pound per 1000 sq. ft. if Hydrated Lime has not been used, or Sodium Nitrate may be used where Hydrated lime has been applied. The rate of application of Sodium Nitrate should approximate 1/2

pound per 1000 sq. ft.

Murate of Potash may be used occasionally throughout the summer and rates of 1/2 pound per 1000 sq. ft. should be sufficient. Murate of Potash will give body to the grass and develop plant structure, so it is desirable to use this material to make the grass more resistant to scald and disease. However, Murate of Potash and Hydrated Lime should not be used as a cure-all or as a panacea. They may be helpful in overcoming scald and other difficulties, such as the use of Hydrated lime for algae. It is far more important that a good flexible watering program be established, one that where the amount of water is reduced during humid weather as well as one that will help prevent the over abundance of water after sudden unexpected rainfall. It is believed that a well regulated program where the grass never becomes too lush, correlated with a program preventing a matted condition will help prevent all kinds of turf trouble in the Southwest. Where grass is allowed to starve after heavy spring feeding and matts are formed, all kinds of trouble may be expected.

The writer has observed that where complete fertilizer has been applied weekly at very light rates, such as, 2 pounds to a 6000 square foot green of a grade 6-2-4 fertilizer, good results have been obtained. Nitrogen may be from an organic or inorganic source as desired. This is not a recommendation but can be used as a test trial for a more thorough understanding of fertilizer rates. The above are summer rates and in no way may interfere with spring and fall applications.

It should be understood that any chemical fertilizer and a great many other chemicals such as Arsenate of Lead, will severely damage Bent turf during hot and humid weather. If applications are necessary, rates should be materially reduced, such as, if Arsenate of Lead is used 1/2 lb. per 1000 square foot is far safer than 1 lb. per 1000 sq. ft. or it would be better to use 1/2 lb. or less of Murate of Potash per 1000 square foot. Rates of Ammonium Sulphate and Sodium Nitrate should be reduced to 1/2 lb. or even less per 1000 square foot.

It has been observed that applications of 1/2 lb. of Sodium Nitrate with 1/4 lb. Murate of Potash have given splendid results where heavier applications of these materials severely damage the turf during hot and humid weather.

The most critical time in watering is after a heavy rain in hot humid weather. The grass is very apt to loose much of it's root system from high water table and possibly fungi working in the soil. The surplus water giving drowning effect on the roots and if the grass does not loose it's roots, there is lack of aeration when the greens are in a puddled condition. Grass may take on the appearance of wilt or even die from the lack of moisture when the trouble has been caused from too much water. Under these conditions and periods of scald and when roots have been lost, several very light waterings per day should be resorted to, being careful not to let gravational water enter the subsoil, further preventing its drainage. The surface should be kept moist, not wet, grass may thin and in either case, surface soil which is exposed to the sun will dry out readily. Applications of Sulphate of Ammonium at a time like this might cause a temporary toxicity in the soil which is probably already aggravated from organic acids due to the lack of aeration. It has been observed that a matted turf and recent use of chemicals may also

aggravate this condition.

After the surplus water has been allowed to drain from the subsoil and where the turf has thinned and shows evidence of damage, it has been found that light applications of Hydrated Lime, 1 lb. per 1000 sq. ft. used two or three times will prevent algae or scum. The application of Hydrated Lime may be followed by very light applications of Murate of Potash 1/4 to 3/4 pounds per 1000 sq. ft. one or two applications are usually sufficient. When the turf definitely shows signs of recovery, light applications of Sodium Nitrate may hasten recovery, rates should approximate 1/2 to 1 pound per 1000 sq. ft. and should be spaced from 5 to 7 days apart. Great care should be taken not to over-feed at this period.

