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TABLE OF CONTENTS

THE USE OF FUNGICIDES IN TURF GRASS DISEASE CONTROL

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More people are concerned with the establishment and maintenance of turf grass than any other single crop plant. The social pressure to have picture window turf whether it be on the golf course, in the park or in the home lawn is increasing each year. The battle to produce this quality turf begins with the seed bed preparation and continues on and on with the continuous procedures involved throughout the growing season.

Many factors can influence the establishment and maintenance of turf grass. Among these are varietal adaptation, fertilization, watering, aeriation, insect infestations, compaction and diseases. Although many of these factors can cause a gradual or sudden change in the general condition and appearance of turf areas, diseases are generally recognized as one of the major causes of poor quality or unsightly turf.

To most persons, turf diseases are commonly associated with some type of organism. It must be understood that the effects of too little or too much water, temperature, fertilizer or chemicals may produce symtoms on grass which are identical with those caused by the turf disease fungi.

The three most common turf grass diseases in this area are brown patch, dollar spot and Heminthosporium. These diseases and many others are caused by fungi. These fungi are generally microscopic in size and are unique in that they do not contain chlorophyll as do the higher plants. For this reason, they must obtain their food directly from dead organic matter or from living plants. The three diseases described above are all caused by fungi which can live on either living or dead organic matter.

In general, for a disease to develop in a stand of turf grass, three things must be present; (1) There must be a population of susceptible grass plants. (2) The disease causing fungi must be prevalent in the area. (3) Finally, environmental conditions must be favorable for disease development.

Despite the value of fungicides in combating turf diseases, the first line of defense against turf pests is good dense turf. Turf which has been properly constructed and properly maintained will show greater tolerance to disease and insects as well as weed invasion. This is not to say that such turf will be immune or completely free of disease but will show greater tolerance to invasion and will be able to recover and fill in once disease occurs. In many instances, severe outbreaks of these diseases in localized areas may be traced back directly to poor management or adverse weather conditions which weakened the stand of grass.

Since diseases are capable of developing in turf regardless of the

general condition of the grass, it is essential that these pests be combatted directly. It is in this light that turf fungicides should be considered. Turf fungicides have been used on golf courses and bowling greens for over 40 years and more recently have gained considerable recognition for use on home lawns and other turf areas.

Basically, fungicides may be classified in two categories related to the general manner in which they are used. These are protective fungicides and eradicative or curative fungicides.

The most opportune time to control or destroy an organism is before it builds up or becomes established. A series of protective sprays applied at regular intervals acts as a barrier to disease development. The fungicides used in this type of spray reduce or keep the fungus population from multiplying, thereby minimizing the potential for disease development.

Eradicative or curative fungicides are employed after disease has appeared. Since damage to the grass has already occurred and the fungi are well established, it is necessary to use higher concentrations and to spray at closer intervals. Although eradicative fungicides are capable of stopping further disease spread, they cannot cure severely diseased plants. These plants are usually destroyed by the fungus infection. Once the disease is checked, it is necessary to bring the grass back by proper management procedures.

FUNGICIDES AND NEW DEVELOPMENTS IN FUNGICIDES

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A fungicide is a chemical substance used to prevent or cure a fungi infection. Fungi are a simple group of plants that have no green coloring chlorophyll. Mycologists, scientists who study fungi, have named about 75,000 species or kinds of fungi. Luckily, for turf men like us, a limited few attack or host on turf and ornamentals that concern us.

One of the first fungicides used was the Bordeaux Mixture. It contained 4 lbs. Copper Sulfate and 4 lbs. of Hydrated Lime mixed in 50 gallons of water. Used originally in 1882 as a spray on grapes as a theft preventative by the French and was found to protect the plants from downy mildew, a fungus disease. It was used as late as 1920 on putting greens (USDA Bulletin No. 12, 1932).

Injurious fungi are called rusts, smuts, mildews, molds, and other names such as blights depending more on its appearances than by its scientific class. "Damping Off", a fungus in seedlings, can be prevented by treating seed with either Thiruram, Oresan, Cuprus Oxide, Mecuric Chloride or spraying immediately following germination.

All major manufacturers of fungicides, their products, and the fungus or fungi, these products control were named at this point. However, it is well to rely on reputation and suggestions of successful men in your area or reliable sales people calling on you.

For selection of a fungicide, consider carefully: Cost, effectiveness, phytotoxicity, safety, level of compatibility, shelf life, availability.

Procedures of application: After correct identification of fungus and accurate selection of fungicide - follow directions on the container label exactly without variance. Most failures are due to incorrect Calibration of Spraying Machine, or spreader in case of dry mixtures. Know the size of area to be sprayed. Remember size of area to be sprayed. Remember that 7.99 ft. or 8 ft. wide one (1) mile long is one acre. Put your best man on the operation or do it yourself. If he is inexperienced, give him a trial by using a harmless dye like Victoria green crystals by Du Pont and give him a specific area to spray. Different textures of color indicate differences in coverage. Wind drift, watering prior to, or after, time of day or night will alter results. Proper distribution of chemicals will be the secret to success.

Keeping records will be helpful as to when to expect outbreaks of disease and chemicals or fungicide used successfully in the past. Available publications with pictures of fungi and their control should be in your reach.

A healthy plant (turf) one that has been planted in a good seedbed, fertilized, watered, mowed with a sharp machine will have far fewer attacks from fungi than turf improperly maintained.

PRE-EMERGENT WEED CONTROL

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Definition of Pre-emergent weed control - Control or killing of weeds before they become established.

Before 1960 there were primarily only three widely recognized pre-emergent control materials; namely, Pax, chlorodane and tricalcium arsonate. Now there are over 20 pre-emergent control materials being sold and many others being tested and developed. Pre-emergent weed control is therefore a relative new development in the turf field.

ADVANTAGES AND DISADVANTAGES:

There are both advantages and disadvantages to pre-emergent weed control. These are as follows:

ADVANTAGES:

1. Only one application is needed annually which may be applied during the dormant season when labor is not at a premium.
2. Materials have a long residual requiring only single application (Crabgrass germinates all season long).
3. Weeds (ex-crabgrass) are killed before they become unsightly or crowd out desirable grasses.
4. No dead weeds are left to mar the beauty of the turf.

DISADVANTAGES:

1. High cost of initial application.
2. Toxicity of most post-emergent herbicides to germinating turf grasses.

PRE-EMERGENT WEED CONTROL IN NEW TURF AREAS:

The value of pre-emergent weed control in establishing a new turf area was demonstrated in recent Texas A&M tests. These tests showed that, five weeks after sprigging, treated plots showed 80-90 percent cover while similar untreated plots showed less than 10 percent cover after same period. Both lateral coverage and root development were reduced by weed competition.

When establishing Tifgreen (Tifton 328) Bermudagrass stolons Bandane, according to the Texas A&M report, was the only one of eight commerical materials tested that provided adequate weed control with little or no injury to the Bermudagrass stolons. In establishing sprigs of common, Tifgreen (Tifton 328) and Tex-turf 10 Bermudagrass Zytron G, Dacthal and Bandane all gave good pre-emergent weed control with no retarding effects on the Bermudagrass sprigs. Simazine gives excellent pre-emergent weed control but is toxic to Bermudagrass. It can be safely used, however, on St. Augustinegrass, Zoysia and Centipede grass.

FACTORS INFLUENCING PRE-EMERGENT HERBICIDES:

Dr. Lloyd Stitt of Velsicol Chemical Corporation at our 1964 Texas Turfgrass Conference reported on the mode of action, movement and hazards of pre-emergence herbicides. He reported some materials have their activity in the vapor phase, others in the liquid phase, while still others in both liquid and vapor phase.

The action of crabgrass per-emergent controls is on the root development. Therefore, a considerable portion of pre-emergence herbicide activity is related to depth of rooting. If a herbicide is applied and localized or tied up in the immediate surface, it will not kill those plants that are rooted deeper. There is little movement of pre-emergent materials in soil although rainfall may cause movement of materials.

Stauffer Chemical Company tests have shown that pre-emergent materials should be applied alone. Organic fertilizers especially interfere with the action of the herbicide they report.

Arsenicals depend on the greater sensitivity of crabgrass seedlings than other established grasses to arsenicals. When using a material such as calcium arsenate a problem is encountered in that soils vary in the amount of arsenate naturally in the soil and also vary in their ability to tie up or buffer arsenates. Soils high in phosphorus, clay content or organic matter require more arsenic for control of crabgrass than do the opposite type of soil. Arsenic and phosphorus are quite similar chemically and react very much the same in soils.

APPLICATION OF MATERIALS

Rates of application, timing of application, soil type variations, etc. have all been thoroughly tested by manufacturers and research institutes; therefore, the label instructions should be followed. In addition, however, keep a record on the date of application, rate applied material used and its exact formulation and areas on which applied. Record also information on management practices such as fertilizing, watering, renovation, verticutting, top-dressing, aerifying along with climatic factors such as temperature and rainfall. This information can be important in evaluating or determining the beneficial or adverse results obtained from materials used.

POST-EMERGENCE WEED CONTROL

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Post-emergence is any treatment made after an emergence. A post-emergent is a chemical treatment which is applied to a crop after the crop is up but before the weed appears. On most golf courses when a post-emergent is used, the chemical is both post-emergent to the weed as well as to the turf. It might be said that we use a post-emergent when a pre-emergent has not been completely successful. The following are factors which effect the use of a post-emergent and give best results.

1. Proper chemical for the job. The use of a chemical will greatly vary to the location and climate of an area and even within the city itself. At this time there are more than 250 herbicides on the market. Before use of a herbicide, each golf superintendent should set up a test plot on the course. By experimenting on a test plot it can be determined what will be the most effective control in the area.

2. Following directions carefully. It is said that most companies spend in excess of one million dollars to get the label on their product approved. It is important to use the recommended amount on the package and to follow directions carefully. In the use of DSMA the top growth of crabgrass and dallisgrass is often killed too fast and does not translocate the arsenical to the root system which will kill the weed permanently. Many greens have been completely burned up by people who have not followed directions properly and have not tried their method on a test plot before using the chemical on the entire area of a green.

3. Proper distribution of the material. Often we think of the use of a material by "X" number of pounds in 50 gallons of water. The important factor is the number of pounds per 1,000 square feet; this determines the amount of material applied per plant. Each individual plant should have the same amount of water. The distribution of this depends greatly on the spray nozzle. The man applying the material should use his knowledge and judgement concerning the application and mix the proper quantities carefully.

4. Proper amount of Surfactant. It is very important that a surfactant is used when treating weeds. In the past soap flakes were often used, but modern science has developed many surfactants for use with different chemicals. It is especially important to use a surfactant in the correct quantities.

5. Proper condition of the plant at the time of application. To get good control of a post-emergent, it is important that the plant is in its maximum growing condition. If the plant is not growing well, it is difficult to get good movement of the material within the plant. It is also difficult to get the materials to move through the stomate or cuticle of the leaf.

6. Proper environment at the time of application. Most post-emergence will not work when the ground is dry. Follow the directions as to the best time to apply a material. The weeds should not be treated when it is windy since a drift could cause the kill of a desirable plant. On a calm day, it is not as difficult to get the proper distribution of the chemical on the plants. The temperature also makes a difference on the effectiveness of a kill. DSMA works best when the soil temperature is above 70°F. At temperatures below 70°, DSMA is ineffective. This is true of many other chemicals on the market also.

7. Proper equipment. The most important thing about the machine used is whether or not it can be calibrated. Many people have successfully made machines at home for the job. Calibration is the key to good distribution; therefore, the person who applies this should be able to control the pressure and volume. A machine should also have the ability to agitate the material continuously.

It is good practice to have one machine for insecticides and fungicide and another for herbicides. If the same machine is used for all spraying be sure it is well washed with a detergent, rinsed with a potent solvent and then rinsed again with water after each use. Always wash all parts of the machine including the hose and spray nozzle.

Unused materials should never be stored in the tank. The material will chemically change and contaminate the machine. It is much cheaper to buy additional material than risk the loss of a green or a spray machine because of improper maintenance.

Millions of dollars have been spent in developing and experimenting with post-emergent materials. Further information on weed control may be obtained from the following sources.

a. Texas A&M (Specify division)
b. County Agent
c. Periodical articles
d. Research Centers (Texas Research Foundation, Renner, Texas)
e. Private enterprise
f. Fellow Superintendents

SAFETY IN TURFGRASS MAINTENANCE

John W. Hill, Director
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I would like first to express my appreciation to the administration of the Turfgrass Conference for permitting me to participate in your conferences throughout the years. As I recall, this is my fourth talk before your annual conference, and it has been a pleasure to visit and work with you in your accident prevention program.

The subject of safety has been discussed and explored for many years; and generally, the first question asked about "safety!" is, "What is it?" A recent creed proposed by the National Safety Council began with the following statement, "Safety is positive; it is doing things the right way." This same thought could be restated as follows, "Safety is doing good productive things the right way." Safety is doing any work the correct way. If the job is done correctly, it is done safely. I believe we can take any crime such as a burglery, a bribery, or even a killing and apply the above statements to them and find that they are not safety because they are not good, and they are not correct. I cannot imagine "Pulling off" a burglery safely as these philosophies just do not apply to things that are wrong or things that are being done wrongly. Accidents and the resulting injuries occur when a job is done unsafely or incorrectly, when an employee does an unsafe act, or when an employee uses an unsafe tool or unsafe machine.

In reviewing accidents that occur in normal turfgrass maintenance, we find that the majority result from the use of hand tools and material handling. The basic application of accident prevention to these causes involves the selection of suitable employees with the physical and mental ability to perform the task to which they are to be assigned. The second objective is to secure the proper machine, tool, or device and maintain it to the highest standard of efficiency at all times. The statement has been made many times that accidents are a result of human behavior, and the percentage of accidents which are a result of human behavior vary anywhere from 80 to 95 percent. Even though we maintain tools and machines at 100 percent working efficiency, they within themselves are not the cause of the accident. In the larger percentage of cases the accident cause is the employee and his own action.

In his talk earlier in your Conference, Mr. Mascero described trends and advancement in machines and devices used in turfgrass maintenance. He described the new mechanization that has developed in your activities, but at the same time indicated that labor is still involved in 70 percent of the activities in turfgrass maintenance. This brings to mind the fact that man was created to do things with his hands and feet and that at any time he increases his ability to work by the addition of tools and machines, he increases his possibility of accidents. Certainly, our hazards are not as great in walking as they are in riding in an automobile or airplane. We must agree that the increase of ability to work by the use of tools and machines in our mechanical age has

increased our productivity per person, but at the same time it has increased our possibility of accidents because the machines, the tools, and the devices add to the hazards.

In our consideration of safety in turfgrass maintenance, we must include the people we employ--the laborer, the foreman, the supervisor, or the administrator. Each has his own responsibility so far as safety is concerned. The administrator must make decisions as to personnel and procedures to be followed that are in line with safe ideas and practices. These philosophies must be transferred to supervisors and foremen in order that they might instill in the laborer the responsibility for his own safety and behavior. All are subject to human error from the top administrator to the lowest laborer. Training and job knowledge must be provided for any employee if he is to do a job efficiently and safely. Training should be so designed that it will provide the proper attitude on the part of all employees. By proper attitude we mean job pride, job confidence, the sense of belonging, and the sense of being responsible for accidents to himself and his fellow workers. There are many new safety philosophies being developed and especially in the field of employee attitude, employee concern, and the employee relating his job activity to the cause of accidents.

In consideration of machines, tools and devices used in turfgrass maintenance, we must consider design, use, and maintenance. A machine, tool, or device should be designed to effectively do a specific job if that job is to be done the right way. A proper tool or machine should always be selected for the job it is capable of doing and used for that job only. Many accidents are a result of using machines or tools designed for some other type of work but being used in cases of emergency or being used unwisely. Certainly, proper maintenance of machines, tools, and equipment is essential to a skillful job as well as a proper job and the resulting accident free job.

May we conclude by saying that safety is positive. It is doing things correctly, productively, and in the right way.

20 YEARS OF PROGRESS IN TURFGRASS MAINTENANCE

Tom Mascaro
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West Point, Pennsylvania

It is my pleasure to be invited to this, the 20th anniversary of the Texas Turfgrass Conference. Through the years, I have attended most of these conferences and have watched the membership grow from a very small group to this impressive audience that is here today.

Having been involved in the turfgrass industry for some 30 years or more, it is particularly interesting to see and participate in the evolution of turfgrass management. I would like to quote a remark made by Dr. Ferguson at one of the Texas Turfgrass Conferences, whose subject was progress in turfgrass research. Dr. Ferguson stated that if we were to take a look at the progress made just today, it couldn't be measured. If we were to look at the progress made in turfgrass research during the last week, we still couldn't detect any real changes. If we look back over the last year, we would notice some progress, but not a great deal. If we were to analyze the progress made over the last five years, we would measure some very definite changes. But if we went back over the last 20 years, we would see that a great deal of progress has taken place and that we have really advanced considerably. These advances have come about because men such as you gather here to discuss problems to seek new ways to do your job better. Dr. Ferguson's remarks apply to my subject. We have a tendency to take for granted all the equipment that we have today. We even do some complaining about it. Yet if we were to look back through the years, we would find that we have made tremendous strides in the development and perfection of turfgrass management tools.

I will illustrate this progress with slides. If we go back twenty years or more, we find that golf course superintendents or greenkeepers, as they were called in those days, held meetings and carefully studied the new equipment that was available to them then. There were new well-built horse-drawn mowers. On display you would find leather horse boots in various sizes so that hoof prints would not show on turfgrass areas. There were push-type greensmowers, horse and human pulled sod-cutters and all sorts of supplementary tools geared strictly to human power. Manpower was readily available in those days. A maintenance crew of 30 men was not unusual. Maintaining the golf course was back-breaking and time-consuming work. But the game of golf was different, too. There were many people who could not afford to play golf and so there were fewer players. There was not the same demand for perfection either. There was not the heavy and constant play we are so familiar with today.

With the advent of the gasoline engine, conditions changed. Machinery began to appear. Heavy tractors with internal combustion engines were developed and they began to replace hand and horse-drawn mowers. Greensmowers, too, were equipped with the internal combustion engine. Although they were highly inefficient, they were the last word in those days.

Golf course superintendents adapted this mechanized equipment to golf course use. For instance, many courses had a generous supply of "spuds" on hand. These were metal projections fastened to the iron wheels of the tractor to prevent them from slipping on wet turf and hills. Later on, the rubber tire was adapted to turfgrass tools. These adaptations were proof positive that there was a need for equipment that was adapted to golf course use. The turfgrass manager was expressing the need for it when he added the "spud" to the tractor tires.

Eventually the rubber tire was adapted to turfgrass tools. But there were many arguments pro and con and I can still remember that the rubber tire provided fuel for many a bull session. Some thought its use was extremely harmful and would eventually kill the grass. But progress demanded the change, the turfgrass manager swung over to using it and he made more progress. Where would we be today without the rubber tire?

