1950

OKLAHOMA-TEXAS TURF CONFERENCE

1950

R. C. POTTS, CHAIRMAN

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Compiled by:

WEST POINT LAWN PRODUCTS

West Point, Pennsylvania

WELCOME

C. I. Pontius, President
University of Tulsa

Mr. Chairman, officers and members of the Texas-Oklahoma Turf Association, it is a real pleasure to be here and in behalf of the city of Tulsa and the University, we welcome you people and particularly you people from Texas. Any time that we can gain or take anything from Texas, we are just that much ahead. You know that spirit which you have in Texas. We are trying to cultivate it here in Oklahoma. The only time I see you disagree is when two Texas Universities have a football game-- then things get pretty intense. But you try to horn in on that and both sides gang up on you. That is a great spirit.

I'm pinch-hitting for my good friend, Joe Parkson. We used to fight the battle of turf and grass and water out here at Oakhurst, back in 1931-2-3, when we had lots of what we don't want now. I can appreciate how important water is to this story of turf. I was raised on a farm and I know a little bit about the effort needed to raise grass.

Now just before I came down here today, I received a communication from Dr. Howard Sprague, the director of the Texas Research Institute, of which I am a trustee, and I noticed a quotation that was very apropos to this today. "With twenty million people added to the world's population each and every year, and with dwindling natural resources, we must obtain more and more from less and less. The world's future is truly with science, the only frontier." I know that you men are scientists from the standpoint of improving the texture and quality and fighting diseases in the turf here in Oklahoma. It pains me, as a Pennsylvanian, to see a tree cut down in Oklahoma. It takes years to grow a tree and God knows we need the shade here. But I discovered that it is more difficult to grow a tree for shade and grass under it. We have tried about everything on the campus and today our success hasn't been anything to brag about. So I'm hoping that you men will give us the solution to that problem.

I would enjoy talking to you longer, but you have a very long program. I hope that you guests will find the city as hospitable as I have found it in the twenty years that I have lived here, that your conference will be instructive, and pleasing to you and

entertaining and that you will come back to see us again.

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WHAT'S NEW IN TURF

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

Fellows, it is grand to be here again. Thanks to both the Texas and the Oklahoma Turf Associations for making it possible for me to be here by paying my travel expenses. I hope that I can bring you something that makes my trip here very much worthwhile.

The best information that I can bring you tonight is a word of the research picture over the country-- primarily the training of young men in this important field. At our field day at Beltsville, Maryland, on October 19, we had ten students in turf from five experimental stations. We sat around for 3½ hours discussing research projects. I have never sat in a more interesting session. These ten students one by one got up and told what he was doing at the experiment station, how he was doing it, giving the techniques, explanations of how he came to be doing the work, and so it went all around the circle until all ten students had been heard from. Gentlemen, that is the salvation of our future-- the training of young men in this work. And that is why we are charting our course on a program of training more young men through turf research fellowships.

It is a thing we started down here at Oklahoma A & M and I have just indicated to R. B. Lewis, director of the Texas Station, that we would like to convert our research grant over to a turf research fellowship. A research grant doesn't train anybody; it just hires labor. But a turf research fellowship takes the cream of the crop out of an agronomy class, as Dick Potts, Mr. Elder, Dr. Murphy, and Dr. Sprague are doing. They pick the top men that are in the class and put them to work on a specific subject.

It is going to be my pleasure on January 28th to present this type of information to the United States Golf Association at the annual meeting in New York; we appreciate how you fellows have been working to get

this program underway to develop information right here in your respective states that is applicable to your conditions. We have known for a long time that the information that we develop at Beltsville, or New York, or any place else doesn't necessarily apply to your conditions here. You must develop the specific information according to your particular requirements.

I am going to lead off tonight with some pictures. I don't have all the pictures I would like to show you but those that I do have, I think, represent some of the significant advances in turf and again I say as you come to these meetings and as these students develop their problems, they are going to bring you this new information that I have more or less been predicting all along. I have known where we are going and I have had to look 10, 15, 20 years ahead. In fact at our field day I told the boys there that the program that we have started is building for the next generation. Well, actually we are developing information for immediate consumption but at the same time we actually are building for the next generation. Noer and I are not going to be in this work forever. It is impossible. We must be building for the young fellows to take up this work and carry on.

Most of you recognize Pine Valley Golf Club at Pine Valley, New Jersey. The principle thing I want to tell you about Pine Valley is not about the physical features, but about the tremendous change that I have seen in the turf in the past three years. It has been almost two years last week since I had seen Pine Valley and in that time I learned that he had been raking and aerifying the fairways once a month straight through the season. And I was impressed by the change that I saw. Every time I had been down there previously there were large dry spots in the fairways. The soil simply became dry and even though they set a sprinkler on there every twenty-four hours, it would not become wetter unless they went in there with forks, opened the soil, and let the water in. Since he has been aerifying, not one localized dry spot has occurred. In that time I have seen the bentgrasses improve and spread. I was really impressed by that and before that he had been having trouble getting bent grasses to grow. Now, that is all white dune sand and with some Pennsylvania clay added and it was not properly blended. It was put on in layers and apparently the aerification procedure has blended those layers and has given him a more uniform soil condition and better water-air relationships.

The other new thing there is the program of planting

of U-3 bermudagrass on the fairways. U-3 bermudagrass is being planted into the fairways in two inch plugs and it is rapidly taking over and giving them a clover free turf. True, it loses color in the fall but I am going to show you some more pictures of U-3 bermudagrass and let you be the judge.

From the architectural standpoint the new West Palm Beach Country Club at West Palm Beach, Florida, is designed so that every part of the course can be mowed rapidly with power machinery. They blend into the landscape perfectly and facilitate machine maintenance.

Here's another thing that is new. I say new because we have not as yet used it in practical golf course maintenance. These are plots of urea-form fertilizer on our Alta fescue lawn at the Plant Industry Station at Beltsville. We have been testing the urea-form fertilizer now for about four years. We have had three years of field testing on it and we are about ready to say that this is one of the fertilizers that we would like to have. We are not forgetting that the natural organic fertilizers are indispensible because of the minor and trace elements that they carry. Milorganite and other fertilizers are being used in these similar experiments as standards. One of the things that urea-form fertilizers seems to give us is long-time, slow availability so that one heavy application of nitrogen in the spring will last us throughout an entire growing season. Anyway it is quite new and we hope that it will come on the market this winter so that we can get some more tests on it. It will in no way replace or displace the natural organics on the market because as yet there is not enough of those to meet the demand. This is an attempt to supplement that demand.

This is Zoysia japonica producing a turf in our part of the country that we have never known before for golf. You notice the cushioning mat that it has produced. That is a firm mat against which you can play a crisp, pinch shot so that the ball will fly true. There is no question about that and we are not worried about the mat development because we know that we can control it with modern aerifying equipment. With this grass we can completely control crabgrass, clover, goosegrass, and most of the other weeds of turf because it is so aggressive, disease resistant and drought tolerant.

Our big trouble at Beltsville is crabgrass. And that is true of Washington, Philadelphia, Louisville, St.

Louis, Kansas City and all the way through there. Crabgrass no longer worries us because we know that we can whip it with the better grasses which we are growing today.

Here is a selected seeding of Zoysia japonica heavy with seed in the field. We are definitely going after seed production of Zoysia japonica. This is a field of Zoysia japonica in full seed production in Beltsville in June 1949. Those seed heads are so close they are almost touching. The yield was approximately 1000 pounds of seed to the acre. This is Zoysia japonica in the greenhouse. We took six of our selected strains that are high seed producers and took them in to get some additional seed. We stripped the ripe seed off these in the greenhouse, planted the seed in plots, and got seedlings and then set the seedlings out in the spring on two foot centers. By that method one pound of seed would plant 120 acres. One ounce of seed would plant six acres. So you see we can make a little go a long way if we set out minds to it.

Here we are using the common leaf sweeper in harvesting the zoysia seed. We are working on better methods of harvesting zoysia seed. Some of these plants produce seed very close to the ground. I don't think we need any suction, but we may need a brush because the seeds don't all come off.

Now turning to bents for a moment, I want you to look at a comparison of Arlington (C-1) bent and Washington bent at Rhode Island. Now Rhode Island is a long way from here and yet we see the same story repeated no matter where we are. Arlington bent is much more disease resistant than the Washington bent. Neither of these plots have been treated for diseases since about 1940. The Washington bent is almost all destroyed from the diseases. The Arlington is still healthy without any disease treatment. That is the thing that we are looking for and that is what I am going to talk a little bit more tomorrow on this disease problem.

Somebody was questioning today the statement that bent roots should not go down 12, 14, 16 inches. It has been done before; it is being done today; and it is going to be done more in the future. This is a set of putting greens cut at 3/16 of an inch at Pittsburgh. That plug is 12 inches deep and the roots are all the way down.

One of the new things that has come out in the past year is the mole-drain. It is not a new principle. It is a new machine adapted to turf, designed to drain a

green that had no previous sub-drainage built into it. How successful it is going to be remains to be seen. We have our fingers crossed. At least it is serving its purpose. I saw the experiments set up in New York a couple of weeks ago and it looks good. But I want to show you another use that this particular machine has that we are using at Beltsville. It makes these slits in the turf eighteen inches apart which makes a perfect opening for introducing new grasses into established turf without interrupting or interfering with play. That does seem to be the end of our efforts. We must let play go on as though nothing happened and yet we must maintain perfect turf and even improve it.

Here we are dropping seedling plants of Zoysia japonica. We grew the seedlings in the greenhouse during the winter and then in May the seedlings are all established and are doing well. They are then set on 18 inch centers in the furrows which are eighteen inches apart. Within a year or two we will have a turf of zoysia combined with bluegrass and fescue.

Here is U-3 bermuda and Z-52 zoysia at Cleveland, Ohio. They have survived at least one winter up there, and U-3 has survived at least two winters at Norfolk, Nebraska, and it is moving up into New York state and Connecticut.

U-3 bermuda holds its color later in the fall than any other strain of bermuda that we have worked with for the past fifteen years. We have had it at Washington for almost twenty years. It has never winter killed. It is sufficiently aggressive and yet not overly aggressive. You will be hearing more of U-3 bermuda in the future.

Now let's go down to Tifton, Georgia. Some of you are asking about these new strains that are being developed at Tifton, Georgia. They do have something better than common bermuda. Tifton 57 is one of the best so far. I think Tifton 57 is going to move westward to Texas, Oklahoma and California. It is highly resistant to the common diseases of bermudagrass. Tifton 57 has a finer blade, it is more free from disease, and it is more aggressive. Common bermuda is simply filled with disease. We are definitely moving in the direction of better bermudagrass through breeding, selection and testing.

Now at Beltsville we are testing bentgrasses on the fairways and putting greens. The question arose es-

pecially up there, "If we get bermudagrass on our golf courses, what's it going to do on our greens?" So in a three foot path between the bentgrasses, we planted two rows of sprigs of U-3 bermudagrass and in about four weeks they had covered completely that path. We are observing the spread of U-3 bermuda into the different bents. We find that where we have good, strong bentgrasses, the bermudagrass doesn't invade very much. But where we have weak bentgrasses, the bermudagrass invades rapidly. Doesn't that tell you something? I have seen bent greens down in this area that are weak and thin and have shallow root systems. They can't resist bermuda. But if they had proper drainage, proper soil conditions and were aggressive, the bermuda would creep into them very, very slowly. So we must make our bent greens better if we want them to keep bermuda out and when we do, you don't even have to worry about U-3 bermudagrass growing into them.

On my way through Philadelphia to New York to a meeting, I stopped off at Merion Golf Club where we have several U.S.G.A. tournaments to be held this year and next year. I saw this new design of the Aerifier operating on Joe Valentine's greens. He never would permit an Aerifier on his greens before because it tore the turf, it roughened it and it was not completely satisfactory. This is a newly designed self powered, hand-operated model. Here it is equipped with a device that I never saw before until last week and that is the wire coils or, I believe they are called Flexi-press, which shatters those plugs and produces a top-dressing. Here he is just making the first cut across the green and he goes in a circular direction ever-widening. It takes about an hour to do the average green of 6000 square feet. The next operation is whipping it with a bamboo pole. This has not been touched as yet with a pole. A light roller finished the job and I saw two golfers come on the green after the job was finished and you couldn't tell whether any thing had been done or not. There was no deflection of the ball because those coil springs had completely held the turf in place and it had not roughened the playing surface.

Now I know that there are many greens in this country that have not been aerated in any way because either the green chairman, the greenkeeper, or the members would not stand for the greens to be even temporarily out of play. So I do think this is an advance. We feel that this is another step in the right direction. We are continually looking for any new developments that will help us to maintain turf more easily and economically.

That probably isn't by any means all of the new things in turf that I can tell you about, but it certainly does hit some of the high-spots. I have been agreeably surprised at the way in which our National Cooperative program has developed. Next spring I am going to be out in California. The boys in Los Angeles and San Francisco are getting behind a research and educational program that they have never had before. Those of you who were out at the National Turf Conference and visited California courses will realize that they are going in the right direction. They have stuck year by year with seaside bent and in the winter when it gets cold, they have big blotches of discolored grass that turns dormant early in the fall and gets slick and you can't hold the ball on them. Three years ago I was here and I walked over every green at Southern Hills and picked every single spot of still green and active grass. I took 25 samples back to Beltsville. Those were planted carefully in the greenhouse, planted out in the field in the spring, and we planted plots of them in our gardens. Today two or three of those 25 selections from Southern Hills are quite outstanding. They stay green all through the winter, and there is no dormant period. That means a great deal to the golfer.

Question: Can you tell me anything about the cost, availability and adaptability of U-3 and Tifton 57?

U-3 is now being produced in two commercial nurseries. One is at Washington and the other is in St. Louis. The supply is limited because it is just barely started. The demand is far greater than either of those two nurseries can meet. Tifton 57 bermudagrass has passed the experimental stage and is being distributed to golf courses in lots of one square foot to a customer.

There is one thing that I have not told you about and that is recent results of the Merion (B-27) bluegrass. I saw some good bluegrass at Southern Hills today and I believe that bluegrass may have a place down here in combination with some of your perennial warm-season grasses. First we have to find the perennial warm-season grass that will allow Merion bluegrass to persist with it through the summer without undue competition. We have been very happy with it. It definitely is more drought resistant than commercial blue grass. In Denver they have to water fairways almost every day and Merion bluegrass will be green and thriving when common bluegrass is wilting and dry. We are definitely developing seed supplies of B-27 blue

grass. We were set back this year because of a freeze on June 28th.

One of the best pieces of turf at Beltsville today is common Zoysia japonica mixed with Merion. The common Zoysia japonica is fertilized and cut at about 3/4 of an inch, and before the zoysia started to lose color in the fall, the B-27 was thriving very well. So you can see what we are trying to do. We are striving to get seed production of Zoysia japonica, striving to get seed production of this new bluegrass. We have other things on the way. Penn State has a creeping red fescue that for two years has withstood mowing at a quarter of an inch. We have not been able to hold red fescue in Washington in pure turf but when we seed them with Zoysia japonica, they come through splendidly. We have found this out. Every place we have Zoysia japonica turf we always have a moist soil under that turf. It certainly looks as though that zoysia is going to give us something in the crabgrass belt. It may be one of the answers to the home-owner's problem-- a lawn free of crabgrass. But like many other things, these new grasses and combinations will require much testing before definite recommendations can be made and it is up to each of you to do a lot of the testing on your own courses.

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WHAT'S NEW IN TURF

O. J. Noer, Agronomist
Milwaukee Sewerage Commission

One thing that really impresses me is the group that I see before me from Oklahoma and Texas. I have been coming into this country for many years and, when I say that this group that you have here-- not only of men who are doing the practical work of maintenance-- but the talent from Oklahoma and Texas A & M to say nothing of Sprague and Tom Longnecker, I know that you are on the road to better things in turf in this area. If you can get these men from the station and from the school interested in working on your problems, you have accomplished a great deal. They have the tools and the know-how to do some of the pioneering work. Your job, as I see it, isn't to make an experiment station of your golf course, but to produce turf which is pleasing to the members of the club. For that rea-

son I feel that the basic work must be done by these people trained much better than you are in the work. Then you can take their findings and work with them to see whether they are adapted to your particular conditions. When you do that you are going to make the progress in the South that has been accomplished in the North.

I am always glad to see Fred Grau at these meetings and out around the country because I think Fred has done an outstanding job as director of the U.S.G.A. Green Section. I hate to see the curtailment in the budget which is preventing him from going to many of these meetings. I think that each and every one of you, if you have any influence, should do something about it.

As many of you know, we had a bad summer in the North. I felt that you must be getting along pretty good down in Texas and Oklahoma because there were no outcries from that area. We received plenty of them all the way from Kansas City up to New England and even Canada. As Fred said, it probably was one of the worst years we had in 25 years. I myself would evaluate it as the second worst since 1925. I think 1928 was a bit worse.

As I went around the country, the thing that impressed me most was the shallow roots. They really present a problem to the man who is charged with maintaining the turf. When roots are near the surface and temperatures are up in the 90's and 100's, it is no easy job to keep the grass in good playing condition. Some of the boys did it, but with them it was a seven day week, 24 hours a day. So I can't help but feel that that is one of our most pressing problems. We had more soil samples sent into us this year than we have had in any two years, and I know that the majority were prompted by shallow root systems.

I was glad to see those pictures that were shown, particularly about the non-capillary pore spaces. I think that we have not given enough thought to that. In other words, we have driven home to you for twenty years the importance of this 50-50 relationship, yet I think the framework of that soil is probably just as important as the amount of air. Unless we have a goodly number of those non-capillary pores in the soil, we are going to be defeated in times of heavy down-pouring rains even though the drainage is otherwise seemingly good. In other words, we must have pores in there big enough to move the water away rapidly.

I was in Chicago in June when the first heat-wave struck. On some golf courses the club officials were amazed that there was no turf around the cups. What happened was this-- it rained about 2 or 3 o'clock in the morning and when it stopped the temperature was still about 100. The players came on the turf with the water still on, and it would just ooze out of the turf with every footstep they took on the green. Then it was a wonder that turf suffered on those areas. And so I think that is one of the things that is extremely important and we must give more thought to the non-capillary pores.

I question whether even though we started out with the ideal combination of silt, clay, sand and organic matter that it will stay that way over a twenty year period. I believe that is why we are going to profit by the Aerifier, the drilling machine and other aerating equipment, in order to do what the ordinary earthworm was doing before we used lead arsenate and Chlordane to keep him under control. I am not trying to tell you to bring the earthworm back because the golfers will not tolerate a green covered with casts. That is just out and we must find some other means to accomplish what was being done in the past.

I think many of us in the North have an advantage that some of you don't have in the South. That is, while some of you laugh at us because of our winters and cold weather, I think the alternate freezing and thawing that we get in our soils helps to improve the physical conditions that we get in some of our sub-soils. And you don't have that advantage down here. You may not shiver as much as we do, but we do have some advantage.

Bob made mention of a thing which I feel is important and that is chlorosis. Incidentally, I saw some very bad chlorosis a week ago in Florida. I have seen much more iron chlorosis in the last year than ever before and I have seen it on soils that had over 20% clay. I feel that our trend toward over-phosphating and over-liming is tending to accentuate the iron problem. I have some analyses in my pocket for a man in this state and I just happened to look at the results for several years ago. I notice that at that time with the Truog method, there were about 200 pounds of available phosphorus to the acre. Today it is 800 plus and I can't tell how many plusses should go after that 800 because when we get up to 800, we know that there is so much phosphorus there we don't have to waste the time diluting it. I think that is probably a thing

that may be a factor, particularly on some of these soils where the reaction is well above usual. I wonder if we should worry quite so much about phosphorus fixation in some of our greens, particularly if there is a reasonable amount of organic matter present in the soil because I think the presence of organic matter tends to mobilize the phosphorus and prevent too serious fixation.

While I was in Florida, practically all of the mowers that I saw being used in the Miami-Palm Beach area were hand putting green mowers on the winter grass. The boys, I think, are going back to that on ryegrass and on most winter grasses. Maybe they are not wrong in what they are doing. They use a power mower, of course, in the summer on the bermuda. I saw injury last summer on our bents up North and I could show you a picture, if I had them with me, that I feel positive was aggravated by the friction of the drum on some of the power mowers, particularly in the hot, humid weather where root systems were shallow.

I have a picture showing brown footsteps on a green in Maine, just from the traffic of a player walking across when there was excessive wilting on the green. In Maine they are not accustomed to temperatures in the range of 90 and 100 and they are not accustomed to moisture deficiencies. But last summer they had the driest summer in 105 years and I suppose that they will never get another one while the present greenkeepers are still living.