In some areas after scald injury and with or without the above treatment, spots of yellow turf may be observed, the grass in the affected area is usually very soft, weak, and in many cases shows a tendency to die. Very light applications of Ferrous Iron may be found to relieve this condition. Rates of applications should be 1/2 lb. per 1000 sq. ft., two to three applications should be sufficient. Results usually can be determined in a very short time or in a one or two day period. In no case should the application of Iron be overdone as it is known to be toxic to vegetation and in some instances is used as a weedicide.

This yellowing of the turf or chlorotic condition, at a time when Iron should be more available than usual, because of the lack of aeration, and the formation of organic acids, is hard to understand. The phenomena is probably caused by loss of roots, causing the grass to feed in the upper horizon of the soil where the base elements are more strongly consentrated, causing Iron, Maganese and Aluminum to be less available. The lack of Iron seems to cause this chlorotic condition and unless corrective measures are taken immediately the grass will usually die or the period of recovery will extend over many weeks. Test trials on limited areas are recommended before general application is made. Iron, Sodium Nitrate, Ammonium Sulphate, Murate of Potash, in fact all corrosive materials should be watered-in immediately after their application.

If it has not been necessary to use Hydrated Lime and after the excessive moisture has been allowed to escape from the greens and when the turf shows signs of recovery, light applications of Ammonium Sulphate 1/2 lb. per 1000 sq. ft. accompanied with applications of Murate of Potash 1/4 to 1/2 lb. per 1000 sq. ft. have been known to hasten recovery. In some cases spiking will help recovery as it allows aeration.

It would seem at this time that we are using too many different chemicals such as Arsenate of Lead, Pyrethrum with soap, Nicotine Sulphate, etc., for the control of chinch-bug, sod webworm, cutworm, grubs, and others. It is recommended that DDT 50% wettable powder be used as trial test at not more than 1/2 lb. per 1000 sq. ft. or 10% Sabadilla dust may be used for chinch-bugs at 100 lbs. per acre when using power dusting equipment or if using hand dusting equipment at slightly heavier rates.

BERMUDA GRASS GREENS

The advent of Bent grass greens into central-eastern Texas brings increasing problems to golf courses with Bermuda grass greens, especially those clubs that cannot go into a construction program. The tendency will be to expand the area where Bent is now growing to where it will be increasingly more difficult for the specie to survive, at least until the more disease resistant selections have been proven adaptable or more suitable selections made.

To combat this invasion of Bent grass greens, the greenkeepers in this area will be forced to improve their Bermuda greens, for the demand will be so great for Bent that the members will insist on them. Probably the thing that has held the development of Bermuda greens back more than anything is that Bermuda grass is commonplace and the tendency to believe that it will get along pretty well by itself. This opinion held true in airfield planting, "Oh, this is just Bermuda grass, you could hang it on the fence a week and it will grow". This opinion should not prevail any more here than does the growing of Bent in New England, Washington, and Oregon.

The first thing to remember is, that the care of Bermuda grass putting greens is an every day function that requires careful advance planning. By proper maintenance beautiful Bermuda greens may be had that are comparable to Bent grass greens but are more of a challenge to bring to perfection than Bent.

Bermuda grass is a ravenous feeder of nitrogen. In most areas the tendency has been to use a complete grade fertilizer high in phosphoric acid, this is just the opposite to what Bermuda requires. It is a good feeder, in other words, it can forage for itself because of its root development and does not require as much phosphoric acid as does the northern grasses. All grass tends to mature in the summer and phosphoric acid helps to hasten maturity, making a stubby turf and potash tends to stiffen the stems and leaf structure. Nitrogen increases vegetativeness and helps prevent maturity. To much nitrogen will cause a weak wide leaf plant and excessive growth, increasing the necessity for top-dressing and if top-dressing contains manure, this will only aggravate the already existing trouble. The better practice is to have the growth of your greens under control and this is hard to do if top-dressing contains large quantities of manure, as nitrogen may be released when you least expect it.

The better plan for summer feeding of Bermuda grass is to use a nitrogenous fertilizer at rates that will keep the grass vegetative but not to the amount that will cause the leaves to be coarse.

