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NEW DEVELOPMENTS IN TURFGRASS MANAGEMENT

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The field of turfgrass management is currently following the general trend in all American technology. New materials, operational methods, automation, and personnel management are being adopted in all phases of the work. Your obligation to users of your product has forced these changes in order to provide them with the most enjoyable or usable turfed areas for the longest possible period of time.

There are many machines and materials currently being marketed that will point the way to even better application of new management principles. Many more, however, are gimmicks designed to catch the fancy of the unwise who continually look for the easy way out of a problem. Many people have been lured into the turfgrass field simply because it offers new leeway to their questionable talents. For instance, the use of automatic irrigation systems has expanded tremendously in the last couple of years, not only in arid sections of the country, but also in the upper Midwest, Northeast, and Canada where the irrigation season is only two to three months long. Too many of these new systems simply do not work properly. The material is not the only cause for failure - poor design is probably the major factor. Automatic irrigation has proven itself to be a useful tool in proper application of water and in the elimination of many man hours of work. Criticism is based on the activity of a few people whose activities degrade the entire industry.

Just look at the numbers of new mowing machines, vertical mowers, fertilizers, chemicals and soil amendments on the market. The ballyhoo and claims of many are reaching fantastic limits. These developments make it more important than ever that the turf manager carefully scrutinize all angles of every new item prior to purchase. He must know what he wants and draw up absolute specifications to assure his receiving it. He must convince his purchasing agent or committee that certain things are necessary, and substitutions based on price alone could be hazardous. Now, more than any time in the past, quality is of prime importance.

Many of the "new" practices are revivals of old methods, proving the great degree of art still remaining in this business. Spiking and topdressing, for instance, are going through a renaissance of activity. Why? Because they help provide better quality turf on golf courses.

Composting of soils is a very old practice currently being reactivated in many areas - parks as well as golf courses. With good soil being harder to acquire, users must build their own. In the Boston area, it is illegal to move sod out of some townships because sod removal means soil removal. The Salem Country Club, north of Boston, has to buy soil from New Hampshire. This is not an urban problem, since good topsoil has been almost impossible to get in or near Augusta, Georgia.

Topdressing revival has been accomplished by several factors. These include advanced soil sterilization procedures such as easily handled liquid and gaseous sterilants, composting, and soil pasteurizing with heat. New self propelled topdressing spreaders also contribute greatly. Even though these machines are rather expensive, if one man can topdress and drag ten average greens in a day, the cost is worthwhile. (This has been done, by the way).

Soil amendments are enjoying tremendous popularity now not only because good soils are hard to get, but also because of mistakes we and our predecessors made years ago. Since a good deal of time is required to judge these things, it is very likely we are making mistakes in some of their uses today and will suffer again in the future.

New chemicals making their appearance on the market offer better controls for many problem weeds. Among herbicides, MCPP and Banvel D seem to be doing an excellent job eradicating hard-to-kill broadleafed weeds safely - even in bentgrass turf. Others are, no doubt, on their way, and careful application of these new tools will reduce future weed problems.

Fungicides are being added to our list of turf aids almost as rapidly as insecticides. Dexon, for the control of Pythium, is among several notable new contributions of our industry. This in no way detracts from older chemicals made by other companies. It does, however, mean that the purchaser must insist on buying from the companies that assure quality control.

One of the greatest developments in mowing is the hydraulic tractor-gangmower combinations. This machine saves transport time between mowing areas and reduces mower damage on streets and service roads. Dethatching and trash pickup equipment is becoming quite important on golf fairways being heavily fertilized and irrigated. New spray equipment is easing the chore of chemical application. Spinner-type fertilizer distributors greatly reduce the time required to fertilize large turf areas.