I noticed while I was in Florida the condition of the bermuda at the time of seeding the winter greens. Some of them had completed the seeding because the season is starting earlier in Florida than it ever did before. Twenty years ago it was almost January 21st before they played on those courses. I saw a lot of play even in the Miami area and the Palm Beach area and I was told that play started this year in early November. But I was curious to see what the condition of the greens was with respect to the thickness of the mat of bermuda. I have a feeling that sometimes some of you have not had too good luck with your seedings because you have not been rough enough with the bermuda. The mat that Fred was talking about as a protection is a fine thing so long as the seed can make contact with the soil. But if the seed is scattered on top of a thick mat, it will germinate but will not really take hold and make a good growth. So if they work that mat, get the seed down to make contact with the soil, then if there is a mulch on top they get a

better stand of grass.

There seems to be a trend toward using more bluegrass in some of the greens in South Florida. In the old days it was straight rye and nothing but rye. Most of them are seeding with bluegrass and red top at the first seeding in the early fall and at the second seeding they come back with ryegrass. The reason for doing it is that the bluegrass seems to stand up better in the spring season along with the rye.

Fred showed you a number of bermuda's, the Tifton strains. When I was at La Gorce about 10 days ago and looked at the greens there, although they had been seeded with winter grass, I don't think it would have made much difference. The greens were so low that the fringes have been built up about six or seven inches above the outside and, as a consequence, the bermuda and some of these finer textured strains have taken over there. I know in particular that so far as the Number 14 is concerned, if the average golfer were told that it was a bent green, I am sure that he would not question the statement at all.

I also saw some fine work that had been done at one of the courses in renovation of a fairway. There are a number of fairways at the Everglades Club where they were anxious to get the St. Augustine and other strains out of the turf and develop a good strain of bermudagrass, and they certainly accomplished their purpose. They did it by using a combination of sodium arsenite and 2,4-D along with heavy rates of fertilizer. St. Augustine is a grass that doesn't tolerate sodium arsenite and goes out under those treatments. On the other hand, there is a course at Fort Lauderdale which is one that has a very sandy soil and they have never had any fairways until they introduced St. Augustine. They have a very fine stand on the fairways and I am sure that the players are very much more satisfied with the St. Augustine than the weeds and burrs that were on those fairways before that was done. I think maybe some of the more active clubs would prefer bermudagrass because, in my opinion, you can't get a better fairway than the close-cut bermuda fairway.

In Milwaukee during the Society of Agronomy meeting, a group went out to see Milwaukee Country Club and in that group was Dr. Hoffer who is with the Potash Institute. He is a man who is more interested in golf and turf than he is in selling potash. You can always take him out to see the turf on any golf course. Hoffer has been very much interested in tissue testing

and when we got out, he used the potash test which he had in his pocket to test some of the fairways. For the first time I felt that maybe he had something in which there was promise. The old cobalt tissue test I couldn't get excited about because I wasn't good enough to operate it and get consistent results. I felt that if I couldn't get consistent results, 50% of the greenkeepers would have the same trouble. So for that reason I wasn't very much impressed with it. But when he made those tests and got rather consistent results, I thought maybe he had something and I got him to send me some of the papers and I took them with me to Florida and used them. I will say that while I do not know whether the levels he set are correct, the tests have worked rather consistently. It looks to me as if it may have possibilities, and I hope that some of the boys at Oklahoma, Tom Longnecker and Sprague, and the boys at Texas A & M will do a little work with it. I believe you can get the particulars by writing to Dr. G. N. Hoffer.

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OBJECTIVES OF THE GREENKEEPING SUPERINTENDENTS' ASSOCIATION

Agar Brown, Secretary
National Greenkeeping
Superintendents' Association

The Greenkeeping Superintendents' Association is an organization which has been in existence since 1926. It was started by a group of greenkeepers in Illinois, Ohio and Pennsylvania. They had learned to perform their occupation by trial and error methods. Their purpose in forming an organization was to combine their efforts to promote the greenkeeping profession and to better the position of the men engaged in the profession. These objectives of the Association have not changed.

In years past the greenkeeper was a man hired on a short time basis. Through the efforts of the National and the district groups the picture has changed and the greenkeeper is recognized as a necessary man in year round management of the golf course and club grounds.

One of the original features of the Association which still remains in effect is that a fund has been set up, whereby an expression of sympathy in the form of cash is given to the beneficiary in the event of the death of a member.

Another objective of the original organization was to make available information pertaining to the profession by means of a publication. This publication has come through several changes. Since 1932 it has been called The Greenkeepers' Reporter. I am glad to say the circulation of the magazine is growing all the time. The magazine is sent to each member of the Association and complimentary copies are provided for his club superiors.

Each year the National Greenkeeping Superintendents' Association, in cooperation with district organizations, sponsors a National Turf Conference and Show. This event is held during the first week in February every year. There are 2 or 2½ days of conferences plus 2½ days of exhibits by manufacturers of equipment and supplies. During that time the Association has its annual business meeting and election of officers.

We would like to have more representation from this part of the country. I have application blanks with me, and will be glad to answer any questions you may have about our organization.

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COOPERATIVE BACKING OF TURF RESEARCH BY THE OKLAHOMA GOLF ASSOCIATION, OKLAHOMA SECTION P.G.A. AND OKLAHOMA TURF ASSOCIATION

Joe Dahlman, Pro
Mohawk GC, Tulsa

There is a project started on soils at Oklahoma A & M College. This was originally started with the United States Golf Association Green Section, I believe, quite a number of years ago. Dr. Noer and Fred said they were getting old and probably couldn't keep it up so they were turning it over to the Oklahoma Turf Association and the Oklahoma A & M College. I think it

is a good idea because we have a chance now to work with the soils that we are interested in right here in the southwest. It will also be opened to Texas, Kansas and other surrounding states.

I have heard Oklahoma and Texas mentioned here this afternoon but I would like to call attention to the fact that there are quite a few people here from Kansas and I believe we have a few donations from some of the clubs in Kansas. I can't give you the exact figures as to how much money we have raised so far. I think it will be in the neighborhood of six or seven hundred dollars, which I believe will give them a chance to go ahead and get started. This work is being done with the cooperation of the U.S.G.A. Green Section, the Oklahoma Turf Association and the Oklahoma A & M College, and is now being sponsored by the Oklahoma Turf Association, the Oklahoma Section of the P.G.A. and the Oklahoma State Golf Association. So you can say all the golfers are back of it.

You will have graduates and professors who are willing to help you with your work, and it is a great service for what little money it is going to take. In fact, the way they figure it is that it is going to take about $1,000 for five years to work this thing out. I don't know how many clubs we have in Oklahoma, but I am sure we have 50 or 60 clubs, at least. If each club will put in only $50.00, it will only take twenty clubs to make $1,000. So there is no reason why we can't do it.

Fred Grau mentioned this briefly and I think it is a good idea so I am going to touch on it. It is the idea of a Turf Research Fellowship that each section is more or less sponsoring. It is the education of one to three men or whatever they can handle, and they will take those men and put them on any subject on which you lack information. In other words, if you want somebody to work on soil research, they will put a man on that. If you want him on turf, they will put him on turf.

To do that is going to take about $1500 a year for three years or a total of $4500. That will take a man up through his doctor's degree. I think it is a splendid idea,not only from the thought of research but the thought of helping some young fellow to get started. Either way you look at it, it doesn't take too much money for the good that will be done.

PROGRESS REPORT ON TURF RESEARCH AT TEXAS A & M

R. C. Potts, Agronomist
and
Professor A. W. Crain
Texas A & M College

Our program has been underway for about 16-18 months.

In Texas we have elevations ranging from sea level to some 8,000 feet. Our frost free days vary from 180 to 365 a year. We have all the diseases of grass found in the United States. We have all the parasites and insects plus some more.

We are developing our research program along two lines. One is maintenance, the other is improving grasses for growing on greens, fairways and lawns--grasses that will have a more pleasing color and will compete with the weeds, diseases and insects.

We will accomplish a great deal if we find turf grasses adapted to the different environmental conditions in Texas. Since bentgrass greens are grown only in the northern part of the state and bermudagrass in the southern, that doubles our problem. We haven't undertaken to work with bentgrass because we hope that our friends in Oklahoma will help us out.

Mr. Crain is going to show you some pictures. These pictures will be divided in to two parts: (1) some of the problems that we have in the state and (2) the approach that we are taking to some of these problems.

A. W. Crain:

These pictures will show some of the work that is presently underway at the college, and then some of the problems that we have encountered.

This series of five slides was made last spring at the River Oaks Country Club in Houston. Some of you fellows were a little afraid to use the Aerifier on greens. Here is No. 4 green being aerified, this is the first operation. Immediately after the Aerifier goes over, it is top-dressed. The members played on it only 48 hours after the operation had been completed.

The next few slides show some problems which we en-

countered in connection with a trip collecting some 110 samples of bermuda last June. This is a high school field in East Texas where drainage is sometimes a problem. Most of the light colored areas are crabgrass and there is some dallisgrass. The field is not properly drained insofar as surface drainage is concerned. It isn't uniform in contour. When the sprinkling system is placed in the middle of the field, it delivers about three or four inches of water to one part, and the other part never receives any water. A field can't be watered when it isn't properly leveled.

This brings up a problem that people in Oklahoma will be interested in as well as people in the northern part of Texas. It shows a bent green with some of the bent cut at a different height. This strip around the green, about four feet wide is cut a little bit higher than the rest of the green. By cutting it a little higher it competes better with the bermudagrass.

Here is another green we ran into that was somewhat of a surprise to the greenkeeper. There are trees all across the back and along the sides of this green. When we dug around the side of the green, we found many tree roots growing toward the green. A trench could be dug every few years around the green to cut the tree roots.

Here is a problem on a football field, using 2,4-D to kill white clover. It killed whiteclover all right, but the bermudagrass was burned as well.

You will note some of the types of grasses that were picked up on another trip into South Texas. We now have about 125 selections under observation. This represents the different plots of a fine strain of bermuda. We found some new diseases of bermudagrass on this area.

Question: What is this bug that is getting into bermudagrass down around Kingsville?

Prof. Potts: That is known as Rhodes grass scale. It was first found on Rhodes grass which is a pasture plant.

Question: Do you know the distribution of that scale now?

Prof. Potts: The scale apparently is spreading pretty rapidly over the Southern part of the State. It has been found at Houston, Weslaco, Winterhaven and Corpus

Christi, Texas, and points between.

Question: What about control?

Prof. Potts: They have tried about everything, but as yet there is no successful control. We have two full time men working on this scale and in a short time, I am sure, we will have some control.

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PROGRESS REPORT ON TURF RESEARCH AT OKLAHOMA A & M

H. F. Murphy
Head, Dept. of Agronomy
Oklahoma Agricultural Experiment Station

In making this progress report about turf work at the Oklahoma Experiment Station, I might say that we have two projects set up at present. One of these projects deals with the grass phase of turf. We call it "Turf Development and Maintenance". The other porject that was just recently set up is "Mechanical Composition of Soils in Relation to Turf Development". We aim to tie these two things together and in the end hope to get something that is worthwhile.

The objectives we have in mind in connection with these two projects are: first, introduction of new kinds and strains of grasses. We are planting these in nursery plantings for observation in order to determine their desirability as turf grasses in this section of the country. It is a matter of finding suitable grasses for highways, parks, cemeteries, athletic fields and golf courses. At the same time we are making some observations in connection with the growth of certain grasses under shade. Second, we are interested in overseeding summer grasses with winter grasses. We are trying, in general, to secure a lawn that is more or less green the year round.

Those are some of the objectives under the grass phase of the problem. Under this particular work we are carrying out three different things-- some clipping practices, watering and fertilization. All this work is very important when it comes to developing and keeping a turf. Clipping studies involve high, low and intermediate cutting. Some plants are watered and

some areas are fertilized, with nitrogen primarily. In this work we are studying two grasses in detail-- bermudagrass and buffalograss. The clipping heights are 5/8 of an inch, one inch and two inches. We fertilize with ammonium nitrate to furnish 100 pounds of nitrogen and 150 pounds of nitrogen to the acre; these are compared with a no treatment check.

I am not going to say too much about results because we have not been carrying on this work for long; however, there are a few things that have shown up which may be of interest. The nitrogen, as you all know, gives its usual indications of darker colored foliage. The two inch clipping of the buffalo somewhat favored weed growth, but bermudagrass looked good under all clippings. Those, in general, are the results from these two grasses at present.

Another objective in our program is to study methods of bermudagrass control. Mr. Elder will give you a report on this particular work later on in the program.

In regard to the soils work, we have not done a great deal as yet. We are just getting the project approved. Some of the objectives that we have in mind in connection with the soils are the study of infiltration rates from different artificial mixtures which may be used on greens. In this particular case, we are interested in sand, silt, clay, organic matter and other things that may be included in connection with these, and in trying to find out what mixtures will have good moisture penetration and good moisture capacity and that will allow for good root development. You must have root development because of the tremendous amount of water that a plant must have. I don't know whether or not any of you appreciate the fact that whenever a plant takes out one pound of mineral matter from the soil, it uses about 8000 pounds of water. When a plant must have lots of water, you either have to stand over it with a hose or else it must have roots which are sufficient to get some from the medium in which it is growing. There is a compromise between the two-- a fairly good root system and a source of water.

We also are interested in sub-grade material, drainage and the like. Drainage is very important. Both water and air are essential in the soil. It is very important as far as the life of the plant is concerned, that there be the proper relationship between moisture and air and a sufficient amount of nutrients to main-

tain a good growth.

Another of our objectives (which is sort of a preliminary) is to take a rather complete survey of the profiles of greens in the state. We will contact greenkeepers who know what greens they always have trouble with and what greens get along fairly well.

In connection with the grass planting, we can report a little progress. This first project was started at a time when we could not make any plantings in the fall. It was necessary to make the first planting of these grasses in the spring of 1948. We wanted to start some of the fall grasses and we knew it wasn't the right time of year, but we thought that if we made things as favorable as possible, we might be able to get by. We made spring plantings of eight grasses at that time-- Alta fescue, Kentucky 31 fescue, sheep fescue, intermediate wheatgrass, hard land Western wheat and sandy land western wheat. General results of this planting were that Alta fescue and Kentucky 31 fescue looked rather promising for parks and roughs. They seem to stand the hot, dry weather fairly well and they hold their green color pretty well. We found it pretty hard to maintain Chewings and sheeps fescue during the summer. The Western wheats might be all right for the roughs in Western Oklahoma, although they do not make a turf.

During the spring of 1948 we also made some plantings of summer grasses, including sand lovegrass, weeping lovegrass, side oat grama, Tuscon side oat, buffalo, dallis, yellow bluestem, blue grama. The buffalo and blue grama looked best for lawns, but we probably would confine the last two to Western Oklahoma. The dallis and the weeping lovegrass grew longer in the fall and the weeping love comes up quite early in the spring. The yellow bluestem forms an excellent mat, is fairly drought resistant and will withstand rather close clipping. But it throws up seed heads rather promiscuously and it does die out early in the fall.

In the fall of 1948 we made some plantings of fall grasses. We used Kentucky bluegrass, perennial rye, New Zealand and Victoria ryegrass, Alta fescue, seaside creeping bent and two different mixtures of Kentucky bluegrass and Alta fescue and, I think, some Victoria in those mixtures. Kentucky bluegrass went through where it was watered and was fairly good, even without water. New Zealand Victoria ryegrass has, of course, rather fine leaves but we found some rust. It has been hit rather badly. The seaside bent made a

fairly good growth when watered, but it was rather spotted.

This last spring we made small plantings of a different material. We planted several strains of buffalograss from seed and then we planted several strains of bentgrass, both from seed and sodded. Also we planted Zoysia matrella and an Oklahoma hardy centipedegrass. I would say that in this planting of several selections of bermudagrass, the U-3 looks pretty good. It is dark green all through the growing season, is relatively free from diseases, has a fine leaf, but we think it is just a little bit too vigorous. If we could get a bermudagrass that maintains its green color yet wouldn't spread so badly, we might have something. We wanted to compare B-27 Kentucky bluegrass with ordinary commercial bluegrass and we made a planting of those this fall.

That just about summarizes the report of the plantings that we have made at the station. If any of you have any grasses that should be included, we would be very glad to have them. I'm afraid I could not answer any questions you might have. So I'll refer you to Mr. Elder because he was the one who did the work.

Question: How is centipede for winter hardiness?

We have had this winter hardy centipedegrass ever since 1934 and it has been in there ever since.

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GRASSES IN RELATION TO THE GENERAL PUBLIC AND THEIR HABITAT

Henry Walter,
Oklahoma City Park Department

I think in the beginning we should remember that in Oklahoma and Texas we have natural grass areas and grass has been one of the dominating factors in the development of this section of the United States. We don't need to go into that. We know that everything that has been developed here came from the use of our native grasses. Incidentally, I have been informed that there were some 150 species of wild grasses iden-

tified in Oklahoma. Of course, a number of those are not too common.

As a rule, the public is generally indifferent to grass. Now I imagine most of you gentlemen work with highly concentrated areas of grass, such as golf courses and while we get a section of the public at these courses, we don't get a complete cross section because most of the golf players know that they must treat the turf in a certain manner if they expect to enjoy it next time they come out. But the public is not that way; they are indifferent. You can observe this by driving into any city, particularly in the dry season, and notice how badly the lawns look. I don't know how they are in Oklahoma City. As we drove through, there were numerous cases of fires where the native grasses along the road were being burned. It was just through indifference and carelessness of the public. If some of us were to go into some of the National forests and behave there like they do here with careless matches and cigarettes, many would be in jail or paying heavy fines.

As a rule the public is very indifferent. They have always taken the attitude that the grass, like the atmosphere, was here when they came and it is just one of those things that they take for granted. They don't have to do anything about it, so why bother. So we have that problem to consider first of all.

The next problem is the value of turf areas in urban sections. We get into large cities like New York and Chicago; we find that grass doesn't exist there except in public areas and the only chance the people have to see what grass looks like is to go into some public area. There is really an appreciation of the value of turf. As I said, it is in these public areas that most of the people get to use grass, and again I must say, unfortunately, the people are indifferent again. If a walk doesn't happen to be where they want one to be, they will make one and the heck with the grass, and soon you have a path. I am sure that all you folks run into that problem in the various phases of your type of work.

Another attitude towards turf areas in urban communities is the value that they have as physical and mental relaxation places for people who are rushed every day with their business. We know that green is one of the most restful colors that we have and these areas are oases in the desert of hustle and bustle and people really do enjoy them. Many times they don't

appreciate them until they are deprived of their beauty. I think people who live in desert areas appreciate this more than we do. Those of you who have traveled in what we call the desert areas are immediately amazed when you drive down and see how the most humble home will have a beautiful grass area. I think the very fact that they have no natural grasses makes them appreciate these green spots they maintain in front of their homes.

I expect this next topic has been discussed pretty thoroughly-- the requirements for a good lawngrass. It should be permanent, it should cover well, should hold its color during the winter, should not grow too tall and it should tolerate use. That is the type of grass we are looking for in park work and you gentlemen are probably looking for the same thing. Unfortunately, to my knowledge, such a grass doesn't exist. So there is really a lot of work to be done. In this section of Oklahoma Kentucky bluegrass can be grown and, I believe under all conditions where it can be grown, Kentucky bluegrass did fit these above specifications just about as well as any grass you could get. In our area around Oklahoma City, I know of no good Kentucky bluegrass lawn. In Texas they have the St. Augustine grass. We have to rely on bermudagrass and, of course, each one of those grasses is taken for granted by the people. They think all you have to do is plant it and it will maintain itself from there on. Some of the new strains of zoysia may be fit in our section of the country. We don't know. We have some strains of zoysia in our greenhouse and in spring we want to plant a few plots.

I think there is a great need for public education in lawn maintenance and appreciation. Now perhaps this Association that you gentlemen have has done more to promote this type of work than any other group. The Park Executive Group has fallen far short because there are so many phases of park work that we don't have much time to go into specialized fields as you gentlemen are doing. But the proper feeding, watering, mowing and the proper use of the new chemicals for weed control, are some of the things the public should be informed about. My first impression of landscaping which came when I got out of college consisted of going out on a bluegrass lawn and digging out crabgrass. Fortunately, we don't have to go through that long procedure any more and it is a far cry from that to these new weed controls and the feeding programs that are being studied and promoted and developed for the better maintenance of turf.

I think now I will summarize briefly some of the remarks I have made. The Great Plains area is naturally a grass country. The public as a whole is very indifferent to the maintenance and use of turf in public areas. Urban populations need grass areas for their physical and mental well-being. I think that is basic. There is a definite need for better lawngrasses for use in this area. And last but not least there is a great need for educating the public in appreciation and maintenance of good lawns. I think the whole core of the substance is to educate the public to the appreciation and the proper use of grass areas.

