# FIRST ANNUAL TURF CONFERENCE

SPONSORED BY:

CENTRAL PLAINS TURF FOUNDATION

AND

KANSAS STATE COLLEGE

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WEST POINT LAWN PRODUCTS
West Point, Pa.

# GREETINGS

R. I. Throckmorton, Dean
Kansas State College

This is really a pleasure for me because I am quite interested in the type of work represented by this particular group. As I was sitting down in my home just after lunch today wondering what I was going to say in the way of greetings, I jotted down three or four lines. To my mind they are important.

A conference such as this does not just happen. It could not become a reality through the efforts of the men here at the college alone. It represents the combined efforts of the men out over this and other states who are interested in turf work together with the efforts of the men at the college who are interested in the same field. It is a result, in my mind, of a few individuals with imagination, aggressiveness and belief who put these things all together, the result of which is this conference and also this foundation. The leadership which we have in this group indicates very definitely that the Plains Turf Foundation will have a long and useful life. It will grow and will meet a real need throughout this region of the central plains.

The first thing I anticipate is that by a year or two from now when a program is being prepared, it will be necessary and desirable to make provision for several discussion groups for at least a half day. In one group you will have men who are interested primarily in golf greens, in others those interested in cemeteries, in others those interested in parks, and in still others those interested in private homes and so forth. I think that is the future of this particular conference and I am going to be around to see if my prediction doesn't come true in about two years.

The other thing I would like to say is this, The Kansas State College like other state colleges has been devoting its educational and research programs almost entirely to things of economic importance. This has been particularly true of our research program. There are many of us who would like to have been doing something that would not bring immediate economic results but we just could not do those things. There is an increasingly favorable attitude towards research and it appears that there will be a lot more research done in this field of recreation, whether it has to do with

turf related to golf courses or whether it has to do with our parks. So I am personally delighted to have you people here today. I know you're going to have a good conference and I hope I will have the opportunity to visit with most of you.

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## WHY A TURF CONFERENCE AND A TURF FOUNDATION

### Parks

John G. Firsching
Department of Parks
Wichita, Kansas

All of you very well know that a park system consists of numerous facilities. I will not go into detail as to what these facilities are, but let's take a look at an average park system.

If you were to take hard-surfaced areas such as roads, walks, parking spaces, etc.; areas upon which buildings and other structures are erected; and areas taken up by shrub plantings and other miscellaneous features, you would find what is left devoted to turf would be over 75% of the total area. This is approximately the figure you will find in most park systems. Now, in comparison, if you were to take an average piece of private property, something like a 50 by 100 foot lot, you will find that the approximate amount of space allotted to lawns would be less than 50% of the total area.

We have a lot of turf problems in our park systems. We have varied types of turf to develop and maintain. We have more or less done our job by trial and error. We have made many mistakes and as a result we haven't acquired the quality of turf we would like. Let me cite just a few problems that we have.

We have unattractive turf as a whole. We do not have the turf that they have on the eastern seaboard such as the nice year-round green Kentucky bluegrass lawns, the bents and so forth. Most of our lawns are constructed of the native grasses such as bermuda and buffalograss. These grasses brown out in the winter and remain brown pretty much in the early spring or late fall. They cause a fire hazard. We lose many trees and shrubs, and sometimes even buildings because of the fire hazard they constitute.

We also have a problem of insects, diseases and pests on our turf. Many studies have been made throughout the country, particularly in the East on insects, diseases, and pests causing damage to turf and something has actually evolved from experiments as to their control. But I defy anybody here to find a complete, written-up compilation on the control of insects, diseases and pests that may be affecting our native grasses used as turf in our particular area. There is a lot of work in that particular field.

We also have a problem of weeds. We do not have the weeds they have in other parts of the country. We have Johnson grass here and other weeds that are a little more difficult to control.

We also have our maintenance problems. I defy anybody to give me a very accurate account on just how to satisfactorily maintain any type of lawn that we grow here in Kansas. You may do it one way one year and get fine results and by following a similar program the next year, you won't get the same results. We haven't worked out the maintenance problems or practices to the point where we can more or less set up a standard. There is also a lot of work in that particular field. You know when we fertilize most of our native grasses, we normally take care of the weeds as well. We have to get those things down to fine points. The timing element is most important.

We have our watering problem. You know that we have to change our watering from year to year and now at this time when we have shut the water off, we should actually have it turned on.

I will not go into detail on other miscellaneous maintenance and renovation practices or discuss the encroachment of our native grasses on shrub and flower beds, etc.

Now let's get right down to the main topic - the question of Why a Turf Conference and Turf Foundation? I have indicated earlier that there is over 75% of an entire park system devoted to lawn. That 75% costs money to construct and maintain. As far as the park system is concerned, we are interested in doing a job economically as well as efficiently. Therefore, a foundation of this type will certainly make the construction and maintenance of lawns less costly.

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## Cemeteries

Sam Shannon
Sunset Cemetery

Why join a turf conference? For myself I would probably be selfish and say that I might be benefited. But for us here becoming members, we could discuss mutual problems and have mutual aid, find our solutions, keep informed on advancements made in the field of producing better turf, learn from each other and representatives of the allied industries how to do a better job and thus serve our separate communities and do the job more efficiently.

During the past few weeks I have received letters from several Kansas towns telling me of their turf problems and the chief problem seems to be crabgrass. Some would like to know how to get rid of quackgrass, some prefer bluegrass to buffalograss. They are interested in learning how to best care for this grass. Others present the problem of how to destroy crabgrass, foxtail and dandelion without injuring their shrubbery. I think a good many of us would like to know that.

Now when I have problems, I just run up here to Dr. Pickett, Professor Quinlan and these other fine men all of whom have been more than willing to listen and give me the benefit of their study and research. You men out over the state of course do not have such a wonderful opportunity of personally contacting these men. So I believe a turf conference would be of real benefit to each of us.

I like to think of grass in the words of John Ingalls. "Trees decay, harvests perish, flowers vanish, but grass is immortal." In closing I would like to extend an invitation to each of you to visit Sunset Cemetery.

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## Home Owners

L. R. Quinlan
Kansas State College

I don't know just why I was put on the program to represent the home owner unless some of the members of the committee have been down to look at the turf in my yard. They probably assumed that we definitely need a turf research program after looking at my lawn.

In the twenty years that I have been here at the college, I have received many letters regarding turf. It seems that most of those questions were from people who were really emphatic about their turf problems. These letters prove very definitely that we need more research work done in this section. I think the only thing that has been published by the college as far as I know is a little pamphlet that Professor Zahnley and I have collaborated on and that was printed in 1934. As far as I know, that has been the only thing that has been published here. The reason, of course, is because work has been done.

In about 50% of the letters that I get from home owners, I find that they are clamoring for a new grass. They have tried bluegrass, bermuda, buffalo and they want to know about bent. Many of you who have worked with bent know that it takes at least five times as much work to establish bent as it does to establish some of these other grasses. I always write back and tell the people this, but I sometimes wonder if I said the right thing. A year ago last summer I visited Great Bend. I was surprised to see several bentgrass lawns that have been in five years and doing well. That was a little contrary to what I had been suggesting.

Not so long ago a Wichita paper published an article about Manilagrass. I think it was written by the county agent. They had a picture in the article of a beautiful Manilagrass lawn. The next week I received 17 letters and clippings of this article. Then other letters came from others that told me the same thing. That is something else we should know about.

I have discussed this with many nurserymen who are vitally interested in the turf problem because they are working with the home owners more closely than any other group of people. Of course, we all have homes and we are all interested. Most of the nurserymen have told me that there is a definite need for more re-

search work in turf.

We have many problems that are unanswered. There are little things that pop up all the time that lead me to think that we must have more research. For instance, in front of the Horticulture building here on the campus we have bermudagrass that was planted about 25 or 30 years ago. Today the bluegrass has run out that bermuda. We get a lot of requests each year on how to get rid of bermuda, not how to plant it. I am satisfied that we have some hardy strains of bluegrass in this section that we should isolate and experiment with in order to determine how they are adapted to different regions of the state.

We used to think that buffalograss was foolproof. We have had many letters in the last five years regarding buffalograss.

I am also concerned about the turf problems down in the southeastern part of Kansas. Down there they have the heaviest rainfall in the state and still they have a lot of trouble from native bluegrass. Then, too, there is no end of grief with weed killers. I can't blame the home owners for being confused with all of these compounds that are on the market. We need more information-- cut and dried information on the control of weeds. The climate in Kansas is somewhat representative of the areas that surround us. That gives us an idea of the wide range in rainfall, temperature, evaporation and other growing conditions. To me it presents a tremendous challenge to this turf foundation and I believe this foundation can solve them.

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## Industry

Ross McCausland
Wichita, Kansas

We folks in industry have a lot to do with grass. We have seeds, fertilizers of various kinds, insecticides fungicides, weedicides, ground conditioners, and we have equipment to use these things. The manufacturers of these items can only by research, such as we anticipate here at Kansas State College, keep up and know that their ideas will fill the bill.

As we have gone along, we have had quite a lot of changes. Take for instance fungicides and insecti-

cides. We have had changes in these items in recent years, particularly in those that go into golf course and park work. We have almost dispensed with lead arsenate for the control of worms in golf course grass, and new insecticides, such as chlordane, are taking its place. The manufacturer must keep up with these changes so that he does not become oversupplied with out of date items. We, as the distributors, of these fungicides and insecticides, must keep up with the changes so that we do not get too much stock that is hard to sell. It is a problem to make it all come out even.

We in our job contact the home owners a great deal and you would be surprised how many people ask us for information. A lot of dealers selling seed do not have as much information as they need to give proper help, and those that do have the knowledge have trouble prescribing as the conditions under which the average lawn is to be started are not the most desirable. We have people who have a new house, and then come in and ask what they should do to get a lawn. The new home owners have spent all their money on the house, and usually do not have any money to properly condition the soil before they seed the lawn and they have very little money for seed and none for any kind of plant food and it is a problem to get them started.

We also have people come in who have money to spend on lawns, and I think that is something that we do not want to overlook in this conference. We have people that want a nice lawn and the cost is a minor consideration. When you get into a golf course, park department or cemetery, you must watch the expense when it comes to turf or other things. I think we should consider both the home owners who have little to spend and those who want a nice lawn regardless of cost in the experiments carried on by this college and foundation.

We in industry need turf foundations cooperating in research work to give us proper information to pass out to our customers and these turf conferences will help us a lot.

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## Golf Courses

L. E. Lambert
Dodson, Missouri

On the golf course, I think, the words grass and turf are the same. Without grass you do not have a golf course. Therefore, we are deeply interested in any research program, any knowledge that we may be able to gain in any way to help us in the maintenance and improvement of our turf. There are several areas, our greens in particular, where we have highly developed turf which we must maintain sometimes under average conditions. We can't keep players off a green even though it rained the night before. In the past, I went out at night, watered greens, and in a few hours it rained. They still played golf the next day. How to maintain balance, how to get the right species, the correct soil mixture, those are our problems and we need a lot of help on them.

We have three types of golf courses which, I think, should be mentioned: the private course, the municipal course and the fee course. The private course operation is usually controlled by a budget. We work with a budget as a rule and we can do just about what we want within that budget. The municipal courses are also somewhat the same except for the fact that they have other sources of income. The fee course, of course, is a commercial proposition and is a question of profit and loss. But all of them need help. We need help to stay within our budget, improve the course and keep golf within the reach of our member. The municipal course needs help to maintain its golf course and offer the best possible facilities for the average player. The fee course owner needs help so that he can make a little profit.

I think that covers the reasons why we on a golf course want a turf conference, we want a turf foundation. We want the knowledge, the know-how, so that we can do a better job.

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## Institution Grounds

Chester Billings
University of Nebraska

It seems that after the park men, home gardeners, golf course men and representatives of associated industries present their problems, the questions relative to establishing and maintaining good turf have been presented. We do have, in many cases, considerable difficulty with both turf establishment and turf maintenance where use is extremely heavy. For instance our athletic grounds, not so much the main playing field on which we have some of those major scuffles, but on practice and intramural fields, the turf takes severe punishment. So far we have been unable to maintain a stand of grass on such areas. The same applies where thousands of students moving about the campus, cut across lawn areas every hour of the school day. Trying to grow Kentucky bluegrass under such conditions in our locality has not proved satisfactory. Professor Quinlan mentioned that people are eager to try most any new grass they see or hear about. Maybe we are not doing all that could be done to provide the public with new grasses. Perhaps this would be a quick and economical way of trying new grasses under average conditions.

A year ago we secured a start of velvet grass, which it seems no one in our locality was familiar with. First year results were excellent and nearly everyone who has seen it would like to secure planting stock. We are uncertain as to hardiness as well as other characteristics of velvet grass and will not recommend it until we feel that it will perform satisfactorily in our section of Nebraska. Our hope was that it might survive under extremely heavy use, on sandy soil and over heat tunnels where Kentucky bluegrass does not survive. Perhaps the newer U-3 bermuda or other grasses will be the answer to some of these problems.

Other questions which I would like to present concern mowing practices, removal of tree leaves and fertilizers. Four years ago we changed from reel to rotary type mowers. I have been asked how long we expect to get by with cutting high without removing the clippings. Apparently no harm has resulted so far but this does not mean we will not have trouble in the future. Could there be some association here with lawn diseases?

Leaf removal is a troublesome and expensive operation.

There are several companies pushing the sale of leaf pulverizers. A large eastern university recently came out with an article in a leading college magazine which stated that they had developed such a machine which performed this operation successfully. So far we have not succeeded in locating a leaf pulverizer that would meet our needs. With the use of such machines can we get by with high clipping without removing either leaves or lawn clippings?

All of us realize the value of a good fertilizer program. In our own case inorganic commercial fertilizers are used for lawns because a limited budget does not permit the use of the more costly organic fertilizers. One eastern experiment station recommends mixing fresh manure with leaf mold to attain a temperature of 150 degrees. This material should be turned every six weeks over a period of six months. Obviously this is a rather expensive procedure to get weed-free compost. There might be a less costly way of meeting this need.

Irrigation, which has already been mentioned in this meeting, requires careful planning. For example a civic minded group of men gave us a $16000 underground sprinkler system for a two block area on our campus. Sprinklers cannot be used a good part of the season in twenty-five percent of the area due to the mist encouraging mildew on a large bed of polyantha roses. The sprinkler system performs very well but more careful planning either as to method of watering or in landscape planning could have solved this problem.

The difficulty of keeping good help is quite a problem in connection with institution grounds due to the seasonal nature of the work. Men cannot afford to be idle three or four months out of the year. This difficulty could no doubt be overcome somewhat as far as institutions are concerned by an exchange of help among the different departments.

Last but not least are the good fellowship and exchange of ideas which a meeting such as this makes possible.

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# SOILS COMMON TO CENTRAL PLAINS AREA,

## ORIGIN AND STRUCTURE

H. E. Myers
Kansas State College

It is indeed a pleasure to have you men here and to be a part of the program. I surely appreciate the significance of this meeting. Reference has already been made to John Ingalls' immortal words on grass in which he started out like this: "Grass is the forgiveness of nature, her constant benediction." Now in spite of all these fine words, he disregarded the fact that nature can come along and put crabgrass in just as easily as she can put in bluegrass or buffalo, if not easier sometimes. Certainly one of our problems so far as turf foundation is concerned is to find ways to make desirable grasses grow easily and successfully in a wide variety of places.

This discussion of mine dealing with soils in the Central Great Plains Area is a rather large topic. However, I surely appreciate the limitation and will attempt only to give a few general points pertaining to this problem. In this discussion obviously I will favor Kansas conditions more than others, but I hope the statements I make will apply in a general way to this Central Plains Area including the states of Nebraska, Kansas, Oklahoma, parts of Missouri, parts of Colorado and so forth.

So far as you people are concerned, you are all familiar with the soil in a general way. Some of you perhaps do not appreciate it as much as others. Some of you may recognize it more as an obnoxious thing with which you have to work since you are fundamentally interested in grass. On the other hand, some of you may appreciate soil because soil is soil.

Now soil is something that is more or less living. To say that soil is something dead is not quite right because in the so-called dead soil, we probably have as much living material as we have growing on the surface of that particular soil. So when we take the surface and the subsoil together, we have something that is really living. This same living thing about which we are speaking has characteristics unto itself. Characteristics that are not found in any other body in any part of the world and so far as we know in any part of the universe.