Maintenance of all this equipment was extremely difficult and there weren't many men who were mechanically trained to take care of it. We can laugh over it today but there was a time when wooden coil boxes and the magneto system of the Fordson tractor was a great mystery to many people. When they had to test the power of the spark, they were quite certain it would kill them. The need for trained people began to make itself felt. As is always the case with we humans, such needs are gradually filled and men became trained in the use and care of mechanized equipment. It no longer held such fears for them. As they used the new, mechanized equipment, new ways were being found to do the work better and faster. And industry spent a great deal of time and money, through these years, to supply turfgrass people with equipment that could replace hand labor. As a result, today we have some wonderful machines available to use to perform the jobs that were done by hand in the old days.

The trend toward complete mechanization still continues. Today it becomes a must. The turfgrass manager has many time and labor-saving machines at his disposal. But he is faced with an increasing shortage of manpower for the many jobs that still must be done; he is faced with phenomenal growth in the golfing population; he is faced with growing and maintaining good turf with limited maintenance time. I doubt that any club can continue to operate for long with maintenance equipment that is designed to meet the needs.

The rubber-tired, engine-driven tractor was a tremendous innovation in its time. Even it had to undergo refinements and changes to meet requirements for use on turfgrasses. The changes and advances continue. They continue because there is a demand for the best possible turf. They continue because you bring those demands, and the problems arising from them, into focus at meetings such as this where interested men come together to discuss their common problems. It's here that ideas are born. It's here we discover what is needed. Progress can only come through such exchanges of ideas and frank discussions of problems. It is my hope, and I know the hope of all of us gathered here that such conferences as this one at your own Texas A&M University will long continue. These are the activities that stimulate new ideas and institutions such as Texas A&M that help pave the way for the invention of new equipment and techniques. New equipment and new techniques will assure us of the growth of good grass for all those who wish to use it and enjoy it.

MANAGEMENT PRACTICES

Tom Mascaro
West Point Products Corporation

Turfgrass management practices are many and varied. To the novice, it appears to be a confusing series of operations which have no logic. Yet if we stop to analyze the profession of turfgrass management, we find that there is a great deal of logic to it. Certainly we must acknowledge that we are dealing with nature, which is totally unpredictable, and we must forever be on the alert to the whimsies of natural forces.

First breakdown management practices into five simple categories. This is the system I use in filing over 20,000 slides that I have taken on the subject of turfgrass management. These five categories can be compared with the fingers on your hand. The index finger represents SOIL. The second finger represents GRASS. The third finger represents WATER. The fourth finger represents NUTRITION. The thumb represents MANAGEMENT. These are the five primary categories that should be considered in turfgrass management. If anyone of these categories is out of balance, or missing, we are in trouble. Let's take each category separately.

SOIL means that we must know something about the soil profile. We must become familiar with the texture of the soil and make sure that it will maintain its structure. We must learn to manipulate the soil properly so that grass roots have room to grow. We must know what it needs to give it good structure and good texture and how to help it retain that good structure and texture to produce healthy grass. If soils are poor, it is simple to find it out. Poor soils can have all the ingredients for producing plants but they are compressed and compacted. Such soils have poor structure and they can be improved with the equipment available today to cultivate them. There are soils amendments available to improve soil texture. When we take steps to improve soil texture and soil structure, we are manipulating the soil to produce the crop we wish - healthy grass.

GRASS is the second category. This is the living plant which covers the soil and will only grow when the right species is selected for any particular area and use. When the right species is used, it will develop well only if it is cut properly and not abused excessively. Even the right species of grass will not endure if it must withstand heavy traffic without being given proper attention. It must be made immune to insects and diseases. It must be permitted to breathe and, if it develops thatch, that must be removed. It must be fed and watered adequately. All the tools and supplies we need are available to give the grass every opportunity to grow and flourish.

WATER is the third category. The life and growth of the grass plant depends upon water. Too little or too much can be detrimental to the growth of the plant and it will suffer. Therefore, proper irrigation and drainage are essential. Surface drainage must be provided

for. Seepage must be eliminated as it occurs. Water must not be supplied to the plants faster than the rate of absorption of a given soil. We must learn to manipulate water so that the effects of wetting and drying make the soil expand and contract. We must realize, too, that water is a lubricant that reduces friction of the soil particles. Excessively watered areas puddle and become compacted. We must learn to use water so that the grass and the soil receive its full benefit. We must learn, too, the many signs that indicate the presence of too much water, or lack of it. When grass "footprints" easily, the soil may be holding too much water. If water oozes out of a soil sample when the sample is squeezed gently between the fingers, too much water is present. If the reasons for excessive water are not immediately discernible, we look for poor sub-surface drainage, or seepage; two problems that can be corrected by installation of adequate drainage systems. When grass suffers from lack of water, we may be at a loss to correct the situation if irrigation water is not available. However, if we have taken the proper steps to manipulate the soils, to plant the right species of grass, to care for it properly, the grass will have a much better chance of survival during such periods of stress.

NUTRITION is the fourth category. Grass plants must be fed just as you and I. Here again, care must be taken not to over-feed or under-feed. Too much food encourages lush growth. Lush growth is not only a future cause of poor health, it also means more frequent mowing and more time spent on maintaining it. An inadequate supply of plant food retards the growth of the grass so that it cannot produce cells fast enough to permit it to keep up with the traffic and use it has to bear.

The soil must be given the food that it requires and a soil sample will provide the answer to its needs. Plant must be also placed deeply in the soil so that roots will penetrate down into the soil profile. Surface feeding of grasses generates surface roots. When this occurs, the grass plant cannot withstand traffic, it cannot survive during periods of hot weather, and management must be on a 24-hour a day, 7-day a week basis.

Here again, if we have taken the first important category into consideration - the soil - and we have prepared it properly, plant food will move down into the soil, the roots will grow down deep, the grass will survive traffic and weather.

MANAGEMENT is the fifth category. The green thumb that determines the manipulation of the other four categories. It is the management of the soil, the grass, the water, and the nutrition. Some of this knowledge is obtainable from books, but a large part of it is obtained from only one source--experience. The turfgrass manager who uses these categories as a guide has found a logical approach to cope with his turfgrass problems. By using them as a guide, he can establish a sound management program. And if all the categories are considered, the task of producing good turf becomes much easier.

Remember--the next time you have a problem, determine first whether the problem is in, or caused by the soil, the grass, the water, the nutrition, or the management program. Once the cause or causes are determined, the cure can be found.

WILT AND TURFGRASSES

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Water is one of the essential substances required to produce a beautiful turf. It is common knowledge that deficits of moisture result in stunted plants and if the deficit is severe enough, the plants die. Wilting is a visible symptom of a water deficit. Let us look at some of the reasons water is important for plant growth. Water serves several functions in plants: (1) it is an essential constituent of the protoplasm; (2) it serves as a solvent for the dissolved salts and gases; (3) it is an essential element for photosynthesis; and (4) it is essential to maintain turgidity. Not all of the water going through the plant is required for these functions. Only about 5% of the water that passes through the plant is used for these functions.

The most important part of the soil-plant water relations is the internal water balance of the turf plants. The internal water status of the turf must be maintained at an adequate level or the physiological and biochemical processes which produce the growth and development of the plants are severely limited. The water balance of the turf is determined by two processes--absorption and transpiration. The difference between transpiration and absorption determines the internal water balance of the grass, and consequently, it wilting. When transpiration greatly exceeds absorption, the grass wilts.

Absorption of water depends primarily upon the availability of water in the soil. Soils have the capacity to hold different quantities of water available to plants. Sandy-textured soils usually hold about 3/4 of an inch per foot of depth and clay loams about 2.5 inches per foot of depth. Therefore, plants growing on clay loam soils are able to withstand drought better than those growing on sandy soils. Another factor to consider in water availability is rate of water infiltration. In general, sandy-textured soils have a high water intake rate and clay soils a low intake rate. Even though a sandy soil has a low water holding capacity, it does have a high intake rate and provides good aeration; however, for good turf growth and development, it will require irrigation at frequent intervals. Clay soils will store large quantities of water but will take water slowly, and frequently develop aeration problems. Clay soils should be irrigated slowly and avoid over watering. An ideal soil for turf production would be one composed of a mixture of sand and clay with perhaps a small amount of peat. A mixture composed of 6 parts of sand, 3 parts of clay, and 1 part of peat provides a good rooting material for turf. This mixture has a high water intake rate, good water holding capacity, and is relatively free of aeriation problems unless excessive compaction takes place.

An extensive root system is essential to maintaining a high rate of absorption of water from the soil. Dense hard layers in the soil restrict root development and thus water absorption. Restrictive layers should be avoided in selecting a site for establishing a turf. Good

drainage is also necessary for turf development to prevent salt build up in the rooting depth and to provide adequate aeriation for extensive root development.

Transpiration is the other major process which determines wilting of a turf. Transpiration is determined primarily by atmospheric conditions. Solar radiation, wind speed, air temperature, and air humidity are the important atmospheric qualities which cause transpiration. In general, these are the qualities we have less control over than the things which affect water absorption. Transpiration increases with increases in solar radiation, air temperature, and wind speed and decreases with increase in air humidity. It is common knowledge that a hot dry day produces greater transpiration than a cloudy humid day. A series of hot dry days requires frequent irrigation to prevent water stress on the turf and the resultant wilting.

Wilting of a turf sometimes occurs on hot dry days even though the soil moisture is adequate. This is caused by the fact that water absorption by the grass roots cannot take place rapidly enough to keep up with this high transpiration. Under these conditions, wilting will occur in the afternoon. The turf can be helped by "fogging" water on the grass surface to raise the humidity around the grass leaves and to lower the temperature. This reduces transpiration so absorption can more nearly keep up with transpiration and the grass will regain its turgidity. Only enough water should be added to wet the grass and not the soil.

Wilting of a turf sometimes occurs when the soil is saturated with water. This is caused by poor aeriation and the plant roots are deficient of air. Under these conditions the grass roots cannot absorb water fast enough to keep up with transpiration and the grass wilts. Adequate aeriation is necessary for water absorption by grass roots. This "wet" wilting as it is sometimes called can be overcome by drainage. The excess water should be drained so the air can get to the roots and normal water absorption can take place.

BEAUTIFICATION OF GROUNDS: PARKS, SCHOOLS, INDUSTRIAL SITES

James W. Kitchen, Supt. of Grounds
Park Administration Dept., Texas Technological College

The ultimate in landscape design is achieved through the combined efforts of the Architect and the Landscape Architect. Turf as a part of the total landscape is one of the most important features as it is a means of providing a proper setting to better display other plant materials.

Man has constantly changed the environment as evidenced by the variety of landscape styles and forms. Formal landscapes to completely naturalistic settings can be observed in all aspects of public areas.

In developing a landscape setting for public areas, a "balance" in the use of materials should be employed. A review of budgets for maintenance of public areas reveals that from sixty to eighty percent of the total budget is expended for labor. This is true even with modern, updated equipment; the use of the latest maintenance techniques; more effective herbicides, fungicides and insecticides. Labor is the largest budget item for maintenance of public areas.

In the planning of new facilities or in the renovation of old facilities, consideration should be given not only to aesthetics, but also to the cost of maintenance. The following factors should be considered in reducing maintenance:

1. In most cases, it is easier to obtain money for new facilities than for improvement of older facilities. Planning is the important key to success. Do it right from the beginning even though the initial cost is higher.

2. Selection of plant material. Select insect and disease resistant plant material adapted to the region. Plant material which produces an abundance of litter from large flowers or fruit should be avoided. A few well chosen varieties can be just as effective as a larger number of plant varieties for landscaping.

3. Lawn areas:

    a. Use mowing strips adjacent to walls, buildings, and under fences.
    b. Keep grass flush with paved areas.
    c. Develop bed areas for continuous mowing by avoiding sharp corners.
    d. Avoid impossible to mow areas. Substitute low maintenance ground covers for grass.
    e. Heavy shade and extensively traveled areas: Use shade tolerant ground covers in heavy shade. Pave well traveled areas where grass cannot survive under heavy traffic.
    f. Install the most efficient sprinkler irrigation system possible in regions where natural rainfall is not adequate.
    g. Provide for free movement of equipment from one area to another.

INSECTS, INSECTICIDES AND NEW DEVELOPMENTS

George Davis
Stauffer Chemical Co., College Station, Texas

All of you are at one time or another concerned with insect damage to both turf and ornamentals. In past conferences principally turf insects have been discussed; however, today I would like to show you slides of some of the more common insect pests found in and around golf courses, parks and institutional buildings. Brief comments will be made about each and should you like further information, feel free to ask questions after the talks are completed.

Insects considered today are normally broken down into three classes.

1. Sucking pest
2. Chewing pests
3. Miscellaneous pests depending upon the way they feed and cause damage to plants attacked

Typical sucking insects are aphids, thrips, spider mites, leafhoppers, lace wing bugs, whiteflies, scale insects, mealybugs and chinch bugs. Generally these insects insert a sharp proboscis into the plant and suck moisture and nutrients from it. When infestations are heavy, severe damage or death will occur.

Common chewing insects are various caterpillars, leaf rollers, webworms, pine tip moth, bagworms, grasshoppers, white grubs, sod webworms, army worms, and cutworms. These insects cause injury by chewing on the foliage, stems or roots. Heavy infestations will cause the attacked plants to be weakened and unsightly or to be killed.

Miscellaneous insects considered today are flat headed borers, round headed borers, shot hole borers, gall forming insects, and leaf miners. This group may have either chewing or sucking mouth parts but their damage is somewhat different from the other chewing or sucking insects. In case of the gall insects, the attacked plant is caused to make abnormal growth which supplies the insect with a home and food supply.

Controls for insects on turf and ornamentals have not changed much during the past several years. We still have the old reliable chlorinated hydro-carbons such as chlordane, DDT, Dieldrin, Lindane, Heptachlor and Toxaphene. Phosphate insecticides such as malathion, trithion, thion, aspon and diazinon continue to be effective. Sevin so far is the only carbamate insecticide in common use. Generally speaking sucking insects can be controlled with the phosphate insecticides and lindane while chewing sects are controlled with chlorinated hydrocarbon and sevin. Preventive or general insect control is usually accomplished with a combination of a chlorinated hydrocarbon or sevin plus a phosphate. The combination of insecticides give a wide spectrum control. For specific insect control recommendations, I would suggest you get leaflet 1199 entitled "Texas Guide for Controlling Insects on Ornamentals." This is an Extension Service publication and is available at your County Agent's Office.

New developments in ornamental and turf insect control are slow. Several companies have been doing considerable work with systemic insecticides and they show promise on some plants and some insects. Systemic means that the chemical is absorbed by the plant thus becoming part of it and any insect feeding on the plant would of course also eat the chemical. Most of the present systemics are phosphates which are highly toxic to animals and to plants. Some plants, however, are tolerant to these chemicals and labels have been registered for their use with the USDA. I would strongly urge that if you use systemics read the label carefully, and follow directions closely. The Extension Service has not recommended these materials as yet because of their toxicity to plants and animals but they are interested in them and when they feel they can be used safely and effectively, they will recommend their use.

I have enjoyed having the privilege of talking with you today and appreciate very much the opportunity of being a part of your program.

SURFACTANTS AND THEIR USE WITH HERBICIDES

Albert W. Crain, Agronomist
Goldthwaite's of Houston, Inc.

The tables have been turned. The last few years, I have suggested topics to Dr. Holt to get Dr. Jim Watson to discuss--Topics about which we knew very little or didn't understand. Dr. Jim has always presented a difficult subject in an informative manner. This year Dr. McBee has given me a "Tuffie." I hope when I've finished you will know something about surfactants. And, most of all, appreciate the importance of using pesticides according to directions and the indiscriminate use of surfactants is dangerous.

Nature of Formulated Herbicides

Surfactants (surface-acting-agents) are perhaps the most universal constituents of herbicidal formulations. In the synthesis, formulation and mixing of herbicides, surfactants are added to provide emulsification, dispersion or solubilization of various mixture components. Note, there are volumes and volumes on this subject; volumes on surfactants in pesticides, pharmaceuticals, cosmetics, petroleum products, non-pesticidal agricultural chemicals. If I were man enough to investigate literature enough, I feel that the first sentence of this paragraph could be repeated for each of these mentioned broad categories and others in lieu of herbicides.

In this panel discussion, you have heard about two types of herbicides. There are many others; add to this the unending number of plants on which herbicides are used, broad leaf, waxy leaf, hairy leaf, etc. Each needing a different nature of surfactant to aid in doing the desired job.

It is usually not economical to apply pesticides in a concentrated form. To secure coverage over a wider area most materials are diluted before use. In the case of sprays, water is the most common diluent or carrier, with light petroleum oils, which serve as solvents for the active ingredients, and have considerable insecticidal value as well. Dusts are diluted with finely-ground inert materials such as talc, clay, pyrophyllite, gypsum or lime. The physical and chemical properties of the diluent (or carrier) often have a profound effect on the efficiency of the pesticide.

These diluents, or carriers, active ingredients, normally become more complicated by having been treated with some form of surfactant. Many of the products sold are changed or effectiveness "improved" or made more useful by adding (or adding more - since some was used in manufacture) surfactants.

Surfactants in the chemical sense may be molecules acting on molecules. Surface on surface may be the influence of the chemical surface on the surface of the plant.

The plant leaf or stem or root is a complicated chemical compound. Will the plant (chemical compound) resist, or repel or blend together, be

absorbed, be adsorbed, or other descriptive means of coming together be desirable?

Surfactants may or may not be desirable because of the nature of the plant being treated. More or less of the surfactant may be from detrimental to necessary for results.

Many pesticides work more efficiently if they are combined with materials which act as wetting or SPREADING AGENTS, STICKERS, PENETRANTS, OR EMULSIFIERS. All of these are generally referred to as surfactants. A wide variety of such chemicals, ranging from soaps to complex synthetic compounds have been found useful in the formulation of sprays and dusts.

The Physical and Chemical Nature of Surfactants

A molecule (smallest particle of complete product) must exhibit opposing characteristics in order to function. A part acts on oil, another part on water; a part on the active herbicide another part on the talc or other carrier. The oil-water surfactant would contain lipophilic (oil) and hydrophilic (water) characteristics; the amount of these two needed would depend on the relative proportion expected of oil in relation to water.

Surfactant chemical categories of importance in agriculture are nonionic, cationic and anionic.

NONIONIC - Molecules obtain surface acting properties without forming ions. They rely on either linkage or hydroxyl groups for hydrophylic character and hydrocarbon groups for lipophilic nature.

The nonionic mature (non-chemical active to point of not breaking molecules down into ionic components) makes this group widely compatable with many chemicals and quite useful in hard water.

