extra

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MID-ATLANTIC
ASSOCIATION OF GREENKEEPERS

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DR. ERNEST N. CORY, DIRECTOR

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GOLF COURSE CONSTRUCTION IN RELATION TO EFFICIENT MAINTENANCE

By O.J. Noer

The subject assigned is Golf Course Construction in Relation to Maintenance. Unfortunately, there is little experimental evidence on which to base a discussion. It is necessary to draw upon observation more than anything else. I feel that architects and construction superintendents would do a better job of construction had they had maintenance experience. Then some of them would do things differently. There have been a great many headaches for the first two years or longer after play starts because there has not been enough care taken in the construction of the greens and other features to make the course better from the standpoint of subsequent maintenance.

Good greens are the most important thing on a golf course. Twenty years ago good greens were enough--nothing else mattered. That is not quite true now. Good greens are so commonplace that the golfer takes them as a matter of course. He expects good greens. As a consequence, fairways and tees have become uppermost in the minds of these men.

In areas where the native soil is heavy and the subsoil compact, drainage comes foremost in the construction of greens to simplify maintenance after they are put into play. I like to think in terms of subsoil and surface drainage. Both are equally important. If the subsoil is tight and extremely heavy, tile drainage is obviously required. Too many architects install tile, but not in the right way. Some greens have only one or perhaps two lines of tile. They are helpful, but do not move water fast enough during the critical periods; when there is a week or two of heavy down-pouring rain. Surplus water should be removed quickly so the soil does not stay saturated over a long period of time. My own preference is for a gridiron or herring bone system, in which the main line bisects the green and the laterals make a 45 degree angle with the main. The system resembles a tree in outline. The main line represents the trunk, and the laterals the branches.

Tile lines should be spaced not more than eight to ten feet apart where subsoil is heavy, and the lines should be from twenty to thirty inches deep. The trenches should be back-filled with a coarse material such as pea gravel, as close to the surface as possible. In other words, up to the depth where the cups are to be set. This method provides a porous column to conduct water quickly down to the tile.

The subgrade should be built and contoured to facilitate drainage and not necessarily follow the final surface contours that are established from a standpoint of play. In other words, it might be best to have the subsurface slope slightly from the center toward each of the adjoining tile lines. Then water will follow the subgrade and flow over to the porous material and pass down into the tile. This certainly facilitates drainage. I am sure you will not go wrong by doing that. There may be a simpler way, but I know that this one works. I do not think it is always necessary to slope the grade from the center towards each line. It might be possible to have a subsoil gradient cross all the lines so the water goes down through the topsoil until it reaches the subsoil and then follows a natural course down to the tile lines.

Enough thought is seldom given to subsurface drainage. The problem is different in some areas. In Oklahoma, for instance, the water contains a considerable amount of salt. The quantity is not great and yet, the accumulated effect is beginning to tell on some of these greens. It is going to be necessary to wash the excess salt out of the soil during the winter time, and then an accumulation will not be sufficient during the summer to be detrimental to the grass.

Surface drainage is extremely important. Too many greens are built of the conventional type, with the slope from back to front. This is especially true on the smaller courses. It is done, no doubt, to assist the golfer so the green will hold any shot. Players ordinarily walk on to the green from the fairway; they never approach from the back. If the slope is from back to front, the front part of the green, which is used the most, is the last to dry out. The surface water should move off the green in more than one direction. The quickest way to get water off any surface is by surface run-off, particularly where the soil is heavy and compact. That is why greens should be contoured so most of the water drains away as surface run-off, then good subsurface drainage can dispose of the gravitational water held by the soil. It quickly will move out of the root zone either down through the soil or the tile lines. There will be much less trouble and it will be possible to go through trying periods of heavy summer rainfall without extensive loss of turf.

We hear discussions pro and con regarding the necessity of using tile. Both advocates may be right. Charlie Erickson of Minneapolis told me he thought the use of tile in greens was the bunk. He thought they were never needed. At his course, Minikahda, the subsoil was extremely good, and the passageways between the soil particles were so large that every green had a million drain lines instead of seven or eight. Tile drainage wasn't at all necessary there. Tile would not be needed anywhere if a tent could be placed over each green in the summer. Then, soil moisture could be controlled. Drainage and soil condition would be immaterial. But, without such protection in summers when there is a week or ten days of down-pouring rain, followed by exceedingly hot weather, turf takes a beating if soil conditions are not right. A blue color in the subsoil is an evidence of inadequate drainage. The soil is blue because the iron in it is in the ferrous or reduced state. It is that way because the water saturated soil is devoid of oxygen. If the soil has big enough spaces it is seldom completely saturated with water, then the subsoil will be brown or red because the iron is fully oxidized. It is what the chemist calls the ferric state.

Some architects place a coarse layer of gravel over the subgrade, with tile underneath it. They depend upon this porous gravel layer to trap the water and lead it down to the tile lines. In many instances these layers are from three to five inches thick and then, of course, the topsoil is placed over it. This method provides good drainage. There can be no question about that, but sometimes I wonder what would happen in areas like West Texas, where the temperatures are high and the climate dry. Brisk winds and hot dry weather would necessitate more frequent watering than would otherwise be needed. I am not prepared to condemn the practice because it may have possibilities. However, if the surface soil placed on the subgrade is a good one-- a medium sandy loam or one of a similar nature-- I feel sure a gravel layer is not essential, provided the water can pass through the surface soil and along through the subgrade to the tile lines. It is particularly true now that we have the Aerifier and other means of preventing surface compaction and keeping the surface soil in good physical condition.

Too little attention is paid to the topsoil used on greens. It may mean many headaches during the first few years while top-dressing to build a good soil layer above the heavy soil. It would be better to make the soil right when it goes on the subgrade. More information is needed about the physical characteristics of soil, yet there are enough good greens to justify the statement that a medium sandy loam is the kind to use. The sand particles in a medium sandy loam vary in size and are not all uniformly fine; the range is from fine to coarse. This provides large passageways in the soil to facilitate movement of water and air. You have all heard me say that the ideal soil is one of 50% solids, 25% liquids and 25% of gas or air. That is about the relationship in a medium sandy loam.

The amount of organic matter should never exceed a quarter by volume, with 30% as an outside figure, but somewhere between 20% and 25% is better. Farther north many clubs use more organic matter. They get by most times, but there is a chance for trouble during the unusual season. That is the time to be prepared for. One should be able to cope with whatever comes. If the amount of organic matter is too high, the soil stays too wet in periods of heavy rain. Then in dry periods, localized dry spots develop. It is extremely difficult to get peat and other humus materials to rewet themselves. They contain a waxy substance which tends to repel water. Excessive amounts of organic matter keep the soil too wet in late winter and early spring, and make snowmold much worse.

With respect to silt and clay, I am of the opinion that there should be some in any soil. I dislike some of the mixtures used in Florida-- that is straight sand and peat. The silt and clay fractions have a definite function from the standpoint of soil performance. They are the materials that take and temporarily hold potash, phosphate and some of the other materials that a plant must have, and release them later for the plant to use. Organic matter does the same thing. So clay and silt have a useful function, but the amount in soil should not be high. To the soils physicist a sand is any soil containing 85% or more of sand particles. The other 15% may be clay and yet the soil is a loamy sand. On the other hand, a clay soil is any soil containing 30% of clay particles. By increasing the amount of clay by 15% a loamy sand becomes a clay soil. It takes large amounts of sand to appreciably affect a clay soil, but very little clay is needed to profoundly modify a sand. That is something to be remembered.

Contours on greens are not only important for surface drainage, but from other standpoints too. In the early twenties it was customary to build greens that resembled the Rocky Mountains, insofar as surface contour was concerned. A few architects still do it that way, but fortunately, not many. We have gone from hand mowing to power mowing, and it makes no difference what we think about hand versus power mowing-- the workmen on the course will settle that question. It is hard to get men to push hand mowers, even though one might prefer to have the mowing done that way. The change to power mowing must be taken into account during construction. Contours on the greens should be sweeping slopes, and not the familiar abrupt banks. Steep banks are not good practice anywhere. Long sweeping slopes on and around the greens-- and banks around tees-- enable more effective use of power mowing equipment.