The soil as we know it today was not created as such. The soil that we know today is a product of its environment. The environment of a soil can be divided into five general categories. First of all there is the parent material. The parent material is a very important item so far as the soil is concerned. I want to illustrate that by calling your attention to a thing I have observed many times going east from Altamont to Columbus. For just a few miles east of Altamont, perhaps four or five, we go through an area where the soils are extremely red-- soils formed from limestone principally. Then we drop down just over a little slope and you don't see any more of those red soils the rest of the distance. The parent material changed within a distance of a few feet. The soil characteristics reflected the change in the parent material.

Over the Central Great Plains we have a variety of parent materials. There are shales, sandstones, limestones, all of which give rise to what we call the residual soil material. Then there is the wind deposited sands and silts. There are also the glacial till materials and the alluvium deposits down along the streams.

A second and very important factor so far as soil environment is concerned is the climate. The major portion of climate that influences soil to a great extent in this Central Plains Area is rainfall. The other factors of climate include the temperature and wind movement, but the major factor is the rainfall. The reason why we get the difference in soil resulting from rain is because as the water passes through the soil, the soluble materials are taken out. Consequently, in the eastern part where the rainfall is in the neighborhood of 45 inches, we find the soils are very deficient in soluble materials. As we go westward into eastern Colorado where we have 12 or 13 inches of rainfall, we find that the amount of soluble material plus the amount of readily soluble material increases very materially.

Rainfall is important because of leaching and it is also important because of the erosion factor. So far as erosion is concerned, we can think of it as detrimental. Yes, it is detrimental usually, but also it has a vitalizing effect so far as soil is concerned. It will tend to keep the soil youthful.

Another factor so far as soil environment is concerned is the vegetation that grows on the soil. You might

say immediately that the soil determines the vegetation. Sure, it has a very important bearing on the vegetation, but the vegetation that has grown on that soil in the past centuries has had a very marked influence in determining the characteristics of that soil. Obviously, you know as well as I that through this Central Great Plains Area grass has been the dominant vegetation. Yet on the eastern side of this state and Oklahoma and Missouri, the trees have had a very material effect on the area so far as the soil is concerned.

Fundamentally from the standpoint of our particular program, the soils that have developed under grass will tend to be more fertile than the soils formed under forest cover. That doesn't mean that we do not have soil problems. We do, but we are fortunate in that they are not quite as great as they would have been if the soils had been formed under forest cover.

The fourth factor so far as environment is concerned is the slope of the land. If we have soils formed on a level slope with the rainfall and the parent material the same, we will have a soil that is distinctly different from a soil formed under the same environment except for slope. There are a number of reasons for this. When we have a flat surface, more water is going to go through that soil, there will be more leaching, there will be more movement of the fine particles from the surface into the subsoil. That will mean that we will have a heavier layer in the subsoil. We will also have on the flat surface the absence of soil erosion. On the slope we will have more run-off, less water going into the soil and more erosion. The greater erosion is going to keep up with the soil forming forces so that we will not have the extreme results of soil forming forces that we have on the flat surface. The slope is very important in determining the characteristics of the soil.

The fifth and last factor is the age of the material. The age is very important. Now the older the soil gets in general, the poorer that soil becomes. Here in this Central Plains Area the oldest soils we have are down in the southeastern parts. Also we have the greatest rainfall which has added to the weathering and added to the aging of the soil. In certain other areas we have very young soil. The youngest of the soils are those along the flood plains. The next youngest will be those that have been laid down under the influence of wind action. In general we find that the young soils are more productive, more vigorous

than are the old soils. The age is a very important factor and that is one of the things many people overlook. Soils, like people, will age.

I want to bring out some of the soil conditions as they occur from east to west in this Central Plains Area. While I am basing my statements to the results we have here in Kansas, I think they will apply in a general way to the rest of the Central Plains Area. Let's consider the soil surface of Kansas. In the eastern part of the state, the soils tend to be acid. Over in the western part they are not acid and frequently are alkaline in reaction. The nitrogen in the eastern part will tend to be higher than in the western part of the area. In the eastern part of the state we have an abundance of available iron in the soil. In the western part of the state a deficiency of available iron frequently shows up. That is associated with the soil conditions in this area. So much for the chemical materials of the soil.

In a general way in the eastern part of the state the soils will tend to have a heavier subsoil than they will in the western part of the state. That is significant because in many instances you people are dealing with made soils or at least where the surface soil has been removed. This makes for a more undesirable soil in the western part of the state.

So far as general conditions are concerned, from north to south we increase the temperature. There isn't too much change in rainfall. The principal climatic change is temperature. The more obvious change in the soil is a change from the red soils in Oklahoma to the darker soils in Kansas to the still darker soils in Nebraska. That means that if we go north, the amount of organic matter in the soil has increased and that is a rather significant point so far as the management of the soil is concerned.

Now another point I want to make deals with the soil profile. By that I mean the vertical section down through the soil. The more fertile soil is right at the surface. If we go into the soil, the organic matter becomes less and the available phosphorus will become less. If we take off the top soil and work with the subsoil, we are going to have a serious problem so far as the management of our golf greens, the management of our parks and so forth are concerned.

In Kansas there are at least 25 physically distinct types of soils that have been separated in the state.

I am not speaking of different soil types, but different soil groups that have different soil characteristics.

The soil problem that I have outlined here obviously is very general in nature. I have not tried to illustrate any specific management practice. I do want to make this point, however. I recognize fully that the soil is not the only factor involved so far as turf management is concerned, but whenever you have solved the soil problem, you have eased up other problems concerning turf.

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## GROWTH REQUIREMENTS

Raymond V. Olson
Kansas State College

Although I am not a turf expert, I have been asked to talk to you about growth requirements. It seems to me that if we knew all about growth requirements, there wouldn't be a need for this conference. Knowing the requirements is one thing, however, and knowing how to carry them out is another. We have to know about both. Since I am not a turf expert, my remarks will be confined to the requirements of plants in general.

I am going to break these requirements down into two groups. One is what we might call the non-soil requirements and the other is the requirements that the plant must get from the soil. Since I am interested mainly in soils, I will dwell mostly on that topic.

One of the non-soil factors necessary for plant growth is a proper temperature. I am sure you all are aware of that. In general most plants will not grow at all when the temperature gets below 40° F. Above that temperature each plant has its own optimum. We have such things as the cool season plants and the warm season plants that grow best in different seasons of the year largely because of temperature effects. I am not going to go into detail on that because I think that point will come up later in this conference.

Another factor that is necessary for plant growth is light. Plants, as you know, obtain their energy from the sun. The sun puts out energy in the form of light. Plants are unique in being able to use that energy.

The plants are not like us. We must eat our energy in the form of foods that have been manufactured by either plant or animal life. But plants can take the initial energy from the sun and store it up in forms that are available to animals so that we can get it. Light, then, is an essential requirement for the growth of any plant.

There are two characteristics of light that are important. One is light intensity. Intensity of light is important in plant growth. It has generally been found in studies that that total vegetative growth of plants increases directly with light intensity. Anything less than the full intensity produces less than maximum growth.

Another factor that is important is the day length. As some of you know, day length is very important in producing flowers and fruits. Each plant has its own day length for its reproduction process. But aside from producing flowers and fruit, the total vegetative growth of all plant species increases directly with the length of the day.

There is another non-soil requirement I want to mention and that is that plants need a source of carbon dioxide. I mentioned that light energy is absorbed by plants and put into a form that animals can use, but in doing this the plant uses carbon dioxide from the air and converts it into food with the aid of the light. Carbon dioxide, then, is an essential requirement for all forms of plant life. The supply of carbon dioxide is seldom critical because we always have a lot of it around us in the air.

Let's turn now to the soil factors that influence the growth of plants. Probably one of the first things we think of is water. Plants must get water from the soil. I mentioned that plants have to get carbon dioxide. In order to allow carbon dioxide to enter the plant, Mother Nature had to put some holes in the leaves so the carbon dioxide could get in. Mother Nature made a lot of little holes or stomata all over the leaves of the plant and carbon dioxide enters through these holes. Since stomata are present in plant leaves, water vapor can move out through them and in this way water evaporates from leaves. That is why a plant uses so much water.

Soil water is held in the soil by the fact that the soil attracts the water. At the same time, in order for plants to get the water, they must also have some

attraction for water. We have, then, a constant struggle between the soil that is attracting water on one hand and the plant roots which attract water on the other. In order for the plants to get water, they must pull it away from the soil.

This brings out a situation that until recently wasn't much considered by people concerned with plant water. We used to think that as long as a plant wasn't wilting, it was getting enough water and was growing as well as expected. However, recent experiments have shown that the rate of growth of a plant is proportional to the amount of force it must exert in getting water out of the soil. The drier the soil becomes, the harder it becomes for the plant to get water. The more easily the plant can get water, the more rapidly it grows.

I have some data I would like to quote to you concerning the above statements. It was taken from the work at the United States Department of Agriculture Laboratory in California in which they grew some nut grass on a soil that had a wilting point of 8.2%. That is, when the moisture in the soil became as low as 8.2%, the plants would wilt. Workers at the laboratory allowed the soil to dry to different moisture levels before irrigating it. In one case they allowed the moisture to go down to 9% and then irrigated it. In plots of nut grass they got 9½ grams of produce when they did that. In another case they allowed the soil to dry to only 12% moisture and watered it and the produce was 16½ grams. When they allowed the moisture content to fall to 18%, the produce was 33 grams. You can see from the above data that by more frequent irrigation workers were able to increase the produce almost four times.

Another factor that is closely related to soil moisture is the amount of air in the soil available for plant growth. In order for plant roots to function or for seeds to germinate, it is necessary that there be a supply of oxygen in the soil. The roots of plants respire in the same way we do. They give off carbon dioxide and take in oxygen. One would expect, then, that if the roots had to have oxygen in order to function and kept on using it and in the place of putting oxygen back put back carbon dioxide, there would be a good chance of the oxygen supply in the soil becoming exhausted. That possibility always exists and must be guarded against.

Perhaps I should mention the importance of the effect

of a decrease in soil oxygen content. Some recent research was done by the USDA at Beltsville in which the workers compared the effect of various oxygen conditions in the air surrounding roots on plant growth. They found that when the oxygen content got as low as ½ of 1%, there was no growth. This work was done with tomatoes. From that oxygen percentage on up to 21% which is what we have in the atmosphere around us, there was a constant increase in growth with the increase of oxygen content. With any plant at any oxygen level, one can increase growth by increasing the oxygen content. Any depletion of oxygen in the soil results in at least a certain decrease in plant growth.

We have then the problem of keeping oxygen in the soil for the plant roots to use. That is a problem that can only be solved by maintaining some open channels between the atmosphere above the ground and the roots in the soil. We must have some open channels so that oxygen can get down in the soil and the carbon dioxide can get out. In order to have such channels, one requirement is that we have a soil that has a good physical structure. It must be a soil that has a lot of pores in it.

The other requirement is that a part of these pores that are in the soil must be free for air to go through. We must have the pores and we must have them so that they are free. In order to have them free, we must have good drainage. We can not have the pores all filled with water or there will be no way for this exchange of gases. I am sure a lot of you are familiar with these problems. I am sure that when a lot of you make greens on golf courses, you put in a layer of gravel or stones of some sort to provide drainage so that the water you use can drain away without building up and filling in the pore spaces. I know that in many cases you will go over the greens with rollers that have long spikes in them to push holes in the green to allow air to get in.

One more subject I would like to mention in respect to what plants require is the subject of plant nutrients. It is the one that we think of most often and have talked about and advertised the most. The plant nutrients are necessary for plants to grow. If there is any one of a number of nutrients absent, the plant cannot grow.

There is an old slogan that many of you may have forgotten, but I want to mention now. That is "C Hopkns

Cafe, Mg". This term spells out all of the essential elements the plants obtain from the soil or air for their growth except for boron, zinc, copper and manganese. The C stands for carbon that is taken from the air as carbon dioxide. The hydrogen comes from water and the oxygen comes from water.

The rest of these are the nutrients the plant gets from the soil. The P stands for phosphorus, K for potassium, N for nitrogen, S for sulfur. All of these are nutrients that are required by plants and that they get from the soil. In the word "Cafe", Ca stands for calcium, the Fe for iron which are obtained from the soil.

Then if we say Manager and abbreviate it as Mg, we get magnesium which is also obtained from the soil. This slogan then gives us the nutrients that are required by plants except for those previously mentioned. If any one of the nutrients is missing, the plant will not complete its life cycle but will die. If any of these are present in just a little deficiency, the growth will be seriously harmed.

Plant nutrients are generally broken up into two groups. One group is called the major nutrient group. It is called that because a relatively large amount of these major elements is required by plants. The major nutrients include everything in the C Hopkns Cafe except iron. The minor nutrient elements are iron, copper, boron, zinc and manganese which are required by plants only in very small amounts.

The three major nutrients that are common in fertilizers are the three that are most likely to be absent from the soil in sufficient amounts. They are nitrogen, phosphorus and potassium. I am not going to say anything about the fertilizers themselves or how often we need them because our next speaker will take up that subject.

The next two major nutrients, calcium and magnesium, are not so likely to be present in deficient amounts. In general the soil will have enough calcium and magnesium. Occasionally in eastern Kansas the soil will become acid and then to correct that acidity, the practice is to lime it. The lime contains calcium and magnesium and that acts as a source of calcium. Although the major purpose of liming is not to supply calcium, still it does add it.

There is one other major nutrient that hasn't been

mentioned yet and that is sulfur which is usually present in sufficient amounts. It is an element that we do not have to worry about in this section of the country.

Let's look now at the minor elements-- iron, boron, zinc, manganese and copper. Of these, we will most often find deficiencies of iron, manganese and zinc in our more alkaline soils. In the western part of Kansas we have deficiencies of iron. Under such conditions there are often possibilities of zinc deficiencies. As far as you people are concerned, the primary nutrients you will be interested in are the major elements, particularly phosphorus, nitrogen and potassium, which are added mostly in fertilizers. The other elements are also needed by plants and while they are not generally lacking in soils or soil mixtures, there may often be unsolved problems that can be solved by using one of these minor constituents. We must, therefore, keep the minor elements in mind.

The element boron, which is another minor element, is most likely to be deficient in areas of high rainfall, particularly in places where there has been too much lime applied. The other element, copper, is most likely to be deficient in soils that are very high in organic matter.

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## FERTILIZATION

F. W. Smith
Kansas State College

Insofar as this topic of fertilizers is concerned, I want to start off with this subject with what I consider more or less the foundation and say a few words to you this afternoon about fertilizer materials.

It has already been pointed out that we are concerned with three elements-- nitrogen, phosphorus and potassium. On the fertilizer bag that you gentlemen buy at the fertilizer dealers, you see a series of three figures. I use 10-30-10 as a typical example. The first figure there refers to the percentage of nitrogen in that fertilizer material. That we designate by the chemical symbol N. Secondly, we have the 30% available phosphoric acid. From the standpoint of fertili-

zer chemistry we designate that with the symbol $P_2O_5$. Finally, we have another figure of 10 and that designates 10% water soluble potash. This substance is designated by the symbol $K_2O$. Some of you may wonder why we use K as the symbol for potassium. The reason is that we have already used P and obviously we cannot use it again. It would be too confusing, so we have resorted to the German name for potassium, Kalium, and use the K.

Inasmuch as the element nitrogen appears first, I would like to say a few words about nitrogen fertilizer carriers. There are a number of nitrogen fertilizer materials available on the market. Some of these materials can be purchased as straight goods and used as such. Certain of these materials are used in the production of our so-called mixed fertilizers. Some of the materials are not satisfactory in the production of mixed fertilizers and therefore are used largely as straight goods.

Insofar as the most common nitrogen fertilizer used in Kansas is concerned, I think I am safe in saying it is ammonium nitrate. One of the main reasons we use so much ammonium nitrate is because it is produced in a plant in the southeastern part of Kansas and, therefore, is available in considerable quantity throughout this whole region.

Ammonium nitrate is a solid substance, a white salt in the pure state. In the pure state it contains approximately 35% total nitrogen. Therefore, among the solid carriers of nitrogen it is very near the top with respect to total nitrogen content. The commercial product that we purchase will contain 33 or 33½% nitrogen at the present time. The reason that it is not 35% in its content is because there is a certain small amount of material added to keep the material in a good physical condition.

Other carriers of nitrogen commonly used in this state include ammonium sulfate (21% N), calcium cyanamide (20.6% N), and anhydrous ammonia (82% N). These materials are all solid substances except the anhydrous ammonia which is a liquid when maintained under pressure.