A club operator near Milwaukee has mechanized to a high degree, using hydraulic gang mowers and automatic irrigation. He realizes the irrigation must be checked periodically during night operations. The man who checks it will be riding on the gang mower setup, well supplied with adequate lights to do two jobs at the same time. This same operator has eased the problem of picking up balls from his driving range. It will be a lake - using floater balls. A gentle current in the lake will concentrate then at the outlet, so he will recover clean balls with a dip net.

You see, the turf business today is truly a complicated one. New materials and methods continue to open new opportunities for us all. All these wonders must still be accomplished by men, though, and manpower is the most expensive single item on any turf manager's budget. Dave Miller, superintendent at the 42 hole Saucon Valley Country Club in Pennsylvania uses between 35 and 42 men - depending on whether they wish to work 8 or 9 hours a day. In spite of this seemingly large crew, his organizational ability has reduced his manpower budget from 68% to 63% of the total budget. Many superintendents are striving to mechanize where possible to reduce total man hours required to maintain turfed areas. By so doing they can pay better wages, thereby demanding a better class of workmen. The expenditure for higher wages and better personnel actually means a saving since they make better use of their time, take better care of the tools, and can be trusted with more detailed jobs.

Today technical assistance is available from a wide range of sources. State Colleges and Universities in approximately 32 states have people qualified to assist in solving turf problems. Most national and statewide commercial firms dealing in turf supplies employ one or more field representatives capable of rendering assistance in general or special problems. The United States Golf Association provides a Green Section service to member clubs. One golf course superintendent said that he had agronomists running around his course all the time with some con job or another. Turf managers must weigh the advice of consultants because personal opinion still plays an important role in attaining the goals of good turf.

Recently several country clubs have been approached by management groups offering to take over the chores of entire club management, including the course itself. Most of these have proven unsuccessful, probably because of the lack of personal interest by the men in charge of the operation. But I'm sure that this will continue to be of interest to clubs and opportunists who see shortcomings in the current system. Contract management of industrial and home lawns has become a profitable business in most cities. The future of the current golf course management system will depend upon efficiency of operation and the general conditions of the course.

Consultants, paid by a club to assist the golf course superintendent, are not necessarily an evil. In industry, engineering consultants play a vital role in assisting highly trained but overworked employees in solving special problems. Few turf consultants are efficiency experts. Any saving they might make is through the use of inferior materials or methods. Such savings are not in the best interest of the people who retain them. They should be employed to improve playing conditions by using their technical knowledge and broad experience in the field. Sometimes the aims of the club members or board of supervisors are in good faith but fail miserably. In one instance, a superintendent had worked at a club over 20 years - quietly and efficiently with the money made available by his budget. A hot shot became manager, the members wanted a better course, so a consultant (a flower grower, by the way) was hired. Between the manager and consultant, the superintendent soon began receiving directives every Monday morning, laying out his entire week's work - how much and what time. After normal hours of work, the superintendent was not to set foot on the property. In about two years the course began to degenerate - it took that long for the earlier good management to peter out. Members then fired the superintendent, manager, and consultant. After a year of hard work, the golf professional is bringing the course back into form - largely on programs initiated by the superintendent many years before. We must be thankful that few managers or clubs operate like this one.

To retain the system as it is now, the turf managers must not use new developments as a crutch to get them out of unforeseen difficulties. The new tools must be used to reduce the likelihood of the unexpected. Turf management must not busy itself in simply reacting to symptoms of weakened turf such as diseases, weeds, and wilt. They must anticipate problems with weak turf and correct the basic cause of trouble. By so doing, your employers will achieve greater enjoyment in your product, your employees will develop a greater sense of pride and accomplishment, and you will develop a greater sense of security from a job well done.

MOWING PRACTICES - AGRONOMIC PRINCIPLES

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To be suitable for the production of turf, a grass plant must be able to grow and persist under the environment to which it is subjected. Good turfgrass is judged by standards of playability and usability as the case may be, and unless a grass is able to survive under the type of maintenance demanded by players or users, it must be replaced or maintenance practices must be modified; otherwise, use must be restricted. For those concerned with the production of turfgrass, restriction of use always should be considered a last resort. The primary objective of the supervisor is to produce high quality turfgrass suitable for use or play irrespective of environmental adversity.