Since I do not play golf I may be more critical about the location of traps than the golfer is. My viewpoint is from the maintenance angle. I do not like to see large traps out in front and to the side of the green anymore than is necessary. Very often the approaches directly in front of the greens have the worst turf on the fairways. One of the first things asked is: What can be done to improve turf on approaches? In many instances, the best thing is to widen the areas to lessen traffic congestion both by the players and by machines. In most instances this is the reason for poor turf. The same situation prevails on many greens where provision was not made to distribute traffic off the greens to the next tee. Everybody follows the line of least resistance; instead of walking over a mound, the low path is taken. There are many instances where soil compaction due to traffic congestion has been responsible for poor turf. Building the green so traffic is distributed over a wider area as the players walk from green to tee greatly simplifies the matter of maintenance.

Fairway drainage has not received enough attention on many courses, particularly where the soil is heavy. I have in mind a course in St. Louis-- and there are more like it in other areas-- where efforts to improve fairways have not been too successful. Seepage out of the side hills in the fall and early spring needs to be corrected before turf renovation. I have some pictures which illustrate the necessity for drainage to intercept seepage.

When a new course is built requirements for lime to reduce acidity of soil should be satisfied well ahead of seeding, and the fertilizer needed to get a good stand of grass should be applied. It is much easier to get a good stand of grass at the start than to improve it later. The tests conducted by A.E.Rabbitt show that when soil has an adequate amount of fertility, much less seed is needed to secure a uniform and good stand of grass. Where funds are limited the thing to do is to apply lime, if needed, along with plenty of superphosphate and work them in to the soil. This is the one time they can be mechanically incorporated with the soil. Saving should be at the expense of nitrogen because it can always be put on after growth starts. However, it is important to use some nitrogen before seeding on soils which are very low in organic matter. Otherwise, growth will not be satisfactory.

Tees are also important. In this belt from Washington across through Indianapolis, St. Louis, Louisville to Kansas City, the question crops up continually: What can be done to improve the character of our tees? In the first place, many clubs build tees too small during the construction. Nobody can maintain good grass on tees of postage stamp size. There must be enough area on the tee for grass to repair itself under the playing conditions which prevail on the course. If play is heavy, tees must be larger than if play is light. On a course like Old Elm in Chicago, where the course is crowded when there are 25 people playing at one time, turf does not get the abuse that it does on public courses where it is not uncommon to have three or four hundred players go over the course every day of the weekend and almost that many during the week. So size is important. Then there is the matter of shade. In many instances there is altogether too much shade for some of our grasses to survive. There is the further complication of tree roots. When tees are large and not too shaded, good turf depends upon the kind of grass. Maybe Fred Grau has the answer. I'm sure I do not have an entirely satisfactory one. But I will say this, one cannot expect bluegrass or fescues to make a satisfactory tee in this area or farther north. The bluegrass doesn't make a close enough knit turf to keep out crabgrass, clover and some of the other weeds. I don't think fescue is vigorous and sufficiently fast growing to repair itself under heavy play.

Many years ago there were complaints about the tees at one course. I got them to make two tees, considerably larger than the old ones. One was seeded to red fescue, and the other was planted into a vegetated strain of bent. Before play started anyone would have chosen the fescue tee, but it went to pieces by midsummer of the first season. Even in Toronto, where climatic conditions are most favorable, the fescue could not repair itself fast enough under the moderate amount of play. The bent tee was much better, so that is what was finally adopted for all their tees. The tees were enlarged and cut extremely close with a power greens mower to keep turf tight. Players dislike fluffy grass on tees which is the reason for close cutting of bent with a greens mower.

There are some excellent zoysiagrass tees on two of the courses in Louisville. Tees on one of the courses were much smaller than one would expect. Yet the zoysia turf was surprisingly good. This grass does well there when adequately fertilized and properly cared for. I do not intend to imply that zoysia is what you should plant. Maybe the combination of bermuda and bluegrass is a better answer. It is something to be tried, but the selection of the best grasses for tees is still something which requires more study.

DISEASES OF TURF

By
C.K. Hallowell

I'm fresh from the Pennsylvania Farm Show, having just come down last night. The thing that I got out of the show is that such a multitude was there. More people than ever seemed to be coming to see the show-- 85,000 on Monday, 135,000 on Tuesday and I don't know how many were there yesterday as I left there late yesterday. I think there were two main things I got out of the meetings at the show. In farm production-- and our golf course production is not too far away from that-- the emphasis is being put on quality. During the war when it was easy to sell products, people got away from thinking about quality, but there was no doubt about it that every meeting you sat in and everyone you talked with was emphasizing quality. So I think you are also going to hear about that this year in golf courses. People are going to look for and demand a little bit better turf all the time, and rightly so.

The other thing emphasized was efficient production. You appreciate that in your golf course maintenance game. Mechanization and anything to do the job better with less labor are being sought. I bring it along as a contribution to you, as I think that is what you are up against in the golf course game. In 1949 it will be producing better turf and doing it more efficiently.

The control of turf diseases is just one phase of it. I have tried to determine when the first turf disease control was done. Many of you, who have been in the golf course game for twenty years or more, realize disease control was started by the Green Section during the mid-twenties under the direction of Dr. John Monteith. The finding out the right fungicides to control the different diseases was a remarkable piece of work, and it is too bad there was ever any lapse in such experimental work. I hope you agree with me that somebody should continue the work in research on turf diseases. Let it never be laid aside, but let it never have all or too many of the Experiment Stations working on it. The fine thing about Fred Grau's work as Director of the Green Section is the co-ordination of all the research work-- getting one or two Experiment Stations to work on certain problems and others to work on different problems.

In Pennsylvania for the past few years there has been research along the lines of turf diseases. What I have to report to you today is from observations of what has been done in Pennsylvania. In '41 the Penn State College Research Department put a graduate student down in Philadelphia area to do some field work under Dr. Wernham, who was then directing the turf disease research program. Since the turf disease program is more severe in Southeastern Pennsylvania than at State College, it was decided to do the fungicide comparison work in the Philadelphia area during the summer months. At the end of the season of 1941 the results indicated a material which came to be known as Thiosan was a helpful fungicide in controlling large brownpatch. The fungicide was later named Tersan. As the result of the finding the golf course superintendents went into that war period, when mercury was taken away from them, with a feeling they still had a helpful fungicide. The new material, Tersan, does have some variations in the control of turf diseases, but is widely used in controlling large brownpatch. The material never retards the turf which is a factor since large brownpatch occurs at a period when the temperatures are likely to retard the growth of grass.

As a result of the war the research work was discontinued. When the war period was over and things began to get back to normal again, the golf course men raised the question with the College of whether they were going to continue the disease control research program. Finally it narrowed down to the stage of "Yes, we are going to do it, but personnel is extremely limited...There is nobody here we can find to put in the field with the students." At that time there were no graduate students available to come out to do the work and that was due to the war. The work for the summer would be done if a man could be located to do the work. A few of us got together and put it up to the School Board and the School Superintendent to find someone-- someone in that area who could carry out the work. They recommended a science teacher. So three years ago this work continued in the field. Dr. Thurston, who is in charge of turf research at Penn State College, Joe Valentine and a few others met to decide what materials would be tried and how the work should be carried on. Nobody had any idea that we could get very far the first year. One material put into that comparison was a cadmium material that had been given to the College for the research men to try on potatoes and apples. It didn't seem to have a bit of promise or place, but since it was available it was put on the turf along with some eight or ten other materials. Comparison plots were put out, using mercury in the form of Calo-Clor as the standard fungicide.

In a short time one material began to stand out, showing a lot of promise in turf disease control. It was most effective as to dollarspot. It was the same year that Rhode Island reported a Puratized material was an effective fungicide. The same man continued for three years in the work of carrying out comparisons of the different fungicides. It often happens in research work, as it did in the turf work, the first few years the results were outstanding; the control by the different materials was rather clear cut, some materials showing no control, the check plot showing a lot of disease, and a few materials giving excellent control. The findings for the three years indicate the subject of turf diseases should be studied further and the relationships of soil fertility, maintenance practices and chemicals used should be studied. In other words, as we get into these newer chemicals, we find many of them are selective. They are not as inclusive as the mercuries. But, they do have a place, and it may be the new fungicides may be used at less frequent intervals.