Ammonium nitrate and ammonium sulfate are readily soluble and also readily available for plant utilization. These materials may be applied to grasses at any time from seeding until early in the spring. Calcium cyanamide should not be applied directly with the seed of

small grains as germination may be reduced considerably. It should be drilled into the soil several weeks prior to seeding or used as a topdressing during periods of winter dormancy in the case of the grasses. Anhydrous ammonia may be applied to the soil before seeding, and with proper care this material may also be applied to sods after planting. Due to the expensive equipment involved, this material is usually best applied by a custom operator.

Care should always be exercised in topdressing growing grasses so as to avoid making applications at a time when the foliage is moist. Serious burning of the foliage may result if nitrogen fertilizer comes in contact with moist vegetation.

Ordinarily nitrogen fertilizers are so completely soluble that no special efforts need be taken to place these materials below the surface of the soil. The nitrogen fertilizers, quite unlike phosphatic fertilizers, penetrate readily into moist soil and are almost immediately available for plant uptake.

## Phosphatic Fertilizers

Phosphorus is an extremely active element. It was discovered in 1669. Apparently it was first used as fertilizer in the form of bones in 1662 in England. A large amount of commercial phosphorus is used in fertilizers. Its other uses include its war value as a material for incendiary bombs and smoke screens. It is also used industrially in matches, poisons, metallic alloys and medicines. There are five important acids of phosphorus. However, only two are important in fertilizers. These are:

(1) Orthophosphoric acid - $H_3PO_4$

and

(2) Metaphosphoric acid - $HPO_3$

For fertilizer purposes there are three sources of phosphate.

(1) Rock phosphate
(2) Bones
(3) Iron Ores

## Rock Phosphate

1. Hard Rock or boulder phosphate - occurs in rock

like formations - sometimes is pebbly - occurs intermixed with clay and salt rock.

2. Soft Rock or earthy phosphate - mixed with clay - sticky when wet - powdery when dry.

3. Pebbly form - gravel - light gray to black in color - mixed with sand and clay to a certain extent.

Rock phosphate deposits seem to come from marine origin. Water organisms extract phosphate from seawater. Upon decomposition these skeletons leave phosphate behind. Deposits of phosphate contain teeth and parts of bones of marine animals. Sometimes there is a replacement of limestone with calcium phosphate.

Phosphate beds are mined by hydraulic action. The clay is removed by washing. The soft rock plus clay from hard rock phosphate washings is sold as colloidal phosphate. Colloidal phosphate contains about 20-24% $P_2O_5$.

Raw Rock Phosphate - first mined in the U.S. near Charleston, S. C. in 1868. Florida deposits were found in 1881. These began to be developed in 1887. Tennessee deposits were found in 1893 and the western deposits in 1889. The U. S. has about ½ of the world's investigated rock phosphate resources.

## Raw Bones

Raw bones contain 2-4% N and 22-25% $P_2O_5$. Steaming bones removes considerable N, (drops to 1-2%), but $P_2O_5$ content goes up to 22-27% and becomes more available than that of raw bone meal.

In 1840 Liebig discovered that bones treated with $H_2SO_4$ were greatly increased in availability of $P_2O_5$. In 1842-43 Sir John Lawes put this knowledge into practice in the form of making superphosphate.

## Iron Ore

Many iron ores contain phosphate. A little phosphorus in steel affects its quality so it has to be removed. This is done by treating ore in furnaces lined with limestone. The phosphorus combines with limestone and makes calcium phosphate. This appears on the surface of the molten mass as a slog. It is run out as a molten slog and is then cooled. This is called basic slag or sometimes Thomas phosphate. It runs from 17% to 20% $P_2O_5$. It is rich in calcium, therefore, it is

basic in reaction. It is used quite extensively in Europe.

The principal phosphate fertilizer sold in Kansas is superphosphate. Superphosphate is prepared by heating rock phosphate with acid. This treatment makes the phosphorus more easily soluble. There are two groups of superphosphates depending upon the percentage of available phosphoric acid carried in the fertilizer. The first group includes superphosphates which have 16 to 20% available phosphoric acid and is commonly referred to as ordinary superphosphate. The other group of superphosphates includes those which have 42 to 48% available phosphoric acid and is commonly referred to as treble or triple superphosphate. In either of these types of fertilizer all of the indicated phosphoric acid is chemically available. Furthermore, the phosphorus in these superphosphates is readily available to plants under practically all conditions.

Numerous Kansas experiments have shown that it makes no difference with respect to yield increases, which of the two materials is used so long as comparable amounts of available phosphoric acid are furnished. Therefore, the farmer should buy whichever material supplies the most available phosphoric acid per dollar invested.

For the manufacture of superphosphate, fairly pure rock phosphate must be used. The presence of too much $CaCO_3$ will require too much acid. Too much iron and aluminum will cause the product to be sticky.

Calcium metaphosphate is a fertilizer prepared by the Tennessee Valley Authority. It is distinctly different from superphosphate in that it contains an entirely different form of phosphorus. This product contains the equivalent of about 62% available phosphoric acid. It has appeared in small quantities on the Kansas markets.

Defluorinated phosphate is a fertilizer prepared by a special process designed to remove the fluorine contained in ordinary rock phosphate. This removal of fluorine results in a product which is somewhat more available to plants than ordinary raw rock phosphate.

Colloidal phosphate is a low grade natural phosphate carrying about 20% total phosphoric acid. It is obtained usually as a waste product in the mining of higher grade rock phosphate. The colloidal phosphate carries less total phosphoric acid because of the pre-

sence of clay and other impurities. Chemically and mineralogically the phosphorus compounds in rock phosphate and colloidal phosphate are nearly identical.

All phosphatic fertilizers are comparatively much less soluble than either nitrogen or potash fertilizers. Therefore, it is more important to place these materials properly with respect to the soil than in the case of the others. The soil also has a remarkable "fixing capacity" or the ability to immobilize added phosphates.

## Potash Fertilizers

Muriate of potash (60% $K_2O$) is sometimes purchased by Kansas farmers to be used on potash deficient soils in southeastern Kansas. Sulfate of potash (48% $K_2O$) is used much less frequently. Either of these forms of potash fertilizer is completely soluble in water and moves fairly readily into the soil. However, most potash is supplied to Kansas soils as a component of mixed fertilizers.

## Mixed Fertilizers

Virtually all mixed fertilizers used in Kansas contain a higher percentage of available phosphoric acid than of nitrogen or potash. Therefore, for most practical purposes these mixed goods should be handled in much the same manner as straight superphosphate. Mixed goods should be placed in the same manner with respect to the seed as the straight superphosphate and used in such quantity as to meet the basic requirement of available phosphoric acid. Most mixed fertilizers used in Kansas can be profitably supplemented with additional nitrogen fertilizer in order to insure maximum growth of grass. The previously mentioned suggestions relative to topdressing of grass with nitrogen fertilizers should be followed in those cases.

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# REPORT ON COOPERATIVE WORK BY USGA GREEN SECTION

Fred V. Grau, Director
USGA Green Section

A discussion about cooperative research in other parts of the United States can be very uninteresting, especially when you might have the feeling that it doesn't apply to your particular conditions. Let me assure you that nothing has been quite so satisfying to us than to have a part in and to assume the leadership in developing a national cooperative turf program. I am going to give you a little bit of the history because I don't think some of you realize or appreciate how long we have been working on this project.

The USGA was organized in 1894 for the purpose of harmonizing the rules of golf. The Green Section was organized in February of 1921. The Open Championship was held at Columbia Country Club in Washington. A week before the tournament the putting greens were nice and green; they played the Open Championship on bare ground. They realized something had happened and that much more information was needed about growing grass on championship courses. The USGA and the USDA joined hands in developing the USGA Green Section which is now almost thirty years old.

At first most of the work was on seed mixtures. I have a lot of fun going back through those old files and finding out what they talked about back in 1921. Piper and Oakley wrote a book in 1923, Turf for Golf Courses. That is the only book that has been published up to now. Our book, Turf Management, is coming out at the end of the month, being published by McGraw-Hill and will cost $6. It is the first authentic turf management book in 23 years.

A few of the accomplishments of the Green Section research over these thirty years includes developing information on soil mixtures and about fungicides. Dr. Monteith has made a lasting contribution to turf because of his work with fungicides.

Arsenate of lead was one of the Green Sect on's big contributions. A large part of the weed control program was brought about as a result of lack of control of insects. No weed control program in turf today is complete unless you have a sound insect control program. Weed control was one of my first jobs in 1927

at the University of Nebraska. My mark still shows in front of the dairy building where I spilled some iron sulfate on the sidewalk. It is a permanent stain. We realized then that we could not use that chemical in the tombstone cemeteries because of the stain. Weed control since then has grown until now there are several national weed control conferences held each year over the United States.

Then there is the whole subject of improved grasses. I don't know of anything that we have done that will be of greater benefit to more people than what we have done toward developing improved turf grasses. The bents, improved bluegrass, improved fescues, improved bermudagrass are all included in our work.

During the period 1940 to 1945 there was very little activity in the Green Section. Things were practically at a stand still. In 1945 I had the opportunity to take the position of Director and immediately we set about to develop this national cooperative program. It simply means that we all are working together in the common interest. We don't have a whole series of independent research projects. They are all tied in together and that has been very stimulating. We tied this work up with one of the most important things we can do-- encourage the training of more young men in this important field of work. When you know grasses, it fits you for almost any line of work. If you know your grasses, soils and fertilizers, you can go into turf work, pasture and forage work and many different lines. You are not limited in any way. During the past five years we have trained several excellent top-notch young men, given them their PhD degrees in turf management in special sproblems relating to turf which has added to our knowledge of turf management and we have our future leaders in this work as well. Some of these men already have taken important positions in state experiment stations and they will be leading the turf work in their areas from now on.

One of the most important things that we have done in the last five years is to develop Turf Research Review. It cost us quite a little money to put it out. It was sent free to each experiment station in the country and to everyone who has contributed financially to the development of the cooperative program. There are a few remaining copies and they are being sold at our office for $1 each, postage paid. We want to get this out every year. It lists the names of the experiment stations, the names of the project workers in turf, the names of the projects and gives

a list of the publications and reprints from each station dealing with turf. It is a good inventory.

I am just going to name the stations that are listed in this Turf Research Review. At the Beltsville Turf Gardens, the USGA Green Section is cooperating with the United States Department of Agriculture. The Department of Agriculture puts about $7500 a year into this work, whereas we put into it about $35,000 a year. The list of projects being carried on is too long to read, but we are concentrating on some of the newer things that probably you couldn't afford to do here. We are sort of testing out new ideas, new projects and especially zoysia. We have the only full scale zoysia breeding evaluation and testing project in the world. It is pretty big. We have several acres devoted to individual plants of zoysia. We could probably build a turf to almost any specifications on the basis of the plant material we have in our gardens today.

The group out in California got together because they needed work in that area. What they read about turf at other stations over the country didn't apply to them because they have unusual conditions. They got their heads together, asked Dr. Stoutemyer, who went out there from Iowa to head the turf project and they are getting things done. But, strangely enough, the very grasses that are most successful on putting greens in this area and at Beltsville, Maryland, are the best in Southern California. So maybe some of the things we have do apply to their conditions. The U-3 bermuda has been highly successful in the East and is also the best strain of bermudagrass in southern California. So it is rather pleasing to find that some of the things we have done are finding usefulness all over the country.

Connecticut has concentrated almost entirely on insect control. One of the insects that has been bothering us for many years, especially up and down the eastern seaboard is Pheretima hupiensis or stinking earthworm. It absolutely would not respond to arsenate of lead. It just ate it by the ton and loved it. But Chlordane has controlled it. That is a national advancement. A lot of the information that we have been passing out on these newer insecticides has come about as a result of some of the original research work at Connecticut.

At the Everglades Experiment Station in Florida we have been testing the southern adaptability of some

of our bentgrasses and some of our bentgrasses are successful in the southern tip of Florida. There we have now a series of bermudagrass, centipede grass and the southern grasses that are giving us better results in the sterile sands in Florida.

At the Georgia Coastal Plains Experiment Station Dr. Glenn Burton is heading the turf research program there and is doing an absolutely outstanding job. Already Tifton 57 bermuda has been developed as a result of the breeding and turf research program. Tifton 57 bermudagrass pushes the common bermudagrass out of the way and also pushes ryegrass out in early spring. It is really a great improvement. That is only one of the things that has been done down there. Centipede grass seed production and insect control in turf have been important projects. The use of sawdust as topdressing material has proven absolutely successful.

In Indiana we have the Mid-West Regional Turf Foundation, the pattern on which the Central Plains Turf Foundation has been built and it has been doing a grand job. Several good men have been graduated from Purdue University in turf management and a number of projects are under way. I just can't go into it in as much detail as I would like, but much important work is being done at Purdue.

Harvey Lantz is here and you will hear from him later so there is no need for me to elaborate on the work being done in Iowa. Iowa is one of the places where there is no formal agreement between the USGA Green Section and the experiment station. It is being done quite informally. We furnish the materials and assistance, if possible, but there is no exchange of funds. What they get comes from the greenkeepers association and from the college and from what Harvey can steal from some other project without getting caught. He has been doing a wonderful job in testing some of these newer grasses, in testing new fungicides, in running practical trials on putting green grasses on the college golf course and other things.

In Kentucky again we have informal cooperation. There we are testing some of these newer grasses and combinations. Already one of our newer zoysias seems to be outstanding for turf in that area. Believe it or not, Kentucky bluegrass is one of the poorest turf grasses in the heart of the bluegrass region in Kentucky. That is sort of hard to believe, but there are no good Kentucky bluegrass fairways in that region.

At Massachusetts we are studying the combinations of zoysia with cool-season grasses. We have had zoysia up there at Amherst, Massachusetts, for twenty years. It is perfectly adapted but is brown in the winter and people don't like that. We have been working for several years now on "marrying" a warm-season grass with a cool-season grass and we have achieved almost complete success in some cases. I would like to tell you more about that later this afternoon.

At Michigan we set up a copperative project wherein the Detroit district golf association put in $750 a year, Mid-West Regional Turf Foundation and USGA Green Section $375 each per year to support a three-year turf research fellowship. The result of that was the graduation of Dr. William Daniels who has now taken the job of heading the turf research and extension program in the great mid-west area. I saw him in St. Louis and he is doing an outstanding job. There he studies the relation of fertilizer and management practices and watering to the degree of excellence of fairway turf.

At Missouri we had a project nicely going studying the adaptability of some of these warm-season grasses but the project was dropped at the University of Missouri because of lack of personnel. They couldn't keep it up so it has been transferred to Purdue and is being carried on by Dr. Daniels out of Purdue. We will have to drop the Missouri Agricultural Experiment Station from this list next year. It is rather a shame because it is right in the heart of a great deal of turf-growing in an area where nobody had good lawns.

At New Jersey a great deal of work is being done particularly on weed control and on management practices. Ralph Engel is working for his degree there and is doing an outstanding job. I just can't list all of the things that are being done.

At New York they are studying the usefulness of the mole-drain in draining turf areas that were not equipped with a good drainage system to begin with. This was started two or three years ago. It looks like that project is going to be very useful. They are also studying the control of crabgrass with potassium cyanate and other chemicals.

At Oklahoma we have had an excellent project supported by the Tulsa Golfers Fund for War Wounded and now contributions are coming in from golf courses and

other turf interests in Oklahoma. It is supporting a $5,000, five-year project on the study of soil conditions under turf, with emphasis on putting greens. It is a very useful and necessary piece of work.

At Oregon again there is informal cooperation. There we are concerned mainly with the production of these improved seeds which is so important to your work.

One of the best and one of the largest set ups in turf research is at the Pennsylvania Experiment Station, State College, Pennsylvania. Some of you who are members of the American Society of Agronomy will be there for the annual meeting next August. You will see some of their work at that time. They have a four-year course in turf management so that an undergraduate student may specialize in this course. He gets training in all of the agricultural sciences, but in special subjects like pathology and entomology he would be studying the control of insects and diseases on turf rather than on tobacco or some other group. It is working out very well. Pennsylvania is the only state that has a complete turf program combining research, resident teaching and extension.