Now I think it is necessary to repeat two terms already used: Hydrophylic (chemically active on water) and Lipophilic (chemically active on oils). All sorts of combinations of these are needed so the chemists work on HLB (Hydrophylic/Lipophilic Balance). This balance expressed numerically helps to catalog the various combinations (higher the number the greater the proportion of hydrophylic characters).

Now think in terms of many different families (or sub groups) of nonionic surfactants required to work oils, of many types, various qualities of waters, solids, or gases; thus, you can visualize a given surfactant being composed of many different families of varying HLB's. The principle described in this paragraph can be extended to ionic (cationic or anonic) surfactants.

CATIONIC and ANIONIC - These can best be described together. Ionic (cationic and anionic) surface active agents can be regarded in the same manner as nonionic with the added complication of electrical charges. Cationic, a positive (+) charge; anionic, negative (-) charge. For

example, in a soldium oleic soap (surfactant) the active portion is anionic; likewise, ammonium salts surfactants would be cationic in nature.

According to technical chemists with chemical companies the number of these combinations or blends is unending and complicated. Whether we like to think of such a complicated topic or not, we will, in that one day these may be required listing on a herbicide label.

How do Surfactants Perform their Functions

There is a balance of forces regulating the tendency of a liquid to wet and spread on oily or waxy surfaces. Surfactant molecules are active on interfaces of molecules. Think of a drop of oil broken down into a few million molecules and a drop of water likewise broken down. Thus, a film of this oil-water-surfactant on a leaf would be "a molecule thick" rather than a "drop" thick. Another example, soap and water make into suds or form would be small bubbles of air trapped in a film of liquid (water).

Add to this now the positive and negative charges to get other types of chemicals to break down to be useful. Chemists making surfactants are somewhat like a good cook making a new dish - trial and error, educated guesses, guess and by gosh.

What Effects do Surfactants Exert

Liquid formulations of oil solutions of esters of 2,4-D (post-emergent herbicide) must be diluted to a weak concentration to be applied to plants. Water becomes a cheap diluent. Surfactants must be used to make a formulation that can get into and move in a plant (weed). Without the surfactant the 2,4-D water could never spread thin enough to enter the pores of the leaf.

Moderation in adding surfactants to solutions should be the key. A pint in 100 gallons of water might cause a mess whereas an ounce would perform wonderful.

Some surfactants show phytotoxicity. Cationic surfactants are lethal or inhibit growth of many species of fungi at a wide variation of concentrations. Nonionic showed little influence on fungi and anionic even less influence. Thus, there are many showing no toxic characteristics, so their principle use is regulating colloidal properties of the spray.

This regulating the activity of the herbicide ranges from (1) increase, (2) decrease or (3) ineffective in changing the activity of the herbicide.

You are aware that certain surfactants properly sprayed on turf or trees (or any "good" plant) in advance of expected frost, will prevent frost on these plants. An over dose can hurt by being washed into the soil and make the soil water so wet the plant can't get the water thus wilt. "Wiltpruf" is a trade name of a surfactant that can be sprayed on leaves of tree to prevent wilting of tree when being transplanted.

Surfactants Help Make a Plant Act Unnatural

The biological use of herbicide-surfactant mixtures is influenced by such as volume of spray, spray pressure, coverage of weeds, relative humidity, temperature, stage of growth and drought stress. With these factors considered the following things surfactants may do to leaf surfaces.

Improve coverage, remove air films between spray and leaf surface, reduces interfacial tension in leaf cuticle (surface), there are other things that happen to get the active ingredient of a systemic herbicide into the phloem ("blood stream") of the plant. Contact herbicides must enter the leaf. Remember, leaves are, naturally, adapted to exchange of grass but not adapted to absorb liquids and translocate them systematically. Thus, surfactants are essential to get plants to "take a dose of poison" (post-emergent herbicide) in a manner not normal to the plant. Or in the case of pre-emergent herbicides surfactants help get the poison to enter a seedling in amounts sufficient to kill it.

Literature Cited

Behrens, R. W. The Physical and Chemical Properties of Surfactants and Their Effects on Formulated Herbicides. Weeds, Oct. 64.

Currier, H. B. and Dysing, C. D. Foliar Penetration of Herbicides - Review and Present Status. Weeds 7, No. 2., 1959.

Frear, D. E. H. Pesticide Handbook - Entona, 17th Edition, 1965.

Freed, Virgil. Agri. Chem. June, 1958.

Hill, G. D., Jr., Belasco, I. J., and Phloeg, H. L. Influence of Surfactants on the Activity of Diuron, Linuron and Bromacil as Foliar Sprays on Weeds, Ind. and Biochem. Dept., Exp. Sta., E. I. DuPont de Nemours & Co., Inc., Wilmington, Del. (A mineo report).

Jansen, L. L. Surfactant Enhancement of Herbicide Entry. Weeds.

_____, Gentner, W. A., and Shaw, W. C. Effects of Surfactants on the Herbicidal Activity of Several Herbicides in Aqueous Spray Systems. Weeds.

Steiner, G. W. and Watson, R. D. The Effect of Surfactants on Growth of Fungi., Phytophthology, Vol. 55, pp. 1009-1012.

PROFESSIONAL TRAINING IN RECREATION AND PARKS

R. C. Potts, Assistant Dean
College of Agriculture

At present time, Texas A&M University has in its College of Agriculture a new School of Natural Biosciences which includes the departments of Range Science, Wildlife Science, a Ph.D. program in Forestry and a new department of Recreation and Parks. This program is Texas A&M's effort to keep up with the demand of the changing picture in land use and for training men in this very important area.

Today, many different federal and state agencies are involved in outdoor recreation. The new department of Recreation and Parks will train managers for private, state, federal and municipalities. Recreation demands are increasing fantastically each year. Texas A&M through its training in agricultural science and landscape horticulture has trained many professional people who now have responsible positions in the area of turf and park administration throughout the state and nation.

Dr. Leslie Reid has been employed to head the new department of Recreation and Parks at Texas A&M University. The curriculum that has been outlined for students in Recreation and Parks will concentrate on biological and physical resources important to outdoor recreation and the social economic relationships which occur when people use land and water areas for recreation. The first and second year students will study a broad range of science and humanity courses. From then on study areas will cover conservation, wildlife, safety education, ladnscape horticulture, civil engineering, sociology, physiology, agronomy, wildland recreation, forestry, park administration, campsite design, recreation development and landscape construction and maintenance. The curriculum that has been devised is very versatile which is necessary because the field of Recreation and Parks is research oriented, activity oriented as well as people oriented. It is felt that under Dr. Reid's leadership, Texas A&M University has the opportunity to develop both a research and education program in the field of recreation and parks that will be unparalled by any other university in the United States.

We invite those people interested in recreation and parks to give us their support as well comments on what is needed in this most important area.

ALTERNATIVE MANAGEMENT PHILOSOPHIES
DIRECTION VS. DEVELOPMENT

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One of the perennial problems in management is the question of delegation of authority. How much of the job should the boss see to personally, and how much of it should he turn over to his subordinates to do by themselves? This is not a simple problem, but the answer most often given is that "it depends on the circumstances," and of course that answer does not help any at all. There should be some better guide lines than to just "depend on the circumstances." For example, what circumstances should the manager expect. Can he use one delegation pattern for one circumstance and another pattern for another circumstance? Which circumstance requires which pattern? Can the same supervisor with the same subordinates switch back and forth from delegation to no delegation? What would happen if he tried to do this?[1]

Fortunately, many of these questions have been studied, and management theory is able to call on the results of psychological experiments, industrial field studies, and economic analyses to draw a few conclusions to serve as guide lines to a manager faced with the problem.

The contrast is between centralization and decentralization, concentration and delegation, autocracy and democracy, and represents both a basic philosophic orientation and a method of organizing and operating a company or a department.[2]

The Problem

There are basically two ways of looking at the manager's job. One way is to consider that the manager, or supervisor, is responsible for the successful accomplishment of the job he is now working on. The other is to consider that the manager, or supervisor, is responsible for building and maintaining an organization to handle jobs of the type he is now working on.

Notice the contrast. In the first case, the present job is the central focus of attention. The supervisor uses up men, equipment, and supplies as necessary to do the job. If one of his men cannot do the work, he is replaced with one who can. If a piece of equipment is unsatisfactory, it is replaced. Men wear out, equipment wears out, supplies are used up, but the job gets done. That is all that is important. The very fact that the job is so important causes the supervisor to give it his close personal attention at all times. In fact, the job is about all the supervisor has time to worry about.[3]

Now look at the second case. Here the supervisor is not looking at this particular job so much as at a string of jobs, this one, the next one, and the one after that. Each job may be a bit different,

require different equipment, different skills from his men, different supplies, and different lengths of time to accomplish. The supervisor then, is not so willing to use up or replace a man to accomplish the present job if he can foresee the need for that particular man's talents on a future job. Also note that the supervisor's attention is on the men, their equipment, and the job coming up next, rather than being concentrated entirely on the present job.

Although this contrast has been drawn a little extreme, the two types of supervision are sufficiently distinct to be labeled by one of our leading management theorists, Rensis Likert of the University of Michigan, as "employee centered and "job centered."[4] Each offers certain distinct advantages, and, of course, certain disadvantages.

Centralization, Concentration, and Autocracy

Contrary to the beliefs of many of its advocates, a dictatorship is not the most efficient type of operating organization. Nor is it possible to reap continuing benefits from tight control of operations.[5] If from no other reasons, the cost of maintaining a control system, plus the lack of innovation and consequent lack of improvements in the operation would probably cause the tightly controlled system to eventually lag behind the more free, looser organization.[6]

Why, then, would anyone want to centralize authority in a single individual, or in "headquarters"? From many reasons, the following seem to be the most valid.

1. To accommodate the personality of the boss.
2. To achieve quick response.[7]
3. To gain control of equipment and supplies (not necessarily cost of time, since centralization often results in more cost of time as decisions are slowed down going through channels).[8]
4. To permit the accomplishment of a job requiring knowledge (or analytical skills) not possessed by subordinates.[9]

These are all fairly apparent. But perhaps it should be noted that a paradox exists here. Sometimes authority is concentrated in the boss so that he can get things done quickly--like, for example, when there is a fire in the paint shop. But if this concentration is permitted to continue when there is no emergency, and subordinates must go to the boss on every decision to be made, the operation can bog down quickly.

Autocracy is necessary, of course, when the boss is the only one in the group who knows how to solve the problem, or what must be done, or how to accomplish the task.

Two disadvantages of centralized authority have already been mentioned. First, the fact that if the boss does all the thinking and makes all decisions, everyone else will just follow along, like buck privates in the Army. The disadvantage is that sometimes these subordinates have some good ideas, but if you never hear them, you can never use them.[10]

Second, the fact that if subordinates must run to the boss on every decision, it can slow down the operation greatly, and keep the boss so busy that he cannot do anything else--such as planning future operations, for example.[11]

The third major disadvantage of centralization is that it causes poor morale. That is, poor morale for everybody except the boss. Poor morale results in such things as absenteeism, high employee turnover, lack of enthusiasm, apathy, labor trouble, increased accident rates, and other types of inefficiency.[12]

Decentralization, Delegation, and Development

The ideal situation, it seems, would be the following:

1. The men know what to do and how to do it, so they do not have to come to the boss often with problems.
2. The men are motivated to do their jobs to the best of their ability, and they do their jobs even when the boss is absent.
3. The boss can spend his time planning for tomorrow, designing better ways of doing things, studying, and improving the operation. He does not have to spend his time putting out fires, hiring new men, stopping arguments, salving wounded feelings, or handling union grievances.

As in any idealization, it is probable that these objectives could never be completely attained. But they can be approached through a carefully planned program of organization development.

It is doubtful that any supervisor could step in and set up an organization over night that could behave as outlined above. On the other hand, it is quite possible to step into an organization that is functioning this way and to destroy it over night. To build, train, and develop a team of employees that can function in such an independent and effective manner is quite similar to the growing of a good, thick, healthy mat of turf grass. It takes time, care, and above all, the proper climate.[13] Let us examine the steps in such a developmental program.

The first step is to select good employees.[14] By good, in this case, is meant employees that can be expected to stay with the company, be dependable, honest, healthy, careful, and intelligent enough to learn the work they will be doing. They do not all have to have supervisor ability, but there should be one or two that could be trained to take over when the present supervisor leaves.

Training these people is more of a problem than selecting them. Their technical training in the jobs they will fill is only one part of their training. Then comes their training in the policies of the company, routines to follow, where to go for information, and all the other facets of operating in the company.[15] But the third facet of training is much more difficult, because often it involves the employee's un-learning of previous training. This is his emotional training.

Many times an employee will come from a job where he was expected to follow orders and keep his mouth shut. Until he is convinced that more is expected from him than this, he will be very reluctant to "stick his neck out" on the new job. And even after he has learned what is expected, he will not "stick his neck out" if he thinks it will be "chopped off" for one reason or another.

It is practically impossible to instill self-confidence into an employee without delegating to him the responsibility for making decisions. In other words, he cannot operate independently until you permit him to operate independently. This means that as soon as he understands the company's objectives and knows some (not necessarily all) techniques for achieving these objectives, he should be encouraged to go out and try the job for himself.

If you want the man to operate on his own, without running to you for his decisions, you must permit him to make mistakes.[16] The cost of the mistakes might be considered part of his training expense. Without the right to make mistakes, the man will be obliged to clear any decision with someone who does have the right to be wrong. Fortunately, most decisions do not involve right or wrong, but alternative ways to do a job, and even though the subordinate might choose a way different from that which might be chosen by his supervisor, the job gets done and the only cost is that it is done with a bit less efficiency than otherwise.

Respect for employees is easy to talk of and hard to accept. Subordinates often have much less education, less social status, and less money than do their supervisors. It is quite difficult for some supervisors to accept suggestions from those who do not have the training and background enjoyed by the supervisors. But the type of communication is absolutely essential to the self-directing organization.[17] A boss who does not get information from his subordinate on an automatic basis--that is, whenever the employee thinks it is important, as well as whenever the supervisor thinks it is important--is operating at a handicap. If the organization is functioning correctly, these people are much closer to the everyday problems than is the supervisor.

In connection with communications and the difficulty caused by an excessive status gap, it might sometimes be necessary to narrow the gap by such things as company parties to bring the boss down lower, or by short course training schools, job rotation, or the use of status symbols to bring the employees to a higher status.

Apparently, employee morale is a function of social progress, rather than social position.[18] It does not matter what job a man has, or how much money he earns, or what kind of car he drives, so much as whether or not he feels that he is respected and is getting ahead in the world. It is the feeling of "getting ahead" that causes high morale. It should also be noted that "getting ahead" does not always mean just earning more money. It can take the form of learning a new job, enlarging responsibilities, meeting new people, developing a skill or developing a reputation, building a house or building a boat, or any of a number of ways that men achieve a feeling of self-worth and progress.

Selection, training, developing self-confidence and independent work habits, self-respect and morale, all have been mentioned in connection with building a work force capable of sustained independent effort. The same considerations apply to the development of supervisors.

In addition to the freeing of the supervisor's time for planning purposes, other advantages of the decentralized operation are the following:

1. Because decisions are made close to the problem, the decision maker understands more about the peculiarities of the circumstances and can make a more accurate decision than can his boss, who is farther from the problem.[19]
2. Performance on the job can be adapted to requirements of the local situation, rather than made to fit a standard performance pattern.[20]
3. Employees develop a resiliency and an adaptability from being required to solve their own problems. They become more versatile and easily slip into supervisor roles.
4. Because many people are permitted to observe, evaluate, and contribute to decisions, these decisions are often more logical than if they were made by a single individual.[21]

Summary and Conclusions

In summary, it can be said that of the two basic management patterns, autocracy or direct personal leadership should probably be used only in cases of emergency or when the boss is the only one who knows how to solve the problem. It is good for a temporary, short time emergency only, and if used for a long time can lead to a great deal of inefficiency.

Development, as a managerial philosophy, probably has the most beneficial long run results, both in the way of morale and in actual performance efficiency. However, it takes a great deal of time to develop a work team, and requires a much higher degree of leadership skill on the part of the manager.

"Don't tell your people what to do; teach them what to do."

Footnotes

1. Tannenbaum, Robert and Schmidt, W. H. "How to Choose a Leadership Pattern." Readings in Management, Richards, M. D. and Nielander, W. A. (editors), South-western Publishing Co., Dallas, 1963, pages 481-494.

2. Sloan, A. P. "My Years with General Motors--Part II," Fortune, October 1963, Vol. LXVIII, No. 4, page 146.

3. Argyris, Chris. "Leadership Pattern in the Plant". Readings in Management, op. cit., pages 459-480.

4. Likert, Rensis. New Patterns in Management. McGraw-Hill Book Co., New York, 1961, page 6.

5. Dalton, Melville, "Managing the Managers", Some Theories of Organization, Rubenstein, A. H. and Haberstroh, C. J. (editors), Richard D. Irwin and Dorsey Press, Homewood, 1960, pages 124-138.

6. This problem on a larger scale has been forcefully set down by F. A. Hayek in The Road to Serfdom, Phoenix Books, University of Chicago Press, 1944. For the basic psychological study of the effect of leadership styles on the individual, see Ronald Lippitt and Ralph White, "An Experimental Study of Leadership and Group Life", Readings in Social Psychology, Maccoby, E. E., Newcomb, T. M., and Hartley, E. L. (editors), Henry Holt, New York, 1958, page 496.

7. Bavelas, Alex, "Communication Patterns in Task-Oriented Groups", Group Dynamics Research and Theory, Cartwright, Dorwin and Zander, Alvin (editors), Harper & Row, New York, 1960, pages 669-682.

8. Davis, Keith, "Management Communications and the Grapevine", Harvard Business Review, September-October, 1953, Vol. 31, No. 5, pages 43-49.

9. Simon, Herbert, Administrative Behavior, The Macmillan Company, New York, 1955, page 40.

10. However, for a more complete analysis, see George Strauss, "Some Notes on Power-Equalization", in The Social Science of Organization, H. J. Leavitt (editor), Prentice-Hall, Inc., Englewood Cliffs, 1962, pages 45-57 especially.

11. Likert, op. cit., page 7.

12. Harrell, T. W., Industrial Psychology, Rinehart & Company, Inc., New York, 1958, page 285.

13. Sayles, Leonard, Managerial Behavior, McGraw-Hill Book Co., New York, 1964, pages 256-264. Also, Likert, op. cit., page 247.

14. Chruden, H. J. and Sherman, A. W., Personnel Management, South-western Publishing Company, Dallas, 1963, page 153.

15. Ibid., page 209.

16. Argyris, Chris, Organization and Administration, Richard D. Irwin, Inc. and The Dorsey Press, Homewood, 1965.

17. Fiedler, F. E., Leader Attitudes and Group Effectiveness, University of Illinois Press, Urbana, 1958.

18. Kahn, R. L. and Katz, Daniel. "Leadership Practices in Relation to Productivity and Morale", Group Dynamics Research and Theory, op. cit., page 558.