In view of what has been said here by O.J. Noer, I think we all realize that a properly designed golf course is a helpful factor in controlling turf diseases. If we look after the fundamentals of golf course construction, we may cut down our disease control problems. Good construction and good maintenance are helpful. Well selected strains of grass are important in keeping disease control at a minimum. Resistant strains should be used. Cultural practices such as mowing and fertilizing have a decided effect on the turf diseases.

Lime was found to have a place in controlling turf diseases, although we have no reason to believe that lime is a fungicide. Sometimes when the humidity is high and the soil extremely wet, hydrated lime checks disease. It has a place as a fungicide when the weather is unusual, and it seems to be a tonic to the grass. It was found that ten pounds of hydrated lime, put on when the turf was dry and poled into the turf, was the maximum amount to use.

A few pictures will emphasize the different turf diseases.

(Slides)

1. This is large brownpatch-- outside ring active. This is what you are trying to stop with the fungicide.
2. This shows dollar spot.
3. Snowmold-- mercury applied in November is recommended.
4. Helminthosporium.
5. Aerifier used in late October--velvet bent did not heal.
6. Layering. It is futile to use chemicals with a soil proposition like that. The use of the Aerifier is helpful to break up layers.
7. Two strains of grass, showing one free of disease and one subject to disease.
8. Here are Arlington bent plots. There is no difference between treated and untreated halves of the plot. Arlington bent was not seriously affected by disease.

. . .

We are not emphasizing that Arlington never has disease. Perhaps you got that out of the picture, but some of you know a little differently. However, this turf mostly recovers quickly after disease is checked, or the disease is of short duration. So I think that when we are thinking about strains that are resistant to disease, you also have to consider the recovery possibilities of the turf. We have seen Arlington rather badly hit with dollar spot, where it is used on fairways in the Philadelphia area, but it never lasts long. When we are talking about bents or bluegrasses for fairways, the question arises: what about our bent fairways and disease? If strains of bentgrass that recover rapidly are used, disease is not going to be much of a problem. There may be times when one of the cadmiums may be used to check the disease. It is being used on tees.

In regard to leafspot on bluegrass there is no known control. High cut, perhaps, but that is not possible on golf courses. The disease comes on lawns cut at 1½-2 inches, and often thins out the bluegrass. I'm not sure that leafspot on bluegrass is due to moisture. Perhaps it is tied up with low temperatures in the spring of the year, rather than excessive moisture. It is destructive on bluegrass fairways and lawns in the spring of the year when rainfall has been limited. However, when the grass should be growing and producing thick turf, this is when leafspot comes in and does its destructive work. Turf often partially recovers; leafspot does not often take it all out, but when the disease has run its course, then the weather is detrimental to the production of good thick turf. So the greatest handicap we have in this area to producing good turf on our bluegrass fairways is that we have no solution as to how to control leafspot.

I would like to comment again on the organic matter layer that often gets into greens. We find organic matter layer in fairways too, and something must be done about it if bent fairway turf is to be satisfactory. There are implements to break up this layer, such as the hollow-tined fork which does an excellent job. But, you all appreciate how long it takes to do a green with a man using the hollow-tined fork. Now there is the Terferator and the Aerifier which can be used and, I think, can be used effectively. We have men who are using the Aerifier on greens in the Philadelphia area, and it leaves the green rather rough right after it is used, but with good maintenance practices, using the dragmat to break up the soil cores and top-dressing afterward, a good playing surface can be restored in a very short time-- 24-48 hours. The undesirable organic layer is thoroughly broken.

Dollar spot is a disease that affects good putting surface. On occasional greens this disease is not checked with the cadmium fungicide 531. When such a condition arises, I would check the maintenance practices, and find out what was below the surface of the grass to see if there was a layer of material cutting off the air and soil moisture. As mentioned, the Aerifier will break up the layer. It may be possible to check the dollar spot by an application of organic nitrogen fertilizer. It is important to keep the turf on greens growing evenly; if there is such growth, turf seems resistant to disease.

It is common practice to water in the early morning, often referred to as washing off the grass-- and the disease. Such a practice makes it possible to observe any development of disease. It is fast becoming the practice to start applying the fungicide when the disease first appears, rather than making applications every so many days.

Large brownpatch varies in its outbreaks; often as long as three years go by between serious occurrences. This turf disease does become active when the rainfall is excessive and there is both high humidity and high temperature. During such periods is the time to determine the effectiveness of fungicides that might control disease. To keep the turf free of disease during spells of weather as described, able management is necessary. An excess of either water or quickly available nitrogen fertilizer must be avoided. It is important that when such weather arrives, the turf should not be lush or soft, but be growing as uniformly as possible. Care in selecting a fungicide that will not check the growth of the turf is also important. Several of the men in the Philadelphia district have found that 10 pounds of hydrated lime per 1000 square feet, applied when the turf is dry and poled into the grass with a bamboo pole, will check the disease during periods when weather conditions are unfavorable to turf. These men who use lime do not classify it as a fungicide, but do find it acts as a tonic when other methods have failed.

New chemicals, such as the cadmiums, are helpful but they are selective. It seems to be necessary to have available at the beginning of the disease period at least three different fungicides; namely, a mixture of calomel and corrosive sublimate, Tersan and a cadmium such as 531.

Turf diseases always seem more abundant in higher cut putting greens than where the cutting is ¼ inch or less. The low cut never allows an accumulation of grass stems and leaves; always there is a new growth of leaves directly from the base of the grass plant or from a single stolon. There are strains of bentgrasses that are much more resistant to diseases than are others and, at a few Experiment Stations, strains of bentgrasses are being selected as to their resistance to disease.

The freedom of disease on any golf course is dependent upon the selection of the correct strains of grasses, the securing and applying of the chemicals proven to give the best control, and good cultural and management practices. It is hoped that turf disease problems on your course will not be severe this coming season.

WATER CONSERVATION IN TURF

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

In the efforts of the Green Section to improve playing conditions and to effect economies in turf maintenance we are trying to develop a national program for water conservation. We cannot confine our work or our program to any one area. Naturally, we think a great deal about you fellows in Maryland and about your problems because we are so close to them, but we do have to think nationally. My thinking on this problem of water conservation is definitely national, but it has a very strong local application in every part of the country.

Water is the most critical, national, natural resource we have in the United States today. Virtually every phase of our national economy depends upon water in large quantities. Water is the most essential factor for all living growth and development. If you took the water out of a person, there wouldn't be more than about a handful left. Every plant is from 80% to 90% water. Without adequate water on the earth, all of us know what would happen. The great deserts of the world give mute testimony. But when water is supplied, the deserts bloom like the rose.

Just why are we so interested in water conservation? Most regions of the country have adequate natural rainfall, you may point out. We probably won't run all the way out of water. Maybe not, but why do cities tell you: "Don't water the lawn this summer. We're running short of water." ? That's pretty plain talk. If there was plenty of water, as in Erie, Pa., to cite an example, the people could run their lawn sprinklers all summer, without ever turning them off, unless the sprinklers wore out. In Erie, Pa., it doesn't even cost anything to use all the water you need. Obviously water conservation up there is not what you would call a critical problem. But, in places where you are told to cut down on water consumption in summer, there must be a shortage somewhere. And why are so many cities and their engineers frantically seeking new supplies of water for the increasing populations of their cities. Some of them are really up against it to get enough water to run their industries and for their homes.

I wonder how many of you are familiar with the loss of ground water throughout the middle west and on the west coast. I can't give you very many details, and I'm not going to give you very much data. What I want to do is to start you thinking about this problem of water conservation. Never stop thinking about it, as it is one of the most important issues with which we are faced today. I'm going to give you the reasons why you should be thinking about water conservation, even though I don't have at hand the exact data to back up everything I say.

A lot of people on their own farms in eastern Nebraska have had to redrill their wells, as the old wells ran dry. The new well had to be drilled from 30 to 50 feet deeper than the old one in order to get down to the water. That means the water level had dropped. Huge war plants have pulled an unprecedented amount of water out of the ground for cooling and for the various industrial and manufacturing processes. Where does that water go? It goes down into rivers, the Gulf and the oceans, and naturally we have for all practical purposes lost it. It is true that some of the water has served its usefulness, but much of it has been lost for future use for a long time to come.