Rhode Island is the oldest experiment station in the country that has had continuous experiments on turf since 1902. They continued those plots all through the wars and never have let them down. It is quite a wonderful thing. They are doing some mighty fine work and more and more the turf interests in that area are recognizing the value of that work and are beginning to ask to help support it. The money is coming in without having to ask for it because they realize that they can't very well do without it. Rhode Island has done a remarkable amount of work on the control of weeds in composts with cyanamid and other materials. It follows the work done by the Green Section some ten or fifteen years ago using chloropicrin as the method of controlling weeds in compost. They have done a considerable amount of work with the mercury compounds in controlling crabgrass. At present they are working on improved Colonial bents among other things.

A Louisiana boy who did his undergraduate work at Texas A & M went to Penn State under a Green Section fellowship, finished there a year ago and then went to Texas in charge of turf and pasture research. He is going to make his name back in Texas with an excellent training in back of him. He studied this problem of compaction in turf soils together with ir-

rigation of fairway turf. It has been an extremely important piece of work. That boy happens to be Jim Watson, now Dr. Watson.

That completes the list of the experiment stations that are actively working in turf research today in a cooperative way. We feel that the list is going to grow because next year we will be able to list Kansas State College and the University of Nebraska; also Virginia and perhaps Ohio. I think you can see that all the way through the United States Golf Association Green Section has played an active part in the development of turf work in the United States. It has been largely on private money from dues that the member clubs have paid in to the USGA. We have needed funds ever since we started. We still do. This year I had $1,000 in my travel item in the budget for three men. You can't do much on that. That is why this conference is paying my expenses here and back to Washington. We don't have the travel money to get out and do the work we would like to do.

There is no reason at all why any experiment station cannot cooperate with us and utilize the material we have and the grasses we have. We have several new ones at the present time and are getting new ones all the time, particularly for special turf uses. We will gladly help you to set up the program so that there is no question whatsoever of our intent. My executive committee has stated its policy that we are to encourage the development of local and regional groups, give them every assistance possible because not only do we get more people working on this important subject, but it takes a tremendous load off our shoulders. Then we can devote time to some of the areas that need help and as yet have not had it.

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## GRASSES ADAPTED TO THE CENTRAL PLAINS AREA

F. D. Keim
University of Nebraska

One of the agricultural fields in which I have been most interested over the years has been the grasses. Naturally I am interested in grass because we have approximately 24 million acres of grassland in Nebraska. This talk will be a little of the shotgun sort because I have a set of new grass slides and I am just like a

little boy who gets a new set of crayons-- I have to use most of them. They will cover many of the common native grasses and a few introduced perennials which have contributed so much to our western country.

There are six native grasses that are great favorites of mine. The first on the left is the old turkey foot or big bluestem, which is probably the most famous native grass in the world. Then from left to right we have switch grass, side-oats grama, western wheatgrass and sand dropseed. There have been a number of important things that have come about due to recent research which I hope to mention as I go along with this story.

## Relatively New Results of Grass Research

One of these that has yielded unusual returns in the adaptation of grasses to soil and climate. I can illustrate this by using pictures of bromegrass, which is one of the most important cultivated grasses on the plains. On the right is a strain of bromegrass from Canada and on the left is one adapted to the southern parts of Nebraska and Kansas. These were planted at Lincoln, Nebraska, in the fall and the picture was taken about the middle of May the next year. The next shows them later on and you see the Canadian strain is not making much growth, but the one on the left which is the adapted one is making a very wonderful growth. At maturity the adapted strain made almost twice the yield of both forage and seed. So adaptation is very important and when this principle is recognized, the growing of bromegrass and other grasses becomes much more satisfactory and profitable.

The same principle can be illustrated with switchgrass, the small one from the north is on the left and the taller ones are adapted further south. Note the gradual decrease in size as one selects types from north to south. Obviously we cannot change these grasses from one place to another without cutting down on production.

## Warm and Cool-season Grasses

Another important development that has come from further detailed study of grass has been the recognition that there are both cool and warm-season grasses. The brome illustrates the cool-season grass and the grama the warm-season grass. The picture was taken in May and tells the story of the growth at different times of the year and the yields. The warm-season grasses

must be planted in the spring and they make the greatest growth during the hot summer months. The cool-season grasses can be planted either in the fall or early spring and make excellent early spring and late fall pasture. By using a combination of the two, an all season pasture of perennial grasses can be made available.

## Processing and Production of Native Grass Seed

The harvesting, processing and production of native grass seed is relatively new. Worn out native pastures and meadows can now be plowed and seeded back to the old original adapted prairie grasses. The processing is accomplished by running the newly harvested seed through a hammer mill and a good seed cleaning mill. Much abandoned land and even good plow land has been reseeded and placed back in useful production.

## Breeding New Strains of Grasses

A rather large number of new strains of grasses have been released by the various experiment stations and are now in production. With the release of these new strains many seed growers are making the production of grass seed a specialized type of farming. The Nebraska station has recently released Lancaster and Lyon bromegrass, intermediate wheatgrass No. 50, side-oats grama No. 52, sand lovegrass No. 27 and switchgrass No. 28. Other stations are making similar releases. This picture illustrates one of the new bromegrasses which Dr. L. C. Newell has recently released. This strain has been named Lancaster. Notice it is a heavy seeder and makes abundant vegetative growth.

## Early Seeding

Now just a word about seeding. The illustration shows that alfalfa seeded the middle of August developed a root depth by November 25 of 3½ feet. Bromegrass seeded on the same date literally filled the soil with roots to the depth of 3/4 of a foot. Grasses seeded much after September 25 at Lincoln, Nebraska, did not make enough growth to survive the cold winters and dry windy springs.

## Obtaining Stands of Grasses and Legumes

Much progress has been made in the procedures for obtaining a catch or stand. All of the principles such as early preparation of seedbed, thoroughly compact-

ing, finely pulverizing the soil, etc., still hold. A new system has been recently developed by the Nebraska Experiment Station and the Soil Conservation Service Research Division. This system has been used for a number of years and has practically never failed, even during drouthy seasons, to obtain a stand of small-seeded grasses and legumes. It consists of the use of a subsurface tiller which leaves all residues on the surface, a packer that thoroughly packs the soil and residue and either a broadcast seeder that places the seed under the residue in moist soil or a drill with special openers to go through the residue. The details of this system are explained in Farmers' Bulletin No. 1997 of the U.S. Department of Agriculture.

## Vegetation and Residues as Moisture Conservators

The more water in the soil, the better is the chance of obtaining stands of small-seeded grasses and legumes. The remarkable intake of water due to grass cover and land covered with straw or other residues is ably shown by Dr. F. L. Duley:

Effect of Crop Cover on the Rate of Water

Intake-- 90 Minutes After Beginning Application

| Crop Cover | Rate of Intake At end of 90 Min. Inches per hour |
|---|---|
| Native sod, good vegetative growth | 3.30 |
| Native sod, clipped close to ground | .65 |
| Straw cover, 2.5 T | 3.50 |
| None, cultivated | .49 |

Nebraska Agricultural Experiment Station, Bulletin 112

The native sod with a good vegetative growth, which should be the condition in a well managed pasture, took in water at about the same rate as cultivated land covered with 2.5 tons of straw per acre. Where the grass was clipped close to the ground and the surface litter removed, as one would find in an overgrazed pasture, the infiltration rate dropped almost as low as on bare cultivated land. The fact that the soil still contained the grass roots did not cause it to absorb water rapidly. This principle is extremely important from the standpoint of yield of hay and pasture per acre.

## Grasses of Interest

Buffalo grass has both male and female plants, and is one of the most interesting and drought resistant grasses of the Central Great Plains area. During the dry years it was used extensively for lawns and gardens in eastern Nebraska. When more favorable weather came or the lawns were irrigated, bluegrass largely replaced buffalo grass. We planted buffalo grass in the alleys of a rose garden at the Nebraska College of Agriculture. The first few years it looked very well, but with frequent watering the bluegrass came in and the buffalo grass almost passed out of the picture. The place for buffalo grass is on the hard drier areas of the plains. In this region relatively few grasses can compete with it.

Blue grama is a very famous grass for the West. The seed takes a lot of processing and the plant does not seed very well. It is nutritious and makes excellent yields of forage where it is adapted. One finds some excellent grama grass lawns on the western hard lands.

Hairy grama is another widely adapted native grass. It is difficult to realize the amount of hairy grama that is scattered over the plains because it is a rather inconspicuous species. It is a plant that looks a great deal like some of the other gramas, but grows smaller.

Western wheat is one of the most widely adapted grasses. It seems to come and go. It has an extremely heavy root system and spreads by underground stems. Some years it makes excellent growth and produces a good seed crop and other years it makes a small amount of growth and seed.

Slender wheat is a common cultivated grass that has a place in mixtures. It probably should be used more in the Great Plains agriculture. Intermediate wheat is an introduced perennial grass upon which some selection work is being done. The grass is used for much the same purpose as bromegrass and it grows in much the same areas. More work needs to be done to find the best place for this grass in the central plains agriculture. The seeds of the wheat grasses are rather easily harvested with a combine. They all make satisfactory seed crops from both the standpoint of yield and quality. The soil conservation service has been advocating tall wheatgrass in places where drainage is poor and the land slightly alkaline. Tall wheatgrass seeds very late in the fall which makes it rather dif-

ficult to harvest a seed crop and obtain a stand the same year.

Salt or alkali grass has always been a favorite of mine because of its value in the sand hills for the location of windmills and farmsteads. The grass is very stoloniferous and not very palatable. The wise rancher will usually locate his ranch in one of these salt grass flats.

Sand lovegrass makes an excellent growth in sandy soils and does quite well on hard lands. It no doubt has a place in the plains agriculture. It comes up rather slowly, probably due to the extremely small seed and it takes some time for a good stand to develop, but when established it makes a good palatable pasture and makes a profitable seed crop.

Needlegrasses are found all over the world. This grass receives its name from the long needle-like awns. The Indians cut the ends off of the awns, tied a bunch of them together and made a brush to comb the ladies hair.

Sand reedgrass is one of the most common grasses in the sandhills. A few years ago I was walking along a large sand dune near St. Paul, Nebraska, and picked up a rhizome of this grass that was running along near the surface of the sand. I walked 24 feet before the rhizome broke off. A plant like this is of tremendous value in holding down blow sand. It grows and spreads in circles and can easily be identified by this habit. It is a rather tough, hard type of grass and not very palatable, but it has a place in sandy land.

Switchgrass is one of the grasses that is easy to harvest for seed because it threshes out about like timothy. Usually the seed does not germinate very well the first year, but by holding the seed over for one year, little trouble is experienced. This grass very definitely has a place in grassland agriculture.

Big bluestem, as mentioned before, is one of the most famous grasses in the world. It is found growing wherever it finds proper soil and moisture conditions. Some selection work has been done on this species, but more should be done. It grows extremely tall and makes excellent meadows. If left standing too long, the stems become hard and unpalatable. The seed can be harvested and planted in pure stands or in mixtures. The picture shows Indian grass, big bluestem and the little bluestem mixture planted and grown from har-

vested seed.

Wild rye is a rather unpalatable coarse grass, but the other day I saw stands planted with a drill on dune sand in Pierce County, Nebraska, that was holding the dunes better than anything else planted in the area. It had made almost as much growth as fall planted rye.

Junegrass is one of the most common of native grasses. The density is not great, but the little Junegrass has a very definite place in our prairies.

Northern reedgrass and bluejoint are two other grasses that grow in very low areas. They are commonly found associated with sloughgrass but I believe they are somewhat more palatable. All three of these spread by a very dense system of underground stems.

The sand dropseed is one of those famous grasses that always come in first on abandoned land. It comes along slowly and doesn't make a very dense sod, but it is always present. There are a number of species in this genus. They are called dropseeds because as soon as the seed matures, it drops out of the head.

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## Flowers and Shrubs

L. R. Quinlan
Kansas State College

I want to change the title of my subject a little bit. I want to emphasize the selection of plants for landscape use. First I want to mention the importance of our native materials in selecting plants for landscape use. Whenever I have suggested the use of native plant materials, I have always seen a little resentment registered by the people who were listening, especially nurserymen. But I think our native trees are the most important of all plant material. For instance, if you take American elm, soft maple, sugar maple, green ash, honey locust and pin and red oak out of the landscape, we will not have much left. There is also red cedar which is used widely, not only in large areas, but in foundation plantings.

We do not contribute very many native shrubs to our landscapes. We do furnish many perennials starting with gaillardia, which is one of the most common, and we could mention many others that are being used. I think that we should consider all of these native

plants because they have come through long periods of drought and adverse conditions more severe than any of us have ever experienced and they should come first in our list of plant materials.

Kansas is the only state in the union that does not have a pine tree native to the state. When brought into the state, some of them do very well and grow a little better in some cases than they do in their native habitat. For instance here on the campus we have some white pines that have grown faster than they grow up in Minnesota.

What about the plants that are not native, but are adapted to this region? Shrubs we have brought in from all over the world. Pfitzer juniper comes from China. We could hardly get along without it. Spreading Evonymus or Patens also come from China. Mahonia comes from Oregon. The white pine from the northeastern part of the United States and the flowering quince from Japan. So you can see we bring these plants from all over the world and they are perfectly adapted. We use them all a great deal.

We have a lot to learn about the adaptation of plants. If any one should have asked me, when I first came here, if the bald cypress would grow in Kansas, I would have said no, under no conditions. It grows in the swamps of the south. But we find when we put it on high, dry lands, occasionally it will grow very well. We have several specimens on the campus. They are about 50 years old and are growing on the highest and driest spots on the campus. When you see something like that, we feel that we haven't learned anything yet. There is a lot to learn about plants that are growing around the country. Take the aspen that comes from the Rocky Mountains. We think this country is very foreign to the plants that grow in that region but still we have a fine clump of them here on the campus. They are adapting themselves to the area quite well.

Now the third thing I want to mention about growing plants for our area is proper care. You have all heard the old expression that it is better to plant just one tree and take care of it than it is to plant a forest and neglect it. I always like to point to the shelter belt that was planted in the west as an example of proper care. They did two things. They selected native plants that were adapted and they cared for them. They were fenced, cultivated and they got a good start. I want to stress very strongly the proper care

or maintenance of our plant materials.

For example, the average home owner that goes into a nursery and sees all these plants that have been growing in straight rows, cultivated, sprayed, watered, fertilized and are growing under ideal conditions takes them home and plants them in his yard. He puts them among other shrubs, crowds them, never waters them, never cultivates them and expects them to grow as they did in the nursery. They will not do it.

Some people think when they buy a shrub and plant it that it should live forever. For instance, you may buy a Pfitzer juniper for $10. You also pay 8 or ten dollars for a dozen cut flowers from the florist. How long do you keep the cut flowers? They last a week or ten days and then fade and we don't think anything of it. We must learn that when we plant things in our yards, they will not last forever. We still get our money out of them even if they grow only a few years.

If we look at yards and plantings, we always see a lot of overgrown plants. They have served their time and should have been cut out years ago. Of course, that comes under proper care and maintenance.

Now it doesn't make any difference what kind of effect you want in your yard. Whether it is a very informal type of house and an informal front yard, or whether it is in a park and you want a very naturalistic effect or whether it is a small contemporary garden in the back yard, we rely on one thing and that is natural plants. I was interested to see a picture of a contemporary garden not so long ago where all of the objects were nicely balanced and it was rather interesting in pattern. But the success of that garden was the informal trees that were around the garden. If you took them out, you would have nothing. So I always try to impress my students with this one thing, if you don't appreciate natural beauty, you will never be a good landscape architect. You will not be successful in any field of landscape design unless you have appreciation of our natural beauty. If you are going to introduce natural beauty in your design and know nothing about natural beauty, you are not going to have naturalistic beauty in your gardens.

The appreciation of natural beauty has real cultural value. It has just as much cultural value as being able to appreciate good music. Now probably you have all had the experience of going through the ordeal of taking music lessons or have bribed your sons and

daughters to take music lessons. I have three children and they all had music lessons. We gave them those lessons not because we think they will ever become musicians, but because we wanted them to appreciate one of the finer things of this life.

Let's just go right back to natural beauty. Surely if you are not landscape minded and don't appreciate the beauty around you, you are missing a very fine thing of life. Speaking of our efforts to beautify areas, I have had people come to the campus and remark about the beautiful campus. They assumed, of course. that the campus was always this way and when we wanted to build a building, we just cut out a few trees and built it. Well, before this campus was a campus, it was a cornfield. Every tree that is here was planted. I can brag about this because I had very little to do with it. It was a beautiful campus when I came here and all I have been trying to do is keep it the way it was when I came.