I hope I have said something that will at least give you some good thoughts on the subject. If there is anything you would like to ask about the problems we have in the parks maintenance, I would be glad to answer them if time permits.

Question: What zoysia do you have?

We have Zoysia japonica, and we got the sod from Beltsville. We planted the sod in the greenhouse and hope that it will increase so that we may be able to put in a pretty good test plot in the spring.

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THE IMPORTANCE OF TURF IN LANDSCAPE DEVELOPMENT

Philip Thomas
Thomas Nursery, Tulsa

Landscaping work has to do with the development of land for intense human activities, not called for in the desert or the great open spaces or in the deep forests. When human activity reaches a certain point, things begin to change. Rough areas must be smoothed over and made accessible, in a form that can be used for travel and for activities around the home.

Landscaping is a supreme art. Painting is done in two dimensions-- length and breadth. Architecture is done in three dimensions-- length, breadth and depth. Landscaping is done in four dimensions-- length, breadth, depth and time. It is this last dimension that makes it impossible to become a successful practitioner of the art by way of the classroom. You can build a

house and make it a certain form, but when you are dealing with a tree which is going to grow and develop you must have long experience to do it. You must know plants by living with them. Learn what they will be like in five, ten or more years.

If one may be allowed to criticize landscape art that is practiced by college graduates, I should say it is long on design and terribly short on knowledge of plants. It is most shamefully true of government financed homes of today. That is true of the plantings that are being made around many homes today. What will they develop into in the next few years?

This fourth dimension, time, is what I wish to emphasize. Time has a bearing on every element of this work, including the turf. Turf is the surface on which the landscape picture is painted. The green is the canvas on which trees, shrubs and flowers are the paints for the landscape picture. The canvas used by the artist is more durable. It doesn't change. The canvas for an oil painting is the same today as it was centuries ago. But in our work the canvas changes every day, and climate and everything else has a bearing on what we have to use in landscape work.

I will use slides of some of the work which we have done, to tell the story. Starting from a rough weed covered terrain, they will show the transformation by the second season. I will show what was and what can be done to the condition,with the proper use of plants and shrubs.

In this picture, thousands upon thousands of people passed through here every year. It is not a picture that hangs on the wall. You live in it. It has the color and perfume from the flowers. This was a difficult position because of the trees. Here, due to the shade, the turf condition was a big problem all the way through. This turf is a good illustration of getting splendid results with fertilizer, without much water. I don't think this year the place was watered at all on the large areas.

This is the home of Charlie Payne, and when we did it there were great trees arching over. We did this pretty much with plants that would live in the conditions where there were a lot of tree roots.

This is a home where I had a lot of difficulty this year. Bob Dunning-Jones helped to advise on this because it was all bare due to the heavy infestation of

roots and the shade. We cut a lot of the trees out to try to develop a turf.

This illustrates the need for turf that will carry the right color all through the year. This is in the fall. If we can get a grass that will keep its color all through the season, the better it will be. There is a need for a grass that will stay green and persist in the shade. If we had bluegrass or bent that would be as green as this condition in the summer, we would be allright.

As I said, landscape work depends on time. You plant trees, but that isn't a permanent picture. As they develop, you have an ever-increasing problem. Tree roots make it hard to keep turf under shaded areas. So in this work we must be looking ahead constantly.

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WHAT EVERY TURF MAN SHOULD KNOW ABOUT GRASSES

Questions: Professor A. W. Crain
Answers: R. C. Potts, Agronomist
Texas A & M College

Question: What are the characteristics and functions of leaves and stems?

Answer: A grass leaf is green because of chlorophyll in it. The chlorophyll molecule in the leaf is very important. Chlorophyll utilizes energy from the sun and converts carbon dioxide and water into carbohydrates, which are the basic materials of plant growth. Remember that light is the source of all energy in plants.

Question: You mentioned that light is the most important factor known. Are we certain of that?

Answer: I think so because how would animals live with out plants and how would plants live without light?

Question: In other words, this process whereby green leaves use the sun's energy, not only grasses but all vegetation, is the key to the existence of all animal and plant life on the earth. Are there any nutrients taken into a plant through the leaves and the stems?

Answer: Not as we commonly know it. Nutrients are taken in through the roots.

Question: You mentioned the roots so let's talk about their functions. What food is taken into the plant through the roots?

Answer: The minerals-- that is, phosphorus, potassium, calcium, and such minor elements as manganese, iron, magnesium, cobalt, etc., are taken in by the roots of the plant. In addition oxygen is taken in by roots. All these materials are added to the carbohydrates and the plant builds tissues, i.e., builds its cells and grows.

Question: How does a grass root grow? Does it push itself-- like pushing a stick into the ground?

Answer: Growth of the grass root differs from that of the leaf. The root grows from the tip or end of the root and exerts many pounds of pressure in its growth process. It grows by cell division. As the cells divide the pressure is extremely great.

Question: In other words the pressure is not from the back of the root, but from the tip of the root itself?

Answer: That's right.

Question: You mentioned taking in nutrients. How and in what form can nutrients be taken in by root hairs?

Answer: In the first place, nutrients must be in solution. Water must be present. The nutrients enter the plant independently of the water, however. They enter in what we think of as colloidal form; however, they first must be in solution. If the nutrients are not in solution they cannot be utilized by the plant.

Question: Mr. Murphy told us yesterday that for each pound of nutrients taken into the plant, it requires about 8,000 pounds of water. What is the function of water? Do the plants get any energy from water?

Answer: Water has several functions in the plant. Acting as a solvent for nutrients is only one of its functions. In addition, it acts as a temperature regulator, i.e., on hot dry days transpiration is greater than on cool days, hence water serves to keep plants cool. This aids in disposing of waste in the plant and in other metabolic functions. Plants get no direct energy from water and for that matter neither

do animals.

Question: We had a great deal of discussion yesterday about the importance of air in the soil. Why do grasses need atmospheric air in the soil? Do they need it in order for roots to function properly?

Answer: Air serves several purposes. If there is sufficient air in the soil it encourages the intake of certain elements from the soil into the plants. If they don't have air, we have putrefaction taking place and your roots will be decomposed rather than growing properly.

Question: We heard a great deal of discussion also in connection with deep root systems. Will you tell me why grass should have a deep root system?

Answer: As the root extends deeper into the soil it is exposed to more nutrients and more water. It might be interesting to note that the other day I had an opportunity to use a soil boring machine on bermudagrass. This machine took a four inch core, six feet deep and at the bottom of that core, the bermudagrass root was still going down. That is not a Texas story; it actually happened.

Question: One thing we might consider here in connection with a deep root system. We might regard a deep root system equivalent to a bank account in that if you had a large bank account and you came here for a period of time, attending a turf convention, you could draw on that bank account during the drought period or period of time when you were not putting money in the bank. In other words, a deep root system will carry you over and, as you fellows well know, if you don't manage your greens properly the grass will fail to develop a root system deep enough to carry the plants through critical periods.

Now let's get back to how we go about handling the soil to develop a deep root system on fairways, football fields, athletic areas and even lawns.

Answer: I think one of the main things that prevents us from getting a deep root system on lawns and any other place is the fact that they are watered too much. What I mean by watering too much is watering too frequently and using too little at any one time. We water a turf and wet about two or three inches of the soil. Below this surface layer the soil is dry. We know that even though moisture is present three or

four feet below the surface, the roots will not penetrate a dry layer. Remember what we said a while ago about the roots growing from the tip? Well, just as soon as that root tip hits the dry layer of soil, it makes no further progress. Time and again we have plenty of moisture in the topsoil, plenty of moisture in the subsoil, but there is a dry layer of half an inch, six or eight or twelve inches down. The roots will never penetrate that dry layer. Therefore, they will never get down to the subsoil moisture. They will always stay in the upper few inches. In golf greens a lot of us have seen a dry layer of sand down about four or five inches. There is no way to get grass roots to penetrate that dry layer except to wet it.

Question: Speaking of golf greens, I think you will find that plants require more water the closer they are mowed. How are we going to develop a deep root system in a golf green as compared with a lawn or foot ball field?

Answer: It might not be possible to get a root system down six feet as we mentioned before, because as we take off the topgrowth we remove part of the factory which produces the carbohydrate material needed by the grass root for growth. If you remove that topgrowth you certainly reduce the supply that would normally go to the roots. However, we must have plenty of air, as has been established previously. The soil must be open. We must have nutrients down in the soil and not concentrate them on the surface. As we apply topdressing high in nutrients such as phosphorus and potash to the greens, the roots tend to concentrate in the surface soil because the soil has sufficient water and nutrients for growth.

Question: Let's move on into something a little bit different and something that has not been covered. What is the relationship between temperature and grasses for grass development?

Answer: That is a very important question. We have been talking about putting some of these cool-season grasses in with the warm-season plants. The various grass species require different temperatures. Some plants will grow at one temperature, while others will grow at another. Let's compare temperature requirements of two grasses-- bermudagrass and Kentucky bluegrass. Starting with the bermudagrass, at 20° temperature, we find the bermudagrass is making little or no growth in a given period of time. When we raise the

temperature to 50°, we find the bermudagrass is making some growth and with over 50° the bermudagrass is growing more and more. As we go on up we can see that the bermuda is growing continuously. As you go from 60° to 100° it really grows rapidly. Don't let anybody tell you that we have temperatures in Oklahoma and Texas that are too hot for bermudagrass. I don't believe that. If the soil has plenty of moisture and nutrients, bermudagrass will grow throughout the summer. But just as soon as we get into temperatures below 70°, it slows down growth very rapidly.

Now let us take a cool-season grass like Kentucky blue grass, ryegrass or some of your bentgrasses. At 40° we find Kentucky bluegrass growing, whereas bermudagrass is partially dormant. At 50° to 60° growth of Kentucky bluegrass is better, and at 70° we find that Kentucky bluegrass is growing at its best. But at temperatures above 70°, Kentucky bluegrass stops growing. That is true of a number of your cool-season grasses. When temperatures get above 70°, the plants stop growing. So in the South where we have high temperatures we are going to have a lot of trouble with those grasses that will not grow in such temperatures. But remember that bermudagrass can continue growing at these high temperatures, therefore, we must learn how to manage it.

Question (from floor): How about bent?

Answer: I am sorry we don't have the exact figures on bent but I feel certain that bentgrass and bluegrass would be similar.

Question: One of the reasons you can grow bentgrass at high temperatures is that you have it on greens which you water excessively every day. The excess water evaporates from the surface and the plant transpires freely, both of these factors help keep the plants cool. Therefore, an environment is developed whereby bents can maintain themselves. Now then, let's get into a phase that would involve something we have had previously. That is-- variation within and between different species-- with relation to their tolerance to shade or different degrees of direct sunlight.

Answer: There are several species of grasses that will grow in the shade. We have one in Texas and that is St. Augustine grass. It will grow in a rather dense shade as compared with bermudagrass. You put bermudagrass in the shade and it begins to get thin. Kentucky bluegrass can stand a certain amount of shade and

grow. But again, most of our turf grasses must have sunlight at least a large portion of the day in order to grow properly.

Question: We have been talking about the variation between species. Would you give us a little bit about the variation within a species of grass? What is a species of grass?

Answer: Our botanists classify species according to the flower mainly. In most cases if the flower is similar, the plant growth is similar. We might say right here that in many cases it is very difficult to cross two species.

Question: Let's get some more about the variation within species. In other words, all human beings belong to one species of animal. Now we are not all alike, and if we look at some of these bald heads, the different heights, and the vim, vigor and vitality of some of them, you can see the difference. What are some variations that exist within a species of grass?

Answer: If it were not for variation, the greens would be in a pretty bad fix. For example let's take a plant that all of us are familiar with-- bermudagrass. We have leaves almost a quarter of an inch broad down to the very narrowest width of bentgrasses. There is a red bermudagrass; we have some with leaves that are blue. We have some that have leaves five, six, seven and eight inches tall. We find some plants that are very susceptible to disease. Others within the same species are very resistant. It is with these variations that the plant breeder must work to develop improved strains. If it had not been for variation, the U-3 bermuda never would have been found. Most of our improved species go back to the fact that there is a great deal of variation within a species.

Question: Next we are going to discuss what a grass can tell us about what it needs. For example, can we look at a plant, walk on it, feel it and tell what it needs? Just what can a grass plant tell us about what it needs, if we know how to read? Can we tell what that plant would like to have?

Answer: I think certainly that we can to some extent. I think when we see a plant turn yellow, it is because of a lack of nitrogen. If it has too much water, the plant can't take in nitrogen. You must have air in the soil in order for the root to function properly. But keep this in mind, if the plant is lacking in wa-

ter, those leaves will not turf yellow. What happens when you cut off a leaf? Does it turn yellow immediately? I don't think it does. When you take clippings and those clippings dry in the sun, you still have a green covering and not a yellow leaf. So don't let it fool you when a plant is turning yellow it does not necessarily need water. It is because of lack of nitrogen.

Question: Would you say that the first thing that happens when grass needs water is that it wilts?

Answer: I think that grass definitely begins to wilt. Usually the upper leaves begin to wilt first-- those that are actively growing require more water.

Question: What about phosphoric acid?

Answer: Phosphorus stimulates root formation and root growth, and aids plants in withstanding extremes in temperatures. A deficiency of phosphorus is, like nitrogen, indicated by a yellowing of leaves, especially along the tip ends.

Question: What about potash? A similar yellowing of the leaves along edges occurs and in some cases brown spots appear.

Professor Crain: Our time is about up. We thank you very much.

WHAT EVERY TURF MAN SHOULD KNOW ABOUT FERTILIZER

Gordon Jones, Agronomist
Bob Dunning-Jones, Inc., Tulsa

1. What is a fertilizer?
2. What are its basic elements?
3. What are the effects of these elements on turf?
4. What affects their availability?
5. From what materials are they derived?
6. What are the differences between organic and inorganic materials?
7. What effect will continued use of different fertilizer materials have on the soil?
8. What are the fertilizer requirements of various turf grasses?
9. How can you best determine these requirements?
10. What do the fertilizer terms -- analysis, grade and formula mean?

F E R T I L I Z E R M A T E R I A L S

INGREDIENT		Effect On Soil Reaction	Quantity Required Per Ton To Give Following Percentages			
			1%	4%	6%	10%
Carriers of Nitrogen	%N					
Ammonia (Anhydrous)	82	Acid	24.5	88	147	245
Urea	46	"	43.5	174	261	435
Ammonium nitrate	35	"	57.2	229	343	572
Ammonium sulfate	20	"	100	400	600	1000
Nitrate of soda	16	Alkaline	125	500	750	1250
*Ammonium phosphate	11	Acid	185	740	1110	1850
Dried blood	10	"	200	800	1200	2000
*Activated sludge	6	"	333	1333	2000	----
*Cottonseed Meal	6	"	333	1333	2000	----
*Raw ground bone	5	Alkaline	400	1600	----	----
*Steamed bone	2	"	1000	----	----	----
Carriers of Phosphoric Acid	$\%P_2O_5$					
*Ammonium phosphate	48	Acid	42	168	252	420
Treble superphosphate	45	Alkaline	44.5	178	267	445
*Raw ground bone	23	"	87	348	522	869
*Steamed bone	23	"	87	348	522	869
Superphosphate	20	"	100	400	600	1000
*Cottonseed meal	3	Acid	672	---	---	----
*Activated sludge	3	"	672	---	---	----
Carriers of Potash	$\%K_2O$					
Muriate of potash	60	Acid	33	132	198	330
Sulfate of potash	50	"	40	160	240	400

WHAT EVERY TURF MAN SHOULD KNOW ABOUT FERTILIZER

Gordon Jones, Agronomist
Bob Dunning-Jones, Inc., Tulsa

I have listed ten questions about fertilizer that every turf man should be able to answer. The first is, what is a fertilizer? A good general definition is that a fertilizer is any material added to the soil to increase its productivity.

The primary elements that make up a fertilizer are nitrogen, phosphorus and potash. These three are needed in the largest quantities and are most apt to be deficient in the soil. The secondary elements are calcium, magnesium, sulfur, iron, manganese, zinc and carbon.

The different elements have different effects upon the plants. Of the three primary elements, nitrogen gives the most visible response. It stimulates vegetative growth-- topgrowth--and gives a good dark green color. Some crops don't require too much nitrogen, but with turf, good leafy growth is what we are after.

The principal effect of phosphorus on turf is the development of root growth and the hardening of the tissues of the plant which in turn makes the grass more disease resistant. Potash influences the general tone and vigor of a plant. It has a kind of balancing influence on the nitrogen and phosphorus when it is present in a mixed fertilizer.

Calcium, which is generally applied in the form of limestone, has at least two effects. First, it has a chemical influence; it reduces the hydrogen ion concentration in the soil, thereby making the soil less acid. Calcium in the form of limestone raises the pH or soil reaction, which is often desirable. The second effect of calcium is a considerable influence on the activity of plant organisms.

I have listed on the outline the principal materials in use today to supply nitrogen, phosphate and potash. There is an asterisk to the left of the materials that supply both nitrogen and phosphate. Anhydrous ammonia heads the list as a high nitrogen material. It has to be kept under pressure and is used chiefly in fertilizer manufacture where it is fixed with other materials. Urea is next highest in nitrogen; it is high priced and hard to get. Ammonium nitrate is about our cheapest source of nitrogen, and in this bermudagrass

territory where a lot of nitrogen is needed, it is a very good material. Organic materials such as dried blood, activated sludge, etc., are all low in nitrogen content.

Among the materials that supply phosphoric acid, 20% superphosphate is the one most used. However, the treble superphosphate is a material we are going to be hearing more about. Production of this high phosphate material is increasing. Raw bone and steamed bone are fine sources of phosphoric acid, but we don't use them much anymore.

Muriate of potash is about the only form of potash in use.

The difference between organic and inorganic fertilizers is easy to remember. Organic fertilizers are the ones that come from living matter-- cottonseed meal, activated sludge, etc. These materials must go through bacterial decomposition before they are available to the plants. Organic materials are slowly available in cool weather, but in very hot weather they may break down too quickly and we have all seen the consequences of that. Inorganic fertilizers come from minerals, probably the best example is ammonium nitrate. Inorganics are water soluble and readily available to the plants. We also are getting more and more synthetics on the market.

We come now to the effect of continued use of different fertilizers. In the second column on the outline you can see the effect on soil reaction of these various materials. You will notice that ammonium sulfate makes the soil acid. Sodium nitrate has the effect of making the soil too alkaline, if it is used over a prolonged period. We should give consideration to the effect on the soil which these materials will produce over a period of time.

The fertilizer requirements of various grasses and of other crops vary. In most field crops fertilizer is used to encourage development of fruit. Phosphorus and potash are used in larger quantities to do this. Too much nitrogen may ruin the effect, so many farm fertilizers are low in nitrogen. Turf, on the other hand, needs fertilizer to produce leafy growth. Bermudagrass, especially, needs a fertilizer high in nitrogen.

Another point to consider when comparing turf and farm fertilizers is that the removal of a crop takes out a

lot of nutrients. But where grass clippings are allowed to fall back on the ground, nitrogen may be lost in the form of ammonia, but phosphorus and potash can be maintained with very little additional application. Where clippings are collected, it is a different story. If you want good greens you have got to apply an adequate amount of the needed elements. Of course, you know there are times of the year when you must cut down on nitrogen to keep the grass from becoming too lush and disease susceptible.

Within the grass family there are variations in fertilizer requirements. Bermudagrass requires a lot of nitrogen. Bluegrass requires less nitrogen, but it needs more phosphorus. St. Augustine and centipede grass have low nitrogen requirements. In fact, they can be thinned out by applying too much nitrogen. I believe bentgrass requirements are similar to those of Kentucky bluegrass.

I think observation is the best way to determine fertilizer requirements. Another way is to make tests. If you think you need lime, put some on a test plot and see if that is what is needed. Apply different amounts of nitrogen to different test plots to determine the quantity needed. Also, we have laboratory tests, but I think you will agree that these don't give you all the answers, just clues. Last but not least, we get basic answers from the research at our experiment stations. They can determine the fertilizer requirements for different grasses under different climatic conditions.

The meanings of the terms analysis, grade and formula provide basic information when deciding what materials to use. The analysis is the amount of specific nutrient elements that a fertilizer contains. For instance, a 100 pound bag of 5-10-5 fertilizer contains five pounds of nitrogen, ten pounds of phosphoric acid and five pounds of potash. When you think in terms of pounds it is easy to calculate your application rates. Some times we speak in terms of units of plant foods. Our 5-10-5 contains 5% nitrogen, 10% phosphoric acid, and 5% potash or a total of 20% or 20 units of plant food per ton.

The grade refers to the percentage of plant foods that the manufacturer guarantees in the fertilizer. The 5-10-5, containing 20% or 20 units of plant food ordinarily is considered a high-grade fertilizer. However, if your turf requires a lot of nitrogen and not much phosphorus, it would be wasteful to use a fertil-

izer of this analysis even though it is a high-grade fertilizer. In other words, the selection of a fertilizer should be determined by the specific elements your turf requires and not just the total number of units of plant food in the material.