19. McGregor, Douglas. The Human Side of Enterprise, McGraw-Hill Book Co., New York, 1960, pages 113-123.

20. Terry, G. R., Principles of Management, 3rd edition, Richard D. Irwin, Inc., Homewood, 1960, page 311.

21. Shaw, M. E. "A Comparison of Individuals and Small Groups in the Rational Solution of Complex Problems", Readings in Social Psychology, op. cit., page 564.

SOIL CONDITIONS - TOP DRESSING - WHY, HOW AND WHEN

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In order to approach the subject of soil conditioners and top dressing in a logical and practical manner, we must first recall to mind what your employer wants on his golf course. Your employer, of course, is the golfer that plays your course and satisfying him is the most important part of your job, regardless of whether you are a pro, golf course superintendent or club manager.

Usually the golfer knows little or nothing about the mechanics that are involved to produce a good putting surface, but he will be the first one to tell you that the greens are not in good shape. He wants it weed free and completely covered with good green tight turf with no grain or steminess to deflect his ball. It's very simple - this is all he wants, and, most of the time, demands.

To satisfy these demands, we must get to the grass roots and naturally this means taking a close look at the soil mixture these roots are growing in. The soil mixture is the base on which you build your entire management program and will be the determining factor in whether your program is economical, efficient, and effective. I would estimate that 80 % of the golf courses have some problem with their soil or soil mixture. This problem is costing them extra maintenance money for excessive labor, chemicals, water and fertilizers. These extra costs can be appreciably reduced by improving the soil structure or texture over a period of time through the use of soil conditioners and aerification. In extreme problem cases, complete reconstruction may be needed.

A soil conditioner may be defined as material that is used to change or improve the condition of the existing soil to meet certain specifications. This may include a wide variety of organic and inorganic materials. On golf greens, the most commonly used soil conditioners are sharp sand, calcined clay and cultivated peat. Other materials that are used in localized areas where available are composed gin trash, well rotted hard wood saw dust, composted leaves, manure, and sewage sludge.

To use any of the forementioned wisely, we must remember what type of soil mixture is most desirable to grow good deep rooted, healthy turf grass on a golf green. An ideal soil mixture for a green should resist compaction, drain well, allow quick water penetration, and have the ability to hold sufficient amounts of moisture and nutrients. The mixture must be of a uniform structure with no layers or pockets.

The amounts and choice of soil conditioners to be used in construction of a green on any given golf course should depend primarily on the basic soil to be used in the mixture. If the soil is high in clay and tends to seal quickly, large proportions of sharp sand and/or calcined clays should be used to increase air and water penetration and hold the flat and fine particals apart. A small amount of peat or other organic material should also be added to help hold the fine or flat soil particals apart and assist in improving the water and nutrient holding capacity of the mixture.

Conversely, if the basic soil to be used is extremely sandy and loose, very little or no sharp sand should be used and larger amounts of calcined clay and peat should be added. These additions will tend to stabilize the sand and increase water and nutrient holding capacity, which is always lacking in extremely sandy soils. A medium sandy loam is a good base soil to start with if there is a choice.

A very simple little test to find out if a mixture is well proportioned is to take a sample, wet it, compact it into a ball, and then let it dry. If after it is dry it will crumble when touched, you can be fairly sure that it will resist compaction, drain well, yet hold enough moisture for growth. If the sample will not form and hold a ball shape when wet and compacted, it indicates possibly too much sand. A droughty condition will exist in this type mixture and exessive amounts of water and fertilizers will have to be applied to maintain good grass growth. If the sample will not crumple readily, it indicates that the mixture will compact readily, may have poor water and air penetration. These conditions will necessitate a more intensive aerification program and a more controlled watering program. Your job is to try to have a mixture somewhere in between the two last mentioned examples.

Top dressing is an operation which must be performed on a golf green occasionally for various reasons. It is one of the most practical ways to obtain and keep a green smooth. It is one of the methods used to reduce thatch build up and keep a true putting surface. It is employed before and/or after overseeding. It is used to cover planting material on new greens. Last but not least, it is the method used to change or alter the soil mixture in an old golf green without resorting to complete reconstruction.

A good procedure to follow to improve this type problem green is as follows:

1. Aerify the green.
2. Apply top dressing.
3. Use verticut to break up aerifier cores and mix top dressing with soil cores.
4. Drag.
5. Sweep.

Following this method you will gradually be changing and improving the soil mixture in the primary root zone. It may take many applications of the corrective top dressing material in this manner to complete the improvement program.

Top dressing using only one soil conditioner is very rarely recommended. Top dressing with only sharp sand or peat or calcined clay will normally only lead to a layer condition which will eventually force you into a complete reconstruction program. Layers are very detrimental to good root penetration and growth. They will hinder water and air penetration. I know of only one situation where I would recommend top dressing with one soil conditioner alone. This would be on a green that has a definite layer of any material near the surface

that is preventing water, air and root penetration. A layer of peat would be a prime example. In this case, I would suggest the following operation:

1. Aerifying with a coreing type aerifier.
2. Removing the soil cores.
3. Applying the soil conditioners (sand or calcined clay - never cultivated peat or organic material).
4. Dragging conditioner into aerifier holes.

This operation will form an enumerable number of french drains which will alow water, air and root penetration to a reasonable debth. This type of top dressing will probably never completely correct the problem but can be used as a temporary remedy.

One last point on proper top dressing, and that is to never apply too much at any one time. At the most, only apply enough to form a layer approximately 1/8" deep. Heavy applications will only smother and set back the turf and increase the chance of mat formation.

LANDSCAPE DEVELOPMENT AND MAINTENANCE AROUND A CLUBHOUSE

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It seems to me that a golf course should be the personification of beauty and orderliness. Further, that this beauty and orderliness should begin at the clubhouse. My topic this morning is Landscape Maintenance Around the Clubhouse. With emphasis on beauty and also with the added prestige and popularity of golf, this topic certainly is worthy of our studies consideration.

To accomplish attractive landscaping around the clubhouse, which can be maintained with a minimum of effort, consideration should be given to the following points.

1. The landscape scheme should be in keeping with the architectual scheme of the clubhouse.
    a. Emphasize the style of the architecture with plantings strategically located in order to flatter or enhance. Do not plant just for the sake of greenery around the clubhouse.
    b. Carefully choose plant materials which will pick up some of the color and the character and texture of the building materials used in clubhouse construction. Contrast can also be good when used suturally and in good taste. This can often be accomplished with color or textural contrast.
    c. In geographic areas where the clubhouse will be used year around, remember that the majority of plants used should look good year around.
2. Ease of maintenance is a prime consideration, considering all of the maintenance the course itself will demand of your staff.
    a. Use materials which will require little trimming or pruning.
    b. If at all possible, edge the planting areas with some kind of edge. Steel edging, concrete curbing or redwood are good edging materials.
    c. Ground covers or ornamental mulches of different aggregate as an integral part of the design, will considerably less the requirement of having to weed planting areas.
    d. Watering can be greatly reduced through the use of those plants or materials that require little moisture or even no moisture at all, such as river stone, or varied colored aggregate.
    e. If possible, incorporate into the planting pleasing use of inert materials such as interestingly formed boulders, colored aggregates worked out in patterns or designs.
    f. Lay out the turf areas around the clubhouse in such a manner that turf can be emphasized as, after all, turf is one of the important components of a golf course.
        (1) Wherever possible, edge turf in the clubhouse area with steel concrete curb or redwood so as to maintain good, clean, crisp lines of design.
        (2) So lay out turf areas around the clubhouse that a

majority of the areas can be cut with gang reel mowers at the same time other outlining is accomplished.

g. In planting, design should keep in mind the traffic patterns which you would like to enforce.

(1) A plant barrier is often needed to prevent cutting across and to channel traffic down the area you wish it to follow.

(2) Heavy ground covers, uncomfortable for walking over, may be used to prevent foot traffic from going across an area.

(3) Use paving liberally so that people may have comfortable areas on which to walk and to rest or wait momentarily before teeing off.

(4) Attractive and comfortable seating is an important part of the landscape scheme around the clubhouse. This should be cleverly integrated into the overall design of the traffic pattern.

3. Parking areas should be adequate, close by and attractively developed.

a. Islands to channel traffic can often be most attractively treated with plants, boulders and aggregate patterns.

b. Often these islands may be made to double as a place to conceal drainage structures, such as drop inlets.

c. The parking lot, if necessary, should be attractively screened or played down somewhat with groups of trees or with interesting shrub plantings to detract somewhat from the drabness that is inherent in a sizable parking lot.

4. The first tee will often be an integral part of the clubhouse landscape scheme.

a. The area of the first tee should be inviting.

b. Traffic patterns should be carefully designed for comfortable negotiation.

c. Seating may be provided and character and shade provided through the use of trees.

d. Attractive planted areas may act as effective means of channeling traffic or as barriers to regulate traffic.

Certainly, as mentioned in the beginning, much thought and planning must go into the landscape development around the clubhouse if it is to be attractive, functional, and of easy maintenance.

USE OF POST-EMERGENCE HERBICIDES

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The classification of herbicides as to pre-emergence, post-emergence, and pre-planting is based on methods of application. As generally interpreted, the above classification indicates that pre-emergence herbicides are applied before emergence of weeds occur while post-emergence herbicides are applied after weeds emerge. The following review will be concerned with only those herbicides classified in the post-emergence category.

Mechanism of action of post-emergence herbicides provides a basis for subdivision into contact and translocated categories. Classification based on mechanism of action is shown in Table 1.

Contact Herbicides

Contact herbicides include those that kill plant tissues at or close to the place of application. Thorough distribution or coverage of these materials on the foliage of the weeds is required to kill meristematic tissues in all buds of shoot tips and leaf axils.

Contact herbicides such as sodium arsenite, endothal, paraquat, diquat, cacodylic acid and refined oils represent some of those more commonly used in turf management.

Through the proper adjustment in dosage it has been possible to use some of the contact herbicides for selectively controlling weeds in turf areas when the turfgrass is actively growing. The herbicides may also be used with little concern of injuring turfgrass during the period when turfgrasses are dormant. Nonselective applications trimming around sand traps on golf courses, along walks, and in similar use sites represent other areas of application.

It is important to exercise some precautions in the use of contact post emergence herbicides. Application during periods when air temperatures are high (90^{o}F+) and when turfgrasses are growing actively may result in considerable injury to the basic turfgrass. The use of high spray volumes and the addition of surfactants to the spray solution would contribute to the severity of turf injury as more active chemicals would reach meristematic areas (Pounts where new turf growth occurs) of the turfgrass.

Translocated Herbicides

Selective herbicides of the translocated type represent the most important group used in turf management. The translocated types must penetrate the leaf cells of weeds and move in the vascular tissues of plants to kill the meristematic regions of both roots and top growth. Selectivity of the selective post-emergence herbicides is generally

classified as of a biochemical nature, dependent upon some rather specific reaction of the herbicides with protoplasmic constituents of weeds and turfgrasses. Selective translocated herbicides that are familiar to most turf maintenance people include: 2,4-D, silvex, 2,4,5-T, 2,3,6-TBA, DMA, AMA, dicamba, tordon, 2 (MCPP), dalapon, amitrol, atrazine, simazine, certain substituted ureas, and diphenamid. The list includes several herbicides that are also classified as important pre-emergence herbicides. Those that fall in this category include the symetrical triazines, substituted ureas and diphenamid.

Soil Active Post-Emergence Herbicides

Within the last decade a number of herbicides have been developed that exhibit high killing activity to established weeds when absorbed by the root system of the weeds. These herbicides are quite mobile in many soil types and are less susceptible to fixation and inactivation in the soil complex.

Tordon, dicamba, simazine, atrazine, neburon and diphenamid include some of the herbicides that function effectively as post-emergence herbicides when applied to the soil in addition to application on weed foliage.

The high mobility and activity of these herbicides in soils require that precautions be taken in regard to applications in turf areas where trees and ornamental plantings are present. Dicamba and tordon may be quite phytotoxic to pine, spruce, privet, forsythia, juniper, taxus and euonymus when the herbicides are absorbed by the root system.

Some flexibility is provided in the use of post emergence herbicides that function through the soil as well as the foliage. Herbicides may be applied in both granular and spray formulations with equal effectiveness.

Susceptibility of Weeds Under Stress

Effectiveness of post-emergence herbicides is influenced significantly when plants are under moisture stress. For foliage applied sprays, leaf adsorption may be reduced due to the lowered permeability of the cuticle and stomates. The cuticle layer on leaves and stems possesses a sponge-like composition and when a plant is growing normally (not under stress) the cuticle layer is in a hydrated condition. In other words pores of the cuticle will contain water under this condition. Herbicides in contact with the water in cuticle pores diffuses into the pore and thus enters the leaf and internal parts of the plant. By contrast pores of the cuticle layer on leaves of weeds growing under moisture stress contain air pockets instead of the film of water. Herbicides in a liquid phase is blocked by the air in the pores and is not readily absorbed into the leaf, thus resulting in lower control levels of weeds. Such a condition may often explain erratic control of weeds in areas of Texas where low relative humidity occurs or where soil moisture levels are very low.

A second route in which herbicides enter the plant is via the stomates. Numerous experiments have demonstrated that herbicides will enter the plant rapidly when stomates are open. One of the most striking examples of the effect of stomates on the penetration of chemicals into plants by stomates

was demonstrated with ammonia in the vapor phase. Leaf and stem tissue of cotton plants were killed immediately when exposed to vapors of ammonia when stomates were open. No effect was observed when the same treatment was applied to cotton plants with stomates closed. Experimental results such as this suggest that herbicidal effectiveness may be reduced significantly when in contact with leaf surfaces when stomates are closed. Stomate closure is induced by high temperatures and low relative humidities. Timing of herbicide application should be made to avoid such stress conditions.

Absorption and translocation of herbicides by weed plants through the foliage or roots, growing under moisture stress generally would be lower. A low plant metabolic activity rate would partially account for this.

High air or low air and soil temperatures which contribute to stress conditions on weed plants will also significantly influence herbicidal activity. High temperatures may provide conditions where rapid injury of surface tissues of weeds will occur thus reducing the amount of chemical entering the plant. Low plant metabolic rates influenced by low temperatures would lessen rate of herbicide translocation even though the active chemical enters the plant. In general, user experience has indicated that herbicidal applications are most successful when made in a temperature range of 70°F to 90°F.

Specific Post-Emergence Herbicides

2,4-D: This herbicide has been used widely since the late 1940's as the major control for many broadleaf weeds in turf management programs. Its use in Texas has been concentrated primarily for weed control in Bermudagrass turf on such sites as home lawns, golf course fairways, parks, cemetaries and industrial locations. Use on St. Augustinegrass has been somewhat limited due to phytotoxicity problems. Within recent years 2,4-D use in turf areas has been generally quite satisfactory as a result of better user knowledge, improved information guides, and improved formulations.

Silvex: Silvex was introduced to the turf manager in Texas during the 1950's. It was found to be somewhat safer to use near ornamental plantings and in areas adjacent to susceptible crops such as cotton. Silvex is most effective for the control of clover in Bermudagrass turf when applied in the late winter and early spring period.

Dicamba: Use of dicamba appears to be primarily for weed control in Bermudagrass turf areas. It is effective as a foliage spray or when applied to the soil and absorbed by the root system of weeds. Its high activity and mobility in the soil requires that precautions be taken when applied near trees or ornamental plantings.

Tordon: Tordon represents the most recent broadleaf selective post emergence herbicide to be introduced. Preliminary research indicates that Tordon is effective against many broadleaf weed species that are not satisfactorily controlled with 2,4-D, silvex or related herbicides. This herbicide is readily absorbed through the root system of plants.

Similar precautions, as with dicamba, should be considered when testing near ornamental plantings or trees. Further research appears to be needed to determine if Tordon can be used in turf management programs.

Organic Arsenicals: DMA and AMA have proved to be two of the most useful post-emergence herbicides for grass type weeds control available to the turf manager in Texas. Much of the research that established the important place of the organic arsenicals in turf management programs was carried out at Texas A & M. User experience shows these herbicides to be the most effective available for Dallisgrass control, nutgrass control and the control of annuals such as crabgrass, goosegrass, flat sedge, and carpetgrass.

Miscellaneous Herbicides: Atrazine, a symetrical triazine is one of the few herbicides that can be used for weed control in St. Augustinegrass. It is effective on such weeds as rescuegrass and burclover acting through the foliage or via root absorption. Best control is obtained when applied before weeds emerge or during the early rapid growth stage. Manufacturers directions should be followed closely for timing of application. MCPP, another newcomer to the arsenal of post-emergence herbicides appears to offer promise for controlling some broadleaf weeds not satisfactorily controlled by 2,4-D. Combinations of 2,4-D and MCPP are now available in some regions of the U.S. for broadspectrum broadleaf weed control. Diquat and Paraquat have been tested quite widely for the non selective control of winter annual weeds in dormant warm season turfgrasses. These herbicides appear to offer promise for the above area of use, however, their value for weed control in actively growing turf appears to be limited.

Table 1. Post-Emergence Herbicide classification based on mechanism of action.

Contact
Diquat, Paraquat, Endothal, Cacodylic acid, Sodium Arsenite, Karsil, Dicryl, Solan DNC, KOCN

Translocated-Foliage
DMA, AMA, Silver, Dicamba, Tordon, Dalapon, Amiben, 2,3,6-TBA 2,4-D, 2,4,5-T, MCPA, 2 (MCPP)

Translocated - Roots
Dicamba, Tordon, Neburon, Atrazine, Simazine, 2,3,6-TBA, Fenac, Diphenamid.

"SURFACTANTS AND THEIR USE WITH HERBICIDES"

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"Surfactants" is the term used to designate the general group of compounds classified as surface active agents. Surface active agents include wetting agents, emulsifiers, detergents, spreaders, sticking agents, and dispersing agents. Surfactants are classified according to their use.

Wetting Agents

Wetting agent is defined as a material that increases a liquid's ability to moisten a solid surface. Such materials function in lowering the interfacial tension of liquid thus bringing the liquid into intimate contact with a solid surface.

The degree of effectiveness of a wetting agent is dependent upon how much it increases the spread of a liquid over a surface area. Effectiveness would also be reflected in what degree the wetting agent increases killing action of a herbicide, fungicide, or insecticide. Under certain conditions, a wetting agent may decrease effectiveness of a pest control formulation. For example if a material is selected to use with a type of herbicide that must be absorbed and translocated in weed plants to effect control, and the wetting agent injures the absorbing surface of the leaf or stem, then this would no doubt decrease effectiveness of such a herbicide. Wetting agents will also materially effect herbicidal performance depending on gallonage of spray used in applications where herbicides are applied as sprays. At a low gallonage, the wetting agent may increase the effectiveness of the spray. If the same chemical is applied at the same rate per acre, but is diluted in a large spray volume, the addition of the wetting agent may result in substantial run-off. Under this condition much of the active chemical would be lost from the plant surface, whereas in the application of low gallonage spray, most of the chemical would be retained on the plant. This example does not necessarily support the practice of using low gallonage sprays, but it does point out that wetting agents may increase or decrease activity of herbicides should spray volume be varied widely.