What can we do about it? On our golf courses we have to use water to grow grass. Should we even be concerned about water? We certainly should. All right, you say, what shall we do about it? In the first place we can use less water. I know what some of you are thinking-- that you can't use less water and still keep greens in a condition to satisfy golfers. The greens must be watered to keep a good color and to keep them soft enough to hold the shot. It isn't possible to get along with less water, you will say. I'm not going to admit that. I'm going to point out to you a classic example whereby less water was used and still there is better turf for the players. That is our chief concern-- to provide the very best playing conditions for the men who pay the bills. Let's assume that you think you are now using what you believe is the minimum amount of water needed to run your golf course, your park, or cemetery, or whatever type of turfed area you have. Now don't get the idea that this does not apply to you because you're not watering big areas. It does apply, but let's start with the greens.

Greens have to be watered every other night, or two or three times a week or you cannot hold the ball on the green. Let's look at some of the arguments, and see what can be done. I am going to cite one instance.

At the moment the first one to come to mind is a course in Memphis, Tennessee. I would not have believed this, had it not been verified by several sources-- but the story is being published in the Winter issue of the USGA JOURNAL. They have bermudagrass greens down there and, like most bermudagrass greens, they required watering virtually every night in order to hold the shots. So they were having all kinds of trouble with thin grass, disease and weeds, and the maintenance cost ran pretty high.

A change has occurred in the past three years. James Hamner, superintendent at the Memphis Country Club got an Aerifier for helping to prepare the Memphis Country Club for the USGA Amateur which was held in September 1948. Jim has used the Aerifier very effectively. I am just citing a principle now. In the last two years Jim has aerified his greens, tees, and fairways thoroughly and at frequent intervals. During the 1948 season, regular aeration coupled with good fertilizer practice, reduced watering to less than half the quantity he had used previously. Now that's a little hard to believe, especially so since previously they had been watering heavily and frequently because the soil was too tight and heavy to absorb the water. Jim had outstanding turf for the Amateur and has provided the club members with better turf that gives him much less trouble from weeds and disease. The turf is thicker and healthier, and the maintenance expenses have been cut way down. The consistent use of fertilizer has had a lot to do with that. The deep aeration has produced a stronger, healthier growth of roots, which are able to forage deeper for moisture. The heavier turf carries the play and holds the shot even though the greens are dry. And the summer of 1948 in Memphis was a dry one. It was not one of those rainy summers, but the turf got along better with less water than it ever had.

All right, you say, if I had tried that during the 1948 season on my greens here in Maryland or Washington or Virginia, why, I wouldn't have any greens left. That stands to reason because the soil and the grass and the whole maintenance program have not been planned for taking care of grass this way. The principle that I am trying to get across to you is that using less water and providing better turf for the golfers isn't just applicable to bermudagrass greens. I concede that bermudagrass is different from bentgrass. Maybe it doesn't require quite as much water as bent. I can't speak with certainty about that, but we are beginning to get the same kind of evidence on bentgrass, where a consistent aeration and feeding program has been carried out. The possibility of using less water on bentgrass greens is particularly promising now that we know that some strains of grass are more drought tolerant than others.

Mr. Ferguson, who is now doing some graduate work at the University of Maryland and has been digging into all sorts of things, recently came across a book that was lately published, which is called, "Water Congestion in Plant Tissues". I have not had time to read it yet, but I assure you that I shall do so and I shall give it a thorough going over. In this book they point out and cite all kinds of evidence indicating that too much water causes congestion in the plant tissues. This occurs when water occupies the space between the cells, instead of staying in the cells as self-respecting water should. Water has no business between the cells. Something else should be there. If you use too much water and the water gets between the cells, then your plant is highly susceptible to disease. The structure is weakened when water is where it shouldn't be, and that is why disease just flourishes. It is a lead, and we are definitely going to follow it up. It is painstaking work. This is another argument in favor of using less water. I don't want you to leave here saying that first Grau is saying to use no top-dressing on greens, and now he is telling us how to grow greens without water. I don't go quite that far, and you all know that. But, there is a place in this water conservation program for each and every one of us.

I grant that those greens where less water is used are going to be harder. Mr. Reinhart told me of a sand-clay base for roads. Some of you are growing greens on that kind of stuff. Actually, there is little difference in the physical make-up of some of our best roads and some of our poorest greens. Maybe that is why the greens are so poor. But if we will prepare the soil and make it porous, and get the roots down where they belong -- instead of having them down two inches, have them down twelve inches-- then we may be able to overcome the hard condition that prevails when greens are dry. We ought to be able to produce good turf on greens that are kept on the dry side.

One thing we can do today that we couldn't do a few years ago is to keep the greens in play and still incorporate the needed materials into the soil. And there are some very interesting things coming up in the future, whereby we can even put drainage into the greens without taking them out of play. That is going to be a neat trick-- to provide downward drainage and horizontal drainage and still keep the green in play. We wouldn't have thought it possible a few years ago.

I want to have each one of you think about this water conservation program, starting with your greens, and two years from now I would like to hear a practical discussion on "How Little Water I Used on Bent Greens in the Summer of 1950". I think it would be an extremely interesting subject. And it will be of value to find out whether or not we are going to be able to provide conditions, whereby we will have less of the disease that Mr. Hallowell spoke about this morning. And this water congestion-- it is a new idea, but definitely one that will bear closer examination.

Greens aren't everything, but they are the first consideration on the golf course. Now let's take some of our other areas-- our rolling fairways, our rolling parkways, and cemeteries and airfields. At the Turf Conference in Knoxville on the 6th of January, Dr. Eric Winters and another man whose name I don't recall, spoke of the loss of water on sloping turf areas in Virginia, Tennessee and Kentucky. The loss of water and of plant nutrients on sloping ground is pretty astounding. I'm not going to attempt to quote anything on this subject as yet because we haven't gone into it deeply enough, but I assure you we are going to do it.

Our two undergraduate students are always looking for a subject on which to write term papers, and you can bet your bottom dollar that this is one subject they are going to get into soon. They'll dig into the literature-- and there is plenty of literature-- on that subject. According to some authorities as much as 60% to 80% of the rain that falls runs off the sloping turf areas. Normal turf areas are supposed to absorb rain and let it seep into the root area, but our turf areas are not what you would call normal. They are decidedly abnormal because when you have to mow fairways two and three times a week, and you have to mow them when the ground is wet, and when they are a mixture of sand and clay to begin with-- you have got a pretty good road surface that is going to shed water. Under those conditions we don't always have the kind of turf that we think we ought to have, or would like to have.

In the first place, we are going to get on high ground, and see if we can help those poor devils down stream from us so, that instead of the water coming up to their second floor rooms, it can only get up to the kitchen. They will thank you for it, since they won't have to sit at their second story windows, but can wade out the front door. I'm joking, yes, but every single person who contributes to this water conservation program is going to help with flood control.

Assume that there are 42 inches to 45 inches of rainfall a year. I doubt very much if more than 50% of that rain actually nourishes our plants. I believe that the other 50% runs off. If we could save a large part of that 50%, which normally runs off, we would be storing up ground reserves of water and taking our root systems deeper to re-use a lot of that stored-up water. So there are lots of advantages to be gained.

How do we do it? To begin with, cultivation of the soil under turf is entirely practicable, and we are beginning to devise ways to do this. One of the ways is through the use of various types of cultivating equipment. One man in New Jersey is using a straight disc, another uses a curved disc and another is using an Aerifier. We have different types of cultivating equipment, some of which are especially designed for the job and some which can be adapted to the job. Any way that will get water to soak into the soil instead of running off is worth trying. With water runoff, fertilizer is lost. One of the figures I heard quoted at Knoxville was that 25% to 30% of applied fertilizer was lost, when rain fell a certain length of time on sloping land after the fertilizer was applied. Most of you can't afford that kind of loss; it is a pretty big loss. If you reported that to your board of directors or your green committee, they would ask, "Isn't there some way we can cut that loss down? We can't afford to throw away a third of our fertilizer." So there is a second reason why you should be interested in water conservation, because it means conservation of fertility. Instead of fertilizer being carried off, it is going to be carried down into the soil where the grass can use it.