Organic sources of nitrogen are suitable for Bermuda grass greens, they do not contain enough phosphoric acid to make the grass stubby or stiff but only enough to supply the Bermuda with this element. Inorganics may be used but if Sulphate of Ammonia is used over long periods of time, it will tend to make the soil acid and corrective methods should be taken.

When lime is used it should be moderately as it is inclined to form Iron and Manganese into insoluble forms.

There are two ways to keep Bermuda greens and the one preferred is to fertilize during the summer with a nitrogenous fertilizer at rates required by the particular soil, at least every two weeks. One course that I know of, top-dressed very lightly applying the material with a Root All Purpose spreader every Monday morning. In this manner, the turf was kept vegetative and tender and putting was on the tips of the blades only. Cutting height was from 3/16 to 1/4 inch. There was absolutely no grain in these greens and the blades were very fine. The greens were mowed every day and the direction of mowing was changed frequently. People visiting this course would ask what kind of grass was on the greens and always seemed surprised when informed that it was Bermuda grass.

I am sure that all golf courses cannot top-dress every week but most of them can fertilize frequently and by combing and brushing create a fine tight turf, it may be found possible to cut down on the quantity and frequency of top-dressing needed. Light top-dressing applied mechanically is not the tedious task that one would suppose. I am sure that most golf courses could top-dress every two or three weeks.

The other method of keeping Bermuda grass is, to fertilize regularly but top-dress infrequently. This usually creates a dense mat and although the greens may have a beautiful appearance when kept well fertilized, the turf will scuff up around the cup during heavy play, which of course is objectionable to the players. It is very important to mow Bermuda greens daily.

On the latter greens, the establishment of winter greens is a difficult task because of the dense mat which must be removed to allow anchorage for the young seedlings, or large quantities of top-dressing will be needed. Probably the total amount of top-dressing used during the year on the frequently top-dressed greens is very little more than used on the infrequently but heavily top-dressed greens when it is accomplished.

In the first method, Rye grass is established very easily in the fall. Rates of nitrogen are decreased and finally discontinued sometime before seeding. Bermuda grass is allowed to grow for a two or three day period, this is done to form an anchorage so, as the grass will hold the top-dressing in place. Only a light inert top-dressing is necessary because the greens have been kept top-dressed all summer.

Prior to top-dressing 10 pounds of Superphosphate and 4 to 6 pounds of Murate of Potash are used and watered-in well. Greens are then seeded in four directions and lightly covered with top-dressing. Greens are then kept mowed but pans are removed from the mowers to prevent picking up seed. After seeding greens should be kept moist at all times but not wet, this may require several light waterings per day. It is desirable to water by hand, holding the hose perpendicularly, using a fine spray, to prevent washing the seed.

Nitrogen is not used at the time of seeding Rye grass to discourage dampening off or pythium. After two or three weeks mowers are gradually lowered and fertilizing is continued, using nitrogen only. Milorganite is a good source of nitrogen at this time as it will not damage young seedlings. Fertilizing is continued through the winter except during periods of cold weather, at very much reduced rates than are used in the summer. Winter greens are

never top-dressed.

Rates of seeding will depend a great deal on the frequency of fertilizing that is anticipated during the winter. There is no truer putting surface than a good Rye green. Resort courses like Pinehurst and Agusta National use up to 100 pounds of Rye grass seed per 1000 square feet. I have seen good turf where around 30 pounds of Rye was used. There is no particular advantage in seeding too light or too heavy. If greens are seeded at too light a rate the grass will stool, causing a rough green and this type of grass has a tendency to stay on longer in the spring than the finer textured Rye.

In the spring when Bermuda grass starts active growth and the temporary winter grass begins to weaken due to hot weather and it will not be very long before it passes out of the picture, it is a good idea to get rid of it. In other words, it is well to shorten the transition period and get the Bermuda grass back into the picture as rapidly as possible. However, in the southern part of the Bermuda grass area, some desire to allow the Rye grass to disappear slowly as the Bermuda grass gradually takes over.