The very same people who have come here and said that we have a beautiful campus will go home and do everything on the contrary to what they saw here. In the first place they saw no weeping willows, red leaf barberry and other horticultural monstrosities. Still they go home and put them in their yard. They didn't grasp it at all. They thought it was beautiful, but didn't know why.

There is a difference between beautiful plants and unusual plants. When you plant a plant of any kind, ask yourself whether it is beautiful or unusual. Are you trying to put it in your yard because you have never seen it before; is the plant adapted? Ask yourself those questions first and I think your yards will look much nicer. In fact I'm sure of it.

(Kodachrome Slides followed)

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# TURF FUNGICIDES INVESTIGATIONS AT IOWA STATE COLLEGE

H. L. Lantz
Iowa State College

First of all let me say to you that I am pleased that you have asked me to appear on this, your first Turf Conference. I hope you folks are entirely successful with your new organization, because you need the kind of contacts and instruction you get by attending meetings of this kind regularly.

If I may, I would like to tell you something about the Iowa Greenkeepers Association. About 18 years ago the association was formed. Arrangements were completed with Iowa State College for a Greenkeepers Short Course. This coming March 12, 13, 14, the 17th annual short course is scheduled to meet at Ames. From a small start these short courses have steadily grown so that we can count on an attendance of 150 to 175 people who are interested in better turf. In addition throughout the summer a meeting is held each month at golf courses in various parts of the state. The attendance here averages 50 to 80 or more. The September meeting is always held at Ames to review the work on the turf garden.

The turf garden was established in 1939 through a cooperative agreement with the Greenkeepers Association, and the Iowa Agricultural Experiment Station, and the U. S. Golf Association Green Section. The turf garden was designed at first primarily to test promising strains of bentgrass. Thirty or more strains have been in the garden and new ones are added from time to time. The objective was to determine whether any of the new strains were in any way better adapted to midwest conditions than the most used strains, Washington and Metropolitan. For the past three years the turf garden has been useful indeed in cooperating in the conduct of National Turf Fungicide Trials, which this year are headed by Dr. Sharvelle of Purdue University.

Another feature of the turf garden during the past 3 years is the addition of plots to test various grasses and grass mixtures. These include plots sown with commercial mixtures such as are offered by Scotts, Earth Carpet, Woodruff and others. Plots for comparative trials include, Merion bluegrass, Illahee creeping red fescue, Alta fescue, U-3 bermuda and Zoysia japonica. These latter grasses were planted alone and in various mixtures. Some extremely interesting plots

have developed, and their behavior will be carefully studied.

Probably one of the most valuable parts of our work in the development of the turf garden has been the opportunity to get a liberal education in the techniques of growing fine turf. Without this first hand experience I am sure that a worker in this field would find himself completely lost, both as a grower of fine turf and as a teacher. There is no substitute for the practical experience gained in the turf garden itself. The turf garden at Iowa State College has been my charge since 1942, and therefore gives you an idea as to why I am here to discuss our findings in the fungicide trials which we have conducted during the past three years.

In the midwest the most prevalent diseases which damage golf greens are dollarspot and brownpatch. Dollarspot under Iowa conditions develops and spreads all season. Brownpatch spreads very rapidly once the weather warms up and the humidity is high. Warm nights as you know are conducive to rapid spread of brownpatch. Control measures are necessary at once, not tomorrow or this afternoon, but now.

Calo-clor is widely used as a fungicide, and its value recognized everywhere. Were it not for several faults we would not look further for a better all around fungicide. In hot weather burn may result following an application or if not burn, the bentgrass may be set back and be off-color for a week. A careless operator can do considerable damage. Careful operators can and do use Calo-clor successfully for the control of dollarspot and brownpatch. The objective in developing new fungicides is to secure fungicides which can be applied with a minimum of disturbance to the bentgrass and at the same time control disease.

There has been a lot of activity by chemical firms in the new fungicide field and during the past five years a number of new trade-named fungicides have been on the market. Tersan, a non-mercury compound, was introduced about eight to ten years ago. Special Semesan was introduced some years earlier and is mercurial. Tersan is preferred by many greenkeepers because it is safe and does not produce off-color. There are many mercurials on the market. It is pretty largely a question of "take your choice" and follow instructions be timely and thorough in making applications.

During the past four or five years a new type of fungicide has been introduced. This is the cadmium complex. At least three of the cadmiums are on the market, Cadmium, Crag and Puraturf 177. Others are still in the trial stages of development.

In order to secure the answers as to how well these new fungicides control disease under midwestern conditions, we joined forces with the National Fungicide Trials in 1949 and again in 1950.

Under central Iowa conditions dollarspot is sometimes more difficult to control than brownpatch. On the turf garden at Ames dollarspot has given far more trouble than brownpatch and for this reason our results are better adapted to an analysis of dollarspot control than to brownpatch.

Our fungicide tests began first in 1948. Included in the plot tests were Puraturf 177 and Crag. These two cadmiums were outstanding as to dollarspot control and it was noted in the fall of 1948 that the four cadmium treated plots remained free of dollarspot, while on the checks and the mercury treated plots, dollarspot became very prevalent by the end of October. In fact these cadmium plots remained free of disease until around June 15 of the following year. In the other plots dollarspot was serious through October, November and in early spring.

In 1949 and 1950 the fungicide studies were conducted on a larger scale with 36 plots in the test. The results were very striking in 1949 and were more so in 1950. The contrast between treatments is so marked this year to the point of being dramatic.

In 1949 the National Turf Fungicide Trials were under the direction of Dr. John B. Rowell, Rhode Island Experiment Station, this year under Dr. Eric Sharvelle, Purdue University. Broadly speaking, these trials were designed to test new fungicides and to compare them with the old standard fungicides. The tests were conducted in some ten or twelve states. The rates of application were established by the different manufacturers. The time, frequency and method of application was left to the cooperator. The turf garden at Ames was divided into 36 plots, with at least two replications and in some cases three replications per treatment. Plot size in one area was 6 x 24 feet or 144 square feet. In the smaller areas the plots were 6 x 20 or 120 square feet. Both in 1949 and in 1950 dollarspot was permitted to develop before the treatments

were begun. The first dollarspot infections appeared about June 15. Treatments were begun about ten days later. It appeared to be desirable to permit some disease to develop and to record the time required to clear up the disease in the different fungicide plots.

Fungicide Trials
Iowa State College - 1950

| Fungicide | Average Infection 7/14 to 8/21 | Infection 9/19 | Infection 10/3 | Weed Count 10/3 |
|---|---|---|---|---|
| **Cadmium Compounds** | | | | |
| Cadminate | 0 | 0 | 0 | 34 |
| Crag | .3 | 0 | .9 | 66 |
| Puraturf 177 | .25 | 0 | .5 | 74 |
| Puraturf GG | .6 | 0 | 1.0 | 49 |
| Carbon & Carbide 1025 | .3 | .3 | 1.0 | 25 |
| Merck 258 T | .4 | 0 | .6 | 135 |
| **Mercurials** | | | | |
| PMAS | .9 | 2.5 | 5.0 | 0 |
| Soilicide | 1.2 | 2.0 | 5.0 | 12 |
| Puraturf | 1.3 | 2.0 | 5.0 | 0 |
| Calo-clor | .25 | 0 | .6 | 8 |
| **Non-Mercurial** | | | | |
| Tersan | 1.9 | 2 | 3.0 | 120 |
| Check | 2.9 | 5 | 5.0 | 343 |

Scale for recording dollarspot infection

0 - No infection visible
1 - slight infection visible
2 - scattered infection visible
3 - medium infection visible
4 - medium plus infection visible
5 - severe - a general infection

Dates of application

June 27
July 10
July 20
Aug. 1
Aug. 21
Aug. 31

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An examination of the table of results will show the efficiency of the cadmium compounds in the control of dollarspot. The results were equally good in the 1949

tests. During the summer it was noted that the bentgrass on the cadmium treated plots appeared to have better green color than those plots receiving the mercury treatments. The observed holding effects of the cadmium compounds is significant as is shown in the table as of October 3.

During the summer the mercury treated plots showed satisfactory control, Calo-clor was especially effective, but at no time was the control of dollarspot equal to that observed in the cadmium treated plots.

The incidence of weeds, chiefly small dandelions, was noteworthy in the treated plots. The near absence of dandelions in the mercury treated plots is significant and worthy of note.

Brownpatch infections in the turf garden were scattered and did not occur until in August. It should be reported, however, that the summer of 1950 in Iowa was among the coolest on record. Cool nights prevailed throughout the summer and under these conditions brownpatch was not a serious threat as it generally is in Iowa.

It is apparent from observations in the turf garden in 1949 and 1950 that the cadmium compounds do not provide satisfactory control of brownpatch and are not recommended for the control of brownpatch. The mercurials and Tersan are dependable and widely used.

Summary

Three seasons of testing at Ames indicate the vast superiority of the cadmium compounds in the control of dollarspot. Applications made in the spring and late summer should provide excellent control of dollarspot. Infrequent applications during the summer may be necessary if infections appear. During the summer when brownpatch is a threat, the use of Tersan or the mercurials are good specific control materials.

Methods of Application

The greenkeeper many times is handicapped by not having good equipment with which to apply fungicides. This reporter believes that a power sprayer is an indispensible piece of equipment on the golf course. It should have a 150 or 200 gallon tank, be mounted on rubber; and have a 7 gallon per minute pump or larger. The Ames Golf and Country Club is our guinea pig. We have found that the power sprayer is the most econom-

ical piece of equipment on the course. One load of 150 gallons can be applied to the ten greens in less than two hours. The ten greens cover about 38,000 square feet, which means that four gallons of spray material is applied per 1000 square feet and this is sufficient to give good coverage. Knowing that the ten greens cover 38,000 square feet, it is easy to compute the amount of fungicide required to do the job. Soluble fertilizers, insecticides and occasionally iron sulfate are also easily applied right along with the fungicides. Then on the fairways, 2,4-D can be applied to take care of broadleafed weeds. Herbicides can be sprayed in fence rows ditches and in the rough. A power sprayer need cost no more than $500 or $600, and some makes on skids are available at $400.

One thing our men like about a power sprayer is that the fungicide job can be taken care of at a moment's notice and at a great saving in time. Our plan of disease control beginning about June 1 is to make a fungicide application each week until September 1st on the theory that this plan should provide adequate protection at all times. A similar protective program is used on the 18-hole Iowa State College golf course and with outstanding results.

Kodaslides were shown as follows

This is a picture of the nursery at the turf garden. We grow a nursery each year of the selected strains of grass which we wish to retain at the garden and we give the greenkeepers of the state who are participating in the program an opportunity to come to the garden and pick up some stolons if they wish to establish a turf garden of any particular strain of grass. Replanting is done each fall and by the first of August, we have rows of bentgrass four or five feet wide that will yield a bushel of stolons every 18 inches.

This is C-115 which was planted about the first of July. Dr. Grau sent it to us from Beltsville with the statement that it was a very vigorous, strong and drought-tolerant grass. It made excellent growth since the first of July.

These plots show the bluegrass, Alta and U-3 bermudagrass and other grasses growing in 19 plots, each about 20 feet square. They are two years old and have already formed beautiful turf. We are favorably impressed with the mixture of Alta and Merion bluegrass.

This is an overall picture of the turf garden itself.

It is about 300 feet long and 50 feet wide. In the center is a plot of bluegrass which we utilized for weed control studies with 2,4-D during 45 and 46. It has been useful in many ways.

This slide shows the Aerifier at work on a part of the garden right about the first of October. We wanted to study what happens as compared with no aerifying. Most golf courses aerify every square foot of the greens so we don't have an opportunity to see what the differences there may be between the aerified and non-aerified turf.

This is the first of the pictures of the fungicide plots. These were taken the third of October. On the right is Crag and on the left Puraturf. These pictures do not give you a true picture of the average condition of the treated plots through the growing season, but they do give you a true picture of the situation as it existed after the treatments were terminated August 31. The Crag plot is beginning to get a scattering of dollarspot. All the rest of these slides show the October 3rd appearance of the various treatments used in the fungicide trials. We will go down the line and you can see the difference in the plots.

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## SOIL AERATION

Tom Mascaro
West Point Lawn Products

Recognition of compaction and soil aeration is becoming more and more evident. A good deal of work has been done on golf course turf with various types of machinery. I would like to show you now a series of Kodachrome slides of a particular type of machine known as the "Aerifier" and also pictures relating to the subject of soil aeration.

The first slide shows a Mexican boy plowing a field with his oxen. This picture was taken near Taxco in Mexico, which is about 100 miles south of Mexico City. The plow is crude as you can see by its wooden construction. Nevertheless, crude as it is, it is turning over the soil.

If you were to ask this boy why he is plowing the soil, I doubt if he could give you the answer. Plowing

the soil has been practiced for many, many years. What the relationship was between plowing and the crop harvest was not known and people did not worry about it too much. What they did know was that if the soil was turned over and loosened, the crops would always be better. The plants were healthier. The plants withstood periods of drought longer.

Today, we know some of the "whys" for plowing soil. We know that plants need air. We know that to get this air into the soil, it must be plowed or cultivated. Soil of good tilth should consist of 50% solids, 25% water and 25% air. Soil in this condition is ideally suited for plant growth.

We here are concerned with a national crop called grass. We can't very well turn under the sod each year in order to have good soil structure. Some means of cultivating soil under turf without destroying the grass crop itself is required. A few years ago, we designed a machine for this purpose. It was named "Aerifier".

The next slide shows a picture of the large Aerifier known as the F-G model. It weighs about a half ton and is tractor-drawn. It has nine independently revolving discs on which are mounted 108 spoons. The spoons, twelve to each disc, are fastened by means of two bolts for each spoon. The spoons enter the turf and bring out a small core of soil. In doing so, the spoon because of its design, swings under the turf producing a cultivating action in addition to removing a soil core. This machine is used chiefly for cultivation of larger turf areas. Single units can be coupled into gangs of three for faster coverage.

The next slide shows the self-powered Aerifier known as the G-L model. This machine was designed for use on small areas such as golf greens, tees and areas where the big machine couldn't be used efficiently. It is powered by a 2½ H/P gasoline engine. It is equipped with sixty spoons and depth penetration is adjustable.

This is a small Aerifier known as the Home-lawn model. It is an inexpensive implement and was designed mainly for use on home lawns. Pushing power is equivalent to propelling a standard 18" lawn mower. This model cultivates soil to a depth of about 2½" or 3".

This is the Aeri-forke and also the Aeri-forke equipped with a pan to collect the soil cores. The Aeri-forke was designed for use on very small areas and for

spot treatment of larger areas.

The pan attachment is used mainly on golf greens where spot treatment of dry spots is needed through the playing season.

Here is a close-up of the Aeri-forke with the pan attachment. You will notice the soil is held in the pan.

All the Aerifiers are equipped with the curved, half-round open spoon. The action of the spoon is shown by this next picture.

This blue print shows how the spoon enters the soil, is driven down and back by the forward motion and is extracted from the same hole in which it entered the turf. The deeper the spoon is driven into the ground, the wider the arc of cultivation. As it leaves the turf, soil is retained in the concave part of the spoon. As you can see, the soil is loosened quite effectively. Air, water and fertilizers can enter quite easily.

Now, let's look at some of the reasons for cultivation of soil under turf. Here is a sample taken with the Noer Soil Profile Sampler. The heavy thatch shown here is about 2" thick. Directly underneath is hard clay. As you can see, the roots of the grass are confined entirely in the upper first inch of the soil. The mat is quite effective in shedding water. This thatch is similar to a thatch roof. Unless steps are taken to destroy this covering, dry spots develop and, since water cannot enter the soil, the plants will wilt rapidly under adverse conditions.

This is a sample of soil taken from a green in Cleveland. Here we see a layer of charcoal about 3" below the surface. Years ago, it was common practice to top-dress golf greens with pure charcoal. As the practice lost popularity, various soil mixtures were used to top dress the greens and, as you can see here, this undisturbed layer of charcoal is still evident. We find that plant roots, for some reason, refuse to penetrate layers of this kind, but will remain above them.

Here is a sand layer about 3" deep. Here it was common practice to top dress rather heavily with sand. This particular soil sample shows only one layer of sand but we have seen instances of many layers. Here again, we see that the grass roots are confined to the very

shallow layer of soil above the sand layer.