The formula is the amount of material needed to make up a certain grade of fertilizer. In the last column of the outline you will find the quantities of materials per ton which are required to provide a given percentage of N, P_2O_5 and K_2O. For example, ammonium sulfate contains 20% actual nitrogen, so in order to get 1% actual nitrogen to the ton, 100 pounds of ammonium sulfate would be required; 400 pounds of ammonium sulfate would give 4% actual nitrogen to the ton and so on. Or, if ammonium nitrate is used, one hundred pounds of the material supplies 35 pounds of actual nitrogen. The nitrogen, phosphoric acid and potash carriers are sources of the necessary plant food elements, but they are not pure and application rates must be judged accordingly.

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WHAT EVERY TURF MAN SHOULD KNOW ABOUT SOIL CHEMISTRY

Thomas C. Longnecker, Soil Scientist
Texas Research Foundation

Soil chemistry is a big field and it is very complex. There have been several books written on the subject. Most of it is theory. We do not know enough to disprove some of the theories that have been advanced so in general we accept them.

To begin with we are going back to the basis of soil. It is nothing more than a mixture of minerals, rocks that have weathered through millions of years. Different chemicals have come out of the component parts and they produce soil. There are a large number of these minerals that we find in our soil. Some of the more common of those are hornblende and quartz. Each one of those contributes some certain basic element and property to the soil. Hornblende, for example, contains a mixture of calcium, magnesium, iron and silicon. Quartz is mainly silicon. Orthoclase is another which contains potassium, aluminum and silicon. Epidote contains calcium, aluminum, silicon, iron and

hydrogen. Biotite contains potassium, magnesium, aluminum, iron and silicon. Tourmaline contains sodium, aluminum, boron and silicon. Apatite has calcium phosphate. Those are just a few of the elements which are contained in all these minerals which make up soil.

The weathering of rock takes several thousands of years to produce what we use as soil. Unfortunately, in many places our topsoil is coming off so we are working with the parent materials from which soil is formed.

Also in the process of weathering, in addition to the breakdown of minerals into something we can grow plants in,we get leaching if it is an area where there is rather heavy rainfall. This is another factor which changes the character of the soil chemically, because certain elements are washed out. In general, if we have much rainfall, calcium tends to leach out of the soil. Sodium also tends to leach out. A lot of soils which were formed from calcium bearing material are acid at the present time because most of that calcium has been leached out. In areas where there has been less rainfall, the calcium is still present even though they were from the same parent material. Those things have to be taken into consideration.

The nutrients which are needed to grow plants may be present in the proportions which the plant requires, or they may not. The main ones which are needed have been discussed already. Some haven't been mentioned, such as manganese and zinc. Iron, boron and copper have already been mentioned. Most of the different soils contain sufficient amounts of the elements. However, in some of our soils, they may not be in the form the plant can use. So that is another factor we must take into consideration.

In this weathering and leaching, if it has been possible to do so, it has created different levels in the soil where different things accumulate. In some of our soils in this area that has not taken place. The Black Plains of Texas are a good example. They are not a completely formed soil. No layering is apparent and all soil above the parent material is uniform and displays the same properties.

I would like to discuss organic matter briefly. No attempt should be made to hold organic matter as such in the soil. Organic matter is valuable if it is de-

composing and breaking down. As it decomposes it produces organic acids which function to work on the soil minerals and make the nutrients they contain more available to the plant. That is a very important function of organic matter. We need to have a constant supply being added to the soil. All grass roots will do that because they form a completely new root system each year and as old roots break down, they are supplying organic matter to the soil.

I would like to discuss the soil reaction or pH. First of all, what are we measuring when we make a test of the soil to determine its pH? The thing that we are measuring is the active acidity of the soil. In other words, the actual pH of the soil solution-- not the soil itself, but the soil solution from which plant roots draw their nutrients. We must distinguish the active acidity from the total acidity because there is a difference. All of the minerals present in the soil are constantly in chemical equilibrium. If one of them gets out of balance, something else tends to bring it back in balance. The soil is always in balance chemically, and if you add some chemical to the soil, it will strive to regain that balance again. So the total acidity is entirely different from the active acidity. The reason for that, as already mentioned, is in the base exchanges in the soil.

Now to go into the background of this a little more in detail. I would like to take up the clay particles of the soil which were mentioned yesterday. There are two kinds of clay in the soil, what we consider the active clay and that which is inactive. In general, the clay fraction of the soil is all particles which have a diameter of less than .002 mm. That is rather small, however, those particles of .002 mm. are not very active. It is generally accepted that unless those particles are less than .001 mm., they are not very active. The smaller particles constitute the active part of the soil and are responsible for the total acidity of the soil. These small clay particles are so small they carry an electrical charge-- a negative charge-- and those particles on the surface attract by their negative charge other particles which are small but which have a positive charge. That includes the basic nutrients in the soil-- calcium, sodium, manganese and magnesium-- and also hydrogen. All these elements are attracted and held on the surface of the small clay particles. That is what we refer to as the base exchange of the soil. These particles added on the surface are called ions and they all carry electrical charges of a positive nature.

It is those particles which contain the potential or actual acidity of the soil. If the clay particles contain nothing but hydrogen ions on their surfaces, it is an acid soil. If those hydrogen ions are replaced, or those clay particles contain sodium, magnesium or calcium ions on the surface, soil has an alkaline reaction. So the proportion of these elements which are contained on the clay particles determines the actual acidity of the soil. There is a constant release of the basic elements from the surface of the clay particles to supply the needs of the growing crops. Naturally, if there is a large supply of what ever elements are contained on the clay particles, it will predominate in the soil solution when you determine the actual soil acidity in a pH test. If there is a lot of hydrogen on those clay particles, there is going to be a lot of hydrogen in the soil solution and your test will show acid. If there is a lot of calcium on the clay particles, your test is going to be more alkaline. There is always a balance between what is contained on the clay particles and what is contained in the soil solution. If the plant takes more out of the soil solution, then equilibrium is attained again by more of these elements coming off the clay particles. So as the plant uses up the calcium in the soil solution, it is replaced by what is present on the clay particles. After the calcium is taken from the particles, it will probably be replaced by hydrogen. In other words, as calcium is used up by plant growth, soil will tend to become more acid. Then, when you supply calcium in the form of limestone, it tends to build up this reserve again on clay particles and the soil regains its original status.

The smaller the particles are, the more surface area is exposed and the greater total amount of the basic elements any particular soil can hold. By having more of these smaller particles in the soil, it will contain more of the basic elements which it can adsorb on the surface of the particles and the higher will be its base exchange. That is the reason why you need a certain amount of clay in any soil to act as a reserve and hold these nutrient elements in the soil and be able to supply them later when the plant needs them.

Now as to the actual acidity that we measure-- for instance, if we have a pH of 6, what does that mean? Actually what we are measuring is the concentration of hydrogen ions in the soil solution. As you move down the pH scale there is a progressive increase in the concentration of hydrogen ions. In adding lime to correct acidity, it takes very little to correct active

acidity. But since you want to correct total acidity, an excess must be added. The more clay there is in the soil, the higher the percentage of small particles, the more lime it is going to take per acre to effect a correction.

What are the effects of acidity on soil? Experiments that have been conducted practically all over the United States indicate that pH itself is not important. In sterile sand or solution cultures it is possible to grow plants at almost any pH. However, in the soil, since it is a complex chemical-biological system, that is not the case. The pH itself has no direct effect but the associated conditions which go with any particular pH are factors which cause difficulty.

What are the factors which go along with any set of pH conditions that cause the trouble? In the more acid soils, say pH 4 or 5, iron and aluminum tend to come into solution. It has been demonstrated that what used to be considered a plant disease actually is a condition brought about by an accumulation of soluble aluminum which blocks up movement of plant food and water. It is not the pH that is causing the trouble; it is the iron and aluminum.

Another thing which will cause trouble with a low pH and also a high one is the fact that your phosphate tends to become tied up. When there is iron-aluminum in solution both of those elements combine with phosphorus to form insoluble compounds. Iron phosphate is insoluble and so is aluminum phosphate. So the plant doesn't get the phosphate. Between a pH of 6 and 7 you get ideal solution of phosphorus. Iron and aluminum tend to go out of solution. As far as most nutrients in the soil are concerned, a pH between 6 and 7 is nearly ideal. When you get above that, you get into the alkaline reaction and run into difficulty of almost the same kind. At a pH of 8, the phosphorus tends to be tied up with calcium as another somewhat insoluble compound.

Also at the higher pH ranges, the trace elements begin to be tied up so they are unavailable. We know that in overlimed soils, iron, manganese and boron are converted into forms which are unavailable to plants. Even if additional material is applied it may be tied up in the unavailable form as fast as you apply it.

Another problem associated with low pH is calcium deficiency. Calcium is an important plant nutrient. In

the extremely acid soil, there is not enough calcium present so plants will suffer from a calcium deficiency. Also it may suffer a magnesium deficiency which goes along with calcium and is usually contained in limestones.

Another thing which I think is extremely serious about low pH ranges is the lowered biological activity. Most of the bacteria which live in the soil must have a pH range which is at least 5.5 or higher-- 6 to 7 is nearly ideal. With reduced biological activity, when you apply organic fertilizers, you will get no response because the organisms which cause the breakdown are unable to function. The same thing will happen if you apply ammonium sulfate. The plants which can assimilate the nitrogen in the ammonia form are very few. Most plants must have nitrogen in the nitrate form. The conversion of ammonia to nitrate is effected by soil micro-organisms. It has been observed in many cases that no response is obtained when ammonium sulfate is applied to acid soil because the ammonia can not be converted into nitrate.

Another thing that will follow from the lower pH because of reduced activity of micro-organisms in the soil is an accumulation of grass roots in the soil. Since the grass produces a new root system periodically, unless the old roots are decomposed, there will be an accumulation of roots or a sod-bound condition. It may get so severe that water cannot penetrate.

I have already mentioned the equilibrium or balance which exists in the soil between the different chemicals present. Occasionally we use the term "buffering" to describe the soil. What does that mean? A buffer in the soil is something which increases the amount of acid or base which must be added in order to make a unit change in pH. If you add a strong acid to the soil, some of these other compounds will take some of the hydrogen ion which makes the soil acid and tie it up in unavailable form. In general that is what happens in the soil from these buffers and it is a good thing it does happen because otherwise when we apply our lime or other materials, we would upset this balance that exists in the soil to such an extent that it would be impossible to grow crops in it.

Another thing in that respect which I think worthy of mentioning is the fact that when we measure the pH of a soil, we are measuring available pH. In other words, all parts of the soil do not have the pH we measure. For instance, if you get a pH of 5.8, that doesn't mean

that every part of the soil has a pH of 5.8. In some research done along those lines, they took a plot of soil about the size of a fist, took very, very small parts from it and made micro-chemical tests of it. They found that in one plot of soil the pH varied as much as 5.4 to 6.1. The significance of this is that we don't have and don't want to have the same pH in all parts of our soil. We want to have a variable pH for this reason. At a pH of 5.4 the plant can get one or more of the nutrients but perhaps it couldn't get others. At a pH of 5.8 in another part of the plot it can get other nutrients it needs. In one little part of the soil, one root hair can get one nutrient that the plant needs and in another section, perhaps an inch away, it can get another nutrient that it needs. I think that is something we have never considered before and it certainly is worth consideration and is valuable from the standpoint of growing any kind of crop.

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WHAT EVERY TURF MAN SHOULD KNOW ABOUT WATERING

Howard B. Sprague, Director
Texas Research Foundation

There is some overlapping between what I am going to say about watering and what has already been said about other phases of turf management. That is natural because the various phases of turf management are interrelated.

In the first place we will classify the areas we are considering from the standpoint of water. All types of non-agricultural turf fall generally into two categories. There is the type of turf where traffic is occurring (foot traffic, primarily) in all kinds of weather, with resultant compaction and the effect upon soil aeration and waterholding capacity. This type includes putting greens, football and other athletic fields and similar areas where traffic is going to occur irrespective of the moisture condition of the soil. That is a tough situation.

Then we have other types of areas that might be called intermittent or occasional traffic areas. Those are areas such as cemeteries, most of the parks that are

not athletic areas, large lawn areas and I would like to remind you that we are also dealing with airfields and highways. The airfield shoulders are areas that don't receive very much traffic, and highway shoulders and the right of ways beyond the shoulders are usually only occasional traffic areas.

The first kind of turf area requires water. The intermittent or occasional traffic areas may or may not need water. Even in humid regions,the question arises, "Should we put in watering systems for these turfed areas, or is it unnecessary?" When you get into drier regions, water systems become more and more necessary.

Watering is exceedingly expensive, both the original installation and the watering after the installation is in. So it must be valuable or we are not justified in going through the expensive operation involved. That brings us to the second point: "When is it necessary to water, and is it necessary to water, and if it is, how much water do we need?" I think we are likely to get a little confused as we haven't stopped to analyse what is actually the situation. Turf culture in general is a complex thing and it is easy to get confused.

The question of when is it necessary to water and how much has a chart with it. We have to think of this question of whether we need to water and how much in terms of total water supply. We know the grass has a requirement of so much water for every square inch of leaf surface. We can also express that water supply in terms of two pounds of mineral nutrient that is taken out.

If you have more grass leaves, there is more transpiration. But the organization of this leaf area has a great deal to do with whether you are using water or not-- a thin turf loses a tremendous amount of water from the soil and you have to consider that loss as well as the actual utilization of water. The poorer the turf, the harder it is to supply the water because only a portion of it is used by the plants. When sod is thicker the temperature is lower and water evaporation from the soil is directly proportional to temperature.

Whether or not you need water is going to depend on whether you have enough in the soil to satisfy the plant requirements. That brings you right down to soil properties which we have been discussing. I would like to refer to this chart to bring home the points that have been mentioned before. Suppose we have a

soil that has a waterholding capacity of 15%. That means the difference between what it can hold when it is saturated and what it has left when the plant begins to wilt is 15% of the dry weight. Weight of soil varies with its character, but for a simple illustration, I'll say a cubic foot of soil weighs 100 pounds. If you have a 15% capacity and your roots are down six inches, you have 7½ pounds of water per surface square foot, to a depth of six inches. If you go down 12 inches, naturally you have 15 pounds of water; eighteen inches you have at your disposal 22½ pounds of water and if the roots go down 24 inches you have 30 pounds of water. Of course, if the roots are only two inches you have only 1/3 of 7½ pounds of water for that grass to use. You cannot consider watering unless you consider first of all what the capacity of the soil is for holding water and, second, whether the roots are going to utilize the soil to draw in the water which is present. We are always going to use natural rainfall to the utmost if there is any natural rainfall.

If you improve the soil so it has a capacity for holding 25% water in an available form, six inches of soil under a square foot will hold 12½ pounds instead of 7½ pounds of water; in twelve inches there will be 25 pounds; eighteen inches -- 37½ pounds; twenty-four inches-- 50 pounds of water.

Another factor which influences when it is necessary to water and how much is the fertility. In general, we know that soils of low fertility have poor water relationships. If you want efficiency in the use of water, don't expect water to take the place of fertilizer. In order for plants to use water, they must have the absorbing organs to take it up. The primary absorption organs are the root hairs, and the root hairs are the first organs to die if anything goes wrong. If soil is too acid or you have too much of some toxic substance, the first thing to die is the root hairs. When you remove all the root hairs from a rise of soil, you have a very low capacity to use water. After the root hairs the growing tips of the roots are the next most important organ in absorbing water, and when those are damaged, you have reached the older roots which have corky bark on the outside and are very poor. If you have high loss of moisture because of high temperatures and low humidity in the air, these damaged root systems may not be able to take up the water fast enough to satisfy the requirements of the top parts and wilting and perhaps death will result.

Remember the plant is just as variable in its root habits as it is in its topgrowth. So the difference between some strain which is capable of growing under rather droughty conditions, when another strain does not, is often below the surface. There may be a tremendous difference in root type, root depth, the abundance of branchings, amount of root hairs and so forth.

Management practices affect the moisture situation and consequently the watering procedure. Very closely cut turf will always have a more limited root system than turf that is growing longer, although we are having some eye-openers as to how deep we can make these roots go even in closely cut turf. But especially if you have a plant that doesn't have the capacity to develop a lot of leaves close to the ground, then close-cutting is going to shorten the root system tremendously.

We come again to this question of the relationship of the grass occupation to the structure of the soil. That is going to have a tremendous bearing on whether you have to water and how often. Under natural conditions, grass is one of nature's most useful methods of increasing the water storage capacity. If you are dealing with areas that must be tramped on during wet weather, you will nullify that effect to some degree. If soil is clayey it doesn't take much tramping in wet weather to get a very compacted soil. If the soil is sandy it won't suffer that undue compaction. That is an estimate you have to make in connection with your management practices.

Also there is this question of soil aeration, which is closely tied in here. The first thing that happens if you have poor aeration, whether it is due to compaction or too much water, is that you don't have enough oxygen in there. I would like to point out an example. If you open a bottle of beer and it is iced, you know you have a gradual release of bubbles. In that case, it is carbon dioxide gas. But the gas laws in connection with water are practically the same. You know that if beer is warm and you open it up the gas bubbles escape much more rapidly. The reason for that is that the amount of these gases that you can hold in water is reduced with increased temperatures. Soil water has greater capacity for holding air at low temperatures than it has at high temperatures. So the danger of suffocation is greater as the temperature rises because, if there is any change of air at all, the soil water will have less air in high temperatures

than it will at low temperatures.

This suffocation is very, very important because of the delicate nature of root hairs which are the principal absorbing organs. If you tied a string around your big toe and got it tight enough, it wouldn't be very long before it turned blue. If you left it on too long, you would find that all the tissues were dead and somebody would have to amputate your toe. That is the same thing that is happening in your sod and grass roots where the oxygen supply is reduced.

I have not given you very much information as to how much water to put on. As a matter of fact, I am going to steer away from that problem to some extent.

Suppose you have a watering system or are just trying to decide whether or not to install a system. What things should you consider? First, have I satisfied the fertilizer requirements, especially nitrogen because water is no substitute for nitrogen?

Second, if you are on a very acid soil, have you taken care of the acidity? If you have acid soil that is going to complicate everything you do, so why spend money on watering when what you should do is correct the acidity? In acid soils there are the root bound conditions, and it is very serious. In normal conditions roots decompose about as fast as they die and when they decompose the organic matter increases the infiltration of the soil. When they do not decompose, they shed water. If that is the reason you are short of water, obviously, installing a watering system is not the answer. The answer is to dispose of that accumulated material.

Next, are the mowing practices those that are required for the use that you are making of the turf? If you mow more frequently or more closely than the grass needs, then you are asking for trouble. If this is a problem it should be corrected before you go to the expense of water.

In the actual watering I think you must live with your turf, and one of the best ways to determine how much water you will need is simply to look at the turf. The soil sampling tubes are the best way I know of to look at the soil, both from the standpoint of air and water. What are the barriers in the soil as far as the upward and downward movement of air and water are concerned? If you have layers impeding downward movement of water they will probably act as barriers to root growth too.

A general principle is that when you do water, put plenty of water on, but don't water so often. Second, don't put too much water on. Waterlogging, particularly in hot weather, is one of the best ways I know of to get into trouble in a hurry. Every root cell must have oxygen. If you are dealing with high temperatures there is less oxygen dissolved in the water than if you are dealing with low temperatures. That is why you can get away with waterlogging in cool weather and you can not in hot weather. We must provide for the disposal of drainage water so there will be air in the soil.

The other thing holds true too-- if you have a deficient supply of water, the roots can die from the lack of water. The first thing that dies from drought is the root hairs. So we must not let the soil get too dry. From experience you learn to tell when a given horizon has enough moisture for the plant's use.

I would like to point out that things like insects and diseases which affect roots are going to have the same effect on root hairs as these other things I talked about. Watering has a useful function there in keeping the plants alive until you can grow a new root system, but you should recognize the cause of trouble as early as possible and correct it.

I think there are many instances when you can grow perfectly good sod without any watering system. If you haven't tried fertilization or a better adapted grass or some of these other things, why not try those before going to the expense of putting in a watering system? Water isn't the answer to everything. If you do have a watering system, try these things and see how far you can go towards cutting down watering costs.

If we can achieve a desirable balance between the nutrient supply, the air supply and the water supply, then we are going to have these very important benefits. First, we are going to have an abundant root system which will extend to considerable depth. Second, we are going to have nature help us develop high infiltration rates and high storage capacity in the soil. If given an opportunity, grass is really remarkable in the improvement it will make in the soil. We are going to have a resilient type of turf from the standpoint of how it will wear, and a very high quality as far as appearance is concerned. Most important of all is that we are going to have a reduction in watering costs, and I think that is very important.