There are several ways to encourage departure of the Rye grass. One is to withhold water for a several day period, then apply a readily available nitrogenous fertilizer like Ammonium Sulphate, it should be applied up to 15 pounds per 1000 square feet, then water generously. Rye usually goes out very soon under this treatment as it becomes very succulent and tender and the quickly available fertilizer stimulates the Bermuda grass, which is needed.

Second method is to apply 15 pounds of Ammonium Sulphate per 1000 square feet when there is dew on the Rye grass, do not water for several days. The Ammonium Sulphate will severely injure the Rye grass and when watering is started again, what Rye is left will become very succulent and disappear quickly.

The third method is to actually kill the Rye grass by applications of Sodium Arsenite, it may be sprayed on or used dry.

It is not good policy to seed Bermuda grass into heavily matted Rye grass, for some unknown reason, it either does not germinate or it germinates and is smothered out. After greater part of Rye has disappeared, which should be soon in any of the three methods, greens are fertilized using 10 pounds of Superphosphate, 4 to 6 pounds of Murate of Potash and a total of 3 to 4 pounds of nitrogen per 1000 square feet. This would include the Ammonium Sulphate applied for eradicating Rye grass. The fertilizer is watered-in, a light top-dressing is applied, greens should then be spiked and seeded with hulled Bermuda grass seed. Rate of seeding should depend upon the amount of existing Bermuda grass on the greens, from 1 to 4 pounds per 1000 square feet. Seed should be covered lightly with top-dressing and should be kept moist, not wet, at all times. The Bermuda should become established very rapidly and maintenance practice recommended for Bermuda greens should be followed.

Selections of fine bladed upright growing Bermuda are desirable, perhaps they will be available in a short time but most every golf course has strains in their greens that should be propagated.

QUESTIONS AND ANSWERS

Q. How much Rye grass seed did you say to seed per 1000 square feet?

A. I didn't say. I said that some of the golf courses like to use up to 100 pounds per thousand feet and I have seen good Rye greens seeded as low as 30 pounds per 1000 square feet but the frequency which you anticipate on fertilizing the Rye greens has a great deal to do with how much seed you should plant.

Q. Is it possible to have good Bermuda grass greens?

A. Yes. If the turf is fertilized frequently, top-dressed frequently and mowed every day you can have very suitable Bermuda grass greens. I think with the advent of Bent into Texas you should have improved Bermuda grass strains.

Q. Is it necessary to cover seed with top-dressing?

A. I think it has its advantages but it is optional. Apply a light top-dressing, spike if you desire, seed, then another light top-dressing and if you want to spike again it is perfectly all right. I might say that top-dressing applied mechanically is much easier than applied otherwise.

Q. What are the rates of fertilizer for Rye and Bermuda grass greens using Milorganite or other fertilizer?

A. On Rye? About the same rate that you should use on Bent during the summer, that is, around 4 pounds of Milorganite per 1000 square feet every two weeks or 4 pounds a week, according to your particular soil, just enough to keep the Rye aggressive and green, comparing it with Sodium Nitrate about one pound per thousand square feet every two weeks and one to three pounds every three weeks should be adequate. You do not want to over fertilize the Rye but it should be fertilized frequently. Rates on Bermuda grass are rather hard to give because a lot depends on the particular soil, whether it is sandy or heavy soil and how much manure compost has been used on it previously. You should know when the greens are too lush and the blades are too wide and growing too rapidly, all you want to do is keep an aggressive even growth the year round and the Rye the same way. Very, very light rates on Rye because Rye does not take very much fertilizer to keep it coming.

Q. Are heavy rates of fertilizer on Rye grass used to get rid of it and doesn't fertilization change the length of life of Rye grass?