This soil sample shows improper mixing. All too often, golf greens and, as a matter of fact, many other turf areas are established without proper mixing of soil. We find pockets of various materials beneath the turf. These pockets become quite evident at certain times of the year.

This soil sample is really compacted soil. A blue color in soil usually indicates a lack of air. The iron content of the soil changes to a blue color when air is not present.

This picture was taken in the spring of '48 at the Olympia Fields Country Club in Chicago. John Darrah, Superintendent there, aerified the greens with 1" spoons the previous fall.

The next spring, he noticed these green spots on his greens. The soil in all the greens tested rather high in plant food content but lack of air made the plant food unavailable. By getting air into the soil, the plant foods became available and the grass started to grow again.

This soil sample was taken from a fairway at the Philadelphia Country Club, Philadelphia, Pennsylvania. This sample was taken about three weeks after aerification. The new roots are quite visible in the loosened turf.

This is O. J. Noer holding a soil sample of a green in Louisville, Kentucky. This green was treated with a hollow tined implement. As you can see, the grass roots are confined only within the hole that was made. Since no cultivation with a hollow tined tool is possible, the soil around the hole is still compacted.

Dr. Grau is holding a soil sample from an adjacent green that had been cultivated with the Aerifier. You can see quite plainly the fan-shaped mass of roots, which spread out in the loosened soil around the hole.

The following three slides show the progress of the turf made at the Philadelphia Municipal Stadium. The first picture was taken in 1946 when an intensive aerification program was started. As you can see, there isn't much turf there.

The next picture was taken at the same time of the year in 1947. You can see the turf has improved con-

siderably. The grass plants are deeper rooted and are capable of withstanding much more abuse. The yearly Army-Navy football game did not damage the turf very much.

The next slide shows the same field in 1948. As you can see, the field has a thick, dense covering of turf that will take almost any kind of punishment. We must remember, however, that aerification is only part of a program for better turf. Proper water management, a good fertilization program and the proper grasses must be included in order to get the stand of turf that we want.

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## WATER MANAGEMENT

Fred V. Grau, Director
USGA Green Section

One of the subjects that I am going to discuss briefly today was assigned to O. J. Noer who was unable to be here and he asked me to cover it for him. I hope you will accept my coverage.

As soon as I was old enough to remember anything about the farm, I remember those bromegrass waterways and helping my dad cut sheaves of the different grasses to show at the state and county fairs. I remember also the water rushing off those hillsides especially after they had been in corn, unprotected, with no vegetation and silting up in the bottom, rushing across the roads after the rain. I remember my father buried three barbed wire fences with bromegrass.

Water management is of tremendous importance and we are concerned with it all the time in our turf work and in pasture work. It is the concern of every single one of us. Here is a statement I wrote up last night when I was making some notes. "It shall be the duty of everyone concerned with soil and grass to save every drop of rainfall possible and to coax it into the soil to reduce runoff and to use only enough water to keep the grass healthy. The curse of water in irrigation is that it is used to excess. More turf is ruined by overwatering than by anything else." That statement is true across the length and breadth of the United States. More grass and turf is ruined by overwatering than by any other factor.

So our plea is to use less water and save more rainfall. That is why we have been talking this whole subject of soil aeration to make the soil porous, to coax the water into the soil, to obtain deeper rooted grass and turf. When you go out and see these bluestems with root systems down 3,4 and 5 feet, you wonder what I am talking about. But then again if you examine many important turf areas where the root systems are only ½ an inch or an inch deep and you should have them down two feet deep, then you realize we do have something to talk about.

Two of the turf research fellowships that we have sponsored in the last three years have been concerned with water management, primarily because we realize that where irrigation was being practiced, more water was being used than was needed. At Penn State Jim Watson studied the effect of moisture and compaction for three years and that same study is being continued another three years under our research fellowship to find out if we can reverse the process. Now we know that by excessive watering and soil compaction we can drive out certain of the desirable turf species and introduce the weed species which are undesirable. Now can we reverse that procedure and by proper management bring back in the better species of grass? We think we can but we must document the evidence and prove it. At Michigan Dr. Daniels worked with the control of soil moisture using the Bouyoucus soil block and has done some outstanding work. In every case evidence points to the fact that only enough water should be used to keep the grass alive.

Both the Maryland and Penn State football teams came back from some of their northern games last year with a high percentage of ankle and knee injuries caused by a soft bentgrass turf slipping out from under the players' feet. It was shallow rooted and overwatered turf and would not stand any traffic. From the stands it looked beautiful, but it doesn't help the players. That can be corrected by proper water management. We can use bentgrass in athletic fields and not have it skid out from under the players feet. The clue to that are the bent tees on golf courses where the traffic is probably worse than it is on any athletic field. There it is possible to have bent turf that will not skid out from underneath any kind of athletic traffic because it is deep rooted. You can develop a deep-rooted turf, but only through the proper water management.

I don't suppose there has been anything that has brought home to us any more pointedly this whole ques-

tion of water management and shallow-rooted turf than the program of soil cultivation. It is quite new and yet it is quite old. It has been practiced and worked with for some time, but now it has broad application. There is a great deal to be done yet on this whole study of cultivation of soils under turf. We have only begun. The first real experiment that I know of is being set up right now at the Penn State Experiment Station designed to try to find some of the answers to the soil compaction and water runoff problem of turf. This project is financed by the West Point Lawn Products through the USGA Green Section.

One of the principles on which we are working very hard is the use of more drought-tolerant grasses. That is an old story to you people out here because you must use the drought-tolerant grasses. You have no other choice. But a great many of the grass selections in the past for turf purposes have not been made from the standpoint of drought because water seemed to be universally plentiful, but we know today that it is not. We are running out of water in many areas.

During the past two years at the turf conferences, we have been drawing on an old Nebraska bulletin and some more recent work from Penn State on water runoff. On most any kind of slope where the soil becomes compacted either from the impact of raindrops or from the compaction of necessary machine or foot traffic, the runoff in a single rain can amount to 80% or more. That is why the big river is always muddy and why you see many other streams muddy. The rain is not entering the soil. That happens on our golf courses as well as on the pastures.

Most of this is based on the infiltration rate of a soil. For instance if I am quoting correctly, I think in the Nebraska work it was on bare ground, cultivated soil and water was applied at 1½ inches per hour. The soil took that rate of water application for about the first ten minutes and after that it began to run off and in ½ an hour, there was less water entering the soil than there was in the first ten minutes. Approximately the same figure was used in the Penn State experiments and it was found that under these conditions with a bluegrass sod, the water was entering the soil at only ¼ to ½ an inch per hour. So the first step in proper water management is to apply the water only as fast as the existing soil can absorb it. That is just plain sense, nothing more. How many times I have travelled through this country and the greenest grass was where the water had run off the area that was be-

ing watered. It was not only a waste of water, but a detriment to the turf on the area that was being overwatered.

We are getting very critical in this water management problem because it has been so badly abused and misused. I don't blame the irrigation engineers and the irrigation salesmen so much because they are going to sell equipment and a system that will give a certain amount of water. But what they fail to tell the user is that the equipment should be used with some judgment and that they can always throw on more water than the soil can absorb. The thing that has made me most happy is to come to these conferences to talk with you individually and have you tell me that your present management practices have reduced water usage in half. That has made me very, very happy. By providing more porous soils, we will use less water and have healthier turf at a lower cost.

I recommend for your reading on this subject the talk given by Prof. H. B. Musser from Penn State at the NGSA conference at Boston last winter. It was one of the best talks on the subject that I have heard in a long time. It was printed, I believe, in the Greenkeepers Reporter. That is worth anybodys reading.

Now just a few words on fertilization of special purpose areas. You have already heard quite a bit about fertilization and fertilizer materials. You have your own ideas. Our policy on the liquid fertilizer is coming out in the November 1950 issue of the USGA Journal and I recommend that to you for reading also.

I like to think of specifications. The engineers design and build according to specifications. We have had very few specifications on special-purpose turf. That just hasn't been available. We are coming closer to it in golf than anything else because the pros want a good turf on which to play the tournaments and on which to teach the members to play better golf.

You know the specifications on a billiard table are pretty exacting. I never played billiards too much, but from the little I do know of the game, it does have a lot of specifications. I noticed that if you hit the ball each time the same way, it will bounce the same off the cushion. Those billiard tables are built to very precise specifications.

Chet Mendenhall wrote a very good article on putting greens and what they should be some time ago in the

Heart of America Turf News Letter. A putting green is probably the most highly developed form of agriculture known today. It is agriculture because we are dealing with soil, grass and the management practices appertaining to it. It is highly specific because we are mowing it down to 3/16 of an inch. There is traffic on it all the time regardless of whether the soil is wet or dry and it is never dry. The air is excluded from that soil and yet we expect that grass to be smooth, dense uniform so that a golf ball when properly putted will drop into the cup from any distance.

A putting green is designed and maintained to very close specifications. The fertilizer management practices used on a putting green are going to be considerably different from the fertilizer management practices used on a cemetery composed of entirely different grasses or on athletic fields where the wear and tear on a turf are different from a cemetery. Every single special purpose turf area will have different fertilizer management practices.

In general we have to supply those basic elements that were spoken of yesterday. The big important single factor in turf management is nitrogen. Nitrogen is the most important fertilizer element that we must figure on. It is the growth element and gives us color and sometimes can burn the turf very severely. So to the present time we have had to depend on organic nitrogen fertilizers when we could get them. Many inorganic materials gave us very quick results which we do not want in turf. The fertilizer that we want in turf is one that can be applied at rather infrequent intervals and will give slow results over a long period of time.

We like to have a uniform growth curve. The Urea-form fertilizer has come closer to giving us that uniform growth curve than any other material. Of course, there are some ups and downs depending upon varying weather conditions. As rapidly as Urea-form can be produced, we want to see it put into a turf fertilizer. That doesn't mean that we are divorcing ourselves from the organic nitrogen fertilizer because we are not. We want the organics because they contain the essential trace elements. That is very important in many cases especially when we take a crop off every day. On golf course tees we need heavy fertilization with nitrogen to help the grass recover from injuries. That is where we want a rapid growth rate because we are taking divots from the grass on the tee every day.

On fairways where there is less heavy wear, rate of

fertilizer can be reduced considerably because there isn't the necessity for rapid healing.

On lawns appearance is 80% but wear and tear does come in especially when the children are young and roller skate on the turf. I talked to the American Rose Society a few weeks ago and I made a statement that captured their imaginations. That was that part of my lawn in the front that gets the heat of the summer sun is planted to U-3 bermudagrass. The children of the neighborhood use our sidewalk because it is smooth and has a nice gentle slope and they can coast. When they get to our lawn, which is at the bottom of the hill, they coast off onto the lawn. They have yet to take out a single tiny piece of turf. That is quite surprising to many people.

We are not fertilizing any particular soil but we do fertilize each particular grass. Each grass that we use will have different fertilizer requirements. As yet we don't know what those fertilizer requirements are. The experienced greenkeepers know in general the requirements of the grass they are using. For instance Arlington bent requires twice as much nitrogen as other bents. I think the first grass nutrient study on which a doctor's degree thesis has been granted was to Ferguson, my assistant in the Green Section. He studied the nutrition of Z-52 zoysia from the vegetative and the seed production standpoints using every known method including tissue testing to determine when the optimum level of any nutrient was present. It is a wonderful piece of work. Immediately we are going to begin the same kind of study for a master's degree on Merion bluegrass.

We are feeding these special turf areas quite largely according to the eye. The eye is probably more sensitive to determine deficiency of nitrogen than anything else.

(These are remarks made concerning
Kodachrome slides)

The Alta fescue lawn at Beltsville at the Plant Industry Station is still good but we know today that planting Alta fescue alone is not the answer. In mixtures it has a place all over the country. This is an Alta fescue lawn in front of the clubhouse on a golf course in southern California. It is quite beautiful and holds its color during the drought that they had and they love it. This is part of the lawn and Alta fescue, bluegrass and highland bent are the mixtures.

This is aerification on the putting greens at Merion Golf Course where the USGA Open Championship was played this past June. Here is an implement that should be used more and more on turf areas. For the last three years this flexible comb has been used on fairway mowers and has been removing crabgrass from fairways. The combs kept the crabgrass runners combed up, the mowers kept them cut off and what was surprising was that the little crabgrass that was left was actually contributing to the turf.

This is a piece of U-3 bermuda turf cut constantly for the past three years at ¼ of an inch. It has never been irrigated and it produced a fairly satisfactory putting surface almost all of that time.

This is zoysia turf never irrigated, producing a resilient cushion of turf, insulating the soil against heat and was preventing evaporation of moisture. This is zoysia seed that is producing 1000 pounds of seed to the acre. That is a single zoysia seedling, one season old. The zoysia creeps somewhat like bermudagrass, but is not as aggressive and is easy to destroy. We can reproduce that kind from seed and it blends well with the cool-season grasses for year-round trouble-free turf. One golf course in Washington has built a series of hot beds where they are germinating zoysia and are setting the seedlings out into the fairway. They will do that only once and that will determine how aggressive it is.

These are bermudagrass fairways at Tulsa, Oklahoma. They are absolutely devoid of color, yet they play beautifully. People love to play them. This is bent greens and bermudagrass is one of the problems. It has been solved largely by the use of methyl bromide. 48 hours later the area can be replanted to the proper bent. This is Seaside bent that was left after the invasion of bermudagrass. It was all killed with methyl bromide and reseeded to Seaside bent.

At Tifton, Georgia, Tifton 57 bermuda is being introduced experimentally into common bermudagrass turf. In about one season, the Tifton 57 crowds out the common bermuda.

At Jacksonville, Florida, they are using mixtures of bluegrass, bent and fescue for their winter putting greens, trying to evaluate this mixture as to whether it will be superior and cheaper to ryegrass which is commonly used there. When we evaluate different bentgrasses for their vigor, we put them into solid bermu-

dagrass as 4¼-inch plugs. In one season we can tell if it is vigorous because in order to stand the summer competition of bermudagrass, any grass must be mighty vigorous. Here we are introducing cool-season grass into U-3 bermudagrass turf. We aerified the area and then seeded. The only place we got establishment was in the Aerifier holes. This tells us that we must aerify more in order to get those holes closer together.

This is a view of Ed Geary's irrigated ranch at Klamath Falls, Oregon. He was the first commercial grower of Merion bluegrass. This is one of his methods of irrigation. This is a view of a field of Merion bluegrass seed at LaGrande, Oregon, where H. L. Wagner is growing the seed. That field yielded about 400 pounds of seed to the acre this year. This is a field of creeping red fescue on the Wagner farms.

This was an excellent bent fairway at our trials at Beltsville. We aerified it in the spring, seeded to Merion bluegrass and a year later the bentgrass was completely destroyed by disease and the only thing surviving was Merion bluegrass. It was not irrigated and was cut continually at half an inch. Now a year later the Merion bluegrass is nearly solid.

This is a compilation of the results between Merion bluegrass and commercial bluegrass. From the standpoint of quality, appearance, color, disease resistance, drought tolerance and crabgrass resistance, Merion bluegrass is way out ahead. Results coming in a year later simply substantiate those results.

Here is U-3 bermuda in southern California after the third heavy frost. The common bermudas that have been in there went off color at the first frost.

Here are Urea-form trials on the Alta fescue lawn at Beltsville, Maryland. We have had them on several different stations on several different types of grass and are satisfied that they produce the growth we want in turf.

Those of you who read Better Homes and Gardens probably read about maleic hydrazide and how it can slow down the growth of grass. Then you won't have to mow it. That is mighty enthralling to the home owner, but it isn't to the grass. In our case, most of the applications killed the grass which, of course, slowed down the growth. Then crabgrass took over.

# SOIL DRAINAGE

J. W. Funk
Kansas State College

I think that all of you have seen the many benefits we receive from aerification. There are a good many problems that come up along with soil drainage which are tied right in with that aerification. The main reason we are interested in soil drainage is that we do want soil air right in there available to the plants. Here in the mid-western part of the country, drainage is usually thought of as a strange problem because our conditions are associated with being somewhat droughty. Oddly as it may seem, the areas that need drainage very much at the present time, and which are getting the attention of many of the drainage experts, are the irrigated areas. Many of the turf problems which come up can be traced to irrigation practices.

We realize that drainage is important from several standpoints. I think that most of us at some time or other have dug a post hole and tried to put a post right back in there. But we found that there was a lot of pore space and we needed more soil to fill that hole back up even though we had the post in there. When we put water in that soil that we put back, it compacts even more. Of course, compaction is one of the problems that comes along with this growing of turf. It seems to be a very important problem, and is one of the problems we are very much concerned with. Compaction cuts down on the supply of air.