A final thing I think we can expect from sensible watering practices, in balance with the rest of the program, is that we will have much fewer problems with diseases, insects and weeds. In other words, your good watering practices need not work in contradiction with any of the other things that we have been talking about. It all fits in together to form a pattern of good management, good from all standpoints.

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WHAT EVERY TURF MAN SHOULD KNOW ABOUT TURF WEEDS

O. J. Noer, Agronomist
Milwaukee Sewerage Commission

At the last meeting of this group, I was assigned the topic of turf diseases and Fred got the weeds. This time the sequence has been reversed. But before going on, I would just like to make a few remarks in conjunction with Fred's talk. One of them is the question of copperspot. When I was in Rhode Island in August, I saw the plots at the station. There was more disease than there had been in the last eight or ten years. There was one section of velvet bent, which they were not using primarily for disease control, but to find out what could be done to prevent mat formation on velvet bent. Some of the plots were being top-dressed, and on other strips lime was being applied at different rates. The plots that did not get any lime had a reaction down around 5.5 and were plastered with copperspot. One thousand pounds or more of lime was about as good as any fungicide so far as that disease is concerned. I had seldom seen copperspot in the Chicago area, Milwaukee or elsewhere; it has been confined mostly to the east. The boys in Chicago, whenever they top-dress, put on a couple of hundred pounds of lime because the sand used in that area contains 20% to 30% lime.

One of the pathologists at Purdue, who is working with the pythium problem, remarked that one of the best ways to curtail pythium is a slight change in soil reaction, either up or down. In other words, if the soil reaction is 6.5 and lime or any other chemical is applied that will throw that reaction slightly one way or the other, it seems to do a lot towards curtailing pythium. It is something that should be explored fur-

ther, so far as this disease is concerned. Pythium was bad last summer and those of you who had it were more or less defeated because you didn't have oxided copper as Fred mentioned. So with those few passing remarks, I am going to go on now to the weed problem which has been assigned to me.

I feel that 2,4-D probably did more to popularize turf with the layman than did any other single development. It made it possible to have a weed-free lawn because broad-leaf weeds are the worst weeds te have to contend with and, instead of that back breaking job of going out with a knife or weeder, one shot of 2,4-D will do the job. While we have materials which can help control grass-like weeds, we need a one-shot material such as that to really solve the problem.

However, I think we ought not overlook the point that these herbicides are only one factor so far as weed control is concerned. It is fine to take the weeds out, but unless you have turf to replace them, you are going to be confronted with another batch of weeds just as soon as the seeds in the soil germinate and become established. So instead of taking any time this afternoon to talk about these herbicides and how they should be used, I would like to cover the subject from the broader angle of getting something to replace the weeds. In other words, we so frequently get letters aaying that they have clover in the greens and could we suggest some chemical to kill the clover. Personally, I think that is like staying out until three in the morning and getting a little shot when you get up at eight, to carry you through the day. The thing is to grow turf that is able to resist the weeds, instead of looking for some cureall that is going to take the clover out of the turf. With those preliminary remarks, I am going to tell the rest of the story in Kodachromes.

The first picture shows what the weeds are. The stock man likes clover; the golf course superintendent does not want any. So it seems to me that a weed is any plant that is out of place. What is a weed on a golf course may be a perfectly acceptable plant somewhere else.

The next picture is one that was taken in Missouri. Here is bermuda, which I think is one of the premium fairway grasses, invading a green. The green has become about five feet shorter because of the bermudagrass. So there, as in this area and in Texas, bermuda, so far as bent greens are concerned, must be classi-

fied as a weed.

This is a fairway at Milwaukee Country Club. The picture was taken in 1939 long before we knew anything about herbicides. I throw this on the screen to show that we did have, even in those days, weed-free turf of pleasing quality. Had Kodachromes been in existence in 1932,I could have taken a picture of the same fairway and you would have seen almost solid clover instead of bent. The course had a reasonably fair stand of grass, they put in a water system, used no fertilizers and ended up with clover. Then there was the problem of changing the fairways of clover over into good grass and the job took much longer than it would today with the chemicals we have on hand to help curb some of these things we don't want in our fairways.

This picture was taken at the same course on the 26th day of October. I took the picture along the number three fairway to show the bent fairways and show the quality of the rough on that course. The roughs are almost 100% Kentucky bluegrass. Before the days of 2,4-D, plantain, buckhorn and dandelion were in those roughs. Today you will see nothing but an excellent stand of bluegrass.

This was taken along the edge of number three fairway at Milwaukee Country Club, showing the bent around the closely clipped fairway proper and Kentucky bluegrass along the edge of the fairway. During the war the roughs at this course, and at many other courses, were clipped close so that the players did not lose their balls. I was at the course one day and one of the better players complained about the fairways. I was a bit surprised because I thought they were good fairways. Upon questioning him, I found that it really was not the fairway that he was complaining about, but the fact that the bent was creeping out into the roughs and, since the roughs were cut close, the man who had a ball one foot off line was worse off than the man who was twenty feet out in the rough. So I told them the solution to that problem was to keep a semi-rough of one tractor width alongside the fairway. They did not do that. Instead, the roughs were cut higher and notice that that was much better than the solution I suggested. By raising the height of cut and giving the bluegrass a good chance to grow, it resisted the invasion of bent from the fairway.

This picture is of Memphis Country Club. Fred did an outstanding job there of helping that club transform fairways, which were of clover and considerable crab-

grass, into an extremely good stand of bermudagrass.

The next picture was taken from approximately the same spot, during the tournament. Unfortunately, the bermuda isn't as green as we would like for the purpose of photography, but I believe you can see that the clover is gone and, if you were there, you would see that there is no crabgrass and that the turf is about the same quality as Southern Hills in Tulsa.

How do weeds get into the turf? When Fred and I were at Amarillo, we went to the airport where they had trouble with weeds. Fred picked material off the tractor wheels, so you can see this is one way of transporting weed seeds from one area to another. Of course, there are many other ways as well.

The next picture shows watered fairways in New Jersey, and I believe you can see more broad-leaf weeds than anything else, in the area. It is a narrow fairway. Water alone has a tendency to increase the weed population of almost any turf area.

Here is one of the plots at Rhode Island in which they were trying to find out how they could control mat on velvet bent. This strip got no top-dressing and the one along side was top-dressed. Notice the heavy population of crabgrass on the top-dressed side as compared with the no top-dressing strip. I personally think they got soil from a place like this next picture. In September I attended a meeting at Spring Lake in New Jersey. I got off the train at Trenton and drove across to Spring Lake. As I was driving I saw this potato field, but so far as I am concerned, it is a crabgrass field. All the vegetation on the right is crabgrass. Of course, soil from an area such as that is, from a physical standpoint, ideal for use as a base soil for many top-dressing mixtures. But I think I would hesitate to take it unless something was done about the crabgrass seeds in the soil.

A couple of years ago I went to Mexico City primarily to visit the Chapultepec course. They had poor fairways and, since rainfall isn't too good, some of the enterprising members were sure that the answer to the poor fairways was water. They went to considerable expense, installed a hoseless system and started to water the fairways. The only thing they got was burclover. This may look like a washed out picture, but the fairways were just as washed out as this when I saw them. There are a few sprigs of bermuda, but the only green portion was just a little leaf at the tip

end of the stem. The soil was so deficient in nitrogen that water alone, of course, did not make the bermuda spread and produce turf.

This is a fairway in North Florida. It is the approach with the green in the background. It is a watered fairway, and I think you can see that about the only thing that is growing is the white clover. The reason for that again is that water alone won't grow grass. With an adequate program of feeding, I see no reason why you can't have good fairway turf in the South. So many of you say that you won't water turf because all it does is bring crabgrass. That is true if you do nothing but apply water. Southern Hills and Memphis are examples of the fact that water can be used to advantage to develop a good bermuda turf on fairways. But water alone isn't what does it.

This is one of the greens at the Chapultepec course in Mexico City. They applied water, and when they top dressed the green, then they used no less than four or five yards of top-dressing to about 4,000 or 5,000 square feet-- and they wondered why the bent wasn't doing very well. You can see all that is growing there is clover. There was a nursery along one side of a fairway and, when a green got too bad, they would take turf out of the nursery and re-sod the green. To me, the whole thing seemed rather wasteful. Since they have gone over to a decent fertilizing and watering program, and do not smother the grass with all that top-dressing, they have developed a much better turf on the greens.

There is the matter of time of seeding. This is one of Rabbitt's series of plots that he operated several years ago. He seeded one series in the fall and the other in the spring. Notice that the fall seeding, particularly where it was adequately fertilized, is a good turf. With the spring seeding he got nothing better than this brown grass over here, which is crabgrass. In other words, the young plants did not get off to a fast enough start in the spring to be able to resist the encroachment of crabgrass in the summer.

This is a piece of turf at Cleveland which was badly infested with dandelion and plantain. You will notice that in the area where the plantain has been killed, the turf is thin and some places are devoid of turf. Unless something is done to encourage the grass to fill in the voids, next year there will be two or three plantains where there was only one this year.

On many of our watered fairways in the north, chickweed is a very serious problem. We thought at first that 2,4-D would control it. It checks it but it does not kill it. Some years ago at Milwaukee Country Club, we ran some plots using 2,4-D and sodium arsenite. We did it because we wanted to find out what would happen with successive applications of 2,4-D on bent. Here you see one of the smaller plots with more treatments. We got fair control of chickweed, but we did so much damage to the bent that the club has never used 2,4-D on any of the fairways.

This is a picture taken in Denver several years ago, showing 2,4-D injury on a bluegrass fairway. In this case, the ester type and not the amine or the salt, was used. Admittedly the rate of application was excessive, and I don't think the picture should be used to condemn 2,4-D, but just to show you that it is not entirely foolproof.

This is a green in the Minnesota area that was treated last summer with 2,4-D of the ester type. The application was made almost a month before I was there and you can see that the bent has started to stage a comeback. There were not too many weeds in these greens and I think more money was spent trying to get the bent back than it would have cost to remove the few small plantains that were in the green.

I am going to show you two pictures to illustrate that dandelions were controlled before we had 2,4-D. This is on one of the courses in the Chicago area. Incidentally, it is a watered fairway and you will notice that there aren't too many weeds on it. That turf was produced without herbicides of any kind. But notice the roughs and the dandelions in them. These roughs were sprayed three or four times with arsenic acid. The next picture was taken the following year and notice the contrast between the two. Now the cost of doing the treatment was probably saved because less frequent mowing was necessary. When there is buckhorn and dandelion in the roughs, they must be mowed to cut off the seed heads rather than to cut the grass. By taking the weeds out, less frequent mowing is necessary. That is true, of course, whether the job is done with arsenicals or 2,4-D.

I told you that 2,4-D does only a passable job on clover control, as compared with sodium arsenite. This is one of the fairways at Milwaukee in the early days when we were working with sodium arsenite, before 2,4-D came into the picture. I think you can see that

we have obtained excellent control of clover, although about three applications were made in order to give this measure of control.

This is an area of crabgrass which was treated with sodium arsenite and this is about two weeks after the treatment was made. I pulled out some of the stems trying to show the new life in the crabgrass plant. This is what happens. Buds start to grow from the nodes and they take root. So if successive applications of sodium arsenite are not made, it isn't going to eliminate the crabgrass.

This picture was taken several years ago in Hartford, Connecticut, showing some test plots which were being treated with PMAS for the control of crabgrass. He is getting what seem to be pretty good results. When I was at Rhode Island in August I was very much impressed with the results being obtained with PMAS on the plots there. It takes three to five treatments to do a job. Yet after I left there and went up to some of the courses in New England, my faith in the material was badly shaken because on some of the greens, I saw not too good results. I rather suspect that the frequent hand-syringing in the daytime was partly responsible for the poorer effects of the material. PMAS is expensive and it, like the arsenics, is not the answer to the problem the way 2,4-D is for broadleaf weeds. What we still need is a one-shot job.

Here is a tee in Guadalajara, Mexico. I was taken to this tee and asked what could be done about getting a good turf and keeping weeds out of the tee. The tee is partially shaded and you can see that the bermuda is very thin. I can't help but feel, when I travel through the South, that you should have less shade around the tees or have some grass that will tolerate shade, if you are going to have good turf and not too many weeds in those areas.

This is a tee at a course in St. Louis showing the goosegrass on the front part of the tee and bermuda in the back. Notice how planting bermuda was the most effective control for goosegrass in that area.

This picture was taken before the war. It is a zoysia tee in the Louisville area. I was there during the war and I felt the tees were going back. This spring when I visited the area, I thought that the man then in charge was getting the tees back in as good shape as they were before. He told me it was a matter of increasing the amount of fertilizer which made the

difference.

This is a bent tee at the Milwaukee Country Club. These tees are always in good condition. I think the members are well satisfied with the tees. They don't require too much maintenance. They are mowed with the putting green mower to keep it tight so that the players don't complain about the fluff of grass when they play and also to keep the turf tight enough so that a man has a good stance when he addresses the ball.

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WHAT EVERY TURF MAN SHOULD KNOW ABOUT TURF DISEASES

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

These are some of the things that I feel every turf man should know about turf diseases. First, if you have a turf disease, how would you describe it? Second, if you have a turf disease, how would you recognize it? That is practically the same but you can't tell anybody else what you have unless you can accurately describe it. Third, and this is more important than knowing what to do, where can you go to get the best information? You know that is really the secret of a man's education. It isn't necessarily what he retains in his head, but where he can go to get that essential information.

The striking thing about the 1949 season in regard to turf diseases is the fact that research people telescoped about five years of work into one because turf diseases were worse in 1949 than we have ever known them since we have been studying them. We threw out many grasses which we thought were good but were unable to withstand the attacks of diseases. This bulletin (Turf Diseases and Their Control--U.S.G.A.) that many of you know about is a standard piece of work and is now being used as a textbook in college courses because it accurately describes many of the turf diseases then known. There have been many new turf diseases found since then. I understand that there are more than fifty fungus diseases of bents and they haven't all been studied by any means. We have a control for only three or four. A new one was found this summer for which we have no control.

I just can't impress upon you too strongly the effect of environment. Now environment is the sum of the factors surrounding the particular plant or object. Temperature and humidity are the two great factors which affect grasses with respect to diseases. Recently some of the agricultural research people found that the disappearance of clover in pastures came about as a result of a fungus which grew only when the temperature was at the freezing point. By contrast, we have the pythium disease which attacks bent greens and many other grasses very severely and occurs only when the temperatures are above 90° and the humidity also is very high. Pythium was very bad on many golf courses in the East and middle west this last summer. It has been studied; it is mentioned in the Bulletin; but nobody as yet has a control for it. The best chemical that was applied was copper, but the minute you say "copper", all the old timers go right back and remember when they used a Bordeaux mixture and got into copper poisoning. I don't believe that will be quite so disastrous primarily because we are using more organic matter and organic matter can absorb and render non-toxic large quantities of copper. That was found in potato studies. The copper poisoning on potatoes was in direct relationship to the amount of organic matter in the soil. Then, too, we have many forms of copper which are not nearly so toxic and really are quite safe for the control of disease. As yet, there are no recommendations for the control of pythium.

Two of the most common diseases that occur on bent greens under low temperatures and rather high humidity are snowmold and leafspot. When the temperatures are still low and the humidity also is low, we have dollarspot growing. Then when the temperature gets high and the humidity is also high, we have brownpatch, and pythium and many other things.

I want to say something about the micro-climate where the plants grow. We talk about the temperatures and humidity and most of that is measured by the Weather Bureau several feet above the soil surface. That is not an accurate picture of the climate where the grass is growing. That is what we call the micro-climate. When you have all of those densely matted grass blades growing in a narrow space, you have an entirely different situation than you have when there is air movement four feet above the ground. We just don't know much about that micro-climate just as yet. But we do know that it is far worse than we suspect it to be from the Weather Bureau readings.

Everything that has been said about watering, fertilizing, accumulation of clippings all have a relationship to disease. By judicious watering and not over watering, by maintaining proper water-air balances in the soil, you will have a healthy soil. Everything Dr. Sprague said this morning has a definite relationship to diseases. The accumulation of clippings is perhaps one of the worst evils because where you have an accumulation, you have a perfect incubator for disease organisms. Where the mat is very heavy, you may have more difficulty in controlling a particular disease because you either do not have enough volume of spray or you do not have enough fungicide to penetrate to all the disease organisms. Soon after you are through spraying, the disease starts all over again because you have all the spores starting to grow.

Here are some of the diseases that we know of on the bents: dollarspot, brownpatch, snowmold, pythium, copperspot, pinkpatch, leafspot, helminthosporium and many others. Most of those are caused by fungi. However, we can have a physiological disease just as well as one caused by fungus. A physiological disease is one in which the grass suffers from some mismanagement practice. It may be overwatering, watering at the wrong time, starvation, overstimulation with nitrogen, and so on.

On the bluegrasses we have leafspot, mildew and there is no use going into detail because on the bluegrasses none of them are being controlled by chemicals. The only place I know of where it is being controlled by chemicals is on putting greens. At the moment that is the only place where control by chemicals is practicable because of the expense involved and the fact that the greens are of a limited area.

Among the fescues we have rhizoctonia, cercospora and helminthosporium and several others, none of which can be controlled by chemicals. Bermudagrasses are severely attacked by leafspot and several others. Dr. Burton has mentioned several of them in his publications. The difference between cotton-patch bermudagrass and the new selected strains demonstrates without a shadow that the best way to control any of these diseases is to grow a better strain of grass, one that is more resistant to disease. With zoysia we have not as yet found a disease that we can name. It appears to have high resistance to all of the known diseases. That doesn't mean that it isn't going to get one because if you take it into a new climate or a new environment there may be a disease there that will attack it. Of

course, it is subject to these physiological diseases because in many places I have seen it very badly mismanaged-- overwatered, underfed, and it just suffered and died. But that was not a fungus disease that did it unless the fungus was secondary.

On the chemical control side there are a number of well-known control chemicals. Probably most of you are already using them. There are new ones being tested all the time. Pennsylvania, Rhode Island and Purdue are probably the three outstanding experiment stations in the country that are working on the control of turf diseases. They are doing it because they have competent pathologists to carry on the work. We are not doing any of it at Beltsville now because we do not have the services of a pathologist. The American Phytopath Society undertook to conduct coordinated tests all over the country this past year and the results are being tabulated now and will be available in printed form before too long.

Mercury long has been a standard for disease control and it still is one of the best. Occasionally when a grass is very weak by virtue of a shallow root system, overwatering, underfeeding or a lack of oxygen in the soil, a dose of mercury may hurt the grass more than the disease. I have seen grass killed by using mercury where it might not have been killed so badly had the disease been allowed to run its course. It is surprising to find that the methods of application differ so much. Some people absolutely swear by spraying these chemicals; others absolutely swear by putting them on dry.

Tersan (tetramethyl thiuram disulfide) has been good for hot weather disease control because it does not injure or retard the grass. But it is still not effective in many cases unless there is some reserve mercury in the soil. The same thing is true with the cadmium fungicides. In many cases they have failed to give control of pinkpatch, dollarspot, and copperspot unless there is a reserve of mercury in the soil. In many cases the greenkeepers just add ½ an ounce of calomel and bichloride of mercury to the 1000 square feet along with the cadmium or Tersan and have gotten better results. Quite a bit of work is being done on that and we will have more reports of that shortly.

Hydrated lime still stands out as one of the better chemicals for brownpatch control. It is not necessarily a specific for disease control, but hydrated lime applied to an ailing, sick piece of turf in the heat

of the summer, snaps it out of it and generally you get recovery. There was a lot of hydrated lime used during the summer of 1949. Three or four pounds were used to the 1000 square feet, dusted on, not sprayed. When you spray you are adding more water and chances are that is why you are having such a bad attack of disease. What we want to do is to dry up the surface of the green and that is why this drainage-oxygen relationship is so very important. If you can maintain a good supply of air in the soil you can keep your surface drier, water less frequently and greatly diminish disease. PMAS has been used to some extent for dollarspot control and, in addition, it reduces the amount of crabgrass. As yet it has not been used very extensively but it has done a good job both for dollar spot control and for crabgrass control on greens.