A. Well that is the object in the spring of course, of using those heavy rates of fertilizer on the Rye, to get it very succulent, whether it would tend to cause it to change the cycle of its life I do not know. I do not think it would, heavy rates of fertilizer used at any other time of year would just make the grass grow rapidly, make it soft and lush, therefore, might cause trouble.

Q. Would you fertilize Rye grass greens during the winter?

A. That is right, about every two weeks except in cold weather, of course, then there is no need of fertilizing. If you use a light application every two weeks I think you will have very satisfactory Rye grass greens.

While we are talking about Rye greens, there is no better putting surface than Rye. I think a good Rye green is better than Bent greens.

Q. Can we get copies of the fertilizing program?

A. Well as I said, this wasn't reqritten, it is general information.

Q. What is the most frequent cause for the loss of Bent turf other than disease?

A. Inadequate drainage and improper watering. I might say that we have had Chlorosis and we have it frequently in periods following scald and when roots are lost. Just why, I do not know, because actually there should be more Iron available at this time when greens are in a puddled condition. I think the cause of the Chlorosis is, in this case, caused by the loss of roots, they are feeding in the upper horizon where the base elements are more concentrated, and the grass is unable to obtain sufficient Iron.

In New England Chlorosis has become quite a problem on Velvet Bent. They have been able to overcome it by spraying one or two pounds of Iron Sulphate per 5000 to 6000 square feet, it is not watered-in but absorbed through the leaf of the plant. Several light waterings per day should be resorted to after periods of scald.

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Adams, James E., Head, Dept. of Agronomy, A. & M. College of Texas

Banks, Ben D., Dallas, Texas, Mgr. Cedarcrest G. C., Park Dept. 4310 Junius St.
Beck, Odis, Waco, Texas, Pro., Ridgewood G. C., 2526 Homan St.
Bell, Dudley, Houston, Texas, Pine Forest Country Club
Bold, Joe H., Dallas, Texas, 5902 Morningside
Bowman, Lee Edgar, Dallas, Texas, Greenkeeper, Cedarcrest G. C. 1800 Southland
Bush, O. J., Dallas, Texas, Greenkeeper, Stevens Park G. C. 3371 E. Ill. Blvd.
Bush, Wm. R., Dallas, Texas, Greenkeeper, Brook Hollow G. C. 1506 Proctor St.

Collard, F. G., College Station, Texas, Instructor, Agronomy Dept.
Crain, Albert W., College Station, Texas, Professor, Agronomy Dept.

Drumm, Tom Edward, Richardson, Texas, Supt., Restland Mem. Park. Box 182
Dubose, Leon W. Jr., Houston, Texas, Greenkeeper, Houston Country Club G. C.
Dunlap, A. A., College Station, Texas, Head, Dept. Plant Phys. & Path.
Dunning, Robert C., Tulsa, Okla., V. P. Southwest Turf Co. 271 W. Victoria

Edgar, Alexander L., Wichita Falls, Texas, Greenkeeper, Country Club
Everett, E. A., Houston, Texas, President, Overton & Ross, Inc. 3221 McKinney
Forester, Dick, Houston, Texas, Pro., Houston C. C., 5004 Plum Dr.
Forrester, Everett G., Roswell, N. M., Pro. Roswell C. C., P.O. Box 5627
Franks, Lafayette, Longview, Texas, Pro., Pine Crest Country Club
Fudge, J. F., College Station, Texas, Texas Agri. Exp. Station