Emulsions

Emulsion is defined as one liquid dispersed in another liquid with each maintaining their identity. Oil dispersed in water by vigorous agitation would be considered an unstable elumsion, since upon standing, the oil and water would separate. Water in this example would be classified as the continuous phase and oil dispersed in the water would be termed the discontinuous phase. One or more materials added to provide a stable emulsion (decrease the tendency for the oil and water to separate) are classified as emulsifying agents or emulsifiers.

The phenomena of emulsification involves surface active behavior in which emulsifier molecules surround the dispersed droplets preventing

them from coalescing and thus prevent a settling out of the dispersed ingredient. Many wetting agents may also act as emulsifying agents.

Stability of emulsions is dependent upon size of dispersed particles, density of the continuous and discontinuous phase and viscosity of the emulsion. Large viscous droplets are difficult to hold in a stable emulsion and may require continuous agitations.

Most herbicides not formulated as salts are not water soluble and thus require the use of solvents to solubilize. The herbicide in solution in the solvent in then combined with an emulsifying agent and is ready to mix with water if it is to be applied as a spray. Most emulsifiable concentrates that you receive are made up in this way.

Adhesive Agents

Adhesive or sticking agents include those materials that cause herbicides to adhere to the treated surface. A number of surfactants also act as sticking agents.

Spreaders

Spreaders and wetting agents are closely related. Wetting agents that reduce surface tension result in a spreading of herbicide. For practical purposes spreaders and wetting agents may be considered together.

Detergents

Many of the common household detergent chemicals have been used as wetting agents, spreaders, and emulsifiers in herbicides. Detergency defined indicates the cleaning power or ability of a chemical to remove soil or grime.

Surfactant Efficiency

Data are presented in Table 1 that show that solid surfaces vary in the degree that they can be wetted by different wetting agents. The results also indicate that wetting agents differ in relative efficiency with which they can wet different surfaces. Research results indicate that one of the reasons why surface-active agents vary in order of wetting ability on different surfaces is due to their differing affinities for solid surfaces. What practical implications can be projected from studies of this type? First the results indicate a danger of using artificial surfaces in evaluating the wetting efficiency of agricultural spray liquids or the use of such information in guiding formulators in the use of these agents in making up granular formulations. Secondly, it appears that standard recommendation that one wetting agent will be the best for all kinds of weed species may not be true.

Choise of Wetting Agents

Since most herbicides are supplied to the user as emulsifiable concentrates, concentrated suspensions, or wettable powders, the surfactant of most concern to the user would be wetting agents. The wetting agent would be the last ingredient mixed with the herbicide in preparing the spray solution.

Although the main reason for adding wetting agents to sprays is to increase coverage of weed foliage, the most suitable agent to use may not be the one that shows the highest wetting ability on the particular surface. Several factors besides coverage should be considered in selecting the most suitable surface active agent and the concentration at which it will be used. The factors include (Furmidge, C.G.L., J.Sci. Fd. Agric., 1964,15):

1. The compatability of the wetting agents and formulations: as discussed above emulsifiers are employed in many herbicidal formulations as stabilizing agents to prevent coagulation of oil globules in emulsions or the flocculation and sedimentation of solid particles in suspensions. The emulsifiers are absorbed at the oil/water or solid water interface. If in the addition of a wetting agent and the agent should react or interfere with the absorption process of a stabilizing agent, unstability may occur with the active ingredient dropping out of the solution.

2. Spray retention and level of herbicide deposition on target surface: preferential deposition of the dispersed phase (active herbicidal portion) giving a build-up of the toxicant deposit during spray applications may be achieved by the use of certain cationic wetting agents, particularly those with short alkyl chains, e.g., dodecyl and didecyl. Didecyl-dimethylammonium bromide represents a wetting agent with deposit-building properties.

3. Influence on herbicidal deposit weathering: Cationic wetting agents appear to be absorbed strongly to the leaf surface and cannot be removed easily by washing with water while most anionic and non-ionic wetting agents are readily redissolved from a spray deposit. The cationic agents should improve rain resistance of spray deposits.

4. Wetting agent phytotoxicity: Phytotoxic effects depend on the chemical structure of the wetting agent and also vary considerably on different plant surfaces. Cationic wetting agents are generally the most phytotosic while non-ionic are the least phytotoxic. Phytotoxicity of certain wetting agents tend to increase in wet weather (probably due to stomatal opening) and on plants deficient in essential mineral elements.

Table 1. Wetting efficiency of surface active agents on solid surfaces (undersides of leaves).

Surface active agent	Wetting efficiency ranking [1] Apple	Plum	Beeswax
Sodium 4-ethyloctyldiethyl-propyl sulphate	1	4	5
Oleylamine-polyethylene glycol 9E	9	33	44
Morpholine oleate	41	37	6

From: Furmidge, C.G.L., J.Sci Fd. Agric., 1964, 15.

[1] Ranking based on concentration for 100% wetting (% w/v).

MULCH AND SOIL CONDITIONERS

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Mulch has been defined as any substance, such as straw, spread on the ground to protect roots of plants from heat, cold or drought. This covers a wide field and gives many avenues of discussion.

ASPHALT MULCH TREATMENT

One of the most commonly observed mulchs used on large scale that we are accustomed to seeing lately is on slopes or flats of the interstate highways. This is not new as 30 years ago in Connecticut, the shoulders of the highways were being handled in a similar manner as the present day mulching is. Stabilizing slopes and flat areas is a chronic problem for engineers on highways just as it has been for farmers. Erosion caused by wind and water can be halted or prevented in most cases, by establishing vegetation. However, unless artificial methods are used to stabilize the soil during the period of germination, forces of nature may remove the seed. Mulching must be used to protect the planting until it is well established.

There are two asphalt mulching methods used most often. One is to spray a film of asphalt, .15 - .30 gallons per square yard on the seeded area and the other method is to apply the liquid asphalt to the straw after it is in place over the seeded area. There are two methods for anchoring straw with asphalt. One is to spray the hay after it is in place over the seeded area and the other is to chop the hay, blow it and mix it with asphalt in the air before it lands on the prepared area. The straw is usually applied at 1 1/2 to 2 tons per acre and the asphalt at 0.10 gallons per square yard.

HYDRO_MULCHING

The word hydro-mulching has become part of our daily vocabulary. This method has been used for many years in crude forms, but in recent years, the improved machinery and demands for faster use has escalated the hydro-mulching method of establishing turf. This method is faster, economical, and very dependable.

Hydro-mulching can be used on areas such as parks, lawns, playgrounds, golf courses, housing developments, turnpikes, re-forestation or any area needing to have turf established.

One of the main constituents of this mulch is a wood cellulose fiber which is combined with seed, water and fertilizer. The success of this method is thoroughly mixing all ingredients and even distribution to the seed bed. Both seed and stolons can be used successfully in this method. Although, there has been some concern on greens seeded recently. Movement of the mulch into small piles during heavy rains prevents the seed from growing through the fiber. The excess fiber has to be raked off the greens and this will not remove all of the material. On the other hand, if the fiber had not been used, the erosion problem might have been much worse.

HAND MULCHING

Hand mulching is the oldest method used and is still used throughout the world. The material used can be of any sort that is locally available. In fact the same materials can be used as for the hydro-mulching method. The cost would be greater but a small area could be covered more economically by hand than with expensive equipment.

Netting of various sorts has been used and with good results. Vegetative grass planting will make a faster start when an open mesh netting is used. If too much light and most of the air circulation is cut out then the plants will suffer and be stunted. There has been as much as two weeks difference in obtaining a complete stand of grass with and without netting. This could also apply to the other mulchs.

MULCHING BERMUDA GREENS DURING THE WINTER

Many courses in the upper south (Tennessee) mulch their bermuda greens and play on temporary ones. This allows play on the bermuda earlier in the spring. This mulch would be protection from cold as mentioned in the definition. The cold winters of the past 3-4 years have resulted in loss of grass from disease activity under the mulch. This is an excellent place for cool season disease (Fusarium) to develop if a fungicide was not used before covering the greens.

SOIL CONDITIONERS

Soil conditioners could be defined as materials that condition the soil. A better explanation might be that they are used to improve the physical conditions of a soil. This really gives us a better basis for discussion of soil conditioners. Many are available now and others are being checked for future release. These materials are being used more on special areas.

Most turf is being used more each year and is resulting in compacted areas which are especially prevalent on golf greens, bowling greens, grass tennis courts, school grounds, etc.

In order to counteract this compacted condition, soil conditioners are being added at varying amounts with good and undesirable results.

A few that are being used are calcined clays (such as Turface, Terragreen, and LuSoil), pine bark, hardwood sawdust and numerous other materials. The calcined clays absorb water whereas sand does not. They do not expand when they are wet which makes them act similar to sand in this respect. This could be objectionable in the event of a pro-longed rainy spell.

Some conditioners are used to speed up permeability while others can be used to slow down water movement. The small size particles will fill in between large soil particles and prevent movement of water. Also, materials that expand when they are wet can be hazardous by stopping movement of water altogether.

Some mulching materials are used as soil conditioners and one of this type is pulverized pine bark. This material has been studies under control conditions for the past 4 years with excellent results.

BENTGRASSES--VARIETIES, GROWTH HABITS AND AREAS OF ADAPTATION

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Green Section, Athens, Georgia

The bentgrasses that we use on our golf courses belong to the genera Agrostis, Agrostis L. "name from Greek agrostis, a kind of grass from agros, a field. The word agrostology is from the same root".[1] Most of the species and varieties belonging to this genus are important forage plants but the ones golf courses are interested in most are Agrostis palustris, A. eanina, A. tenus and A. alba. There are about 25 species in the United States and 8 are found in Texas. There are both annual and perennials. The panicles of many species are purplish or reddish-purple or tinged with purple.[2]

Agrostis Alba, L. Redtop, is a cool season, stoloniferous grass from Europe. It is used in areas where a quick coverage is needed, such as overseeding lawns, pastures and sport turf and occasionally, it is used in mixtures when overseeding bermuda greens for winter play, It germinates readily but is not a strong grass for greens in the south where high temperature prevail as it prefers cooler areas of the United States. It is usually erect and robust with strong creeping rhizomes. It is used less on greens than other types of bents but it is well adapted for use on poorly drained acid soils.

Colonial bent is Agrostis tenuis Sibth, and has short stolons but no creeping rhizomes. Earlier it was known by names such as Rhode Island browntop, New Zealand, and Prince Edward Island. It is not equal to creeping or velvet bent for use on golf greens.

The varieties of Colonial bent are Astoria, Highland, Exeter, and Holfior. Astoria and Highland are the ones most commonly used in the south and mostly in mixtures for overseeding bermuda greens and as permanent turf in higher altitudes in the south, such as above 3500 feet.

HIGHLAND

Highland was selected about 1930 in the southern part of the Willamette Valley, Oregon. In appearance, it is very similar to Astoria and common Colonial although Highland has several distinctive characteristics. It is bluish green with erect robust culms and the liqule is longest of the three with the panicles generally the largest. The panicles and culms are usually dull, and a light red up to the spikelets. It is stoloniferous and susceptible to brown patch.

ASTORIA

Astoria was first selected in northwest Oregon in 1926 by Engbretson and Hyslop. This bent has short stolons, slender culms and is considered a

1 Manual of the Grasses of the United States, Hitchcock, A.S.

2 Texas Grasses, Silveus, W. A.

weakly creeper. It is hard to distinguish from common Colonial on growth habits or color. It is used in lawn mixtures, fairways and sometimes in overseeding bermuda greens. Most of the seed comes from native stands found in southeastern Oregon, north of the Columbia River. It does best in higher altitudes and cooler climate.

EXETER

Exeter was selected by J. A. DeFrance and C. R. Skogley in Rhode Island, eastern Connecticut, and Massachusetts about 1940 and was released in 1963. It is similar to Astoria. It becomes green earlier in the spring and holds its color better in the summer than Astoria. It is very winter hardy, rather bright green, has shown leaf spot resistance, and is best adapted in the north and northeastern part of the United States. It is used in fairways, bowling greens, tennis courts, and lawn mixtures.

HOLFIOR

Holfior was developed in the Netherlands by D. J. van der Have and released in 1940 in Holland. It was released by Northrup, King and Company in the United States in 1963. "Initial selection for short stolons, dense plant growth, and fine leaves. Polycross progeny tested under short-mowed turf conditions. Six plants saved to produce synthetic variety based on uniform maintenance of growth throughout the growing season." [1]

It does not spread rapidly here in the United States but produced good texture with dense turf. Best turf is produced at 1/2 - 1" which makes it best suited for turf other than greens. This grass is fine leaved with darker leaves than Astoria. It has been placed in overseeding trials and is a quick germinator.

VELVET BENTGRASS

Velvet bentgrass, Agrostis canina L. was introduced from Europe. It is strictly a cool season, and a stoloniferous grass. It is found north and northeast of New Jersey. Like most bents, it does best on well-drained soils and is relatively shade tolerant. It can be increased by either seed or stolons. There are 3 selections used, Kernwood, Kingstown, and Raritan.

KERNWOOD

Kernwood was selected at Kernwood Country Club, Salen, Massachusetts. It has a long growing period in that it greens up early in the spring and grows well into the winter. It is medium to dark green and has not been officially released.

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[1] Agriculture Handbook No. 170

KINGSTOWN

Kingstown was selected by J. A. DeFrance and C. R. Shogley from an inbred selection from Piper by J. F. A. North in 1929. It shows good resistance to dollar spot and is somewhat resistant to other diseases. It has a dark green color and shows much vigor and density. It was released by the Rhode Island Agricultural Experiment Station. The smut infestation was eliminated at Oregon Agricultural Experiment Station, Corvalis, prior to variatal acceptance and release of breeder seed. [1]

RARITAN

Raritan was selected at the New Jersey Experimental Station by Howard B. Sprague. Plants were selected for seedling vigor, good seed yield, apparent freedom from disease, vigor of mature plants, and turf quality. Parallel testing of turf plots produced from seed of selected plants accompanied later stages of selection and vigorous variety produced fine quality turf. It displays excellent adaptation to climatic conditions prevailing in New Jersey. [2] It was released in 1940 by New Jersey Agriculture Experiment Station.

CREEPING BENTS

Agrostis palustris Huds. is commonly known as creeping bentgrass and there are two types commercially available, seed and vegetative. There are numerous vegetative strains that have been selected from greens seeded to South German bent and can be planted only by stolons. The other source of creeping bents are Seaside and Penncross.

SEASIDE

Seaside bent is perhaps the most widely used bentgrass in America. Perhaps it is incorrect to call it a strain or a variety. Seaside bent is a creeping bent and most of the seed supply is harvested from stand indigenous to the coastal regions of Washington and Oregon. [3]

It is below average in disease resistance which allows the stronger plants to survive and take over and this often gives a very spotted or patchy effect. An old green which is mottled is a good example of the natural law characterized as "the survival of the fittest". The plants which are most suited to a particular environment will persist and those which are unsuited will die.

The heterogeneous and multiform nature of Seaside bent allows it to be used over a tremendous range of environmental conditions. There is always a strong possibility that within the population there will be some individuals which will be suited to the environment and will persist and form a turf. [1]

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1 & 2 Agricultural Handbook P.170

3 USGA Green Section Record, September 1964, Ferguson, Marvin H.

It appears that with such a wide genetic variability, Seaside could give a good account of itself in the south. In the southeast, Atlanta, Georgia is the furtherest south it is used except for overseeding bermudagreens in the winter. The Par 56 in Marietta, Georgia has has 18 holes of Seaside for five years and it has done quite well. The plots of Seaside at the Athens Country Club, Athens, Georgia have not done as well as other selections of bent.

PENNCROSS

The other seeded creeping bent is Penncross. It was selected at Pennsylvania Agricultural Experiment Station, University Park by H. Burton Musser and staff and was released in 1954. Penncross is the first generation seed produced from 3 vegetatively propogated clones of creeping bentgrass. The parent strain for seed production is identified under the station accession numbers 10 (37) 4 (Pennlu creeping bentgrass), 9 (38) 5, and 11 (38) 4. This is known as the polycross technique. Penncross is vigorous, relatively disease resistant, fine textured, and offers a pleasant color. Despite the fact that the parent strains were selected in Pennsylvania, an area quite favorable to the growth of bentgrass, it has performed creditably in many parts of the United States.[2] The performance in Oklahoma has been generally satisfactory but it has not been greatly superior to other varieties commonly used in the state, in density, tolerance to disease and recovery from attacks.

The plots at Athens Country Club, Athens, Georgia had Penncross for 7 years and it was one of the superior four bents including vegetative selections. This was also the case at Eastlake Country Club in Atlanta, Georgia and at Pinehurst Country Club in Pinehurst, North Carolina where vegetative selections showed to be superior.

During the 1930's numerous vegetative selections were made by the USGA Green Section. The best selections were stolonized in greens resembling a pie sliced for serving. These tests were tried throughout the United States and some of the selections that were used then still rank among the best.

COHANSEY

Cohansey (C-7) has been used as often as any of the selections and it originated in #4 green at Pine Valley Golf Course Club, Clementon, New Jersey. It was selected in 1935 by the superintendent, E. R. Steiniger. The pale yellow green color is objectionable to some people but it has performed well enough to be popular. It is subject to dollar spot but this has not been a real problem with the numerous fungicides available. Reportedly, it has shown some tolerance to brown patch and melting-out. It competes well with Poa annua in addition to masking it.

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1 &2 USGA Green Section Record, September 1964, Ferguson, Marvin H

3 Turf Research by Wayne W. Huffine, H. C. Young, Jr., D. F. Wadsworth, and R. V. Sturgeon, Jr.

OLD ORCHARD

C-52 or Old Orchard was selected in 1934 at Old Orchard Grass Nursery in Madison, Wisconsin by R. R. Bond. Most people like the color and it has been one of the best performers for the past 7 years at Athens Country Club. Fungicides have controlled all disease problems. The adaptation appears to be expanding each year.

NIMISILA

Nimisila is a relatively new selection which was made by William E. Lyons. It has done as well as any of the selections at Atens Country Club. It was impressive enough in the plots at Pinehurst Country Club that 14 greens were planted to it in 1963. These greens were stolonized in June and were ready for play the later part of September. These greens have been played the year around, and have not created any maintenance problems.