Under good drainage there will be adequate opportunity for the water to move away so that any little mechanical force on that turf will cause less compaction. That is very, very important.

I believe we are all pretty well agreed that drainage is important, but we must consider as well what types of drainage we have. Actually there are three types. One is air drainage and there is very little we can do about that. The only thing we can do is watch the location of our turf areas.

The other two types of drainage are important and they are surface drainage and internal drainage. In surface drainage we have two types which are of importance to us. There is always an excess of water particularly in the mid-western part of the country. The rain tends to come in rather short periods but is rather high in

intensity and a good bit of it may run off. That can run off in two manners. One is that it can run off very rapidly and cause trouble or it can run off slowly and may accumulate in pockets and that might cause trouble. As a general rule people who are interested in turf do not need to worry about runoff water that is running off slowly.

Then we get the other extreme and, in that particular situation, the water is moving very rapidly over the surface and in a good many cases we want to get it off of there. That is the situation which we are confronted with in a good many of the turf areas because we want them as flat as they can be. But they can't be flat from the standpoint of the water standing on the turf. It has been found by those people doing research that a good turf must have a slope of about 2% in order to get good surface runoff. As far as football fields are concerned, it means that you will have probably an 18 inch crown in the middle in order for the water to move from the center to the outside in a satisfactory manner.

The next problem which comes up along with surface drainage is what happens to water after it leaves that particular area on which it fell? If it goes right into a natural spot and can run on down to the natural streams, then it is no problem. But if it goes to some low place and stops, then we do have a problem. That can be corrected generally by fixing the contour of the land so that the low spots will be eliminated.

A football field is something that is typical of these flat areas where you do have a crown in the center and the water can runoff to the side. But what happens to it when it gets there? The only possible solution is that we must have some type of drainage to take the water away. It must be a surface inlet to a tile line to allow that water to get away.

In all of our water management, we try to apply the right amount of water, but many times we do not. But under condition, we need internal drainage. That is simply the removal of excess water from the soil profile so that there will be adequate pore space in the profile for the plants to develop in a good manner. We are very interested in that soil air in there. Any plant which has adequate soil air available to it, as well as adequate moisture, will grow a fairly deep root system which is a very desirable thing. A deep root system means that the plant will be more resistant to insects and disease.

What are the conditions where we need internal drainage? In the first place there is a need of water moving through the soil profile. It may be that we have small soil pores which we associate particularly with clay soils. We are going to have trouble with the water moving on down or in any direction you try to move it in a clay soil. That means that if the soil on which this turf is grown has considerable clay in it, there will be considerable time involved for the water to move down through the soil profile.

As is quite often the case, we have a clay pan that is practically impermeable. What are we going to do about it? An internal drainage system is generally necessary. Subsurface drainage systems generally include a tile of some sort which is used to collect water and transport it to some outlet so that it can flow off in our natural channels.

When I say tile, there can be a couple of kinds. You can have cement tile or the ordinary burned clay tile. There are a few limitations which we must put on it. In the first place we are bound to have certain possibilities for the water, as it flows through the soil and into the tile, to pick up some soil particles. If it does and the particles get into the tile, those particles might drop out and stop up the tile line. So the tile must have a definite grade and an 0.2% grade is suggested as a minimum.

How does the tile work? I imagine there are some of us who have the mistaken idea of how the tile works. In the first place, it is just a small cylinder of burned clay. The tile used here is a little different from that used for sanitary sewers because there is no bell joint on it. The tiles are simply laid end to end and the water flows through the crack between the tiles. They are usually laid together just as closely as can be. Does that sound odd? Well, it really is not, because most of them are rough enough on the end so that the space is large enough for considerable water to flow through.

It is possible to buy two different grades of tile. One is rather porous and the other quite water proof. It is much better to buy the tile that is not completely water proof but is fairly water proof because water within the structure of that tile is very important. The tile itself is usually laid on a solid footing. A trench is dug with a slightly rounded bottom so that the tile will stay in position. Over the cracks between the tile on the upper side only, a

small piece of tar paper is put on mostly for the purpose of keeping out anything that might fall in during the construction process. Later on the water will enter from the bottom side anyway. Above that tile area generally is a layer of about 8 inches of a small gravel which is quite permeable to water.

Now what about an outlet? Generally you will have water flowing at seemingly odd times of the year. That means that you are going to have a very wet area at the outlet of this tile. That means it should go to someplace where it won't be objectionable. That is usually a natural ditch. We cannot run the line out into mid-air, but we need a structure of some kind right there. It doesn't take much to protect the tile outlet and it should be built.

On the end should be a removable gate or screen of some sort. That should be removable so that if there is anything inside, it can come out. Surprisingly enough, the roots do get in there particularly in the spring and tend to come on down the line and get caught on the screen and stop up the line. So a removable screen is quite an advantage.

We have to fit the tile together and form some type of system. We have some definite systems which we should try to follow up so that we will get effective drainage all over the area which we are trying to drain. In order to do that we must consider some of the types of systems. When we have a clay pan layer which outcrops in some particular place and causes poorly drained conditions, we can lay a tile right in close to the place where it comes out and collect the water. That is generally called an interception system. As a general rule, however, we are interested in broad areas where the same problem exists over the entire area and we have to apply the system so as to give the water a chance to get into the drain.

There was one thing that we must think about and that is as a general rule if you have a system coming from two different directions, that means that two lines must join and if they join, you will probably have some trouble. The best way to avoid having any trouble like that is to use a manufacturers joint or a Y with a desirable angle in it. Generally the joint is an angle of $45^{\circ}$ or less. You can buy a regular joint from the manufacturer which will fit right into the system. Or it is possible to fit regular tiles with a chisel and hammer, but that is a lot of trouble. So those probably are not so good. The best way is to

buy the manufactured joint.

We haven't mentioned one thing and that is how closely together should e place these tiles and how deep they should be. These are two problems which are tied right in together. The deeper they are placed, the farther apart they can be spaced. The tiles are placed much closer together in turf and are much closer to the surface than for agricultural land. Probably a desirable depth is about 20 inches and a desirable spacing is 20 feet apart. Of course, this tile would generally be placed when the green was constructed so that there will be no later disturbance. The system should function satisfactorily with no trouble later on.

There is one thing that has been used quite a bit in England and that is the mole-drain. The mole-drain as a whole is a drainage channel with nothing left to hold it. A steel conical shaped piece on the front of a machine is pulled through the ground and it forces the dirt off the side and when it gets through, all you have left is a round hole. There is also an opening to the surface. They can be used fairly easily. There is a little bit of trouble for the water to enter through the side of the opening because, in the first place, the sides are compacted. Generally you need a fair amount of clay in the soil in order to get the mole-drain to stand up. The big thing with them is making a connection into a drainage system after you have it across the area. An already constructed green can be mole-drained without stopping play. There is nothing on the surface that will show up and will not cause any great amount of trouble. But some digging will have to be done so that the water that comes into that drain can come out and go into a natural opening someplace. I think there is room for considerable work to be done on the use of the mole-drain in this country.

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# CARE OF TREES

Ray A. Keen
Kansas State College

The matter of trees and turf is usually in conflict. Turf men and home owners usually want to have their cake and eat it too. They want a lawn and they want trees in the same area. We know that the best lawns and forests are seldom found one on top of the other.

Trees require all of the good things that you have said about soil that the grass requires. Ordinarily, out in the timber where the tallest trees grow, the soil gets an annual layer of leaves which act as a top dressing and it gets every bit of the twigs and branches that fall. The trees are a permanent type of vegetation, we want them in our golf courses and institution grounds. The soil has a layer of grass on top. We know the requirements for grass and take off some fertilizer and plant nutrients in that crop of grass we mow, we rake up every leaf and twig that falls and carry it away to the compost heap. The soil is walked on by people, run over by machinery and if that doesn't get it compacted, we go out with rollers and roll it some more just to make sure that it is well compacted and not springy. This all results in bringing the roots of the tree to the surface. They can't get along without air any better than the grass can. So the grass roots and tree roots are in direct competition.

I want to show you a few pictures now and take a tree program from the planting to the final removal which, we hope, will be 300 or 400 years away. Let's begin with the selection of trees. This is one of the quadrangles on the campus in the winter time. You can see the structure of these young trees. These are growing upright, but we want in this area a high tree so that we can see those lovely college buildings.

Here is a young tree and it is characteristic of most young trees. It grows with a single strong leader. When you get trees from the nursery and plant them, retain that leader. If you have to remove every other branch from the tree, still keep the leader. Ordinarily it isn't necessary at all, but it used to be the fashion to remove the leader from the top of the tree, and then the tree would not grow straight.

When we buy trees from the nursery, there are always

labels on them or they should have labels on them. In this case the label wire hasn't been removed. It girdled the tree and the top of it is dead. In planting trees, remove the label if it is wire and be careful about putting guy wires around the tree if they are unprotected metal.

As I mentioned, it was the fashion to take the leader off the tree. The tree responds by branching out in every direction as this one does. We have this condition arising as a result. The branches all grow from a single point. It is very important to keep that leader or select a new one to replace a leader that has been lost.

Here are two leaders on a single tree. Notice that they have come to a parting of the ways. The tree has begun to split, which is a very common thing where the top is removed from the tree. The best cure is an ounce of prevention. All is not lost when a double leader splits. By properly cleaning that area up and keeping it painted over a series of years, the callus will roll in and the tree will be saved. It is never as nice as a tree that is properly grown, though.

The big complaint against the old soft maple is that they last only 50 or 75 years. We should think of those who come after us and leave some long-lived hard wood trees for them. A good way to prevent that damage is to use good structural engineering and get up into the tree and take the load off of the branches with cables. The stronger structured trees require no such extra treatment. If possible this type of support is the best, non-rigid support. It is called triangular cabling by the arborist.

In removing branches a great many mistakes are made. We saw them off at the shortest diameter and the food doesn't move up and keep the stub alive so that it heals over. Food moves in nearly a straight line down the tree trunk. We should not leave stubs.

When some people cut a branch, they get up and cut it at any place and in any way and then it splits and leaves a ragged wound that doesn't heal. There are three cuts to use on every large limb. One of them should come up from below out on the limb, one up from below to prevent splitting and then go out beyond the undercut the diameter of the branch and saw the limb off, and the third cut is down next to and flush with the trunk and that gives you a perfect job that will heal. Then put a coat of good quality tree paint on

the wound. On evergreens it isn't necessary to paint. As soon as a branch is removed, the resin begins to be deposited and protects the branch. But if the wound on an evergreen is large enough, paint should be used.

This shows the healing rate that a healthier tree can be expected to produce. Notice that the healing is most rapid from the side of the wound. The paint protects the exposed wood.

People often ask the question, what should we do when elms get too big? Here are two trees that are the same age. This shows the topping process, not done by good men, but by tree butchers. If your budget allows it, it pays to get expert care for your trees, men who are not going to fall out of the trees because they use proper equipment and know what they are doing. A hand saw is dangerous and a power saw even more so.

This man is using a pull cut type of saw, one that keeps the man closer to his work and each stroke pulls him closer to the tree rather than swing him away from it. He is wearing a harness and safety rope. If a limb falls and hits him, he cannot fall out. That makes them relatively safe up there.

Here is a tree that has been topped. You can see that it has developed a fine new head. But let's look at it ten years later. Notice that these square stubs have all decayed inside and the tree is really on its way out. The telephone people and power and light people observe the law that no two objects can occupy the same space at the same time. So they remove a tree limb. If they would be a little bit neater about it and take the limb off down next to the trunk, many trees would last many more years.

A raised water table will sometimes surprise you and kill out the large roots at the bottom of the tree and sometimes result in its death or damage to the tree. In this case Campus Creek which usually is dry for a number of months during the year, has been running now for a number of years and the deep roots in this tree were killed. The tree was blown over by the wind.

This is just the reverse. They raised the grade in this case and put a dry well around the tree. Then also they put a rock fill around the roots so that they can get air and the tree is still alive today.

How much can a tree take? This is Oakley, Kansas, where they get 15 to 18 inches of rain a year. On one side

of these trees there are store buildings and on the other paved street with a planting strip two feet wide. There is a row of honey locust in there. Yet they are still growing. I think maybe we can plant some other trees also and get good results from those tough spots where the more common trees refuse to grow.

Just a word about fertilizer. If you want fertilized trees, you must get it down to where the roots are. There are many ways of doing that. You can drill holes down and place the fertilizer in the holes. You can punch them down using a crowbar, which compacts the soil somewhat, but it also gets the fertilizer down. There are other methods of putting it in the soil by injecting it in liquid form or blowing it into the soil by using compressed air with the fertilizer in powder form.

Here are some of the troubles we have with trees. This is chlorosis or iron deficiency. Here it is in a pin oak. By treating those trees with equal parts of sulfur, aluminum sulfate, iron sulfate and ammonium sulfate, you can sometimes get good results, fast growth and good color. Here is a tree that has chlorosis only on the one side. We have treated that soil many times. You can see the difference because on one side the leaves are dark green but not on the other. This is all in one tree. We know these minerals don't move around the tree as much as we expect. That tree was treated by an injection method. The tree greened up in just a matter of a week or so as we see in this second picture.

Another common thing you see on trees that have white wood is this bleeding or wet wood disease. Inside that tree trunk, if you put a pressure gauge on it during the warm season, you will find that the pressure will go up. I measured 16 to 20 pounds here on the campus. This is due to fermentation by bacteria that are in these wet wooded trees. We don't know how to cure it, but we can help that wound heal by drilling a hole practically through the tree. When you drill through there, have on your old clothes because if the pressure is up, it is going to gush out like warm beer and will smell worse. After the pressure has been released anything it drips on will be killed, the liquid is so toxic. So we put a short pipe in there which should fit tight and paint around it first to let it drip out away from the roots. If you write us, we will be glad to send detailed directions.

Frequently we have people ask what to do when they find mushrooms or toadstools growing on the side of the tree. It is usually too late then to save the tree. This is a honey locust with a beautiful fungus on the bottom. It is not marked on the tree, but mower damage at the base of the tree gave the fungus entrance to the wood.

Here is another tree trouble. In this case it is the cedar hawthorne fungus. Here is the same thing on the cedar. You can keep it off by spraying with a good fungicide.

These pretty little things are eggs of insects. Those eggs hatched out into these little worms. They have a ravenous appetite and in a few months can make a tree look completely bare.

Occasionally we get letters telling us that there are borers in the tree. This damage is not borers at all but is caused by sap suckers. They are a rather large member of the woodpecker family. They eat the inner bark. Lead poisoning (with a gun) is the best way of controlling them. They are not beneficial like the redheaded woodpecker and any other woodpeckers that live off of insects.

Here are some borers and the type of damage they do on the inside of the tree. There are long tunnels and you can generally find the exit holes, but have difficulty finding the entrance holes. The best protection against those is to keep the tree growing vigorously.

Not all insects are harmful. We have a great host of beneficial insects. The past year the city spent quite a little bit on having the entire city sprayed for canker worms. The past season there wasn't a single worm to be found. I live over the hill outside the city and my woods were completely defoliaged when the city was sprayed. But this year I wasn't troubled because the parasites had destroyed the canker worms.

We have methods of controlling these insects and diseases all of them involving some of the new spray materials. This is the hydraulic type of sprayer where you take many gallons of water to put on the spray material. They are quite effective in reaching the top of trees and especially in applying fungicides where you want the whole surface of the leaf covered.

A word of warning now about using spray equipment for insect, disease and weed control. In this case it is

a truck depot out in one of our western cities. It is a place where they unload drums of material for oil wells and also an occasional drum of 2,4-D or other weed killer. A little bit got spilled around here. But look what is happening over here. The trees are dying and for blocks away, you can trace this damage to plants. The more sensitive ones were killed, but it only damaged the more hardy trees.

Of course, not all damage comes from that sort of thing. Up at the National Shade Tree Convention, they had this exhibit. You saw this tree-destroying bat. It is an ordinary baseball bat, but in the hands of children in the play ground who beat on the tree, you will find that they can kill the tree.