Gafford, Thomas R., Ft. Worth, Texas, Pro., Ridglea G. C. Box 401
Garrett, Ray B., Wichita Falls, Texas, Pro., Country Club, Box 2444
Gayther, Nowell, Bryan, Texas, Pro., Bryan Country Club
Gibson, J. W., Bryan, Texas, Dow Chemical Co., 408 W. 28th St.
Goforth, Jack H., Dallas, Texas, Tenison Golf Course, 1206 Caldwell St.
Goldthwaite, Frank, Ft. Worth, Texas, Texas Toro Co., 122 S. Main
Goldthwaite, Howard, Houston, Texas, Texas Toro Co., 1645 Bissonnet St.
Graham, Clyde Mack, Denton, Texas, Supv., N.T.S.T. College, Box 5981, T.C. Sta.
Grau, Fred V., Belltsville, Md., U. S. Golf Assoc., Green Section
Gregory, Charles J., Ft. Worth, Texas, Salesman, Texas Toro Co., 122 S. Main

Halmbacher, Tom F., Houston, Texas, Greenkeeper, City of Houston, 6405 Taggart
Hampton, H. E., College Station, Texas, Dept. of Agronomy, Texas A. & M.
Hardwicke, Irwin, Dallas, Texas, Mgr., Tenison Golf C., 403 City Hall
Hardwicke, John C., Carlsbad, N. M., Pro., Riverside C. C., 1017 N. Canal
Harpool, Walter S., Denton, Texas, Harpool Seed House (part owner), Box 364
Havard, Chester A., College Station, Texas, A. & M. College of Texas
Hendrick, LeRoy G., College Station, Texas, Grad. Sr., Texas A. & M. College
Hines, Oliver D., Ft. Worth, Tex., Greenkeeper, Worth Hills G.C., 2623 Loraine
Hogan, C. W., Lamesa, Texas, Lamesa Country Club
Holden, Wilson B., Lubbock, Texas, Supt. of Parks, 2004 29th st.
Hornbuckle, H. T., Odessa, Texas, Pro., Odessa Club, Box 508

Houston, L. B., Dallas, Texas, Director of Parks, Box 403, City Hall
Hubbard, Jack L., College Station, Texas, Agronomist, Tex. Agr. Exp. Sta.
Hughes, Frank E., Houston, Texas, Texaco Country Club, Box 749

Jennings, James L., Bellaire, Tex., Greenkeeper, River Oaks C. C., 4991 Laurel
Jones, Gordon H., Dallas, Tex., Agronomist, Civil Aero. Adm., 4618 Va. Ave.
Jones, Luther, G., College Station, Tex., Prof. of Agronomy, Texas A. & M.
Justice, John K., College Station, Texas, Student

King, Dick H., Ft. Worth, Texas, Supt., Mt. Olivet Cemetery, 2017 Bluebonnet D.

La Vail, Matt., Houston, Tex., Salesman, Overton and Ross of Houston, Inc.
Lewis, R. D., College Station, Tex., Director, Tex. Agr. Exp. Station
Longnecker, Thomas C., Renner, Texas, Sr. Soil Scientist. P.O. Box 43

MacKenzie, Wm. R., Dallas, Texas, Golf Instructor, Dallas Country Club
Mitchell, Alfred George, Ft. Worth, Tex., Supt., River Crest C. C.
Moore, T. Wylie, Dallas, Texas, Mgr., Stevens Park G. C., 1619 Taft St.
McCrory, Rufus A., Tyler, Texas, Greenkeeper, Willow Brook C.C., 4295 Oakland
Morgan, Ralph H., Tyler, Texas, Mgr., and Pro., Willow Brook C. C., Box 583
McGeehee, C. D., Lubbock, Texas, Mgr., Lubbock Country Club, Box 217
Moncrief, James B., Beaumont, Tex., Agronomist, U.S.D.A., Box 3102
Machaek, Frank R., San Antonio, Tex., Grounds Supt., Oak Hills Country Club
McClasky, Frank, San Antonio, Tex., Grounds Supt., Breckenridge Park G. C.
McGregor, Ted., San Antonio, Tex., Entomologist, Eng. Sec., Hdqs. 4th Army
McNutt, Robert B., Houston, Texas, Greenkeeper, City of Houston, 517 Birdsall
Miller, C. Wallace, Ft. Worth, Tex., Agronomist, Civ. Aero. Adm., 1522 Jarvis
Mills, Milton C., Ft. Worth, Tex., Greenkeeper, Glen Garden G.C., 3228 Burton

Nowotny, Arnold, College Station, Texas, Student, A. & M. College of Texas

Overton, Wm. D., Ft. Worth, Tex., Mgr., Glen Garden G. C., 2916 Glen Garden Dr
Owens, Robert Russell, Ft. Worth, Tex., Head Greenkeeper, River Crest C. C.