ARLINGTON

Arlington, C-1 was collected in 1928 from the practice green at the Country Club of Atlantic City, Northfield, New Jersey. It has a bluish green color and is rather slow growing. It creates a whirl effect if it is not mowed closely and it seems to do best when combined with Congressional. It does best with good drainage.

CONGRESSIONAL

Congressional, (C-19) was selected by R. P. Hines, Jr. in 1936 from the #13 green at the Congressional Country Club, Rockville, Maryland. It is an attractive dark green and is a good variety to be used along or in combination with C-1. It is susceptible to brown patch. It has done well at the Eastlake Country Club in Atlanta in combination with Arlington C-1, but is not very impressive at Athens, Georgia or Pinehurst, North Carolina.

WASHINGTON

Washington was selected at the Arlington Farms by the USGA Green Section and was originally collected at the Washington Golf & Country Club, Rosslyn, Virginia and tested as C-50. It has a short growing season compared to other bent selections. The texture is very poor in the south. It seems to take the heat but doesn't make a tight turf.

TORONTO

Toronto was increased vegetatively and tested as C-15. It was selected at the Toronto Golf Club, Long Branch, Ontario in 1936. It has a dark green color but is susceptible to dollar spot and brown patch. It has to have good management.

EVANSVILLE

Evansville is a new release of 1963 by the Indiana Agricultural Experiment Station. The selection was made in 1958 on the #5 putting green at the Evansville Country Club, Evansville, Indiana. It has a dense turf and

and if fine leaved with a dark green color. It appears to have some resistance to dollar spot and to some extend to brown patch. The grass is so new that it hasn't been tested in the south and at this time no plots have been planted to it.

PENNLU

Pennlu was selected at the Pennsylvania Agricultural Experiment Station, University Park and was released in 1954. It has shown wide temperature range, high disease tolerance, vigor but shows fluffiness when not managed correctly It is not being used as widely as Penncross.

FERTILIZATION

There is a wide choise of fertilizers. How much, when, and the method of application will depend upon the kind of fertilizer. Matching the material and the method will give a healthy grass. Fertilizer for bent greens should provide nitrogen (N), phosphorus (P_2O_5) and potash (K_2O) in the ratio of 3-1-2. A good formula is 1/2 pound of nitrogen or less per 1,000 square feet per month on bentgrass in hot weather, and 1 pound per month during cool months. This practice will provide about 9 pounds of nitrogen per 1,000 square feet per year. If the 3-1-2 ratio is used, you will apply 3 pounds of P_2O_5 and 6 pounds of K_2O. These two nutrients do not leach readily and may be applied in the spring and fall when the weather is cool. The amount of fertilizer may vary slightly and this must be an individual course program. But practical experience has shown it is not wise to overstimulate bentgrass during hot summer months.

Practically all of the bent selections have been made in the northern part of the United States and some selections are being grown in areas not originally considered applicable to their adaptation. We need a breeding program and selection of bents slanted toward being more adaptable to the southern environmental condition.

The bents being grown further south due to the constantly recurring poor transition from cool season grasses to bermuda are a persistent reminder that a year around grass would be desirable.

PERMEABILITY - THE KEY TO VERDANT TURF

Dr. Marvin H. Ferguson and Dr. H. E. Hampton
USGA - Green Section, and Soil and Crop Sciences, respectively

All growing plants must have adequate supplies of both moisture and air. The essential nature of air is not always realized. Oxygen, a component of air, must move into the plant through the roots and is needed in an energy releasing process which must take place in every living cell. Energy in turn, must be expended in order for plants to absorb both water and nutrients. In fact, the very existence of plants depends on air just as does the existence of animals.

The entrance of air and water into the soil and their movement down through the soil depends upon pore space relationships. Pore space refers to the portion of the soil not occupied by solid substances. By soil pores is meant the tiny voids, cracks, and crevices between the solid particles. The soil solide include both the mineral grains from decomposed rocks and the organic matter of living and dead plants and animals. Soil pores are usually too small to be seen with the naked eye. They vary from submicroscopic to perhaps the size of the head of a common straight pin. The pores in soils do not form a continuous tube but are more like the large rooms of a natural cave which are connected by narrow passageways.

Water enters the soil and moves downward in the soil through these tiny pores. Fresh air gets into the soil and foul air escapes from the soil through the soil pores. Furthermore, root growth takes place through the pore spaces of soils. The smaller of the soil pores, called capillary pores, function chiefly to hold moisture. The water in the capillary pores is held very tenaciously. The more rapid movement of soil water, the movement of air, and the growth of roots are through the relatively large pores which are referred to as non-capillary pores.

Soil porosity is determined almost entirely by the textural condition, the structural condition, and the amount and nature of the soil organic matter.

SOIL TEXTURE

Soil texture refers to the size distribution of the mineral particles in the soil. From the standpoint of texture, the mineral grains vary from about the size of No. 2 shot down to particles so small that they cannot be seen even with the aid of the highest power of a microscope. Particles larger than No. 2 shot are classed as gravel, chert, stones, or rocks and are not considered in soil texture although these large particles would influence the character of the soil. The textural particles of soils are classed into three general groups according to size - sand, silt, and clay.

Soil particles of sand size are relatively large, can be seen with the naked eye and present a gritty feel like sandpaper. Silt particles are tiny - so tiny that they are not gritty but have the velvety feel like wheat flour. Particles of clay are extremely small. They are neither gritty nor velvety. When wet they are sticky and plastic.

It is the sand grains that lend courseness to soils; it is the clay fraction that cause the soil particles to stick together into clusters or groups called aggregates. Soils which contain a large amount of clay particles, possess high amounts of total pore space but the poor spaces are chiefly of capillary size. Course-textured soils (those containing large amounts of sand), on the other hand, present low amounts of total pore space but the individual pore spaces are larger.

No soil is composed entirely of a single fraction - sand, silt, or clay. Soils are variable mixtures of course and fine particles. Twelve different terms, each composed of one to three words, are called textural names. Each denotes the approximate proportions of sand, silt, and clay in soils. The textural names are as follows:

Sand	Sandy Clay loam
Loamy sand	Clay loam
Sandy loam	Silty clay loam
Loam	Sandy clay
Silt loam	Clay
*Silt	Silty clay

*Very uncommon in the Southwest.

SOIL STRUCTURE

Soil structure is another physical property that has much to do with the total porosity and especially with the non-capillary porosity of soils. Soil structure may be defined as the arrangement of the primary and secondary particles of the soil into patterns. In this definition, "primary particles" refers to the individual or ultimate particles of sand, silt, and clay whereas the term "secondary particles" refer to the clusters or aggregates of primary particles. Now it is necessary only to describe what is meant by "arrangement" and by "patterns."

If a number of soils or soil layers are examined in the field, it will become evident that the aggregates are of different shapes (types) and that they also vary in size.

The aggregates in some soils or soil layers are rounded or roughly spheroidal like shot. They are distinctly pervious and each breaks up by a complete crumbling of the entire aggregate into smaller ones similar to the larger ones except in size. Such aggregates are said to be granular in type.

The aggregates in other soils have clearly defined angular edges, the aggregates are generally dense and rather impervious, breaking up along well-defined cleavage planes. The surface of these aggregates are not rounded but are flat and usually present a shiny appearance. The particle composing the aggregates are nearly always dispersed, that is to say, the larger aggregates are not commonly composed of smaller aggregates as in the granular type. Aggregates of this group are divided into three types: (a) blocky(cube-like) similar in shape to sugar cubes; (b) prismatic in which the aggregates are upright like a number of bricks standing on end side by side; and (c) platy in which the aggregates are laying flat like bricks in a wall.

Another type of aggregate, which is very common in our soils, is called subangular blocky. This type of aggregate might be said to be an aggregate which is partly like a granular type and partly like a blocky type (a portion of the surface tends to be rounded and the remainder of the surface tends to be flat and shiny).

The type of aggregate is a part of structure but not all of it. In other words, soil structure is more than merely the type (and the size) of the aggregates. Soil structure includes the ability of the aggregate to resist disintegration when disturbed by tillage or by the force of falling or moving water and it includes the cementation of one aggregate to another. Stable aggregates which are not strongly cemented one to another make for more desirable structure whatever the type.

The stability of aggregates and the cementation between aggregates are considered in determining the grade of soil structure. Such terms as poorly developed, moderately developed, and strongly developed denote the grade of structure. Terms describing soil structure put together the grade and the type of aggregate giving such terms as poorly (developed* granular, moderately (developed) * blocky and the like.

SOIL ORGANIC MATTER

Soils contain variable amounts of organic matter. The amounts in ordinary soils of Texas vary from less than 1% to as much as 6%. Being a porous substance, organic matter contributes directly to the porosity of soils. Inasmuch as soil microorganisms and the products of organic matter decomposition are extremely important in the development of soil structure, organic matter indirectly influences porosity. The formation of non-capillary pores, especially, are dependent upon the presence of active organic matter.

Whatever soil is used for the production of harvested crops, the organic matter content of the soil declines. The more intense the use of the soil and the greater the amount of plant material removed, the more rapid the loss of organic matter. The organic matter content of turf soils may increase or decrease over the years depending on the climate and the amount of growth removed. The deterioration of soil structure and the reduction in both total porosity and non-capillary pore results from the loss of organic matter.

SOIL PROFILE CHARACTERISTICS AND PERMEABILITY

The total porosity of a soil must be about equally divided between large (non-capillary) pores and small (capillary) pores for the soil to be permeable and also to have sufficient water-holding capacity. Furthermore, non-capillary pores must be present with little alteration in size and distribution down through the profile for the soil to be sufficiently permeable for good growth of most plants.

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*The word "developed" is usually omitted in structural terms and often the "ly" is also dropped, eg. "moderately developed granular" becomes moderate granular.

Most soils of the Southwest may be placed in four general types insofar as profile permeability is concerned. These four include (1) soils which are classed as excessively permeable, (2) soils which are referred to as moderately permeable, (3) soils which are classed as slowly permeable, and (4) soils which are known to be very slowly permeable.

The first group are coarse-textured soils with little change of texture or structure to a depth of three feet or more. These soils are excessively permeable because the high amount of large sand grains cause large pore spaces and the soils do not contain enough fine particles to fill in the large pores. These soils usually contain low amounts of organic matter, and exhibit little structural development. In this soils' structure is not essential for permeability. No sharp changes in either the amount or size of pore spaces occur so there are no soil barriers. Soils of this type include the Lakeland, Brennan, and Enterprise.

Soils of the moderately permeable group include soils which are medium-textured with reasonably good structure to a depth of three feet or more. Also included are soils which have a coarse-textured or medium-textured surface underlayed by a finer-textured subsoil of clay loam or clay. The permeability of this profile type is due to the moderately to strongly developed structure especially in the subsoil. Included in this group would be such soils as the Ruston, Willacy, and Amarillo.

The third profile type includes soils which are moderately fine-textured or fine-textured in the surface soil and subsoil. The permeability of such soils is determined by the structure of both the surface and subsoil. A good structural condition is essential to provide sufficient non-capillary porosity for even the slow movement of air, water and roots into and through the soil. Slowly permeable soils include the Houston, Lake Charles, and Victoria.

Soils which fall in the fourth profile type are very slowly permeable because they are lacking in non-capillary porosity either in the subsoil or from the surface downward. The soils of this group are fine-textured in the subsoil if not in both the surface soil and subsoil. The imperviousness is due to the almost complete absence of non-capillary pores because of the poor structural condition. Soils of this group include the Lufkin, Beaumont, Edna and Foard.

EFFECT OF LAYERS

In the foregoing, the attempt was made to show that the permeability of soils is influenced by texture, structure and organic matter as they effect porosity particularly the presence of non-capillary pores. If the profile of a soil is fairly uniform with respect to non-capillary porosity and there is a significant amount of large pores, the soil will be desirably permeable. If, on the other hand, a soil as a whole or a soil layer does not contain large pores because of the textural and structural condition, the soil will be relatively impervious. Furthermore, if there is a distinct difference in the non-capillary porosity of two adjacent layers, a barrier to the movement of water will be set up.

Because of the variation in non-capillary porosity of the materials in the different layers the downward movement of water is retarded. Even though all layers are more or less pervious, water will not move into a lower layer until the layer above it becomes at least partially saturated. If the conditions of porosity in the two layers differ only a little, the thickness of the saturated soil in the upper layer need not be great until the water crosses the barrier. If, on the other hand, the porosity of the two layers differ considerably, the entire upper layer may become saturated before the water will enter the lower layer. Indeed, in extreme cases, the downward movement of water is so retarded that the root zone of the plants becomes saturated and poor growth of grass results.

It is a common practice to topdress a lawn or other turf area with so-called "top-soil" which may vary from sand to a fine-textured soil. Any growth of grass, mat and thatch are usually left on the old surface. Such a practice develops at least two barriers - one at the junction of the added soil and the vegetative material and another between the vegetative material and the old surface soil.

A condition encountered now and then in areas of turf, and such a condition is particularly common on golf greens, is the build-up of layers of distinctly different materials which have been used for topdressing in times past. In extreme cases, one may find as many as five or six layers composed of sand, peat, and the like. Each junction between two very different materials, constitutes a barrier. In this connection, a layer of mat or thatch can provide the barrier which impedes the entrance of water and its movement into the soil.

Except in cases where small wet areas occur on lawns, parks, or fairways drainage by means of tile or other structures is seldom needed. Areas of intensive turf use like the putting greens and perhaps the tees on golf courses frequently need drainage. If tile drains are installed on putting greens, the construction of the green should be according to specifications of the Green Section of the U.S. Golf Association.

In this connection, the argument has been presented that a barrier occurs at the junction of the green mixture and the sand layer and another at the junction between the sand layer and the gravel blanket around the tile. And such is the case! However, if the materials used have passed approved laboratory tests and the construction has been strictly according to specifications, the retardation of the downward movement of water will be slight and will be desirable rather than troublesome.

In the management of turf, every effort should be expended to avoid the development of layers and therefore barriers. This is especially true when turf is exposed to heavy traffic. In order to grow healthy turf on any area, the top 12-18 inches of soil, whether natural or mixed for the purpose, should have the textural and structural conditions necessary to provide good permeability. Then all topdressing material must be very similar to the surface layer in order to maintain conditions of uniform porosity and to avoid barriers.

USE OF FERTILIZER - WHAT ARE YOU AFTER

L.W. DuBose Jr., Superintendent, Houston Country Club
Houston, Texas

The first thing that should be done is to take soil samples. Samples should be drawn 2" deep. It should be stated when they are sent in that they were drawn 2" deep. Most of our root system will be in the top 2" so that is what we are most interested in.

Some time back Dr. Trogdon gave us the 4-W's and the 3-R's. The 4-W's are what amount of, which fertilizer, when and where. The 3-R's are right amount of the right kind at the right time.

We know we need nitrogen phosphorus and potash plus trace elements to grow a healthy plant. Phosphate, potash and calcium are plant food elements that one can build into the soil. Or build up a bank account to be used as it is needed. Nitrogen can not be used in this manner.

On Bermuda, magnesium is an important plant food element. It becomes a critical element especially on sandy soils. Dolomitic limsstone contains magnesium and is an economical source. Such soils will normally require calcium. Both calcium and magnesium can be supplied by using dolomitic limestone.

A soil analysis report that comes from Texas A & M University will show your pH, organic matter, predicted nitrogen level, phosphorus, potassium, calcium and salinity hazard. Actually we do not need to know as much about nitrogen as we do phosphorus, potash and calcium. The need for nitrogen will result in poor color, slow growth, thin turf and the presence of weeds and clover.

We need to know a little more about phosphorus. To grow a good healthy green plant we should have 200 to 300 lbs. available P_2O_5 per acre. On fairways, we should have 75 to 100 lbs, available P_2O_5 per acre.

Potash we need 300 to 400 lbs. available per acre on greens and 150 to 200 lbs.for fairways.

On a new golf course there is a need for higher available nitrogen than on a golf course that is well established. Once a golf course has a good turf a slower releasing form of nitrogen will give ample growth and color for a longer period of time.

On greens where clippings are removed we need to add more nitrogen, phosphorus and potash than on tees and fairways. In the Houston area you will find that from 15 to 20 lbs. of nitrogen is used per 1000' per year on greens, and from 8 to 10 lbs. or more phosphorus, and 8 to 10 lbs. of potash on greens. On tees and fairways 3 to 6 lbs. of nitrogen are used, 1 1/2 to 3 lbs. of phosphorus, and about the same amount of potash unless soil samples show they need more.

Some grasses require more fertilizer than others. I believe this will hold true on greens, tees and fairways.

Time of application is important. We should apply fertilizer so it will be taken up and used by the plant we want to feed. This inables us to grow a good healthy plant that we want and discourage the ones we don't want.

Fertilizer should be applied at rates to maintain a good turf. Some times we look for color more than we do for a good quality turf.

Soil sampling should be done each year. It will tell us whether or not we need lime. There are a lot of people here at our conference who can tell you what you should use if you could show them your soil sample report.

Up to this point I have talked about fertilizer elements being applied to turf. My own fertilizer program is as follows:

FERTILIZER SUMMARY

Area	Size	Amount Fert.* Per applic.	No annual applic.	Annual Need Total N per 1000	per year
Greens	150,000	15# per 1000'	15	13 lbs.	15 tons
Tees	6 acres	25# per 1000'	2	3 lbs	7 tons
Fairways	80 acres	25# per 1000'	2	3 lbs	88 tons

* Milorganite

DOLOMITIC LIMESTONE

Greens: Average one time per year -- 30 lbs. per 1000'

Tees and Fairways: Average one ton per acre each 3 years since golf opened. No lime the last two years, and I don't expect to, but once every 5 or 6 years if I continue to use all organic fertilizer

CHEMICAL COMPOSITION OF SOIL, AVERAGE AUG. 1965

	PH*	Lbs. per acre available			
		P_2O_5	K_2O	Ca.	Mg.
Greens	7.20	590	260	4600	1450
Tees	7.35	630	300	7500	1250
Fairways	7.00	370	375	6000	1700

* No salinity hazard exists.

TURFGRASSES OTHER THAN BENTGRASS

Dr. John A. Long, O. M. Scott Co.
Marysville, Ohio

Introduction

To provide a starting place to discuss turfgrasses other than bentgrass, it perhaps would be well to consider for a moment the significant role that turfgrasses play in the profession that most of this group are involved in.

Turfgrasses provide the basic ingredient in most landscape plans which include home lawns, golf courses, parks, cemetaries, industrial sites, school lawns, athletic fields and roadsides. It is the item that you of the turf community direct a major part of your attention to directly or indirectly. A multi-million dollar industry in Texas is essentially centered around turfgrasses. Most of us here today depend on turfgrass in one way or another to provide our source of food and clothing. The vast industry that provides the chemicals to make it possible to grow vigorous and healthy turfgrass depends on turfgrass to survive. Mechanical tools including mowers, tractors and etc, represent items from still another industry heavily dependent upon turf. Turfgrass represents a major subject of discussion in almost any conversation related to the magnificent Harris County Stadium. All agree that this stadium is considered one of the major Architectural and Engineering achievements of this decade, yet, one item looms up to cloud the picture - the failure to be able to grow satisfactory turfgrass. Since turfgrass represents such an important item in our profession, perhaps it would be well to make an appraisal of what we have in the way of available turfgrass varieties for Texas, some of the problems that are encountered in the culture of turfgrass and prospects for better turfgrasses in the future.