I wish to refer again to the work that was done by the Green Section and published in 1933, with regard to the time of watering. We have to repeat this every year because there are new fellows coming in who have not seen that publication, don't have it in their files and we have to remind them of it. We found then and demonstrated conclusively that early morning watering, that means six and seven o'clock,resulted in much less disease and much healthier grass. Nothing else did it. Watering during the day and watering in the evening resulted in many times the amount of disease. Why? Because that micro-climate was moist during the night when the disease was active and these organisms need moisture in which to grow and flourish. By watering in the morning the greens were kept drier through and the "dew" was washed off the grass blades. Dr. Hoffer of Purdue, as O. J. mentioned yesterday, threw an interesting light on this. It has not yet been proven but it seems very logical. With the tissue test,he is testing the "dew" on the grass in the morning. Actually most of that is water of guttation. It is exuded out of the pores (hydathodes) of the grass. But those droplets of dew were so highly charged with nitrogen, phosphorus, potash, magnesium, calcium, all the elements which are necessary for the fungi's growth, that it provided an ideal medium. He argues that the fungus actually grows in a continuous nutrient medium. By washing off the dew early in the morning, you wash the nutrients back into the soil so that the plant can reuse it and you don't get that scalding during the day. When the drops of moisture dry on the leaf, often you can see the crystals of chemicals. I think it is an excellent point with respect to water management.

Now there is a great deal said about breeding resistant strains of grasses. In fact with many of our grasses, especially on the larger areas where we can not afford to use chemicals, it is the only way in which to overcome a particularly serious disease. I showed you last night the comparison between Arlington (C-1) bent and Washington bent and the tremendous difference in disease resistance by those two strains that has been observed in those test greens that the Green Section developed several years ago. Dollarspot would come right up to the edge of one bent but no farther because the other grass was more resistant. We have seen the same thing with brownpatch. We have a new strain of bent at Beltsville which we want to distribute soon for testing in other areas. It is a very rapid growing, drought-tolerant and disease-tolerant bent which came from southern Virginia. In two years we have not observed any disease upon it. We handle our bents a little bit differently than other stations because we do not water them artificially. We are trying to find those drought-resistant bents which are disease tolerant and which will thrive and give good service under a minimum of care. We argue that if they are given reasonably good care, they will be even better. We want to get some of those new bents out into this section as soon as we can do it for you to test them.

With bluegrass there is no question about the results that we have compiled in the last month. Merion (B-27) is highly resistant to the helminthosporium leafspot which is so destructive to the common commercial bluegrass. Leafspot is one of the big reasons why bluegrass turf so often fills with crabgrass during the summer. The disease weakens the bluegrass early in the spring,leaving the turf thin to the point where it has no chance to recover before the crabgrass season and it is just an open invitation for crabgrass and other weeds to come in. We find that the incidence of crabgrass in Merion bluegrass is less because it does not thin out and suffer from leafspot in the early spring.

Some of the fescues that are being developed at the Pennsylvania Experiment Station are highly disease resistant. One of the reasons why we have been almost unable to grow any fescues in Washington D.C. is because of disease. We are finding now that the high disease resistance of some of these new strains is such that I believe we will be able to put into use some of the fescues further South. Several diseases have been reported on Alta and Kentucky 31 fescue es-

pecially during the summer and brownpatch was one of them. So we still have some work to do on those grasses to develop better strains. There is no question that on the bermudagrass, the newer strains are so much more disease resistant that they are able to give you better service and, as I have told some of you before, the Tifton 57 bermudagrass is able to push out the ryegrass in the spring and leaves you with practically no conversion period at all. I have seen that now over several years at Tifton and it is really remarkable because it has so little disease that it has nothing to recover from in the spring except just the dormant period in the winter. I am sure that disease has been one of the big problems with bermudagrass on some of the more intensely managed areas throughout the South.

In summary, we can say that a disease control program consists of several things:

1. Intelligent use of the appropriate chemicals.
2. Intelligent soil, turf and water management.
3. Greater use of disease-resistant strains of grass.

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WHAT EVERY TURF MAN SHOULD KNOW ABOUT TURF INSECTS

Professor Charles H. Brett
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At the present time we have just a little advance information about the use of some of the new materials for the control of insects. Most of you who have had insects in the turf have used lead arsenate considerably. I don't know that there is any big reason for changing. Fred Grau tells me there are some advantages from the standpoint of the control of weeds. But I am going to start here by going through some recipes.

The old standby of using lead arsenate consists primarily of mixing with the top-dressing to get about 5 to 15 pounds per 1000 square feet. That is a seasonal treatment of lead arsenate. This is a rather general control material giving good protection against web-

worms, cutworms, and many of the beetle grubs and earthworms. About 35 pounds of lead arsenate in the upper three inches in lawns and greens will make them highly insect proof. If you haven't used any of these methods, you can spray about one to two pounds lead arsenate in 20 gallons of water per thousand square feet. That is a general recommendation.

Now another one of the insecticides that has been used is carbon disulfide. I think probably the best thing to do here would be to consult the government circular itself. There are some complicated mixtures there and it is better to examine that circular instead of elaborating at this time. It varies considerably. In other words, you may use from a quart to two or three gallons per thousand square feet, depending upon the temperature and insect pest. Things of that sort get involved.

Pyrethrum is another of the old standbys. Here we have a material which is good for the insects in the superficial layer of soil. There is a high-grade preparation of pyrethrum. I think sometimes it is called "Horticultural Pyrethrum". That is a very pure form of the extract and one fluid ounce of this to five gallons of water is sprinkled on the turf at the rate of one gallon per square yard. That material is very irritating to insects and because of that it is often used as a test material to see if you have an insect problem. Spray with pyrethrum and, if you have an insect problem, most of them will be irritated enough to come to the surface, particularly if you do some watering along with application of the material. Along towards the evening is the best time to do it to test the soil for an insect problem.

Now just a little on Chlordane. It is rather difficult to make blanket recommendations for insect control, but occasionally we find something that is excellent and that is pretty much the situation with Chlordane in controlling insects in sod. It is pretty potent stuff, so far as insects are concerned. At least ten pounds of Chlordane per acre in any form should be used, which means you can spray it or dust it or treat the soil in any way that might be convenient. I think that oftentimes they recommend the use of a 50% powder which will then be soaked into the soil, this to give ten pounds of Chlordane per acre, or twenty pounds of the 50% material. That is almost a blanket on control for about all of the different types of insects which may be involved.

Some of the publications which came out to begin with only had a year's record on Chlordane, but now there are two years information available. As I understand it, in these experiments the Chlordane is still in the soil and is still killing insects. How long that is going to last, I don't know and I don't think anyone knows for sure. It may be four or five years before a new treatment must be applied. So it is quite remarkable in that respect.

Another one of the newer insecticides is benzine hexachloride. The gamma isomer is the one that is toxic to insects. It is being extracted and manufactured in the pure form. If it is in the pure form, I think it goes under the special name of "Lindane". Now the new materials on the market are different concentrations of Lindane. That doesn't have the obnoxious odor and some of the disadvantages associated with benzine hexa chloride. It was found to be superior to 100 pounds of DDT. Here again we have a remarkable insecticide which has remained effective for more than two years. Experiments are still in progress to see whether benzine hexachloride will lose its toxicity within a period of time.

Now that reviews the insecticides that are of greatest importance in controlling the insects, and I have just a little information here about the principal types of insects that are involved.

First of all are the white grubs. The white grubs, as you know, are the larva of common June and May beetles. The adult of these beetles is attracted to lights. In the dawning, they will return to the soil so that you do not see the adult beetles around during the day. It requires about three years for them to complete one generation and, during that time, for the most part they are in the white grub stage or larva stage. Soil poisoning by lead arsenate is satisfactory. Carbon disulfide can be used or DDT and then we might come back again to our ten pounds of Chlordane which is probably the better control.

Japanese beetles are not a problem in this part of the country. It is a white grub and probably most of the information concerning Japanese beetles would be applicable to some of the problems here. That would be to use two pounds of methoxy-chlor in 100 gallons of water. That would be about 25 pounds of actual insecticide per acre. Now methoxy-chlor is an analog of DDT. It is being used preferably to DDT because it is less toxic to warm-blooded animals and, in many cases,

it is more toxic to insects. It is superior to DDT in experiments on Japanese beetles. You can also use three to five pounds of gamma benzine hexachloride per acre and it has given good results, and also about 8 to 12 pounds of Toxaphene. Now there doesn't seem to be a lot of work with Toxaphene but it certainly has a lot of promise and it is not as toxic as many of the other insecticides. I think we will hear more about that as we go along.

The green June beetle is a species that we are all familiar with. The grubs cause serious damage to lawns and golf courses in the sod. It is one of the important species in this group. The grubs spend the winter deep in the soil and this insect completes one generation a year in contrast with other white grubs which require three years. The eggs are laid in rich soil where there is a lot of decayed vegetable matter, piles of grass and clippings and manure, and you should avoid them because these are the places which attract the beetles to lay their eggs. Soil poisoning again is an effective means of control. One of the most interesting things about these white grubs is that if you water the soil in the evening, the grubs will come to the surface and if your problem isn't to widespread, you can destroy them while they are out of the ground. I might just mention one experiment that has been conducted on these beetles. It has been found that four pounds of 1% Parathion dust per 100 square yards was effective. Parathion is a very remarkable insecticide. It is not absolutely true, but almost true, that if you can't find anything else to put on a bug, Parathion will do it. But it has one trouble. It might kill you too, if you are not careful. So we must be cautious when we recommend this material.

The annual white grub is another species which feeds on the roots of grasses and burrows extensively beneath the surface. These beetles will occasionally crawl into the ear of a sleeping person, and there are many records of them doing considerable injury by trying to burrow through. So if you have any trouble with that beetle, it is probably the adult of this annual white grub. This insect also has one generation a year. Here again DDT or Chlordane is effective for poisoning the soil.

Bill bugs are a group of beetles that have a head elongated into a sort of snout. The adult beetles feed on the grass and many types of plants. They will attack the new shoots and when this new shoot develops and unfolds, there will be a lot of little rows of

holes in it. The grubs feed on the roots of grasses and we have then another insect which can be classified as a grub, soil poisoning is effective. These bill bugs have a rather interesting habit of stalling. If you touch them, they have the habit of dropping to the ground and playing dead.

Then we have another group of insects which are moths in the adult stage. I think probably most of you gentlemen are very well acquainted with the webworms and possibly have had some trouble with them. You can spray Chlordane on the soil which is infested with web worms at the rate of five pounds of the 5% dust per 1000 square feet. That has been quite effective. Two pounds of lead arsenate in 20 gallons of water per 1000 square feet can be used. Either is effective and will give good control of insects.

In wireworms the larva are the click or snap beetles. They are the ones that if you lay them on their backs, snap suddenly into the air. They get into the sod and do some damage. Four to six pounds of benzine hexachloride per acre worked into the soil gives good control. Twenty pounds of actual DDT per acre is good.

Cutworms are another species of moths. The larva do the damage. Two to three pounds of methoxy-chlor in 100 gallons of water, representing about one pound of methoxy-chlor per acre, will control cutworms. Now methoxy-chlor is a very safe insecticide and I think that if cutworms represented the only problem you had, you might use this in many different places for controlling them. That is about one pound of the actual methoxy-chlor per acre.

Grasshoppers and crickets sometimes develop into devastating numbers and can be controlled by spraying one to one and a half pounds of actual Chlordane per acre. It doesn't matter how much water you use. The important thing is to get one to one and a half pounds of the Chlordane on. This material acts primarily as a stomach poison in controlling grasshoppers. If you are going to be successful with it, the plants should be succulent. It is particularly effective in the spring for controlling nymphs. Later on in the season when it is hot and dry and the plants begin to burn, you may not be very successful with Chlordane. But under such conditions, about half a pound of actual gamma benzine hexachloride is effective as a dust. It kills the grasshoppers more with contact. Here under hot and dry conditions without plant injury, you can get good insect control with that material. Two pounds

of Toxaphene dust or spray is an economical means of controlling them. It is probably the cheapest of these materials and using it is a little more widely recommended for grasshopper control than Chlordane and benzine hexachloride, but they are all good depending upon conditions.

Chinch bugs occasionally get into lawns and golf courses and do damage. If they develop into serious numbers, Chlordane can be used. Six to ten pounds of Chlordane per 1000 square feet will give you control.

There are some new materials being manufactured at the present time by Julius Heim and Company. Probably you have heard of 118 and 497. I think they are still in the experimental stage, but they are showing some good promise here in the control of turf insects and you may hear more about them later.

I got into a little bit of an argument with this group before about earthworms because I always thought they were about the best thing you could have around in the sod and that doesn't seem to be true under some conditions. They can be controlled with mercuric chloride at the rate of three ounces in fifty gallons of water, sprinkled evenly over 1000 square feet of turf. This material, of course, should not be mixed or handled in a metal container. Chlordane also will kill earthworms.

Now something on ants. Sometimes ants become a real problem and there are several species of ants involved. Down in Oklahoma and Texas we have a lot of trouble with the red harvester ant. Chlordane has been found to be the most desirable material for the purpose of controlling ants. A 50% wettable powder in suspension, applied evenly over the turf at the rate of four or more ounces per 1000 square feet, will give good control. That is four ounces of actual Chlordane, and this material plus water will give complete protection from ants for at least six weeks.

Now these red ants do some funny things. One of the things that appears to be evident is the fact that when the soil is moist after a rain or in such condition as that, the ants become very active. The reproductive forms will move about and settle new colonies. Even a lot of old colonies will become excited and move out and start new hills. If you treat ant hills just after a rain and that moisture stimulates activity, you may have new hills started or the old hills start out in a new area. They do all sorts of

things. So sometimes the failure of control by Chlordane is quite logical. Probably the best thing to do, when you are just trying to kill out some hills of these ants on the golf course, is to use Chlordane containing about 3% Chlordane and, of course, the larger the colony, the larger the amount you must pour in there. So if you just keep pouring until you can't pour any more in it, you probably will get the best job because it will be distributed fairly well in the colony. I have been trying to see how small an amount can be used and you can get them very well with just a teaspoon of Chlordane in the entrance, providing the soil conditions and the amount of moisture and various other things are in your favor. But early in the spring under dry conditions is the best time and Chlordane, to my knowledge, is the best control for the ants. I'm not saying that is the only good material you can control them with. There are many other things.

Now that covers in a very few general points some of the insecticides which are used for the control of insects, and some of the insects. Here is something else I thought you might be interested in. We all are concerned, of course, with the toxicity of insecticides in handling them. Many insecticides should be considered potentially dangerous and should be handled that way, but it gives a person a sense of security if he knows a little bit about the comparative toxicity. The Food and Drug Association put out a little booklet and they use DDT as the standard. DDT has a median lethal dose of 250 milligrams of DDT per kilogram of animal weight. That standard was given the ratio of 1 so that other things could be compared with it. On that basis, with DDT as 1, Chlordane has a ratio of $\frac{1}{2}$, pyrethrum has 1/6, gamma 2, Toxaphene has 4, nicotine 35, and Parathion 70. So you can see that is really quite a potent material. It has been calculated that a single oral dose of 30 grams of DDT will kill a man. Only .06 of a gram of nicotine will do the same thing.

Now that is all I have to say. If anyone is interested in getting any of those figures later, I will be very glad to give them to you.

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BENTGRASS GREEN CONSTRUCTION

Bob Dunning,
Bob Dunning-Jones, Inc., Tulsa
and
Ralph Plummer,
Golf Course Architect, Fort Worth

Bob Dunning:

Not all the answers are known in regard to the "best" bentgrass green construction, but methods used today are an improvement over the past. In construction of greens there is the architect's viewpoint-- contours, placement, beauty; there is the maintenance man's view point-- drainage, physical condition of soil, type of grass. Cost of construction must be considered too-- placing greens where they will fit into the natural topography of land helps to reduce construction costs.

From the maintenance viewpoint, the most important feature is drainage. Three kinds of drainage must be considered. First, there is air drainage-- location should be such that there is good circulation of air across green. Second is surface drainage. Green should be graded so water runs off in more than one direction-- greens should never be constructed so all the water runs off the approach. Then, there is internal drainage-- structure of soil and construction of green should be such that free water will be carried away from the grass roots.

Placing a layer of gravel near the surface to increase porosity may be detrimental in that it breaks capillary movement of water. In that case, the green has to be watered too frequently, and the surface is alternately too wet or too dry. There should be sufficient "fines" in gravel to retain moisture, sufficient coarse material for porosity so excess water will drain through the soil.

Poorly drained, poorly aerated wet soil is one of the worst conditions a greenkeeper can encounter. Denitrification takes place under such conditions. Soil condition may be toxic to plant growth. Potash may be made unavailable and scald will result. In the absence of adequate air grass roots are unable to assimilate iron, manganese and copper.

In the proper construction of greens, physical condi-

tion of soil is of utmost importance. Surface should be graded so there are no pockets. The base or subgrade should follow contours which later appear at the surface. Tile should be installed when needed. (It is more often needed in Texas than in Oklahoma.) A layer of pea gravel mixed with the base material should be placed over the tile--there should be enough fine material so roots can grow there. Finally there should be a layer of good porous topsoil.

For the base soil a medium sandy loam is desirable--no fine sand. A sandy clay or clay loam is alright, but not silt. Silt moves through the soil and forms a hardpan layer so water cannot get through to tiles below. The ideal soil is 10% clay, high content of medium size sand-- very little fine sand. There should be some fine gravel, but if the particles are too coarse, spaces are too large and capillary movement is broken.

In summary, we know what we want in a green, though we don't know how to attain those perfect conditions. We want sufficient drainage so excess water will be carried away quickly during rainy periods, but we want to retain sufficient moisture to support plant life, without too frequent watering. Better drainage is the most important factor to build into greens. Out here we are running into the problem of high salt concentration in the surface soil. Good drainage is the only way to eliminate the excess salts. With good drainage there is no reason why we can't have the best bent greens in the country.

Ralph Plummer:

The only original change in the production of bent greens which these fellows haven't explained to you is the incorporation of more peat in the top few inches of putting surface. The principal reason for the success of the bent in the North Texas area has been the porosity of the soil, the open subsoil and the surface drainage.

When we first started out installing bent greens we followed the method of using manure, blow sand and soil. About the time you thought the greens were alright, trouble would start.

When I went to Twinlakes, I started in that way but, when we had five greens finished, we decided it might be a mistake. For the next thirteen, we changed over

to some peat-- not half enough because there wasn't enough money for it. We put in some soil and planted the first green around the tenth of December, just to get started. The first part of March on the five greens that had the manure the seed came up and we had a perfect stand. The others looked very weak as if they were not going to be much good. We didn't know where we stood. About the latter part of July the first five that had done so well started to go out. The others stood that summer even though the water system was out during the month of August. It was 102-103 during those four days.

After that I put in some greens at River Crest Club at Fort Worth. The old bermuda was taken off, and we graded so water would run off the surface in two or three directions. Then it was compacted and we cut trenches through the low area. The main trench was about twelve inches wide and twelve inches deep. We installed four inch drain tiles and on one side of this tile we put coarse rock. These were fed with laterals at 15 foot intervals which formed a herring-bone type of sub-drainage. The amount of topsoil we put back over the coarse materials was about two inches, and this was coarse. Then we mixed materials for the seedbed. I bought twelve carloads of Minnesota peat for the eighteen greens. It was mixed on the basis of about 40% soil, 35% sand and 25% peat. This gave us a seedbed of about six inch depth. Into this we added Milorganite in the proportion of about 400 pounds to the green, about 75 pounds of superphosphate and 50 to 75 pounds of potash. Between the topsoil layers and the bottom layers we put 50 pounds of lead arsenate. After this was done the greens were planted. The greens were officially opened in May. Dr. Grau came down that fall and advised a few changes and saw some mistakes we had made in firming the surface too much with the roller. He outlined a program of feeding every 21 days. That was three years ago and the only trouble they have had was from overwatering two or three greens this past August. The texture of the greens is the same today as then, which shows we are on the right track in developing the perfect surface for bent in Texas.

This general procedure has been successful wherever we tried it. It takes a good deal of money, but the members all are pleased and the play has been doubled everywhere. I will try to give you some details on the actual cost of putting in a bent green. To begin with, in this part of the country you probably have soil on the course that would do. I will give figures

on cost as it was in Dallas. We hauled soil for about thirty miles which costs $10.50 a load. It takes about 140 cubic yards of material for an average green of 6000 square feet. This material, mixed on the basis of about 50% soil, 30% sand and 20% peat, would cost around $1800. The peat is $10.50 a cubic yard and the sand about $3.00 a cubic yard. There is approximately 250 feet of drain tile for each green and it runs 20¢ a foot. There is around 10 yards of coarse material put in the drain ditch and, of course, there is labor. I would say the greens at Lakewood and Dallas Country Club ran in the neighborhood of $3000 a piece.

I did some greens where the soil was a sandy loam, and the sub-drainage not too much of a problem. Those greens, without tile and using the soil on the property, cost about $1000 a piece. From my observations of the soil at various golf courses around here, I think you could put in bent greens for around $1500-$1800 a piece.

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SOIL STERILIZATION FOR WEED CONTROL

W. C. Elder, Agronomist
Oklahoma Agricultural Experiment Station

The term sterilization is somewhat misleading. Sterilization as we think of it is killing of bacteria and all plant life. We think of soil sterilization in our weed work as killing only the weeds in the soil.