What I have just said is of particular importance to you who do not water fairways. To those of you who do water fairways, and I get this from unimpeachable sources, after cultivation of fairways many run into trouble because they are putting on too much water. They have to cut their watering in half. That comes from Denver, Memphis, Cleveland, Chicago and from a sufficient number of places throughout the United States that you have to begin to recognize this as a fact, and not just something we have dreamed up. You can get by with less irrigation water and also with less rainfall by keeping soil cultivated in the fairways, as well as other large turf areas.

Let me give you another example of why I became interested in this matter of water conservation. Salt Lake City is one city where the water situation is critical. They are struggling for water out there and yet everything they grow has to be irrigated--all of their farms, all of their golf courses have to be irrigated. Yet, on an 18 hole golf course, they are throwing $1700 worth of water on their fairways in one month. They have thrown away so much water on their fairways, that they have shifted the grass population from bluegrass completely over to poa annua. Now that they have poa annua they have to continue to throw tremendous quantities of water in order to hold the poa annua. If they stop watering for one week, out it goes and then there would be nothing left but dust.

What's the answer? They have got to become interested in water conservation because, when the squeeze comes, they can't continue to spend $1700 a month just for water. It isn't only the loss of water but the cost of labor to apply it, and the loss of fertilizer, and the more frequent cutting of the grass. This all adds up to a higher maintenance bill. Don't get the idea that I'm talking against watering at all. I'm not. What I am saying is, "Let's use less water and save more of the natural rainfall."

One of the answers to their problem is going to be shifting the grass population from bents and poa annua to a grass that doesn't require as much water. They should be interested in the types of grasses that are more drought tolerant and still produce a good turf. Also, their soils have become compacted due to frequent watering and traffic. The soils are very dense and heavy and the water won't go into them; it simply runs off. So they are not getting the value out of the water they have applied. These are some of the reasons why we have been watching the work of the Aerifier and other equipment. It seems that water applied from a sprinkler will hit the aerified areas and immediately begin to sink into the soil.

Jim Haines, following the Agronomy Society meeting at Fort Collins, got himself an Aerifier and aerified just one fairway, which was the worst one he had. He then watered the fairway, and also an adjoining fairway, which was a little bit better, and he left that one unaerified. The unaerified fairway had to be watered again in a week's time and the aerified fairway was not watered for two weeks, and it was still in better shape than the fairway that had been watered twice. Water is a tremendous item out there, and Jim Haines cut his water bill exactly in half. Although savings may not be so striking in regions where rainfall is more abundant, I think there can be no doubt that this problem of water conservation demands the attention of every one of us.

NEW AND INTERESTING GRASSES

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

As I have said before, we in the United States Golf Association must take the long-range, national view point on many things and we have to do it in the field of grasses as well. Many of you recall the long and profitable work of the Green Section in developing new grasses, and you are familiar with the length of time it takes to develop a new grass. A very good case in point is the new B-27 bluegrass, which we will hear more about and which we are beginning to talk about more freely because we are beginning to see some commercial supplies of seed. Yet, it was 1936 when that particular selection of grass was collected at Merion Golf Club in the Philadelphia area, and all this time it has been checked and tested and increased until we can actually feel a few seeds in the bag and know that, in the next couple of years, there will be small amounts for you to put in an acre or a couple acres of the new bluegrass.

Why are we so interested in this new bluegrass? I think most of us pretty well realize that common bluegrass, as we have it today, has weaknesses and one of its principal weaknesses is its susceptibility to leafspot. Leafspot seems to hit worst in the spring, when the ground is moist, usually when temperatures are low. The fungus attacks the plant, goes all through it, and weakens it to the extent that it cannot recover and give you a dense turf to keep out crabgrass during the summer. That is one of the principal reasons why most bluegrass becomes heavily infested with crabgrass throughout this area. B-27 bluegrass is highly resistant to leafspot. Seldom do we find more than just a few flecks on the leaves. It has another very interesting characteristic, and that is it stands close cutting better than common bluegrass. Much of ours is mowed at half an inch. There is some evidence that it is more heat and drought tolerant than common bluegrass. Seedmen give you 24 pound, 28 pound, or even 32 pound bluegrass, but it doesn't change the character of the plant which that seed produces. The common seed is still susceptible to helminthosporium leafspot. B-27 seems to come absolutely true from seed and seems to be the kind of turf we want.

We have a number of different improved strains, but this seems to be the only one being grown and increased in Oregon at this time. It is being grown in rows out there and we seem to be assured of good production, so we can begin to talk about it. But there is a lot of work that goes into the testing of any new grass and, at the present time, I have just received some reports of the tests that we have on B-27. We have cooperative tests at 20 different experiment stations and 20 golf clubs throughout the country. To get a cross section of the performance of that grass under actual use, it is being seeded into fairways, lawns and research plots alongside of turf produced from seed from commercial strains of bluegrass. This way we will get a direct comparison and our story will be a whole lot straighter. All right, that's just one.

Now, you're not particularly interested in this, but I'm going to mention it because it affects so many golf courses in the country-- and that is our breeding and testing program at Tifton, Georgia. Interestingly enough, some of the best bermudagrass selections, coming out of that breeding program at Tifton, are coming out of their pasture breeding program. Dr. Burton has been breeding bermudagrass to try to find a better one for hay and pasture. Out of that breeding program has come some of the best turf strains which is another example of why plant breeders and agronomists should be interested in both turf and pasture phases of grass work. Dr. Burton has some strains there that are superior to the common bermudagrass in many respects. Bermudagrass gets leafspot just about as badly as bluegrass does. Most of the bermudagrass that we saw down south this fall was pretty badly infected with leafspot, and these new strains are selected primarily on the basis of their resistance to that disease, just as we've been continually selecting bent strains for their resistance to dollarspot, brownpatch and other things.

The literature is full of improvements in grasses for range and pasture, and their work is getting very well under way in the Midwest and in the more arid regions. They are just beginning to wake up to the possibilities. I have just picked up an interesting note in the Agronomy Journal, yesterday, to the effect that one of the finest mixtures ever seeded out on the ranges in Montana has been a mixture of cool-season and warm-season grasses. Now, that ties right in with the work that we are doing, and makes it look as if we are on the right track.

Nebraska has been doing some of that work-- taking their improved strains and blending cool-season and warm-season grasses, and it's working out very satisfactorily for hay, pasture, forage and, from our experience thus far, it looks as though it will work just about as well for many types of turf.

Some of the more interesting grasses-- I don't have any real good pictures of them with me-- are the bentgrasses that we have been picking up. These bent selections have been collected from all over the country. You men actually are doing the selecting and we just pick up the good strains that come out. For instance, in the Cleveland area they had a very bad fall and lost a lot of grass on the fairways, and yet there were strains right in the middle of the bad patches that were perfect so we pick those up and now we're finding superior strains. Those of you who were at our Field Day saw some of our new bentgrasses that came through the summer in fine shape, without irrigation or any treatment whatsoever for diseases or insects. Incidentally, the 1948 season, in the Washington area was, I believe, the wettest in history. It may have been exceeded by one year, but it was about the wettest in a hundred years, which explains the excellent growth of bents in this area. Just thought I'd throw that in for what it is worth.

We may be vitally interested in those grasses that have lower water requirements, more drought tolerance, greater resistance to disease and insects-- something that will give us higher quality turf with greater efficiency and lower cost. This is quite a bit to ask, and we can't go too far in any direction because we have to produce quality turf, turf that will provide the playing surface we need and stand up under the gaff. The gradual movement of the bermudagrass northward, I think, offers some real possibilities. More and more as I talk with the fellows, I find them trying some of these bermudagrasses in a small way-- which is the right thing to do. Don't go whole hog-- give it a trial, see if it will work under your system of management, under your soil and climatic conditions. If it will, you can go ahead in any direction you want. Give it a thorough trial on a small scale. It looks very good on sunny one-shot tees.