Status of Present Turfgrass Species

Bermudagrass

Bermudagrass, is without doubt, the major turf species used in turf applications other than home lawns in Texas. It has, however, an able competitor in St. Augustine for home lawn applications in some of the large metropolitan centers of Texas.

Bermudagrass is classified Botanically in the genus *Cynoden*. The genus *Cynoden* includes several species - *C dactylon*, *C. transvaalensis* and *C magennisii* which are the major ones used for turf applications.

Common and U-3 represent the only varieties that may be established from seed. U-3 established from seed has proven to be unsatisfactory because of the wide degree of variation in plant types obtained. Common bermudagrass still ranks as the major seeded turf variety across the state.

Vegetative varieties or numbered selections that are presently being used in Texas include: Texturf 10, Texturf 1F, Common, Gene

Tift (Bayshore), Ormond, U-3, Tifgreen, Tifway, Tifdwarf, F137, and Sunturf. Begetative varieties that have been tested and used to a limited extent include: Tiflawn, Tiffine, Royal Cape, Uganda and African.

Many introductions obtained from the Plant Introduction Station and from other sources have been and are being evaluated in the turf program at Texas A&M.

The Bermudagrass varieties used most widely in Texas today do not for practical purposes have any serious disease problems. The varieties F137 and Texturf 1F are classified as moderately suspectible to leafspot. These varieties are not at present used widely in Texas. Varieties used for golf greens applications, due to the nature of intensive management programs, are subject to damaging effects of disease organisms; however, with a properly planned preventative fungicidal program the problem is minimized. In most other use areas, bermudagrass is not generally effected by disease activity of any magnitude.

Insect pests at the present time appear to be a major factor effecting limited to serious damage to bermudagrass. Bermudagrass mite has been increasing in severity over the State and is not economically and effectively controlled by available insecticides. Damage from the bermudagrass mite may be lessened to some degree by increasing the frequency of feeding and irrigation. General susceptibility of bermuda's to this insect represents one of the major limiting factors for the species and it appears that an improvement program may be justified in including breeding for resistance to this pest. Sod webworm, Rhodesgrass scale and armyworm are frequently damaging to most present bermudagrass varieties. Proper insect control programs will provide effective and economic control of these pests.

A number of the recently released varieties of bermudagrass have found ready application to golf course putting greens, but their use indiscriminately in other areas should be given careful consideration. The use of hybrids such as Tifgreen, Tifway, and varieties as Texturf 1F, Sunturf, and Gene Tift for general turf areas such as parks, golf course fairways, home lawns and other similar turfed areas should take into consideration several factors before installation in such areas. Cost of installation is high (as compared to seeded common) and maintenance costs after installation runs significantly higher than coarser textured varieties. Where the fine textured varieties are used other than greens, problems of heavy thatch buildup have not been easily controlled due to a lack of large scale thinning equipment. The problem of thatch buildup resulting from the vigorous fine-textured varieties suggests that breeding programs should be so designed to apply limited selection pressure against selections with growth habits that produce a heavy thatch.

Bermudagrass in general is not considered tolerant of moderate to heavy shade. The lack of shade tolerance represents another characteristic that should receive emphasis in plant breeding programs since the species is widely used in sites where tree cover is present. In many such areas, no other turfgrass species would be adapted, so it appears that the solution lies in the area of breeding and selection for shade tolerant bermudagrasses.

Public interest has increased significantly for bermudagrass varieties that produce less vertical growth. Anticipation of less frequent mowing appears to be the basis for this interest. Another possible major benefit that might be realized from more compact and lower profile grasses would be better overall performance as related to less frequent mowing. It is well established that frequent mowing tends to reduce the extensiveness of root development and further requires that maintenance programs be adjusted to provide frequent watering and nutritional requirements to maintain the grass plants with the reduced root system. Selection for low growing types that require less mowing would mean that more normal development of the total plant should occur. Variation in growth profile in source material in the bermuda group suggest that improvement would be possible if consideration be given for selecting against the upright growth profile typical of common bermudagrass. Texturf 10 of the medium leaf textured group produces a lower growth profile and thus would be expected to produce less growth at normal mowing heights. F137 and Tifdwarf have also been reported to produce less vertical growth.

St. Augustinegrass

St. Augustinegrass represents the most popular turfgrass for home lawns in the larger city metropolitan centers along the Gulf Coast and inland to San Antonio, Austin, and north to Ft. Worth and Dallas.

The species is well adapted to the Gulf Coast area in particular. Only one species of St. Augustinegrass is recognized in the United States - this is Stenotaphrum secundatum. Essentially all St. Augustinegrass used for turf in Texas is considered as the common variety. Limited evaluation of several varieties developed in the Southeastern United States have not proven to be better than common for lawn applications.

Brown patch is ranked as the number one disease pest to St. Augustine. The disease makes its appearance annually during the cool-humid fall and spring periods. Where killing frost does not occur, this disease may persist throughout the fall, winter and spring period. PCNB fungicide provides relatively good levels of control of brown patch when used in a carefully planned program. The severity and wide spread distribution of brown patch suggests that breeding for increased resistance to this pest should be a major consideration.

Chinch bug has gradually developed to be a serious problem in St. Augustine turf areas within the past five years in the Texas area. Effective insecticide products are available to combat this insect and must be used periodically to insure adequate protection. At present no chinch bug resistant varieties are available. Based on observed variation in St. Augustinegrass progeny plantings, it appears that breeding for resistance to chinch bug may have good potential.

With interest increasing in turfgrasses that produce less vertical growth, some efforts should be considered in breeding programs to select for compact low-growth profile St. Augustinegrass. This again may provide selections that have a more desirable turf forming habit which should perform better than present varieties from the standpoint

of less foliage removal from periodic mowing.

Miscellaneous Grasses

Zoysiagrass perhaps represents the mystery turfgrass of the turf industry. Periodic promotion of zoysia as a sort of "super" grass generally has not been very successful. The very slow growth rate of zoysia is the major factor limiting more general acceptance and use for turf applications. Maintenance of zoysiagrass as to watering and fertilizer requirements appears to be comparable to the requirements for bermudagrass and St. Augustine. Brown patch disease represents the only major disease that effects this grass based on testing and user experience. Its growth habit is condusive to heavy thatch buildup which has been found to increase severity of disease incidence and problems in irrigation management.

Although cost for installation will run higher, this would seem less objectionable than a two-year waiting period for establishment when planting is done by sprigs, sod pieces, or seeding.

Varieties of zoysia available in Texas include: Meyer, Emerald and Mascarene. Meyer is better overall performer of the three. Centipedegrass has not been used widely in Texas because of a lack of winter hardiness. This species, where it is adopted, produces a very desirable appearing turf cover. Centipede should offer some future potential for Texas if progress is made in incorporating increased cold tolerance. Technical feasibility appears to be good for improving this characteristic based on the release of a variety recently from the Oklahoma Agricultural Experiment Station. This variety has been named Oaklawn and is described as possessing greater winter hardiness than common.

Future Prospects for Turf Improvement

Bermudagrass

Improvement of bermudagrass in many of the characteristics that have been discussed above appear feasible. This is based on the method of reproduction in bermuda and the great amount of variability in the several species. Conventional breeding methods are applicable to Bermuda. Improved varieties may be handled in several different ways with regard to commercial propagation. To date all improved varieties of bermudagrass have been released for commercial use as vegetatively propagated varieties. This would include F_1 hybrids, and natural occurring selections. Vegetative propagation has been quite suitable for the F_1 hybrids as it capitalizes on maximum hybrid vigor which occurs in the first generation. F_1 hybrids that most of you would recognize include Tifgreen and Tifway while natural selections would include Texturf 10 and Sunturf.

St. Augustinegrass

Research conducted at Texas A&M University in the period from 1957 until the present date has provided sufficient information to assure that no particularly serious problems would be encountered in breeding for

improved St. Augustinegrasses. Several breeding methods should be possible with St. Augustine. Multiple hybrids generally classified as synthetics produced by the polycross method would represent one way to go. Single cross hybrids would also provide another possibility while a third would simply use outstanding segregating individuals. Development and release would be hastened significantly by releasing all as vegetatively propagated varieties.

Miscellaneous Grasses

Zoysiagrass and Centipedegrass could also be handled in the same way as bermudagrass and St. Augustinegrass. It would be desirable to have some further basic information relative to method of reproduction and breeding behavior on Centipedegrass before initiating an applied breeding program for the species.

ESTABLISHING COLOR ON A GOLF COURSE

Charles B. Campbell, Jr., Director
Parks & Recreation Department
Fort Worth, Texas

The use of color on golf courses contributes materially to the esthetic appeal of the course itself and to the enjoyment of the game.

Many of today's golfers are as interested in being out doors for exercise, fresh air, and pleasant surroundings in good company as they are in breaking 90. The increasing number of lady golfers reflects the need for more natural beauty on our golf courses. Finally, due at least in part to golf's T.V. exposure, the public is demanding and expecting a country club atmosphere on our public courses. All of the above factors point up the need for increasing the beauty as well as the need for improved maintenance of our courses.

One of the most effective ways of satisfying this need or demand is in the careful selection--and placement--of plant material on our courses which will provide color over as long a period as possible.

Such color can be obtained from flowers, fruit, foliage, and bark, with flowers and foliage being the major suppliers.

The plant material itself may consist of annuals, perennials, shrubs, vines, or trees. My preference, from a practical standpoint, leans strongly towards trees as our primary source of color.

Dealing very briefly with annuals, perennials, and even shrubs, their use should be limited due to high maintenance costs and to the requirements that they be located in out of play areas. Can you imagine a golfer's reaction when he fades his ball just off the green and finds (or fails to find) it in a lush dense bed of cannas? or day lilies? or pansies? or honeysuckle? In the hands of an infuriated golfer working on a 25¢ press, a wedge or a nine iron can devestate a flower bed in an amazingly short time. While many areas on a golf course may be <u>designated</u> out of play, how many of those areas <u>are</u> out of play?

Virtually none as we all know. In some future issue of TTN we can look forward to some square foot costs of color that have been ably prepared by Mr. Phil Huey of the Dallas Park Department. These figures not only provide excellent reference material but, I believe, support my belief that our answer to golf course color both practical-wise and cost-wise lies for the most part in the use of trees--flowering, evergreen, and otherwise.

Before leaving flowering plants it should be noted that cannas and day lilies are outstanding in that they are relatively inexpensive,require less maintenance, are more disease and pest free than most flowering plants, have a long period of bloom, and--importantly--bloom in hot weather when the courses are most heavily used.

You have been provided with a table listing some forty odd trees that can effectively provide color of some sort on golf courses throughout the state. This table has been prepared by our own Scott Fikes, Supt. of Horticulture for the Fort Worth Park and Recreation Department. I was so pleased with his results that I felt constrained to put my name on it as well, but the credit for its preparation belongs to Scott. The approximate bloom periods are for the Fort Worth area and obviously will vary with your own location; but the interrelation of bloom periods should be consistent and adaptable for your area.

The following slides depict most of the trees listed though more frequently than not they will be shown in other than golf course locations. An idea of the bloom, color, and characteristics of the trees and how they might be used on your course can be hopefully attained, however, from viewing the slides.

Location, planting, and care of trees logically follows their selection. Some of the important considerations are:

1. If in turf areas, space trees widely enough that mowers can pass between other trees and barriers such as fences, etc.
2. Groupings in odd numbers of 3, 5, etc, of the same tree are usually more effective.
3. Avoid rigid, geometrical spacing to provide natural effect.
4. Locate plantings convenient to water supply wherever possible.
5. A "twenty dollar hole" for a two dollar tree is better than a "two dollar hole" for a twenty dollar tree.
6. Newly planted trees will require supplemental watering for several seasons. Don't plant more at a time than you can care for.
7. Landscape Architects and Horticulturists are excellent to use when available, but if they don't play and understand golf make sure the pro and greens superintendent assist them in locating plantings.
8. Select plantings that will give a continuity of bloom so that there is almost always some color on the course.
9. Concentrate on plantings that provide most color when course use is heaviest.
10. Plant plantings ahead for entire course and execute in stages; doing only that portion that can be maintained at any one time.

VERTICAL CUTTING AND AERIFICATION

Tom Leonard, Superintendent, River Oaks Country Club
Houston, Texas

Aerification:

The need for aerification dates back forever in agriculture and soil compaction under turf is a problem long time recognized.

I. What causes compaction?
   1. Watering
   2. Rain (Especially heavy rainfall in a short period of time)
   3. Equipment (mowers, sweepers, etc.)
   4. People walking
   5. Golf cars

Traffic in general adds up to a lot of soil compaction.

II. Harmful effects from compaction
   1. A compacted soil surface prevents:
      a. air b. water c. fertilizer from making proper movement in the soil.
   2. When the above fail to move properly--shallow rooted plants, infest the area. Some weedy plants (crabgrass, etc.) will grow better under unfavorable conditions than most of our preferred grasses. As condition (compaction) increases - weeds increase - end up with weeds.

Good things from aerification:

   1. Deeper root growth: because soil is loosened and opened - air, water, and fertilizer can get into soil where they are needed.
   2. More efficient use of water, fertilizer etc. Not as much run-off erosion- wash off. Materials can get into aerifier holes on newly aerified turf. Other areas (between holes) are loosened giving material a better chance to enter and move its soil.

III. Better soil develops:

   1. Increase in deep roots means roots in soil are dying naturally and new roots are being developed.
   2. Dying roots decay, thus adding some natural organic material and leaving natural openings for air, water, and nutrients to move.

IV. Brings soil to surface.

   1. It has been estimated that with 3/4" spoons that 12 tons of soil per acre is brought to surface.
   2. If this soil is good, it can be worked into the turf and serve as a top dressing - it is worked into thatch to help it decay more naturally.
   3. If soil is undesirable, it can be removed and a better material can be added and worked into the aerifier holes.

V. Breaks up layers:

1. Layers very often develope, caused by different types of material being used, etc.
2. Water moves poorly through a layered soil.

VI. Better shot holding.

1. Soil being loosened, helps the ball "bite".

Other types of aerification besides aerifier.

1. Spikers
2. Slicers
3. Groovers

Vertical cutting:

I. Why vertical cut:
   1. Control thatch and grain
   2. Where does this thatch come from?
   3. Thatch accumulates when mover leaves materials under the cut. Plants plus some fallen clippings; and some dead leaves and stems, etc. Thus the undesirable layer of organic material builds up.

II. Why control thatch?

1. It forms a layer that can be great enough to absorb water - preventing it from reaching the soil.
2. It causes the water to actually run off the thatch.
3. Makes it difficult to get materials into the soil. Has a tendency to cause shallow roots.
4. Makes spongy footing.
5. Makes good conditions for disease and insect build up.
6. May start breaking down in such a fasion as to injure growing grass - causing heat- excessive drying and possibly accumulation of soluble salts.

Grain:

Grain- where grass all grows in the same direction - ball rolls fast one way, jumps going into it.

Vertical cutting - removed the horizontal leaves and stems, helps to develop a more upright type growth and gives more leaves per square inch, feet, green, etc.

Thatch and grain - can and has been reduced by raking - combing - brushing. These methods help - are usually slower methods.

To remove heavy grain, action need to be made 1. Across it. 2. Into it - not with it. May need to double back over same strip or in two directions.

Another advantage of vertical mowing? Most people believe that proper vertical mowing has a tendency to stimulate grass growth - put it in more of a vegetative type growth. Shocks it - makes it break regular life cycle-thus prevents seed head formation.

WATER RESOURCES -- PAST, PRESENT AND FUTURE

E.T. Smerdon, Director, Water Resources Institute
College Station, Texas

I want to thank Professor George G. McBee who invited me to participate in this, the Twentieth Annual Texas Turfgrass Conference. However, as I look over the program, I realize that most of the speakers are going to talk about specific problems related to turfgrass, while I'm only going to talk about water problems. I did recently fly out of Los Angeles and have occasion to look down at Palm Springs and see some beautiful green golf courses surrounded by barren brown desert. It was pretty well evident that without water none of the other problems of managing golf courses would be present --- that is unless someone wanted to discuss problems of managing sand greens.

I am a little bit at a loss as to just where to start on my assigned topic. You know a discussion of water resources --- past, present and future could go on for days. I will try to limit myself to a few comments which may be of interest to you.

OVERALL WATER PROBLEMS

Present Supply and Needs

The United States, excluding Alaska and Hawaii, receives an average annual precipitation of about 30 inches. Seventy-one percent of this water is lost by either evaporation or transpiration to the atmosphere. The remaining 29 percent contributes to ground storage or becomes runoff. This water, which amounts to an average yield of 4 million acre-feet per day, is ultimately available for use. This water available for use amounts to nearly 7500 gallons per person each day. Obviously, this is a considerable water supply were it not for many complicating factors. First, our supply is not well distributed either temporarily or geographically. Also, our water serves many purposes that contribute to our standard of living. Many are not uses in the sense that water is lost in quantity. Instead, it may be lost, in effect, because of quality degradation. Our streams serve as the giant sewer in which our sewage and other wastes are flushed to the sea. At the same time our streams must also be the giant water main to provide a large portion of our water supply. If we are to potentially use the water in our streams, maintenance of stream quality is of utmost importance.

At the present time in the United States, approximately one-fourth of the total water that is available for use from streams and from the ground is actually used. Irrigation and industrial uses, excluding water power, are approximately equal and together account for over 90 percent of the total use. The actual water use rate in 1960 was approximately 1500 gallons per person each day when one includes all uses of water. In 1964 the per capita use of water was estimated to have increased to 1675 gallons per day. This is more than eleven times greater than the often quoted per capita water use rate in cities of about 150 gallons per day.

Future needs.

The projected future needs in the United States have been estimated by a Task Group on Coordinated Water Resources Research chaired by Abel Wolman. This Task Group estimated that, in the absence of technological or economic change, by the year 2000 it may be necessary to withdraw from streams and from the ground 2.75 million acre-feet per day. This is roughly 70 percent of the 4 million acre-feet per day available for use. Obviously as the use rates approach this value, tremendous structures would be necessary to impound water from periods of excess for use in time of deficiency. Since future reservoir sites are, in general, less desirable than those already used, inundation areas would likely intrude onto urban and otherwise needed locations. The cost for such massive structures and the transportation and distribution systems will be enormous since the areas of excess water will be in the humid east while the areas of need will be further west. At such time when withdrawal amounts to nearly three-fourths of the potential streamflow, little residual flow will be available for dilution and degradation of wastes which will undoubtedly result from highly complex industrial and agricultural activity.