It is an old practice in farming to destroy some weeds by placing in the soil a chemical that will kill the plant life. When we have an ideal chemical to kill plant life, it will be one that will kill the plants and then get out of the soil quickly. There are a lot of chemicals that kill all plant life. Those that will kill all plant life for a long time we classify as permanent soil sterilizers.

One of the first materials used was common salt. In fact, we still recommend salt under certain conditions. It takes about one pound per square foot to do a good job, but it is very permanent.

Another chemical that has been used a lot and for a

long time is arsenite. If you apply enough arsenite the soil will remain sterile for a long period of time. The time varies with the kind of soil you have. Sometimes we use from four to six pounds per square rod. Arsenite is used a lot on fairways. Also, parking lots are using it for soil sterilization.

Borax has been used recently. It has widespread use on non-agricultural lands. Parking lots use large amounts of it. It is most permanent; the proper amount will last eight to ten years.

Then, we have chemicals that will kill plant life and get out of the soil very quickly. We call these temporary soil sterilization chemicals. One that has been used a long time is sodium chlorate. This material kills plant life for about a year or two. Then, it disappears from the soil. It is used a lot in agricultural work to kill out mean plants that are difficult to destroy by cultivation. In bermudagrass apply sodium chlorate about October or November and make an application of about three to four pounds per square rod.

As Dr. Murphy told you, one of the objectives of the Oklahoma Turf Association is to keep bermudagrass out of bent putting greens. The use of a buffer crop was suggested. This necessarily involved considerable time before a sound recommendation for use of a good buffer crop plant could be made. Temporary soil sterilizers seemed to have a place in this program. Consequently a screening program was set up. Trichloroacetate, usually called TCA, has been used extensively in Oklahoma this year. We have three years results from it now. This came on the market last year as a buffer preparation. It is still pretty expensive. When it first came out it sold for about 44¢ for 60% material. It is now up to 90% material and the price is down in the 30¢ range. Tons of it were sold in Oklahoma this year for use in bermudagrass control.

Bermudagrass control is one of our big problems. We get more letters on bermudagrass control at the station than any other weed. It is a problem everywhere it is used for turf on lawns and elsewhere. TCA looks very good on bermudagrass. It does a pretty good job on Johnson grass, but a better one on bermuda.

Recommendations for its use are: As a spray, one pound of commercial material (60%) in a gallon of water per square rod. This means about 100 pounds per acre. This year if you get 90% material, it can be reduced

to a little better than half a pound to the square rod-- that is applied in water. The material that is coming out now is easier to dissolve than the material that first came out, and it does not spread.

I wish to warn you if you have runoff of water immediately after use, the material may drain to lower places and cause some injury. If applications are made without extra watering or rainfall, it will cut a perfect line and will not spread. It doesn't injure broad-leaved plants as 2,4-D does. It may cause injury if it gets to the root systems of shallow-rooted shrubs.

This material is not as permanent as sodium chlorate. Soil and rainfall conditions may cause trouble. We have had the material rendered ineffective in 30 days, which is not long enough to kill bermudagrass. We made applications in May and rainfall of about six to seven inches followed. We lost our TCA and its effectiveness. We like to keep our bermudagrass down about 40 to 50 days, to kill it out. We took covers off bermudagrass and found it would grow thirty days after being covered completely. After fifty days we had it pretty well under control, if it was shaded down. The chemical must be kept in the soil for awhile.

The possibilities for use on bent greens are as follows, make applications on the first of September and then plant bent along about the 10th or 20th of October. If a tremendous amount of water is applied you are liable to lose the effectiveness, but your grass will be dry and brown and it won't be very practical around the greens. You might make this application early in August.

The other possibility, and we know this can be worked out, is to make the application later. We have found that good results are obtained well into November. We do not advise making applications that late-- we say do it sometime in October. It will carry over to the next spring and then plantings can be made. We don't like to make plantings that late, but that is another possibility.

We also tell you to make applications when you have good moisture in the soil. Don't water too heavy afterward; don't wash it down six or seven inches or you will get rid of the material too quickly and may have to follow it up with another treatment.

Another class of materials that may be used for kill-

ing plant life and other life such as insects and fungi are the volatile sterilization chemicals. They are liquids that volatilize into gases, such as carbon disulphide which has been used a lot in the past. These liquids when placed in the soil destroy all plant life, and they get out of the soil very quickly, so you can make plantings very soon after application. These materials are often called fumigants.

A new material of this type is methyl bromide. The material comes in a can and is released as a liquid and goes into a gas. It is used a lot in greenhouses to fumigate the soil. It goes out of the soil very quickly so plantings can be made.

We got the idea of trying this material around the bent area. We tried it on bermudagrass, Johnson grass and some others with very good results. This is the way the material is applied. A one pound can is placed under an airtight covering of some sort. A 10 foot square covering may be used. Release the liquid under this covering and allow the cover to stay for about 24 hours. Take the cover off and let it air out for about 24 hours, and then go ahead with your planting.

We followed these recommendations very closely and obtained complete control of bermudagrass. Good results also were obtained when we plowed up the soil and let it circulate in the soil as you would in a greenhouse.

We tried using a lesser amount--one pound to a 10 x 20 area. We had very good results. We did get into trouble when we used it on heavy vegetation. We had bermudagrass up to four or five inches and did not get as good a kill. Grass should be clipped pretty close to the ground. Also we had trouble on uneven land. If there was a hump in the plot, we did not get as good a kill at the high part of the hump.

This is what may be done with the material. Make the application around a green one day, air it out and then come back to plant. The only undesirable part is that a cover must be over the plant for one day and this is sometimes a bit difficult to do. We found airtight paper best for covering. Place it on a 2 x 4 and then place loose dirt around the edge of the paper. It takes a lot of work, but it will kill and get out of the soil in a hurry if you want to take the time to do it right. Price of the material is about 60¢ to 70¢ a pound.

Another use for this material is for treating soil used in greens. You can kill weed seeds, diseases and insects with this type of treatment of the soil. If used for killing weed seeds, wet down-- get the seed good and wet-- for two or three days before your application. We say a week or ten days before making the application. We did this last year and killed out the weed seed successfully.

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SALINE SOILS AND WATER PROBLEMS

IN WEST TEXAS AND OKLAHOMA

C. Wallace Miller, Agronomist
Airports Division, C.A.A., Fort Worth

This is a subject that has required considerable thought for presentation because of the technical terms involved with which many of you working directly as greenkeepers and practical turf men may not be familiar. However, it is a problem that all of you who are using water for irrigation of grass will come in contact with sooner or later. I say this because it has been the experience of all irrigated districts that accumulation of alkali salts in the soil eventually occurs to some degree. Naturally in West Texas and Oklahoma, besides the other western states, many of our irrigation waters contain a higher soluble salt content than is found in other localities. At the same time, there is less rainfall in these areas to supplement irrigation for leaching the surplus soluble salts out of the soil as they accumulate. Besides this condition, all soils in their natural state are not suitable for irrigation, as they may have heavy texture, impervious clay layers, poor drainage, and other conditions. However, you men can overcome this situation on golf greens in regard to poor soils, as it is possible to rebuild a green if absolutely necessary. True it is a costly procedure but it is practical and can be done.

Should you have an alkali situation develop on your golf course, you will certainly have to face the problem and obtain all the water and soil analysis possible in order to reclaim the soils. When I first started to work in Arizona, I commenced at one end of the

Buckeye Irrigation District and began to get acquainted with various farmers within the district. The first stop was made with Mr. Cooper, who was no different than any of the other farmers within the area, as he was farming approximately the same type of crops under irrigation as was the common practice in this vicinity. We discussed general agricultural conditions and then I asked him a question regarding the quality of his irrigation water. He said the water analyzed approximately 2700 to 3000 ppm and was considered relatively poor water. This certainly is true. He went on to say this was the only water they had and their soils were not exceptionally good for irrigation but since it was all they had to work with, it was their problem to learn to produce a crop that would return a profit. Farther down the valley I saw Mr. Pfluger. He also told me how many parts per million of soluble salts their water contained and gave a very good account of his farming conditions. This was unusual for a farmer to be quoting ppm of salt in his water. Gentlemen, this has been told to you because these men had learned scientific farming as a necessity, and undoubtedly when you have an alkali problem occur on your golf course, you will master the situation the same way these men have. However, it is hoped that we can present a meager account of information that will help you to be on the watch and keep an alkali problem from occurring. First, you should know the analysis of your irrigation water, as it will tell you whether you might expect trouble to arise. This should be a complete analysis consisting of that shown to you on Chart No. 1. (See page 85).

Here are analyses of four waters, one from Roswell, New Mexico Country Club, one from Midland, Texas Country Club, and two samples of good water for comparison. If you will follow me through on the first sample from Midland, you will notice that it has a total soluble salt content of 1348 ppm. This is not an exceptionally high amount of salt. In going further, you will notice the calcium, magnesium, and sodium are not exceptionally high but that chlorides and bicarbonates are. Also, there is a small amount of 7 ppm carbonate, which when combined with sodium is known as black alkali. When all these analyses are taken into consideration, this water is classified fair for irrigation. Actually, the Midland water would be considered good as compared with the next sample from Roswell, New Mexico. The Roswell water has 4262 ppm total soluble salt. Calcium and magnesium are comparatively low, while sodium, chlorides, and sulfates are exceptionally high. The harmful salts in this water, when combined, would

HART 1. WATER ANALYSIS - PARTS PER MILLION

	CAL-CIUM	MAG-NESIUM	SOD-IUM	CHLO-RIDES	SUL-FATES	CARBON-ATES	BICAR-BONATES	TOTAL SALTS	PH	"K"	CLASSIFI-CATION
MIDLAND	153	62	97	323	161	7	262	1348	8.0	6.3	FAIR
ROSWELL	261	80	1102	1755	712	7	187	4262	8.2	1.1	BAD
	56	23	17	2	43	0	239	267	--	300	GOOD
	147	146	66	19	694	0	444	1462	--	56	GOOD

be sodium chloride or common table salt, and sodium sulfate or Glauber's salts. There is also a small amount of black alkali, as you see a combination of sodium and carbonates would form. This water is classified bad for irrigation and by most authorities it would be considered unfit.

Comparing these waters with the next two samples classified good we see considerable difference, especially in the column "K" that represents the number of inches of water which on evaporation renders a four foot depth of soil injurious to the most sensitive crops. This requires only approximately 1 inch of the Roswell water as compared to 300 inches for that of the good water.

Now let us take a look at the practical side and see what has happened after the water from Roswell, classified bad for irrigation, has been used on bentgrass greens for five or six years. Three to four of the bentgrass greens on the course were lost each summer, while a fair turf was maintained through the hot summer months on the remainder of the greens. Alkali is more harmful to bentgrass during hot weather, therefore bermuda commenced to encroach on the greens where bentgrass did not survive. This can be explained by analysis of the soil as shown in Chart No. 2.

CHART #2

SOIL ANALYSES

Depth	%Sand	%Silt	%Clay	ppm Total Salts
0-2"	65	15	20	7490
2-6"	53	23	24	6080
6-10"	70	16	14	3020
10-18"	69	14	17	2190
18-21"	67	15	18	2500
21-33"	69	14	17	2320
33-42"	64	15	21	2150
42-60"	62	11	27	2050

The high soluble salt content of 7490 and 6080 ppm in the first two soil layers has accumulated in the top 6" of this green. You will note a distinct drop from 6080 ppm at the 6" depth to 3020 in the 6" to 10" depth. The salts decrease to approximately 2000 ppm to a depth of 5'. The high salt content in the top 6" is attributed to the clay layer as determined by mechanical analysis in the 2" to 6" depth. This layer does not permit a rapid infiltration of water so that the soluble salts can be leached downward where the surplus may be taken away by underground drainage. This was further substantiated by the fact that in examination of the greens where the grass had not died, the clay layer was absent.

To obtain a complete investigation of the alkali conditions, the same analysis should be made in the soil as for the water, giving all 7 of the ions shown in the water analysis. Unless complete analyses are carried out, a true picture of the situation will not be obtained and the investigator will not know which combination of salts are accumulating. Unless he knows this, a black alkali condition could be starting and it might be too late to check it before considerable harm has been done. In conclusion, there are five items that I would like to leave with you which may be helpful in preventing or reclaiming alkali conditions that may occur on your golf course.

1. Analyse irrigation water and soil--

   Each golf course, park or other area using irrigation water should have the source of supply analysed and kept on record, so that it can be referred to occasionally should you notice alkali commencing to accumulate where you have irrigated. An analysis should be made once each year if you suspect alkali. Usually your supply of water is from wells for this type of irrigation and soluble salts in well water change very slowly under most conditions. Occasionally a well will go "bad", but very seldom. Analyse the soils before commencing any treatment.

2. Eliminate impervious layers--

   Eliminate any clay layers in the greens, especially if your water is high in soluble salts so that accumulation will not develop.

3. Irrigate heavy less frequently--

After clay layers have been removed and a uniform textured soil is provided, irrigate heavy enough, less frequently, to leach the soluble salts downwards so that they will be taken away by underground drainage. Tile drains should be installed if suitable soils cannot be obtained to a depth of at least 5 to 8 feet.

4. Add gypsum, sulfur and iron sulfate--

If black alkali is present reclamation can be hastened by adding gypsum at the rate of 125 pounds per 1000 square feet, sulfur at 25 pounds or iron sulfate at 2½ pounds. Iron sulfate may also be used in combination with gypsum and sulfur.

PHYSICAL PROPERTIES OF SOIL

AS APPLIED TO TURF MANAGEMENT

W. L. Garman, Soil Analyst
Oklahoma A & M College Experiment Station

Good grass, like a good house, must be built upon a good foundation. When the demand is great houses are built by enterprising contractors with great haste. Webster philosophizes by adding that "to hurry often includes a confusion and want of collected thought". A house may be well situated on picturesque surroundings; it may be of good architectural design, the interior decoration tastefully chosen, and to the prospective home-owner a good buy. But do we not often hear the confidential mutterings of that same home-owner airing his grievances about cracked plaster which runs the length of his beautifully painted living room; waist deep water in his basement playroom; clogged sewer pipes and on and on with innumerable other complaints?

Our golf courses, likewise, are designed to be pleasing to the eye; they are situated across undulating landscapes. In appearance they are beautiful to the casual observer. But, gentlemen, many of the greens on these courses have been built and are still being built in a state of haste with a lack of collected forethought. Their sub-grade fills with water with the coming of the first April showers, their drainage system never fills because it was omitted completely during the construction, the rich green turf at the height of its natural luster becomes spotted with irregular ugly areas known as dollarspot, brownpatch, fairy ring, etc. With good construction, proper fertilization and management, many seemingly difficult maintenance problems could be greatly reduced.

The soil material (foundation) for a green is a synthetic mixture and is composed of sand, silt, clay and organic matter.

Some of the requirements that must be achieved if we are to have a satisfactory trouble-free green are:

1. Porosity such that a saturated soil condition never exists, even during seasonal periods of excessive rainfall.

2. Porosity such that grass roots can penetrate with-

out impediment to a depth of 12 to 18 inches.

3. Waterholding retentiveness such that plants will remain in an actively growing, healthy appearing condition for as much as one week without supplemental irrigation.

4. Resistance to compaction such that large numbers of people can walk upon it without appreciably changing its structural properties.

5. Nutrient holding capacity such that plants can feed from the active clay minerals and organic matter for long periods without the addition of more plant foods.

No one would deny that these requirements would be difficult to meet. I doubt that a contractor could be found who would make a money-back guarantee to meet these specifications. At the present time I do not believe that enough information is available to do this job; furthermore, I do not believe it to be an impossible task.

In order to get a more complete understanding of the problem that we face, let us examine the characteristics of the individual separates which make up the green. These are: sand, silt, clay and organic matter.

The sand is composed of many different primary minerals such as quartz, feldspar, mica, magnetite, etc. Sand grains produce a gritty sensation when ground between the fingers.

The silt fraction of the soil is principally composed of minerals similar to those named above; however, the size of each particle is 1/25 to 1/500 the size of a sand grain. Silt is often called rock flour.

The sand and silt fractions of the soil may be thought of as the skeletal fraction. They give it friability and because of the relatively large size of each particle allow for the free movement of air, water, and plant foods. These substances are relatively insoluble and furnish practically no plant food for the growing grass. If one should take either pure sand or pure silt, moisten it, and plant seed in it, he would discover that germination will occur and that plants will emerge but that growth will cease as soon as the plant food in the seed is exhausted. It is important to have a relatively large amount of coarse and medium sand in

a green. This material, because of its large size and its resistance to compaction, is needed to carry the load of heavy trampling and to maintain favorable structure that will allow for optimum permeability.

The silt fraction is the next most abundant separate in the soil. Its usefulness depends upon the fact that each particle is surrounded by a thin film of water which is efficiently available for plant use. If a plant remains green and turgid during hot dry weather without supplemental irrigation, many such films are needed to supply the root system with its normal daily requirement of water. If a proper balance of sand, silt, clay and organic matter is obtained, the turf should get adequate moisture for several days without sprinkling.

Byers, H. G. and Feustel, I.C. (1) of the U.S.D.A., measured the water holding capacity and available water supply for several soil materials. The following table shows their results.

Table 1- The Relation of Organic Matter to the Water-holding Capacity and Availability of Water

	% Field Capacity*	% Wilting Point**	% Available Water
Loam Soil	20.2	7.10	13.10
Quartz Sand	1.4	0.57	0.83
Moss Peat	166.0	82.30	83.70
1/2 Loam Soil- 1/2 Moss Peat	31.0	14.50	16.50
1/2 Sand- 1/2 Moss Peat	12.7	5.20	7.50

*Amount of water held by the soil after it has been saturated, then allowed to drain by gravity for 24 hours.

**Amount of water held by the soil when plants permanently wilt.

(1) The Comparative Moisture Absorbing and Moisture Retaining Capacities of Peat and Soil Mixtures. U.S.D.A. Bulletin 532. 1936

A survey of Oklahoma greens showed that they contained an average of 75% of sand. It is not difficult, therefore, to understand why frequent irrigation during the dry summer months is necessary. By developing a deeper root zone which is composed of more favorable soil mixtures the interval between irrigations could be lengthened many fold, possibly once weekly. This factor alone would allow for great savings in labor, more time for the green to be in play, and an appreciable saving in expense.

The clay fraction of the soil is regarded as the active fraction. It is composed of finely divided particles which are plate shaped, and are less than .002 mm. in diameter. It is this part of the soil which becomes plastic and sticky when wet and hard and difficult to fracture when dry. It expands upon wetting and contracts upon drying. In addition to these physical properties it holds bases such as calcium, potassium, and magnesium in an available form for plant utilization. The clay fraction is the source of most plant nutrients. Without it plants would become chlorotic, would wither and die. It is called the base exchange complex, because a state of equilibrium exists between the bases in the soil solution and those attached to the clay particles. For example, as calcium is taken out of the soil solution by the plant root, more calcium is released by the clay to take its place. This process is illustrated by the following example:

$Ca_2Al_2Si_2O_9 + 2H_2O + 2CO_2$----$CaH_2Al_2Si_2O_9 + Ca(HCO_3)$

Calcium Clay+Water+Carbondioxide---CaH Clay + Ca Bicarbonate

This process works, not only for calcium, but for other plant foods as well. The primary source of iron is from the clay fraction.

A green which does not contain a sufficient amount of clay in the root contact zone will soon produce grass which is pale and chlorotic in appearance. When this situation develops, as it has on several grass greens in Oklahoma, costly time-consuming frequent applications of top-dressing materials or spray solutions of iron, potassium, magnesium, or nitrogen have to be made.

The organic matter of the soil is of very complex composition. It is composed mainly of carbon, hydrogen, and oxygen, with lesser quantities of nitrogen, phos-

phorus and sulfur. It is not only a source of these plant foods, but it reacts chemically with bases such as calcium, magnesium, and potassium very much the same way in which the clay does. In addition to supplying these nutrients for the growth of plants, it contributes greatly to the maintenance of favorable physical relationships. As pointed out earlier, it increases the available water supply in sandy soil materials. It functions as a cementing agent to promote favorable soil structure so that plant roots can penetrate the soil easily.

The sand, silt, clay, and organic matter then are the building blocks or foundation separates with which we have to work to develop a good medium in which to grow a grass turf. The ratio with which we mix these separates and the depth to which air, water and roots can move freely will determine the usefulness and quality of the surface and subsurface mixture.

Our preliminary survey of the mechanical composition of some Oklahoma greens clearly points out some of the conditions which need correction. Table 2 shows the average physical composition of a good productive loam soil, the present surface composition of several Oklahoma greens and the recommended composition.