The picture is looking brighter for the zoysiagrasses all the time. We're getting more and more work done on it, finding out more about it and we have our greenhouses at Beltsville pretty well filled to the limit of such space as we have, with zoysia. It is producing seed very heavily and we will greatly expand our acreage of zoysia turf at the station next year, for further practical management studies. That is the final answer, and until we have that we can't go out and sell it widely yet. There's been enough zoysia scattered around the country since 1930 that we have some pretty good ideas of what it will do, but there are still many things to be found out about it. Here, I believe, for one of the first times I know about, we are thinking about seed production of a new grass, about which we know very little. Usually when a new grass comes in, people start producing seed of it, and then when we begin to run into problems, we start to study it. But in this case, we are studying the problem of seed production before it ever gets in the field, which is a good way to work it when it can be done.

When many of you go over to the meeting at the station on the first of February, you will see a lot of that work in the greenhouses. More of the breeding work and development work on new grasses is being sent out to experiment stations in a coordinated turf program. By and large these stations have excellent plant breeders, and we'd like to see them do the work. They have the facilities and the land, and more and more we are falling into the role of coordinating all this work. The program is getting so big that we do not have a lot of time for detail-- but rest assured that it will be done as soon as we have the personnel to do it. There are many more things I could say. I prefer, I think, to show you some pictures. Many of you have seen some of them. I think I have some new ones and we can have a discussion on some of those new grasses in which you are particularly interested.

Would you call that a good piece of turf? This is the Z-9 strain of Japanese lawngrass which produces no seed. There is a nice cushion between ball and soil. That turf is very firm, it is disease free and altogether this zoysia has been a very satisfactory piece of turf-- well fertilized, no irrigation, no insect damage nor any disease. For that reason we are giving it a lot of attention and, because of its drought resistance, we are making new plantings of zoysia as rapidly as possible.

Here on the lawn at Beltsville, we put in some common Japanese lawngrass and you can see the spots 24 inches apart which turn brown in the wintertime. This is one of the things that has held it back, because for a long time we didn't see the possibilities of keeping a green color through the winter by growing another grass with it. That brown, straw-colored stuff is zoysia, but the path down which you are looking, has just as much zoysia as the brown stuff at the right. That path was originally bluegrass. The zoysia crept through it and now we have a combination of zoysia and bluegrass that looks for all the world like bluegrass, and that is what we are looking for. That has been going on for some time, and we are quite encouraged.

This is zoysia and bent-- bent overseeded in the fall of 1947. The green strip down there is virtually free of crabgrass and provides an excellent playing surface and sturdy turf that can combat drought. But we can't say yet that it, or any other grass, is the right combination with zoysia, but we are studying them all.

There is B-27 bluegrass seeded in with zoysia, and that has been one of the more satisfactory plots that we had. Common bluegrass is just to the right of the B-27 bluegrass and you can see there is quite a striking difference. (Question from the floor: "How old is that seeding?") That seeding is exactly one year old. (Question: "At what time was it seeded?") It was seeded in early September, 1947.

That was a plot of the Z-52 strain of zoysia with bluegrass, which was growing in the green house from which we harvested seed. We chopped it up into squares and planted them in half an acre of lawn at the Station. I'll try to show you those steps. Now, this is a slow, tedious, costly way of doing it. What we are seeking is a rapid, low cost method of planting a vegetated grass into existing turf, which I don't think is too much to ask. Here we're cutting it into blocks. Here we're shaping those plugs to fit down into the Aerifier holes. We aerified the lawn first-- see those little plugs in the Aerifier holes? Then we put those little plugs in the Aerifier holes. That is slow and laborious, but it serves the purpose here. There they are being pushed down into the holes and stepped on. But you can hardly find those plugs all summer. They were there and they were growing, but they blended so perfectly with the bluegrass, it was hard to tell one from the other.

You are familiar with our U-3 bermudagrass, which was planted in the middle of July. Four weeks later we had a solid fairway turf. We fertilized that very well. We have to recognize the individual characteristics of these grasses. Bermudagrass requires heavy fertilization, especially nitrogen. Zoysia can utilize heavy fertilization, but it also can get along without it. We've got Zoysia Japonica turf at the Glendale Station that we know has not been fertilized in 20 years, and yet it is a perfect covering and practically weed-free. Of course, if we had used fertilizer it would look nicer. There is U-3 bermudagrass with different cool-season grasses seeded into it. The first little triangle in the foreground is Chewing's fescue, which didn't amount to very much. Alta fescue, a late fall seeding, which is wrong, didn't catch too well. The best we have here is bentgrass overseeded on bermuda, and it makes a very nice turf. It is a mixture of seeded bent, 1/3 each of Highland Colonial, Astoria Colonial and Seaside. Here we are trying to grow a mixture of U-3 bermudagrass and some of the vegetated bents, C-1 on the left, C-19, C-27 and C-15. C-27 has not done so well. One of the best plots we have is U-3 bermuda with B-27 bluegrass. It produces a turf that is so tough you can't knock a divot out with a full 8-iron shot.

My talk wouldn't be complete unless I showed you a picture of our 17 acre front lawn at Beltsville. This was seeded in September 1947 with 75 pounds to the acre of Alta fescue. It got brownpatch in the summer of 1948 but, aside from appearance, it didn't seem to suffer any. It is in good shape now. This lawn was designed for looks only, at a fifty mile an hour speed. The grass is coarse but, as it gets older, it gets finer. It is in general use on lawns in Washington, D.C. and Baltimore and over a large part of the United States.

SOIL PHYSICS
(With Special Relation to Green Construction)

By R.P. Thomas

I think that the soil structure of your greens and fairways is one of the most important things with which you folks are confronted. Poor physical conditions of soils limits and, oftentimes, masks other considerations and problems of growing grass. I am going to try to explain some of the things you will be confronted with, and things you will have to consider if you want the best you can obtain in your soils. You folks aren't interested in soils just for the sake of soils. You are primarily interested in growing grass in it, and building a suitable foundation for the players. In other words, you want to give the golfers a satisfactory turf so the ball can be played correctly. A lot of trouble that we have attributed to various things in the past may be attributed to an unsatisfactory physical condition of the soils.

First, I wish to enumerate some of the terms we use. I think all of you folks are familiar with them but, in order to get us all thinking along the same lines, I will describe some of them briefly. We speak of anything larger than one millimeter as gravel. Anything from that size down to .05 of a millimeter, we call sand. Then we go down from there to the next smaller sized particle, which is silt. The next size is clay or colloidal material. In terms of millimeters, anything from .002 mm down, we call clay. The silt range is in between the clay and the sand.

Now you are interested in soil from the standpoint of getting it so plants will root deeply. If we happen to have adverse weather conditions, you do not want to have to apply water extremely frequently. When the grass is deeply rooted, the roots feed over a much larger area, and you do not have to water so often. Now these plant roots are living, just the same as you and I are living. They require oxygen just the same as you and I require oxygen, and they give off carbon-dioxide just the same as you and I give off carbon-dioxide. And a good soil is just teeming with an enormous quantity of micro-organisms. Even though their size is below that of the clay particles, these active micro-organisms give off carbon-dioxide. It is the same as if we were to put about 670 people in this room, and if they remained here any length of time, there would be a lot more carbon-dioxide and a lot less oxygen in the room. We get the same condition in the soil.

What I am trying to emphasize is the necessity for having spaces in the soil so the air and water can move about-- and especially the air. If you have soil that is almost saturated with water-- and many of you approach that condition in your greens every day-- then you are taking up the spaces in the soil, and you have greatly limited the amount of air that can occupy the soil. I have a diagram, and I shall try to point out to you what I mean. I told you that the size of the clay particles is from .002 of a millimeter and down. These minute particles are surrounded with water, even when the soil is air dry. You can realize that this is a pretty thin film of water. Its thickness will run around 1/10 of a micron or 1/250,000 of an inch. You have all seen drawings of these things-- where they draw a soil particle and then draw a different colored line to represent the moisture film. But that doesn't really help you to visualize the size of the moisture film around a soil particle. Oftentimes the moisture film depicted will be as large as the soil particle, and will represent more the picture of a grain of sand. So you have a rather distorted viewpoint in regard to the size of the moisture film as related to a soil particle. I have tried to make drawings here that will show the moisture film in true relation to the particle size. This large particle is just up in the silt range. In other words, the intermediate size between sand and clay. These smaller particles are down in the clay range; they are about 1000 times their actual size. You can see that the green represents the film moisture that exists around a soil particle. The water is held to the soil particle by an attraction between the moisture and the soil particle. It holds this film against gravity. If it wasn't held against gravity, all the water would run off. There is an affinity between the moisture and each soil particle. To illustrate this point, even when we are approaching the minimum amount of water that can be obtained by a plant, the moisture is held by a force 1000 times that of gravity. So you can see what the plant has to compete with, and how closely this water is held to the soil particles.