Clearly, the problem in the year 2000 will be untenable unless there are some very significant technological changes by then. No doubt, some changes will occur. The question is - will enough changes occur as a result of research between now and the year 2000, to permit our standard of living to continue upward?

In considering research needs in water resources, we must recognize that water problems are regional in character. Supply and demand vary as does the type of uses which the water supply is subjected. Water stored underground is being depleted at an alarmingly high rate in much of the Southwestern United States, and particularly in West Texas. New sources of water must be found for these areas or catastrophic economic adjustments are goint to result. Part of our water resource planning is to create an awareness that water stored by nature over many millenium cannot automatically be replaced by hopes, desires, or even technological advancements. The potential from creative research efforts is great. Yet, I doubt if we should justify misuse of a resource with a rationale that science will find a way to solve our plight.

In industrial areas, waste discharge into streams already exceeds the assimilation capacity of the streams in many places with resulting undesirable effects. There is much evidence that new and more complex wastes will result from future activity. This will make the problem of maintaining water quality one of our most severe problems. Agricultural pesticides are now suspect because of their damaging effect at concentrations so low that they became measurable only recently. Much research will be required on water quality problems. Yet, the chances for success are good because of advances in waste treatment techniques which are scientifically feasible in the foreseeable future.

Roger Revelle, when Science Advisor to the Secretary of Interior, pointed out that in the year 2000, the requirements for water may

exceed the average water available from streams and underground supplies in Southern California and the Great Basin, in the Delaware-Hudson, Upper Arkansas-White-Red River, Great Lakes, and Western Gulf regions; and in the Upper Missouri, Rio Grande-Pecos, and Colorado River basins. The deficit in dry years in these areas may possibly be 100 million acre-feet per year in the year 2000--only 35 years hence. Obviously, without some significant breakthroughs in technology, the costs of having sufficient quantities of good clean water will be so great that we will fetchingly reflect on the "good old days" when water was an insignificant item in our daily budgets.

TYPES OF RESEARCH

I am briefly going to discuss research needs in two general categories and then go into some detail on needs which are pressing in Texas. First, we might consider research to increase the supply of water suitable for beneficial use. Here, I mean methods of increasing total supply of water by alteration or circumventing the hydrologic cycle, not by improving the management of the water we have. The second category is concerned with management of water available by natural processes, that is by the normal hydrologic cycle process.

Increase Total Water Supply

The total water supply may be increased by two methods which are presently much discussed, desalination of seawater and increasing precipitation through weather modification. I should not like to dampen anyone's enthusiasm for these approaches because they permit us the luxury of thinking that our problems will be solved by some gigantic breakthrough over the horizon. However, we may be permitting ourselves to exist in a "Cinderalla world" and midnight may be approaching.

Weather Modification

Recently, a National Academy of Sciences panel released a report entitled "Scientific Problems of Weather Modification." This report put a damper on expectations of getting a major triumph in modifying the weather and increasing precipitation very soon. Many past studies on the effect of cloud nucleation have been difficult to evaluate because of shortness of records and problems of getting statistical control. The problem of an apparent decrease in precipitation from cloud seeding is not infrequent. While our understanding of the precipitation process is increasing, vast unknown areas still exist. As yet, it has not been demonstrated that precipitation from winter orographic storms can be significantly increased by seeding, nor that hurricanes can be steered or diminished by seeding, nor that black dust or other surface modifications increase precipitation. Recently it has been pointed out that the time-scale for success in increasing precipitation by weather modification can be measured in decades, not years.

Well planned research in weather modification should continue. But, let's keep in mind that the opportunity for success is not so glowing that other procedures should be ignored. It is doubtful if this area of research will soon solve our water problems.

Desalination.

Desalination of seawater is here. It is also costly. Depending on the process and fuel costs, present estimates range from 30 to 50 cents per thousand gallons or 100 to 165 dollars per acre-foot at the plant. Even the most optimistic projections of water costs from desalination using nuclear energy range from 28 to 11 cents per thousand gallons (90 to 37 dollars per acre-foot). The latter cost is for water where the financing is by Federal Reclamation financing criteria. Transportation costs will add tremendously if such water were to be used in the interior areas of the country, where water could not flow by gravity.

No doubt the conversion of seawater and brackish water inland will add greatly to the supply in some areas. However, it remains that the cost will be high and procedures for conserving our presently controllable water hold more promise from strictly economic considerations.

Reducing Losses by Improved Management

I must define water management to establish what limits I intend to impose on my discussion. Here I will consider liquid fresh water which has fallen as precipitation on the land and assume that the water is subject to our management until it again evaporates. In other words, water in the atmosphere is not considered manageable, nor is seawater. Atmospheric water and seawater were touched on in the previous section.

Consider the average water budget of the United States (without Alaska and Hawaii). Five billion acre-feet of water falls on the area each year. Over 3.5 billion acre-feet of this is evaporated or transpired near where it falls. This amounts to over ten times the water which is presently withdrawn for some form of human use. Granted, a sizable portion, perhaps half, of this water lost is transpired and therefore contributes to the plant growth. Yet, much of this is for so-called noneconomic plants that have value only from esthetic,wild life habitat, and soil protection considerations. I do not want to minimize the importance of these factors, but rather suggest that a portion of that water loss might be reduced and still retain the indirect value of these growing plants.

Texas receives an average annual precipitation of only 27 inches per year compared to 30 inches for the United States. Yet, the characteristics of our average annual water budget are quite similar to that of the nation as a whole. Let us look in some detail at the Texas water budget to see where the major water losses occur. Note that 39.6 times as much water as discharges into the sea from our streams. Also, note that 45.9 percent of the incoming water is lost by transpiration loss is from growing plants. Over 80 percent of this transpiration loss is from so-called noneconomic plants. In Texas the water losses from evaporation including evaporation from lakes and streams surfaces is 148 million acre-feet. The loss from transpiration from noneconomic plants is 138 million acre-feet. These losses, both of which are evaporative in nature, are gigantic and amount to nearly seven times the total stream discharge into the sea. Obviously if

these losses could be reduced, the impact on our water supply would be gratifying.

Consider that it might be possible through research to reduce the losses from evaporation and noneconomic plant transpiration by five percent. The water saved would be 14.3 million acre-feet per year. Let's postulate that this water saved enters ground storage to be pumped provide stabilized seepage flow to streams. This water, available for use, would provide water for 7.6 million people at the 1964 per capita withdrawal use rate of 1675 gallons per day.

To be more dramatic, consider what that 14.3 million acre-feet of water per year would cost if it were obtained by desalination. At 28 cents per thousand gallons, the cost would be about 1.3 billion dollars. Recognizing that some gross assumptions may have been made for the Texas situation, the opportunity for progress through control of losses by the evaporative process is truly fantastic.

The situation for the nation as a whole is essentially the same. Research personnel trained in any aspect of science or engineering, where the fundamentals of soil-plant-water relationships are involved, have a challenging future.

Other research opportunities of great importance include those directed, not toward increasing the potential supply of water, but instead toward maintaining the water in usable quality. These problems include problems of pollution from agricultural drainage. The pollution may be from highly toxic agricultural chemicals or from minerals leached through the soil in subsurface drainage. We must solve the pollution problem or much of our water will become so contaminated as to be unusable. Our potential supplies are simply not great enough to permit us that luxury.

FUTURE WATER PLANS IN TEXAS

To know with assurance what the future holds as far as water planning is concerned would require that a person be a fortune teller. However, our Tenth Annual Water for Texas Conference, held just two weeks ago, brought together its leaders in water planning to discuss this very problem. The Conference theme was "Creative Thinking and Practical Planning." Water plannint is never a simple or easy process. The engineering and scientific decisions are relatively simple to make, given time for adequate studies.

But the political decisions are the tough ones. When transfer of water from one basin to another is proposed, the basin of origin may not want to give up its water. Effective water planning involves the development of reasonable compromises. But the meaning of the word reasonable can be the fly in the ointment. I know when my twelve year old son and ten year old daughter have a difference of opinion and my wife or I seek a reasonable compromise, we find that these two young people often don't agree with us as to what is reasonable! In these cases a little parental authority comes into the picture to solve the problem.

Perhaps we may see governmental authority coming more into the picture in water planning. History has shown that this is often the only way to achieve a long range plan for the effective use of water resources.

Texas is committed to the development of a state water plan. Briefly, I'll review some of the water planning efforts in the State.

DEVELOPMENT OF A TEXAS WATER PLAN

Texas Water Plans.

Plans for the development of Texas' waters have, in the past, been largely uncoordinated. Many agencies have been involved in past planning activities. The State has not provided effective leadership in solving the problems. Therefore, the federal agencies have been attempting to provide the answers. It is probably not possible for agencies such as the Bureau of Reclamation, the Corps of Engineers and the Soil Conservation Service to adequately coordinate their planning activities unless the State provides an overall water plan into which the projects of the agencies can mesh. Also, if the state and local interests in water planning are to be protected, these levels of government must recognize their obligation in helping to finance projects.

U.S. Study Commission - Texas.

Public Law 85-843, approved in August 1958, authorized the establishment of the U.S. Study Commission - Texas. The area to be studied included eight river basins in Texas and the intervening areas.

The goal of the Commission was the formulation of a plan for the development of the land and water resources of the study area to meet the projected needs through the year 2010. The resulting report was to be such that it would effectively serve all levels of government. Eight specific objectives for the Commission's study were outlined. It is important to point out that the Commission was to prepare the best possible plan for the waters of the basins, considering all the resources available for development, but had no authority to adjudicate water rights or allocate water. Many state and federal agencies participated in the planning activities, as did the Universities.

The final plan, published in April 1962, consisted of over 800 pages and included details of needed reservoir facilities through the year 2010 on each of the major river basins. The report also outlined a possible lower aqueduct to transport water from the Southeast part of the State, parallel to the Gulf Coast to extreme Southern Texas. The possibility of such an inter-basin transfer of water was thoroughly studied by the Bureau of Reclamation and later proposed.

The planning of the U.S. Study Commission was very thorough. The major weakness of the plan, from a total State water planning point of view, was that the study area, while totally within Texas, comprised only 62 percent of the State. However, the report has served as a very important guide in later planning by all agencies in the State.

SOME SPECIFIC PROPOSALS

Several water development proposals have been submitted or are in the preparation stages in Texas. As indicated earlier, the desirable

degree of coordination between these plans has not been achieved. I will very briefly discuss some of these.

Texas Basins Project

The Bureau of Reclamation has proposed a 1.3 billion dollar project which includes 17 major reservoirs and a 400-mile canal. This canal will transfer three million acre-feet of water yearly from the State's eastern river basins along the Gulf Coast to South Texas.

Crucial decisions on water rights, agricultural development, recreational by-products, and project finance and operation are involved in the Bureau's proposals. The final report on the project will probably be released this year.

Louisiana Export.

The Corps of Engineers office in Vicksburg, Mississippi, which has responsibility for water development in the northeast corner of Texas, has advanced tentative proposals for using water from that area for large transport to Shreveport, Louisiana, and for irrigation projects in Louisiana.

Colorado River Master Plan.

The Corps of Engineers office in Dallas has presented a preliminary version of a master plan for development of the upper reaches of the Colorado River. This plan has raised a series of major questions about water rights, economic allocations and priorities in and near the Colorado Basin. Some action on the proposals may be expected this year. The Corps is also preparing master plans for the Neches, Brazos, Sabine, and Red Rivers.

Soil Conservation Service.

The Soil Conservation Service already has constructed some 800 of 4,000 planned small upstream reservoirs and flood retarding structures. Many of the State's river authorities have assisted in this program and coordinated the projects with larger water supply and flood control reservoirs. However, only a fourth of the major river basins in Texas are under the unified direction of a single river authority, and the full potential of the Soil Conservation Service program, particularly with relation to recreation development, yet to be realized.

STATE WATER PLANNING AGENCY

The State Board of Water Engineers was established in 1913. The Board had authority to grant permits for water projects and the appropriation of water, and to determine the amount of water available for appropriation. In 1955 the Board was also made responsible for determining the feasibility of proposed federal projects.

Through the 44-year period from 1913 to 1957, the Board of Water Engineers was primarily a quasi-Judicial administrative court. It had almost no staff, and depended upon the U.S. Geological Survey to make the necessary measurements and calculations. The State's role in water development exercised through the Board of Water Engineers, was almost

totally passive. In 1957 three significant new functions were assigned to the Board. It was made responsible for:

1. Preparing and submitting to the Legislature a statewide water report on the water resources of the State.

2. Negotiation with the United States, or any agency of the U.S., for the development and acquisition of conservation storage in reservoirs.

3. Cancellation of water permits or certified filings which had not been put to beneficial use in ten years.

These new responsibilities comprised an action program in both water development and water rights and drastically changed the nature of the Agency.

The State Board of Water Engineers was reorganized and renamed the Texas Water Commission in 1962. This reprganization laid the foundations for the separation of planning and water rights administration.

In 1958, the Board of Water Engineers submitted a brief water plan for Texas through the year 1980. However, the plan was not sufficiently comprehensive to be of value in long range water planning. In addition, many federal agencies were developing plans for Texas and these were not, in the Governor's judgement, adequately attuned to the needs of all of Texas. Therefore, on August 12, 1964, the Governor directed the Texas Water Commission to begin at once to develop a comprehensive State water plan to provide for the needs of all of Texas through the year 2020. The request is an enormous one. Many agencies are participating in the planning effort. One effect has certainly been to bring the importance of water to the attention of all Texans.

Some recent results have been a total reorganization of the State water agencies. The 59th Legislature passed Senate Bill 146 creating the Texas Water Development Board. The Board is directed to be the State water planning agency and develop the comprehensive water plan requested earlier by the Governor. Senate Bill 145 was passed which reconstituted the Texas Water Commission as the Texas Water Rights Commission and freed it of all responsibilities except the protection of public interest and private rights in water development. Senate Bill 144 approved the expenditure of the second $100 million of the $200 million Water Development Fund voted by Constitutional Amendment in 1957. Finally, Senate Joint Resolution 19 submits a Constitutional Amendment to popular vote in 1966 to add another $200 million to the Water Development Fund.

You can see that Texas is moving in water development. The Comprehensive Plan is now being developed by the Water Development Board. I might add that Texas A & M University has been working for over a year assisting in the development of this plann. At the request of the Governor, the Texas Agricultural Experiment Station, the Texas Agricultural Extension Service, and the Water Resources Institute have been working on a very thorough study of future agricultural water requirements. The present schedule of the Texas Water Development Board is for the plan to be ready prior to the next legislature. Before long, we will now know more about how the water in Texas might be developed.

Table 1. Average annual water budget for Texas[4]

	Acre-feet	Acre-feet	Percent	Acre-feet	Percent
INCOME					
Rain, snow sleet	366,600,000				
OUTGO					
Runoff		52,446,000	14.2		
Industrial, municipal irrigation				7,500,000	2.0
Surface evaporation				3,000,000	0.3
Discharge into sea				41,946,000	11.4
Evaporation		145,000,000	39.6		
From plant cover				45,000,000	12.3
From soil surface				100,000,000	27.3
Soil moisture transpiration		168,154,000	45.9		
Non-economic plants				138,154,000	37.7
Cultivated crops				11,000,000	3.0
Range and pasture crops				11,000,000	3.0
Commercial timber				8,000,000	2.2
Ground water storage		1,000,000	0.3	1,000,000	0.3
Totals	366,600,000	366,600,000	100.0	366,600,000	100.0

[4]Taken from reference (5).

SELECTED REFERENCES

1. A Plan for Meeting the 1980 Water Requirements of Texas. Texas Board of Water Engineers, May, 1961.

2. An Assessment of Large Nuclear Powered Sea Water Distillation Plants. A Report of an Interagency Task Group, Office of Science and Technology, March, 1964.

3. Elements of the Texas Water Problem--The Background and Basis of a Solution to the Problem of Water Supply in Texas. U.S. Department of Interior, Bureau of Reclamation, January, 1957.

4. Federal Water Resources Research Activities. Committee Print, Federal Council for Science and Technology, March 25, 1963.

5. Geological Survey Research, 1964. Chapter A, U.S. Geological Survey Professional Paper, 501 A, 1964.

6. Johnston, J.R. The Significance of a Water Budget for Texas. Proceedings, Third Annual Water for Texas Conference, Texas A & M University, College Station, Texas, 1957.

7. Leopold, Luna B. and Walter B. Langbein. A Primer on Water. United States Department of the Interior, Geological Survey, 1960.

8. MacGowan, C. F. Salt Water Conversion, A Progress Report. Agricultural Engineering, 45: 32-33, January, 1964.

9. MacKichan, K. A. and J. C. Kammerer. Estimated Use of Water in the United States, 1960. U.S. Geological Survey Circular 456,1961.

10. Part I - The Commission Plan. Report of the U.S. Study Commission - Texas, March, 1962.

11. Part II - Resources and Problems. Report of the U.S. Study Commission - Texas, March, 1962.

12. Part III - The Eight Basins. Report of the U. S. Study Commission - Texas, March, 1962.

13. Pealy, Robert H. Organization for Comprehensive River Basin Planning - The Texas and Southeast Experiences. University of Michigan, Institute of Public Administration, Michigan Governmental Studies #46, 1964.

14. Revelle, Roger. Water Resources Research in the Federal Government. Science, 142:1027-1033, November 22, 1963.

15. Schleusener, Paul. Research Needs in Rural Waste Utilization. Agricultural Engineering, 45:492-495-499, September, 1964.

16. Scientific Problems of Weather Modification, National Academy of Sciences, Washington, D.C., 1964.

17. Summary and Recommendations. Report of the U.S. Study Commission - Texas, March, 1962.

18. Texas Water Planning - A State Responsibility, A report by the Texas Water Commission, Austin, Texas, 1964.

19. Texas Water Resources Planning at the End of the Year 1958, A Progress Report. Texas Board of Water Engineers, December, 1958.

20. The Structure and Authority for State Leadership of Water Development in Texas. A report to the Texas Water Commission and the Texas Water Development Board, the Texas Research League, Austin, Texas, Volume 1, 1965.

21. The Texas Water Problem - Its Solution and Economic Impact. U.S. Bureau of the Interior, Bureau of Reclamation, April, 1963.

22. Walsh, John. Weather Modification: NAS Panel Report and New Program Approved by Congress Reveal Split on Policy. Science, 147:274-276, January 15, 1965.

23. Water Rights and Water Resource Administration in Texas. A report to the Texas Water Commission and the Texas Water Development Board, The Texas Research League, Austin, Texas, Volume 2, 1965.

24. Wolman, Abel. Water Resources: A Report to the Committee on Natural Resources of the National Academy of Sciences--National Resources Council. Washington, D.C., 1962.