Table 2

Composition	Loam Soil	Okla. Green Surface 0-4"	Okla. Green Subsoil-Surface 6-12"	Recommended Okla. Green
Sand	45.0	75.0	36.0	65.0-70.0
Silt	35.0	20.0	39.0	20.0-25.0
Clay	20.0	5.0	25.0	8.0-10.0

These data indicate that there is too much sand and too little clay in the surface 4 to 6 inches. This means low water storage capacity and low nutrient availability. This situation has developed as a result of poorly constructed greens. The sub-grade of these greens is composed of dense soils of low porosity with inadequate under-drainage. When moisture is plentiful, the coarse sandy surface layer fills with water which results in a reduction of the effective

depth of root penetration. You cannot grow good grass where the root system cannot penetrate to more than 4 to 6 inches.

The next slide shows this relationship. The root depth of the system is restricted in early spring because of a high water table and impervious subsoil. The plant scalds and dies when hot dry weather sets in. If we ever expect to grow good healthy grass with a minimum of effort, we must provide a deeper root zone which is well aerated, yet supplied with enough clay and organic matter to furnish available plant foods for a long period of time.

Mr. Kirk Lawton, Soils Department, Michigan State College found that crop production was decreased 37% by increasing the moisture content from 15 to 40% and also found that by packing the soil at only 15% moisture, the growth of the plants were decreased 64% and the air space reduced to about 1%.

These experiments show that plants are very sensitive to well aerated soil conditions. Dr. Bray and associates at the Illinois Experiment Station have increased corn yields 50% by either pumping air through experimental plots or by applying hydrogen peroxide at the rate of 165 pounds per acre per week. At the present time neither of these systems is economically feasible, but they do show that plants are very responsive to a good oxygen supply. They show that a well aerated soil of good physical structure is equally as important as having an available nutrient supply.

We have a long way to go and much room for improvement in our thinking and practice in developing good turf on greens in the southwest. Soil improvement by establishing more favorable physical relationships and by developing more permeable subsurface root zones is the No. 1 problem facing those who wish to develop better golf greens that require less maintenance upkeep.

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TURF MANAGEMENT PROBLEMS OF CEMETERIES

T. E. Drumm
Restland Memorial Park

I am going to state the problems we encounter in our work. I can't attempt to help you fellows on your golf tees or greens because it is something I know very little about. I am really seeking information. You fellows have been growing grass for a long time. We have been growing grass and expect it to grow, but the time has come when we realize that it needs help and we are ready to help it.

The first problem I will bring up is finances. We operate under a Professional Care Fund and the reason I brought that up was to show you the limited money we have to operate with. The state law of Texas requires us to put up as much as 10¢ a square foot. We double that. We put up 20¢. An average lot is 10 x 20 which has 200 square feet. The principal of the Professional Care Fund can never be used-- just the interest. In other words, we take 200 square feet and at 20¢ a square foot it is $40.00. If that is bringing interest at 5% it is only two dollars. That two dollars is to take care of the 200 square feet for a year. That is one of the problems that we have in the cemeteries. It is to find ways and means of taking care of the grass with as little water as possible, as little mowing as possible and, of course, we hope to use fertilizers. What we actually are looking for is a grass that will be green in the winter, one you don't have to mow, you don't have to water and you don't have to fertilize. That is what we would like, but it is impossible.

Another problem that most cemeteries don't have and we do is one I would like to bring up. We have an underground drainage system all over our cemetery. We have a tile that is very thin and it is mainly to take the excess water out of the ground during rainy seasons. Now I wonder if that will be any problem as far as trying to grow turf with fertilizers, without much water.

Another problem that we have is that grass invades our streets. Our grass comes on a gentle slope to the street edge. I don't know why, but grass just loves to grow on asphalt. From what I gather, it looks like this TCA would be the answer to that. I am going to try it this spring, and I feel it is going to help.

That is one of our biggest problems.

Another problem is that we have lots of shrubbery--big beds of shrubbery-- and against these beds we do have to grow grass. The grass grows right up to the shrubbery beds. So if we put fertilizer on the grass I don't know which is going to get it first. I can't put any St. Augustine around those areas, you know.

We have the problem of watering. We have about 150 developed acres and when I say developed I mean all grass. In the hot, dry weather the land cracks. Our water supply is a lake. This lake holds about two million gallons of water, but if we attempted to have a big watering program, it wouldn't take long to use that amount on 150 acres. What we are really hoping for is through this fertilization program to fertilize early in the spring and try to eliminate the watering.

In my opinion we are mowing too close, and are harming the grass to some extent. We mow about 3/4 of an inch. In other words, our grass is treated like your fairways.

These are our problems. I know a golf green has to be watered and taken care of. You want it to look nice, and so do we but still we have such a limited fund on which to operate that we have to find the most economical way we can to take care of the grass. What we want to know is the ways that we can help this bermuda grass to make a heavier, thicker turf and one that will require less water.

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TURF MANAGEMENT PROBLEMS ON HIGHWAYS

G. H. Bittle, Ass't Chief Engineer
State Highway Department

In addition to blending the highways into the country side, vegetation along the roadside strip serves other practical purposes. One of these is the air conditioning effect that vegetation has on the highway's right of way. Another is the prevention of soil erosion from water and wind. Surface wind velocity is increased when soil is bare and has none of its natural vegetation. At the height of two feet of compacted, bare

soil, wind velocities have been found to be 15 times as great as in the adjacent forest areas and eight times as great as over grasslands.

Drying out of the soil leads to its progressive deterioration as a potential growing site for plants. At the same time, increased wind velocities over dry exposed soil can stir up dust storms in some localities, a dangerous factor to highway safety.

Air temperatures on hot summer days may be 10° to 20° lower in brush and forested areas than in areas of bare soil. There is relatively no moisture in the air in the presence of vegetation; this makes driving more pleasant so far as the comfort of the driver is concerned. Maximum summer soil and air temperatures have been found to be much higher in bare soil areas than in areas that contained much vegetation. The daily range of soil temperature at the depth of 1.2 inches has been found to be $33\frac{1}{2}^{\circ}$ for compacted, bare ground lacking in organic material, as compared with 10.9 with heavy vegetation. Such extreme daily changes are found on any fertile bare soil and are not only unfavorable to the growth of young plants, but they contribute to the rapid drying out of soil moisture.

Since annual species of plants usually germinate and establish themselves in the summer, they are easily killed by the rapid intense drying of the newly exposed soil that is lacking in organic material. In revegetation of poor soil subject to extreme temperature changes, recourse must be made to the use of mulches and seasonal planting so that the plant roots can get deeper into the soil before the season of rapid surface drying begins.

On winter mornings you will see a good example of the protecting and insulating value of vegetation. On bare, exposed shoulders and banks, rapid freezing and thawing bring about soil heaving by the formation of ice crystals. Localities where the soil does not stay frozen and where there is little or no snow are more subject to the frost heaving of the soil. Freezing and thawing of the soil can occur 50 to 75 times during the single winter. Frost action is more severe on moist south-facing slopes. Here frost action will account for the erosion of 1 foot of soil in a single season from a clay bank. South-facing slopes alternately freeze and thaw more than north-facing slopes. Ice crystals up to four inches high are not uncommon. These crystals raise fragments of rock and soil at a right angle to the slope of the bank. The crystals

melt in that form and the fragments settle several inches down into the bank from where they were lifted.

The surface soil creep is active on cut banks originally left smooth during road construction. In fact, uniform smoothly polished banks seem to be particularly subject to this frost action. Vegetation is necessary to prevent erosion in addition to soil creeping and surface heaving that is brought about by alternate freezing and thawing. Surface instability makes the establishment of vegetation extremely difficult. Most perennial and biennial species of plants germinate in the fall and small seedlings are actually thrown out of the ground by frost heavings. In the severe frost zones, shallow rooted vegetation is often heaved out of the ground even after it has been established for a full season'ts growing.

Everyone experienced in roadside improvement is familiar with the lack of uniformity in the successful establishment of vegetation on newly exposed shoulders and road banks. The location where vegetation has failed would be found on areas subject to repeated freezing and thawing, maximum action by wind and sun, and high soil temperatures. South-facing banks will have maximum temperatures of 130° to 150° on warm summer days as compared to 80° and 90° on opposite facing banks. The south-facing banks may require many times the amount of effort to obtain satisfactory vegetation establishment.

In road building soil conditions are greatly altered by engineering activities needed for proper leveling and draining. In rolling topography cutting and filling in creates extensive areas of raw, exposed earth slopes. The newly exposed earth material is frequently quite infertile. It must be thought of as the same as the materials brought out of the newly excavated house basement. Fills are generally not fertile for growing plants but, because the soil is loose, vegetation can be established with the aid of fertilizers and light mulches without too much difficulty.

On the other hand smooth steep cut banks and slopes and compacted subsoil are about the most difficult places for plants that can be created by man. Slopes usually left quite uniform and smooth for the first few months give the impression of engineering precision and symmetry. Although the soil is usually tight compacted, the surface few inches become very unstable when subjected to repeated freezing and thawing and washing by driving rains. Temperatures can be extreme-

ly high and rapid temperature changes take place in the soil due to exposure to wind action. The soil will dry out easily because of a lack of organic material and make it difficult for plants to live. Benching of the surface will aid in the vegetation.

The development of mulching technique is a direct effort to overcome the unusual climatic stresses to which exposed soil areas are subjected. For this reason, mulching should be adapted to meet the requirements of a particular location where it is to be employed. Mulching is most required in the upper steep banks subjected to extreme action by wind and exposure to the sun. Low banks of rich, moist soil may get little or no mulching. On the other hand, mulching is valuable wherever soil fertility or soil moisture levels are extremely low and where the moisture retention by the soil is lacking. Field cuttings and roadside mowing from nearby areas have provided the best mulching materials. Clean hay and straw from oats, rye and wheat are very poor mulching materials. Long fibrous materials mixed with briars, weeds and grasses and thin wood stems stay on slopes best without staking or with least possible staking.

The highway engineer is much concerned with soil conservation. To establish vegetation on roadsides is an important item with respect to saving soil. Sufficient right of way width is necessary in highway construction to properly design side slopes. Some tyes of earth require wider slopes for natural stabilization than others. The ditches must be wide enough to carry off the runoff water without damaging. In the design of highways we provide a rounded bottom ditch with flat slopes. In case the section will not naturally stabilize, some form of sodding of ditch checks is planned. Some side ditches are constructed on grades and will naturally stabilize. Where special treatments may be required, attention is given to sodding ditch checks, flumes or other permanent or semi-permanent structures. Where the highway is constructed in a new location on a terrace, provision is made to take care of all the water discharge from the terrace into the highway and to otherwise conform highway drainage to the terrace incline. If possible, where farm plans and land usage programs are known, adjustment in highway design is given some consideration.

In the matter of drainage, culvert locations are given considerable study. The upstream inlet may be raised to conform with the natural growth to prevent erosion. Consideration is given downstream in that the outlet

is set so that it will not scour. Where it is soil which contains grass roots, the native seed can be handled by normal grading operations. The topsoil is saved for the purpose of facilitating the growth of natural vegetation.

The highway department in our normal construction and maintenance operations has used various types of seed-bermuda, ryegrass and oats. However, in general the most successful throughout the state is bermuda. There are disadvantages to bermuda sodding, one of which is the criticism from the property owners to the effect that the grass enters the fields and is hard to control. This is certainly a justified criticism.

The highway department during the past year has provided approximately 200 to 300 miles of shoulders, ditch and bank protecting vegetation. You all have no doubt noticed the press items where some are criticized for tearing up a road which has secured its natural stabilization and vegetative growth. In many cases the criticism was justified. It is a fact, though, that such a maintenance operation is absolutely necessary because dirt piles up on the shoulder, due to wind action across a bare field, which over a period of time becomes a traffic hazard and must be lowered to normal elevation. The same is true of the ditches. They build up and catch this dirt until they are too small to carry the runoff water and, therefore must be widened to function properly.

We, during the past year, experimented with an asphaltic mulch (process patented) and used it according to specifications. Wheat, lovegrass, sweet clover and perennial ryegrass were sown. The soil was loosened to a depth of four inches and all particles rounded to less than 1½ inches. All vegetation was removed. Commercial fertilizers of approximately 10-6-4 quality, were incorporated into the soil at a rate of 1000 pounds per acre. The seed was sown uniformly in stipulated amounts by a drill seeder. The soil was uniformly moistened to 25% to 35% moisture to a depth of two inches. When dry enough to use rolling equipment without picking up, the area was rolled to develop pressure of 25 to 35 pounds per square inch. After rolling, the asphalt was applied uniformly at a rate of ¼ gallon per square yard. The temperature of the cut bank was not higher than 107° when applied. I am sorry to say that we didn't secure very good results with that experiment.

EROSION CONTROL ON DAMS AND LEVEES

S. H. Watson, Agronomist
Corps of Engineers, Dallas
and
Floyd Fuss, Agronomist
Corps of Engineers, Tulsa

S. H. Watson:

The Southwestern Division of the Corps of Engineers covers Texas, Arkansas, Southern Missouri, Southern Kansas, all of Oklahoma, Southern Colorado and Eastern New Mexico. Our work which we will discuss with you today has to do with the grassing of the downstream slopes on large earth dams and levees along our major streams. Of course, there is some related work, such as landscaping work and grass planting around our buildings at the reservoir headquarters.

The dams that we intend to grass are located climatically from North to South from the coast of Texas into Missouri and, of course, we are involved with the northern and southern grasses. From the standpoint of rainfall, some places will have 50 inches, others less than 20 inches. In some of our areas rainfall is only 8 or 10 inches. As yet we haven't had too much of a grass problem out there because those stream slopes are not adapted to grow grass as yet.

Our primary work in developing grass on those areas is for erosion control and in addition providing some degree of pleasing appearance. But our primary objective is erosion control, both from wind and water.

Our soil materials range from fair soil to almost pure blow sand and pure clay. Here are some of the conditions that we are faced with. Our engineers tell us, and there is no doubt about it, that in the construction of dams, they want a high clay content where the water will be and, as they progress to the downstream slope, they want that soil to be more pervious so that seepage won't give them so much trouble. The water inside the dam builds up a pressure and by putting the more pervious materials on the downstream slopes, the water can seep right on through and come out without any difficulty. However, if we have our less pervious material on the downstream slope, we are liable to build up this pressure which sometimes would cause blowouts and other difficulties.

The slopes on the areas we are working with range on up to 1½ on 1. The dams are up to 140 feet high. I would remind you that those 1½ on 1 slopes are so steep that you can hardly keep a tractor on them.

With the above conditions our moisture relationship is quite bad. We can't keep moisture on the slope because it is so steep that it runs off. So we have a water problem. On some of these soils on the downstream we have seen water erosion so severe that we had gullies from three to five feet deep and up to ten feet wide occurring during a single rain. That brings us to another problem.

They build dams in layers as they go up, which is relatively inexpensive. Once you get those huge gullies in there, that material must be moved back up and it is a lot more expensive to get it back than it was putting it there in the first place. In addition to that the dams are completed almost any time of the year. If the dam is finished in November, it is ours.

I touched on the matter of topsoil briefly. There are several reasons other than the fact that the engineer wants the more pervious materials on the downstream slope. The cost of adding topsoil we consider prohibitive if we can grow grass without it. In addition to that a thin coating of topsoil is often conducive to more erosion than the original material that is in place. In other words, these dams are built and compacted to a very high degree. If you go in there and try to compact a little dab of six inches of topsoil on those slopes, because of the difference in the degree of compaction,we get a dashing rain and the whole thing just goes right on down the slope. So we have come to the conclusion in general that we don't want topsoil on these slopes.

We fertilize quite heavily, especially with nitrogen. Of course, the next process is the seeding of the adapted grasses. We have used almost exclusively bermudagrass so far. Other areas we use the native grasses. In all cases on these slopes we use a hay mulch. It has been mentioned that wheat, oats and rye are unsatisfactory mulches. In Arkansas and other rice growing areas, we definitely prefer rice mulch. We get out farther west and we don't mind the few little wheat seeds and grasses of other kinds that we get in ordinary hay. But we do prefer either rice straw or hay. We usually apply anywhere from 2½ to 4 tons of hay or straw mulch per acre. It hasn't been too long ago these slopes were protected with a gravel blanket

of crushed stone. Gordon Jones was an agronomist in the division and was one of the pioneers in getting grass work underway in the southwestern division.

In Washington a few years ago they decided that they were spending too much money on the gravel blanket and in some cases had to ship the material for long distances and it was costing them money. We have established grass rather successfully on several of these dams at a cost of less than 1/10 of what it would cost to place a gravel blanket.

I would like to mention that we tried asphalt mulch and got good results with it. But it cost us about three or four times as much as hay and since hay mulch gives us excellent erosion control, we see no reasons why we should attempt to use asphalt. There is probably a place for it in the establishment of grass under very unfavorable conditions.

Floyd Fuss:

There are a few things I want to add. Grass as a whole is rather new to the engineer, and one of the biggest jobs in starting a vegetation control program was trying to teach the engineer that there were other grasses besides bermudagrass and that bermudagrass doesn't grow everywhere. The second thing was to teach them that there is a definite time in which grass should be planted.

A very good example of this is the relocation of Highway 217. A good example of what grassing can be when it is done at the right time is the Frisco Railroad relocation on the same project. In the highway relocation, the dirt work was finished around the first of August, I believe. They didn't want to hold the seeding back to the next spring because the contract said they couldn't stop. So they seeded bermudagrass in August and September. The soil is very fine silt, sandy loam. We had to come back and regrass those slopes.

In comparison the railroad work was done by the same man who grassed the highway. That work was finished in March and seeded and there was not one yellow rivulet to be found the following September. So the time of seeding is very important. I am going to bring in some remarks about the project at Canton, Oklahoma. We had to start off with a quartz rock on each slope. It

didn't hold up as they anticipated it would. So I suggested that if we could get a little bit of silt-clay soil into that blow sand, we could build some grass on it. They made the lower half twice as heavy as the upper half, and put some topsoil on the upper half of the slope. With these special funds it was a glorious opportunity to do some investigating as to what grasses might be better for those climatic conditions.

We set up plots. On three of the plots we planted yellow bluestem at the rate of 16.1 pounds to the acre. I thought that was pretty light but that was all we could get ahold of. On three more plots we seeded with a mixture of native grasses. The grasses were sand lovegrass, sand drop seed, blue gravelgrass, buffalograss in the burr and side oat grama. The total amount of seed was 36.5 pounds to the acre. This year we found that the bluestem had developed to where a lot of the plants were ten inches across. On the heavy seeding of our native grasses,we ran into plants of sand love and drop seed which were one inch to two inches and that was probably due to heavy seeding. I think it is pretty conclusive that a person can over-seed.

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CLOSING COMMENTS

H. W. Staten

Members of the Turf Conference, I want to compliment you on the very fine job you did. I think you fellows have done a very, very excellent job, and there isn't any use for me to take any more time talking about grasses. Several fine points have been brought out about grasses. There are a few points I would like to emphasize and stress. One is this: you must get out and live grasses to know how to handle them. I had not realized this, even though I have been a student of grasses for thirty or forty years, until this fall my doctor said to get out my golf clubs and get out there. My first experience was very, very sad. But, I am learning a lot about grasses on a golf course. I am learning to appreciate grasses on a golf course, particularly when I have a ball in the rough and have to hunt for it. I notice some things on our courses.

There are a lot of fellows playing golf and some of our grasses are not thick enough to withstand the use they are getting. I see a lot of erosion. Buffalograss is good, but they are not giving it enough attention in the roughs and fairways to prevent erosion. Of course, I know we have a lot of bum golf players like myself who dig up the grass when they hit the ball and they start a lot of it. But that is a factor on golf courses.

A year ago Fred was telling us about fescue grasses and the possibility of using fescue grass. He was telling us about the Plant Industry Lawn at Beltsville being seeded with Alta fescue and what a nice lawn it was. Last summer I had an opportunity to look at that lawn, and at Fred's work at the Beltsville Experiment Station. That Alta fescue lawn is even more beautiful than he described it. That brings me to this point: grasses are more cosmopolitan as we learn to handle them. Some 15 or 20 years ago, I would have sworn that you couldn't grow seaside bent out here. Now we have some of the most beautiful greens that you find anywhere. We need more research on grasses, learn how to handle them, how to adapt them, how to develop these new strains of grass.

One other point that I should bring to you was brought very, very strikingly to me last week. One of our young men went up north. He brought back some clover plants which had died. The soil was about 14 or 16 inches deep, but still the plants had died. The roots never got down into the subsoil. The boys really dug into that problem and found that down about four inches there was a hardpan. The clover roots got down to that but no farther. It was nice soil, but when the roots hit that layer, they took a right angle turn. That's a problem that has been bothering farmers, and I wouldn't be surprised if you had the same problem on some of your golf courses.

It is really nice to be here, and I thank you for this little time.

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