I want to get across to you, that when we have these fine particles and they have a moisture film around them, then there is no air space. All the air space is occupied by water. When you have the soil pretty well watered, as you try to keep it, you have eliminated a large percentage of the pore spaces which could hold air. Looking down at this cross section of soil, we can see there is no definite arrangement, and a large part of the air space has been eliminated. Even if there were an air pocket down below, the air could not move out. If you had a root down there, active, giving off carbon-dioxide and taking up oxygen, you can see it would be greatly hindered. But if you have some large openings in the soil so the water film will not take up all the space between the soil particles, there is a chance for air to move in and out. When you have a rather small particle size and a high moisture content, which most of you try to keep in your greens, you have greatly reduced the possibility of replacing with oxygen the carbon-dioxide that is generated in there. In other words, you have limited its ability to get air. This is what we term "reduced" conditions, and the plant roots will not live under such conditions. It's pretty much the way it was here last week. The lecture room at the Farm Bureau Show was so crowded that people would open the door, see how thick the air was, and come back out again. Plant roots do the same thing. They are not going to stay where they can't get requirements necessary to live. That means the roots are going to stay up where they can get air. If you have fine soil particles and they are kept well watered, the plant roots are not going to go down. That was illustrated here yesterday by pictures of just such conditions. The soil cannot breathe, and you have what is termed a water-logged condition. Actually, it may not be water-logged-- there may be plenty of space down below that is not occupied by water-- but the air cannot get down in there, and we have what is called poor drainage. You can see that where you have such conditions grass roots stay above these layers or near the surface. These conditions are produced when you frequently spread a little clay or fine-textured soil over your greens. You are making it impossible for air to get down there. You need only a fraction of an inch of these materials to completely cut off air from the soil. So what happens is that the old roots down below become inactive, and new roots will grow only near the surface, and your grass is going to go out.

I have a chart here in proportionate sizes showing the relationship between the water film and the soil particles. You may have your soil in a condition in which there are the right proportion of the large and the small particles-- a mixture of sand and clay. Natural channels result from this arrangement. In other words, we would have channels to serve as breathing spaces for the soil. But if you take these particles and squeeze them around like this, like rolling a ball of soil between your palms, then you have the same effect as when you puddle soil. You are working the soil particles in with the water around them, and you are lubricating that soil so you get all these little particles worked into the larger air spaces. As a result of this you have insufficient air in the soil. All these small particles are blocking the air and water channels. They may be occupying most of these air or water spaces. There can't be any water or air movement. When this pore space is taken up by a film of water there is no water movement through this area. The water is usually held so tightly by the soil particles that the water can not move out nor more water move in. Most water movement is through the larger channels found around the large particles or granules. So when you get these particles so close together that there is not room enough for the normal film of water, and that film is going to be the same size regardless of the size of the soil particles, then you have eliminated all possibility of air getting down in there, and all possibility of water movement in the soil. You all know when you puddle soil-- work it around and get the soil particles together-- then you have a condition such as this one with no or little air space. Then, when that dries out, it is all lumped together and it dries just like a brick. Of course, no water can move through it even when it is dry.

Now, in soil structure, we have other terms which we use. We use the term "pore space". Pore space is the space between the soil particles. Part of the pore space is occupied by water. In this instance, where the soil is largely clay and it has been well watered, all of it is occupied by water. Here, where there is a mixture of both large and small soil particles, the pore space is a mixture of air and water. Now, if you were to take a square foot piece of this soil out of your golf course, and if you were to break it up, the more you broke it up the more soil particles you would have. You wouldn't be able to get it back into that same square foot space. If you keep breaking it up, you can increase the volume by as much as thirty percent. That is because each one of these particles has air spaces around it, and when you break up the soil, you get more air space than is normally present. Now that space that exists between the particles is your pore space. The smaller the particles are, the greater is the pore space. In a sand soil there may be as low as 40% pore space. A clay soil may run up to about 70% pore space. The optimum is around 60%.

Now, when we compare the weight of soil with the weight of water, we have what is termed the "apparent specific gravity". In other words, an expression of the weight of a given volume of soil as compared with the weight of the same volume of water. If a soil has a specific gravity of 2, it means that a certain volume of that soil would weigh two times as much as an equal volume of water. Dr. Grau had some pictures of soil from greens. One soil sample was from a good green and one sample was from a poor green, and yet both soils had the same mechanical analysis-- that is they both had the same amounts of sand, silt and clay. One of them had an apparent specific gravity of around 1.2-- that would be the good soil. And the specific gravity of the poor soil would run up 1.6 to 2.0. That would mean that in the poor soil, even though they had the right proportion of sand, silt and clay, they had worked them in there together so the fine particles fitted into all the spaces, and there was no air space. The soil was very dense.

Now this is one of the things you are up against. Maybe you have the right proportion of materials in your green, but if the particle arrangement isn't right, you are going to have poor soil, and a poor green. We can't examine the soil in place and tell very much about the particle arrangement because the particles are so small that one soil looks pretty much like another. We can't take a core of soil and just look at it and determine what the arrangement of the particles is like. We could if we could magnify it enough, but we haven't worked out a satisfactory technique for that yet. So we have approached this by taking that core of soil and weighing it and comparing that weight with the weight of an equal amount of water. That is how we determine whether the soil particles are arranged too close together or if they have air spaces between them. There can be a considerable variation in the arrangement of soils of the same composition. Soils men are trained to look for certain characteristics by which they can tell if there is sufficient air present in the soil. If I had two plugs here and one of them was water-logged and one of them wasn't, it would be possible for me to tell the difference between them. Experience teaches you how to gauge those things. So much for that. I'm trying to tell you that the particle size and arrangement of the particles are both very, very important. They determine the movement of air and water through the soil.

I want to get across to you that if your soil is air dry or has a low moisture content, it might be satisfactory. You should get a satisfactory growth of grass. But if you come along and raise the moisture content, you have lessened the ability of that soil to breathe by as much as fifty percent. So if the soil is watered frequently, you may have an unsatisfactory grass growth, but if you were to let that soil dry out near the minimum moisture level, your grass growth might improve due to this arrangement of particles in the soil and more available air. In soil we want large particles to hold the channels open. We need particles in the smaller range in order to hold water. Water exists only on the surface of the small particles so if you only have large particles, you don't have enough surface for water to exist on. That is what you have in sand-- a small surface and low waterholding capacity. You pretty nearly have to water twice a day to make the grass grow, when you have a limited amount of surface to hold water. When you get down into the smaller particles, you have an enormous amount of surface to hold water. Just to give you an idea of how this is-if you have a square foot of sand, six inches thick, you will have somewhere around a half acre of exposed surface. That is if you could skin those sand particles and spread the skins out it would cover an area of half an acre. Now contrast that with a silt loam or some other finer-textured material. An equal amount of silt loam would probably have from ten to twelve acres of surface to hold water. So when we go from sand to finer materials we increase the surface many times. This is very important because all you people want your soil to hold water, and the only way you can hold it is on the surface. Soil particles can only hold a certain amount of water on the surface. If this film thickness gets beyond one-half of a micron, water has to move on down, as it just can't be held against gravity when it gets beyond that thickness. So if we have all coarse particles there isn't surface enough to hold sufficient water. But we do need some coarse particles to provide air space, and to form channels so water can get down in to the soil.