This is the last picture just to remind you how much we really need and enjoy our trees and also one last reminder of the things that are threatening them and to make you remember what you had planted. This is an elm shaded street. These trees make up 71% of the trees in Manhattan. Phloem necrosis threatens to take out 99 out of every 100 elms in our cities in this region. It has done it in the states of Ohio and Kentucky and back there. So be careful of what trees you plant. A great host of trees are available. Don't stick to elm. It is a wonderful tree, but I am sorry to say, it is on the way out at the present time. It might be a good idea for the golf courses, institution grounds, cities and so forth to plant a number of different kinds of trees which are well adapted in size and requirements to the site.

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## INSECT CONTROL ON TURF AREAS

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Before considering the control of insects causing injury to plants on turf areas, one needs to know something about insect habits and the various stages in their life histories which have some bearing on the insect control problem. I shall confine my discussion primarily to the control of insects which destroy or interfere with the proper maintenance of the sod grasses, and not those insects which attack ornamental flowers and trees grown on turf areas.

Most injurious turf insects are soil inhabiting species; that is, they live in the soil or on the surface of the soil sometime during their life cycle. Many begin feeding beneath the surface of the soil, and then proceed from the soil to the main stem or crown of the plant. Some may feed upon the parts of the plant above ground, and then return to the soil to deposit eggs or to complete another stage in their life cycles.

Many of the turf insects formerly fed upon the roots of the native grasses and have become a problem with the introduction of the new cultivated grasses. Man has upset the balance in nature to such an extent that insects feeding upon native plants were forced to change to some of our cultivated plants. Therefore, they are not in their natural environment where formerly they did little damage to the turf. Some species cause trouble after being disturbed and deprived of their original food plants. Man has really brought the problem upon himself by disturbing the natural balance in nature.

Some species destroy the surface vegetation only, while others feed upon seeds and destroy roots. A few species do not cause damage, but are an annoyance and interfere with maintenance operations such as reseeding and mowing. Often the destruction of the turf grasses causes dead areas to appear, and soon weeds such as dandelions, crabgrass, foxtail and various others fill in the dead spots. Some of these weeds furnish food for the adults of certain insects, and thereby attract them to the area in which the eggs are deposited. When these eggs hatch, the young feed upon and destroy the turf grasses.

There are several conditions or practices which favor the development of turf insects in the soil or on the surface of the soil. Sometimes the turf is neglected and the desirable grasses die and are replaced by the undesirable species. Webworm moths, cutworm moths and other grass-feeding moths are attracted to these undesirable plants and lay eggs on the area. The larvae or nymphs then attack the adjoining desirable grasses. Neglect also permits ants, burrowing wasps and bees to construct mounds and dig burrows unmolested.

Too close, as well as too frequent clipping, attracts May beetles to the area, since the females prefer grass in shaded areas are avoided for egg laying. Closely clipped lawns are not conducive to long lived lawns and greens, but they are the type most desired

by home owners and golfers.

Occasionally, one sees a home owner sitting on the front steps of his home reading the evening paper while holding the hose and sprinkling the lawn. He does this daily during hot summer evenings. These light applications of water keep the surface of the soil moist, and lowers the temperature through increased evaporation. This procedure is beneficial to the grubs, because the surface is cool and they can feed continuously on the grass roots close to the surface. If one soaks the soil thoroughly, and then allows the sod to become dry for two or three days before watering again, the grubs will leave the surface and go deeper into the soil and do less damage. Frequent light applications of water does the grass very little good, so soaking the sod thoroughly is also good management.

Heavy applications of sheep and barnyard manure which are not well rotted attract May beetles to the area to deposit eggs. The young grubs feed upon this organic matter and small roots during the first summer, and then attack the roots of the grass the second year. Compost or commercial fertilizers do not attract the beetles, and their use also prevents the introduction of undesirable weed seeds. Another advantage of the application of commercial fertilizers is that a good soil insecticide may be applied at the same time.

May beetles and the Japanese beetles feed upon the leaves of shrubs, trees and vines and, therefore, are attracted to the area and deposit eggs in the soil near where they feed. Ornamentals are a necessary part of landscape design, so they should not be eliminated. This is a problem we can do little about unless the plants could be sprayed to kill the adults. Usually, May beetles do not deposit eggs in the soil very far distant from where they feed.

An observation made in Wisconsin indicated that the beetles fed upon the leaves of isolated trees and clumps of trees in pasture land, and then deposited eggs in the bluegrass sod on adjoining sloping hillsides. The grubs which hatched from these eggs killed the grass that exposed the soil to erosion forces, and resulted in the loss in soil and the formation of small gullies.

Large numbers of May beetles are attracted to porch lights, yard lights and lights in parks and around baseball fields. There is some indication that the

females attracted to lights have already deposited their eggs. However, there needs to be further study to determine whether or not these beetles are responsible for the grub population in the turf in the vicinity of the lights. There is a possibility, however, that some species which come to lights may influence the number of grubs in the surrounding turf.

Pure stands of grasses, especially bluegrass, are attractive to these grubs. Kentucky bluegrass is especially attractive to the grubs, more so than a mixture of grasses or a mixture containing white clover. Grub injury is more evident in the spring following dry seasons, because grasses are weakened and more easily killed.

Insects commonly causing injury to turf grasses are those that attack the roots. White grubs should be first on that list. Not only is it injurious, but like all soil insects, it is difficult to control. Chemicals applied to the soil to control the grubs often affect the soil or the plants. Some of the new insecticides show promise of being safe and effective insecticides. Some are quite toxic to soil insects, and only small quantities need to be applied.

The Japanese beetle was mentioned as a pest of turf in the eastern states, but does not occur in Kansas at this time. It will, no doubt, reach Kansas sooner or later. Kansas is centrally located and usually gets the eastern insects as they disperse westward.

Sod worms sometimes cause considerable injury to grass plants in turf areas. Their presence may be recognized by silken webs to which are attached particles of soil. These webs lead to a silk lined tunnel in the soil, usually at the base of the plant. They feed upon the leaves and sometimes cut the plant off as do cutworms. While they prefer bluegrass, they also attack other species of grass.

There is a small bluegrass curculio, the larvae of which feed largely in the stems as a borer. In the Plains region, the mound building prairie ant destroys the surface vegetation in the vicinity of the mound, gathers valuable grass seeds which are needed to regrass the area and constructs mounds which interfere with the proper maintenance of the turf. Armyworm and cutworm moths are attracted to annual weed grasses and dandelions which occasionally replace sod grasses, and the larvae feed upon bluegrass. As a matter of fact, cutworms will feed on dandelions and attack grasses

nearby. Chinch bugs have been known to suck the sap from lawn grasses and turn the plants yellow.

Insects and other animals which cause considerable annoyance at one time or another, but do not destroy the vegetation, are ants, digger wasps, ground beetle larvae, burrowing bees and common earthworms.

These animals burrow in the soil to construct nests and burrows and often make mounds of soil. This soil interferes with mowing and other maintenance operations. Earthworms bring castings of soil pellets to the surface and are sometimes reported as objectionable.

Now I should like to call your attention to some things we can do to prevent these turf insects from using the turf as a abitat and causing injury. First, follow the recommendations for establishing a good turf. The substitution of native sod forming grasses may solve part of the problem. Many fine lawns have been maintained in the Plains area through the use of Buffalograss. Second, the control of crabgrass and weeds through the use of weed killers and the maintenance of a heavy turf. Third, soaking the area thoroughly when watering rather than the use of frequent light applications. Fourth, permit the grass to maintain a fair growth by not clipping too closely. Fifth, commercial fertilizers should be used in preference to barnyard manure unless the barnyard manure is well decayed. Sixth, the application of soil insecticides which have been found to be effective against the insects and not injurious to the vegetation.

I have listed here a few of the recommended insecticidal treatments which are being used at the present time against turf insects.

Results are variable depending upon factors or conditions all of which are not known. Japanese beetles are easier killed than are common white grubs because the former feed closer to the surface.

Following are the names of recommended insecticides, rates of application, methods of application and the insects which are to be controlled.

1. White grub-- Lead arsenate-- 10# per 1000 sq. ft. worked into soil.

   Chlordane-- 2 oz. actual chlordane per 1000 sq. ft.

BHC-- 2 oz. gamma isomer per 1000 sq. feet.

DDT-- 4 oz. actual DDT per 1000 sq. ft.

2. Sod webworm-- 5# of 5% Chlordane dust per 1000 sq. ft.

3. Ants-- Ordinary lawn ants.

Chlordane-- 4 oz. 50% wettable powder per 1000 sq. ft.

1# 5% dust per 1000 sq. ft. at weekly intervals for three weeks.

1/8 tsp. of 50% wettable powder per hill. Water thoroughly.

4. Mound building prairie ant.

Use one oz. of 50% wettable powder of chlordane in one gallon of water and soak mound around the entrances. Leave the mound and repeat in about two weeks.

5. Chinch bugs-- Use 5# to 10# of 5% Chlordane dust per 1000 sq. ft.

6. Cutworms, armyworms-- about the same as for sod webworms.

In applying dusts I think it is advisable to mix the insecticide with a little soil or sand to dilute the insecticide and one can get an even distribution on small areas. It is best to mix the chemical into the first three inches when the lawn is being built. It is more difficult to work insecticides in after the sod is established. However, if one is working-over spots in the sod, I think it is well worthwhile to dig up the soil and work it into the spot. Occasionally, it is necessary to treat the spots and not the entire area. Some places in an area under shade may not have grubs so that one need not treat the whole area. One should be sure to get beyond the dead spot into the edge of the turf when spot treating is done.

I might say in conclusion, that turfs here are more difficult to maintain. We know that in this Plains area even though we have drought, insects, high temperatures in the summer, high evaporation at the surface, we do have some nice lawns and in the last few years they have been quite attractive. The last few years have also favored the soil insects. There has been considerable decaying material in the wheat lands and that has attracted these little May beetles. The application of these insecticides may not kill the grubs that are already in the ground, but it may prevent the little larvae from getting started.

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## WEED CONTROL FOR TURF AREAS

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The presence of weeds in turf areas constitutes a universal problem, whether in lawns, parks, cemeteries, golf courses or airports. This condition usually is due to one or more of three causes; viz:

1. establishing the turf on weed infested ground
2. planting impure seed containing weed seed
3. low vigor and thin stand of grass due to improper management.

Prevention of weed infestation is as easily achieved and much less expensive than combating weeds after the turf is established. The first preventive measure is to make the soil as free as possible from weed seed before planting the grass. The longevity of the seed of certain weeds may make complete elimination impossible, but such seed should be reduced to a minimum by fallow over a period of several weeks or months. If a combination of cropping or fallow can be carried on over a period of two years or more, so much the better. The time and method of elimination of weed seed in the soil will depend upon the species of weeds present. Crabgrass is one of our commonest lawn weeds here. Treatment of the area to prevent seed production for a season will greatly reduce the danger of trouble since this seed does not retain its vitality a long period.

Needless to say, the seed used for planting should be free from seed of troublesome weeds common to turf areas.

Low vigor of the grass may result from any one of three common causes:

1. Starvation

2. Close clipping

3. Lack of moisture

Obviously starvation can be corrected by the proper use of fertilizers. This phase of turf maintenance has been adequately covered by other speakers on this program.

Close clipping is one of the main causes of weedy turf in most sections. We admit that mowing is necessary to keep the area attractive and to maintain a good turf. Cutting too close and too often, however, is extremely injurious. Probably more lawns in Kansas are destroyed by frequent close clipping than from any other cause. It should be understood that the food which supplies the energy for growth and certain vital processes in the roots, as well as in the parts above ground, is manufactured in the leaves. Constant restriction of the top growth by close clipping removes the source of energy and reduces the vitality of the plants. No perennial plant can thrive without sufficient growth to supply the energy needed for the development and maintenance of a strong root system.

Experiments have shown that the root system of bluegrass cut three inches high is from two to four times as extensive as that of grass cut one inch high. Likewise the amount of rhizomes is two to three times as great in grass cut three times as high.

Experiments carried on by the Agricultural Experiment Station at Manhattan show that there is a definite relationship between height of cutting and weed growth. There were approximately ten times as many crabgrass plants on a given area cut 7/8 inches high and five times as many on plots cut 1 5/16 inches high, as on plots cut 2 3/16 inches. Likewise there were approximately sixty times as many dandelions on the closely cut plots as on the plot cut 2 3/16 and ten times as many on the plots cut 1 5/16 inches. All plots were fertilized. Similar results showing this have been reported by Welton and Carroll in Ohio.

A dense turf tends to prevent seedling weeds from getting a foothold and those that may get started are forced to grow more upright as a result of the high cutting that seed heads may be removed in the clippings. Not only are these methods good preventive measures, but even established infestations may be crowded out by close attention to proper practices in management.

Thus far we have considered preventive measures. What shall be done with the weed infested turf? Good progress has been made within the last ten years but much yet remains to be done by way of adapting principles and practices now known to weeds of different growth habits and under various conditions of climate, soils and locations. For example, turf infested with the summer annual weeds such as crabgrass, aristida, foxtail and prostrate spurge should receive fertilizer treatments in early spring and in the fall to increase the competitive growth of the turf before the weeds get started or after their season of vigorous growth is completed. Watering likewise may often be timed to benefit the grass without benefiting the weeds. Winter annual and perennial weeds may receive spot treatments with a suitable herbicide to eliminate them if they are not too numerous. If the infestation is heavy, an overall treatment with a selective herbicide will check their growth, inhibit seed production and reduce the competitive effect to enable the grass to hold its dominance. Even deep rooted perennials such as bindwood may eventually be eliminated by repeated treatments with selective herbicides.

All such special practices should be merely supplementary to the outstanding principle of maintaining a vigorous growth of grass by the judicious use of fertilizers, high clipping and proper watering.

Chemicals have been used for the control of weeds for a long time. Nearly 50 years ago iron sulfate, copper sulfate, zinc chloride and certain fertilizers were used to kill weeds. Later sodium arsenite and still later sodium chlorate and the di-nitro compounds came into use. The greatest advance, however, was made some ten years ago in the discovery of the herbicidal properties of certain of the growth regulating substances, known also as synthetic hormones. This class of chemicals possess a greater combination of desirable properties than any heretofore known. Most other herbicides have one or more undesirable characteristics, for example:

Sodium arsenite - extremely poisonous

Sodium chlorate - highly inflammable

Ammate - very corrosive to spray equipment

Di-nitro compounds - contact-selective-but not translocated.

2,4-D is non-poisonous
non-inflammable
non-corrosive
highly selective
readily translocated
high potency

Properly used the chloro-phenoxy acetic acid compounds constitute the most useful herbicides known. They are certain death to dandelions, plantain and most of the broadleafed annuals and many of the perennials. Because of the suddenness with which these chemicals were turned loose to the public, precautions have been disregarded and damage to valuable plants has resulted in some instances.

Three formulations of 2,4-D are on the market:

Esters - soluble in oil - volatile - quick acting, highly potent.

Amines - soluble in water - non-volatile - slower acting.

Salts - soluble in water - non-volatile - slower acting.

The esters are dangerous to use anywhere near valuable trees, shrubs, flowers, or crops that are susceptible to 2,4-D. Because of the oil carrier, low surface tension and smaller droplets, a light breeze carries drift a longer distance than a water soluble formulation. Adding to the danger is the volatile nature of the esters. Use only in wide open areas, far removed from other vegetation.

The amines are much safer. Low pressure equipment should be used and spraying should be done only when there is no breeze. Even then it is well to cover valuable plants nearby, except evergreens which are practically immune. The amines should be used in parks, cemeteries, lawns, etc., never use the esters in such locations, except on weeds that can be sprayed

in fall or early spring before growth of shrubs, flowers and trees starts.

2,4-D retards growth in new stands of bluegrass and should be followed by the use of nitrogen fertilizer. Bentgrasses are likely to be seriously damaged by 2,4-D. Buffalograss may be damaged in hot weather when growing rapidly.

TCA is the best chemical to use for eradicating most noxious perennial grasses such as quackgrass, bermudagrass, muhlenbergia species and Johnson grass. It is classed as a temporary soil sterilant and its toxic effect disappears from the soil within a few months to a year in regions where the rainfall is ample for general crop production.

Sodium and potassium cyanate have shown much promise as a herbicide for killing seedlings of annual grasses in turf. Crabgrass and most other annual grasses that are coming into bluegrass can be killed without destroying the turf if the treatment is applied when the annuals are very young, preferably in the seedling stage. For complete control the treatment has to be repeated when new seedlings appear.

PMA has been widely publicized as a chemical for controlling weeds, particularly annual grass, in turf. Results have varied from fairly good to poor. Only when applied soon after the crabgrass seedlings emerged has it been at all effective in tests here.

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