Penick, Harvey, Austin, Texas, Pro., Austin Country Club, 115 W. 32nd St.
Penick, Tom, Austin, Texas, Pro., Municipal Golf Course, Box 377
Pohl, Herbert, Waxahachie, Texas, Manager, Waxachachie Country Club

Robbins, J. Shirley, Big Springs, Texas, Pro., Country Club
Ross, Graham, Dallas, Texas, Pro., D. A. C. Country Club, Rt. 7, Box 244
Rountree, James W., Dallas, Tex., Salesman, Wilson Sporting Goods, 2115 Com. S
Rowland, Louis W., Ft. Worth, Tex., Pro., & Course Mgr., Glen Garden C. C.

Schember, Victor E., College Station, Tex., Agronomist., Tex. Agr. Exp. Sta.
Scott, Harry R., Corpus Christi, Tex., Asst. Pro., C. C. C. Club, Box 1657
Shelton, Wm. F., Marlin, Texas, Mgr. and Pro., Marlin C. Club, Box 89
Shockley, R. C., Cleburne, Tex., Pro. and Mgr., Nolon River Country Club
Smith, Elmer B., Supt., Premier Oil Ref. Co.
Smith, James C., College Station, Texas, Agronomist, Texas Agr. Exp. Station
Smith, Ned A., College Station, Texas
Spence, C. L., Alvin, Texas, Owner, Alvin Golf Course, Box 188
Spencer, Wm. E., Mckinney, Texas, Manager, Mckinney Country Club
Sprague, Howard, Dallas, Tex., Head, Agr. Res. Div., Tex. State Res. Found.

Stewart, Jim, Dallas, Tex., Foreman, Park Dept., City of Dallas, 4210 Pennsy.
Stuttle, Jess C., Corpus Christi, Tex., Pro., Corpus C. C. C., Rt. 2, Box 735
Surovik, Wm. L., Jr., Houston, Tex., Dow Chem. Co., 2217 Commerce Bldg.

Thornton, M. K., College Station, Texas, Extension Service
Tnott, Denton M., Ft. Worth, Texas, Foreman, Ridglea G. C., Box 401
Trotter, Ide P., College Station, Texas, Director, Extension Service
Tucker, Woodrow E., Palestine, Texas, Pro., Meadow Brook Country Club

Vavra, Frank L., College Station, Texas, Grass Nurseryman, Tex. Agr. Exp. Sta.
Veal, LeRoy, Dallas, Texas, Greenkeeper, D. A. C. Country C., Rt. 7, Box 344

Wade, Howard M., Freeport, Tex., Dir., P. E. & Schools, Dow Chem. & Freeport Sulphur, Box 1011
Walker, A. H., College Station, Tex., Asst., Pasture Spec-Range, Ext. Ser.
Walker, J. E., Denton, Texas, Supt. of Grounds, T. S. C. W.
Wardlaw, Dusty, Ft. Worth, Texas, Greenkeeper, Northwood Club, 3105 Ave. North
Warner, George C., Waco, Texas, Ruhmann Grain & Seed Co.
Watson, Sydney H., Dallas, Texas, Agronomist, U. S. Engrs., 5210 Homer St.
Whiteley, Eli L., College Station, Tex., Instructor, Dept of Agronomy
Whitney, Clifford C., Bryan, Texas, 100 So. Logan St.
Wright, Fred G., Dallas, Texas, Park Dept., City of Dallas, 812 N. Marsalis