Yesterday we were talking about water run-off. Water runs off simply because there aren't enough of these large channels to carry it down. Water can't go down in these microscopic channels. And if you have only a few of these large channels, when soil is heavily watered, the water can't all go down in. When you get an area like this, where there are no larger channels, then what will happen? You can't pile the water up on the surface. It is going to run off, and you will lose a lot of water as a result of this. The water that does enter the soil is usually near the surface and a lot of it is lost through evaporation too. But if you have enough of these large channels to get the water down into the soil, then you reduce very materially the amount of water that will be lost through evaporation. Below the soil surface the temperature drops very rapidly and evaporation is much less. Only the water that is carried off through the air pores by gravity, or brought to the surface by the film, is lost. That is why shading the ground with a heavy turf is beneficial for limiting the amount of water lost through evaporation. The moisture loss is almost directly proportional to the height of the vegetative covering. That's because evaporation increases very much as the temperature increases, and the higher vegetative covering provides protection from the sun's heat. For each ten degree rise in temperature you will have perhaps as much as two times the amount of water evaporated. So if the vegetative covering is not thick, the soil temperature may rise from ten to twenty degrees, and you can see how much more water will be lost through evaporation. So you can see the value of a heavy vegetative covering, as well as the necessity for having channels like this in the soil so the water can get down.

Now, I'll illustrate this with something else. I have some drawings here. Here is the surface of a good soil-- a normal soil with plenty of air space and pore space, plenty of surface to hold water and the right waterholding capacity. Now, if someone were to come along and put a layer of finer materials, about two inches thick, on top of this surface, the roots would not go down through this added fine layer even though there is plenty of moisture and nutrients in this covered layer. But the roots wouldn't go down because the surface layer cut off the air to the soil below. So all the roots would be congregated at the surface. Now let's consider this two inches of soil. Let's say it has 50% air space, or 50% pore space, that can be occupied by water. That is, this two inches of soil could hold half of its depth of water, or one inch of water. But we don't want it completely saturated, so we'll try to reach about half of its waterholding capacity-- that is half an inch of water. Now contrast that with a soil in which the roots could penetrate eight to ten inches in depth. We are trying to grow grass in two inches of soil with a maximum waterholding capacity of half an inch of water. We could have four times that amount of water, or two inches, in the deep soil. You would not have to water nearly so often when there is no layer of fine materials to limit the air and water movement.

The arrangement of particles is very important, and I don't think I should leave it without saying something about the organic matter. The organic matter is largely colloidal, and is very fine and fits around the mineral particles, like these black spots. But you have to have it properly mixed in order to get it around the soil particles. What does that then do to the soil structure? It holds the mineral particles apart so there are larger spaces between the mineral particles. This gives more surface to hold water as well as larger openings for it to move into the soil. When the organic matter is mixed into the soil by man in an attempt to approach the soil conditions set up by nature, it frequently isn't mixed in well enough. The organic matter should be distributed so it will aggregate the fine particles and the clay and organic matter will act as one unit. In other words, these smaller mineral particles should be covered with the organic matter so they will join together and act as one larger particle. When the organic matter is properly combined with the clay then you have a structure approaching silt. The soil behaves like silt because the small particles are aggregated. Now, if any of you have been in the western part of the United States, the Great Plains region, and if you made a mechanical analysis of the soil, you would find it was largely clay and silt. You take that soil and crumble it between your fingers and there is no coarse material present. But the plants grow in this soil just as if it were sand they were growing in, even though the soil may be silt or silt and clay or even plain clay. The soil behaves like sand because under natural conditions the organic matter is there aggregating the fine particles so they act like larger particles. This is very important. I question that you could ever satisfactorily mix organic matter with fine textured materials and come out with a satisfactory soil structure. It's very difficult to mix the organic matter in properly, so what you are apt to get is an aggregate of mineral particles and an aggregate of organic matter particles. Then, when this gets wet, it runs together and you have no place for air or for water to go down, and your grass won't grow.

It is very difficult to materially improve a fine-textured soil. It is too difficult to mix these fine particles with coarse particles. Now, if you have a coarse-textured soil like sand, there are not too many particles, then you can add finer materials to it and the finer particles tend to aggregate around the large ones. So you can improve the physical condition of your coarse-textured soil, but it is very difficult to go the other way. Probably many of you have tried mixing sand with clay material, and not come out with very satisfactory soil. It still won't take water, and you still can't grow good grass in it. You may improve it, but you won't approach the condition you would have if you started with coarse-textured soil and mixed finer materials with it. If you are going to mix a fine soil with a coarse one, and many of you do that, it should be mixed in a shredder or similar machine before it is put on the green. You will never get a satisfactory mixture or soil structure after it is put on the green unmixed. It is just impossible and I'm trying to point out why.

Some of you here in Maryland may be familiar with the soil we call Penn soils. It is an Indian red soil and there is a strip which runs across Frederick County, up into Carroll County and some in Baltimore and some in Washington County. I mention these soils because they illustrate something I want to point out. These soils have been built on since the first white settlers came here, and you can go into those sections today and find very large brick houses--houses with ten to fifteen rooms. Now, they didn't have the money to build the houses; the money had to be made off the land. Well, they came in there and cut down the forest to make room for farms. The soil had lots of organic matter and a desirable structure. So the settlers removed crops year after year and didn't put back the organic matter, and finally they had only the fine materials left. That land today is worthless. The farm investment people will lend money only on the value of the improvements, the buildings. When it rains it only penetrates to about the thickness of a piece of paper. The fine surface soil dissolves like sugar and all runs together, and then the water can't get in, but just runs off the surface. And that's what some of you are up against, trying to grow grass on your fairways.

In other words, you want those finer materials aggregated. I would hesitate to say that you need 5% or 10% or 15% clay. Under some conditions, you would need 30% clay, and under others, 5% is too much. You can't say definitely because it depends upon how it is arranged with regard to your other particles. I've seen that some of your greens are 75% sand-- very satisfactory greens. And I've seen others 25% sand-- very satisfactory greens. So I don't think you can lay down any rule as to a specified amount of sand, silt and clay. You want to bring together the materials that will provide you with both large and small particles. In other words, you want a soil structure so water and air can get in and the water can be retained for root use. I think that some of the implements we discussed yesterday may be approaching what we want to open up the soil. Of course, this man-made improvement of the soil structure may break down under rain. If it is not too expensive, you can again reproduce the type of soil you want.

GRUB CONTROL IN TURF
(Summary)

By George S. Langford

There are a large number of grubs that feed upon and destroy the roots of grasses. These grubs are all members of a very large beetle family known as Scarabidae. Some of the common scarabs that produce grubs that injure turf are: the Japanese beetle, the Asiatic garden beetle, several species of May beetles and the common green June beetle.

All of these beetles have similar life habits. There is an adult beetle which feeds on the foliage of shade trees and shrubs. These adults lay eggs in grassland which hatch into the grubs that cause the injury. After completing their growth the grubs go into a resting or pupal stage and are transformed to adults.

When lawns or golf greens become heavily infested with these grubs it becomes necessary to kill them before they injure the turf or sod. Arsenate of lead has been found to be effective for killing most turf-inhabiting grubs. Recently DDT, Chlordane and some of the other chlorinated hydrocarbons have proved efficient for eliminating grubs, particularly the Japanese beetle, in lawns and golf courses. Experimental work to date indicates that these new chlorinated materials give good control on many species of grubs. However, it should be remembered that DDT, Chlordane, etc., do not kill all insects efficiently. There may be species of white grubs that will not be efficiently controlled by the use of some of these materials. A greenkeeper should attempt to have the grub injuring his grass identified to find out whether research has shown that the particular grub can be killed with one or more of these new synthetic chemicals. If information is not available a small test should be made before attempting to treat the entire golf course.

Insecticides may be applied either dry or as sprays. Regardless of how they are applied the proper poundage per acre must be applied. Spread the chemicals evenly over the grass and then water them in thoroughly to avoid poisoning domestic animals. Treatments as follows will be found effective for controlling the Japanese beetle and many other closely related grubs:

Arsenate of Lead: Apply 10 pounds of chemical on each 1,000 square feet of surface. A simple way to apply is to mix with sand 1 pound of arsenate of lead to 10 pounds of sand, and broadcast evenly, or distribute with a small fertilizer distributor.

DDT: Apply 25 pounds of actual DDT to each acre treated. Use a 10 percent dust and apply 250 pounds to the acre, or approximately 6 pounds on 1000 square feet.

Chlordane: Apply at the rate of 10 pounds of technical Chlordane per acre. Use method of application recommended for DDT. In recent years Chlordane has been used extensively because of the rapid rate at which it kills grubs.