More often than not, practices which are desirable for good grass growth have to be modified extensively to meet turfgrass requirements for use or play. Such is the case with mowing practices. Height of cut on a putting green may serve to illustrate this point. The reduction in root growth that clipping to a height of 3/16 to 1/4 inch produces is well known - but try and convince a golfer that the green should be cut at a height of 2 or 3 inches! To compensate for the reduction in root growth, all other maintenance practices - fertilizing, watering, cultivating, and programs of disease, insect, and weed control - must be balanced one against the other and applied more intensively and with greater care.

Management practices, including mowing, must be keyed to the use for which the turfgrass area is being produced. Such severely limits the number of grasses that may be used to produce satisfactory turfgrass - only a few (25-30) out of the more than 1100 species known to grow in the United States. In view of the limitation that mowing places on selection of grass and intensity of management it may be well to ask "Why Mow?"

Why Mow? Appearance and playability are the principle reasons for mowing turfgrass. Unless it is mowed, a turfgrass area would soon become like an overgrown pasture - an area covered with loose growing, spindly grasses and tall, rank weeds which cannot persist under normal mowing practices. The manner in which turfgrass is mowed will greatly influence its health, vigor, density, degree of weed invasion, and longevity. In fact, good mowing practices are perhaps the most important factor contributing to a well groomed appearance and the longevity of any turfgrass area. The development of good mowing practices from an agronomic standpoint must be based on an understanding of growth habits and characteristics of grasses.

Growth Habits and Characteristics

On the basis of growth type, grasses may be classified into three general groups. Bunch type grasses, such as ryegrass and chewings fescue, produce new shoots which grow inside the sheaths of the previous stem growth. Stoloniferous grasses, such as bentgrass, spread by runners or stolons which develop from shoots that push through the sheath and run along the surface of the ground rooting at the nodes (joints). Kentucky bluegrass, a rhizomatous type of grass, develops shoots at the underground nodes. Some grasses,

such as bermudagrass and Zoysia, spread by both rhizomes and stolons. This is one reason why bermudagrass is such a vigorous grower and is so difficult to control and keep out of flower beds, gravel walks and similar areas. There are also intermediate types with decumbent stems which root at the nodes, such as crabgrass and nimblewill.

The grass leaf is remarkably adapted for intercepting a maximum of sun rays which are essential for photosynthesis. The long flattened grass blades provide a maximum of exposure with a minimum amount of protoplasm, thus making efficient use of the living tissue. A reduction in the plant leaf area exposed to sunlight reduces the plant's capacity to carry on photosynthetic activity. This is a vital and basic consideration in determining the frequency and height of cut of turfgrasses.

The ability of grasses to withstand frequent and relatively close cutting is related to certain peculiarities of the grass family. Grasses exhibit basal growth, as opposed to terminal growth found in most other plants. Basal growth means simply that growth initiates at the base rather than at the tip of the blade or stem. From a practical standpoint this means that normal and frequent mowing does not cut off the growing areas of the grass leaf. Removal of too much leaf surface at any one cutting may, however, destroy some of the growing points.

Height of Cut

The height at which a given perennial grass can be cut and still survive for extended periods is directly related to its ability to produce sufficient leaf surface for the photosynthetic activity required for its growth. Basically, this ability is related to the inherent type and habit of growth found in the grass. The length of internodes, the number of stolons or rhizomes, and the number of basal buds all influence the amount of leaf mass produced by a given grass; hence, affects its ability to withstand low heights of cut.

Creeping type plants, such as bentgrass and bermudagrass, when properly fertilized and watered are able to produce adequate leaf surface at very low heights of cut (3/16 inch). Buffalograss, although a creeper, cannot produce sufficient leaf mass at low heights because too few basal buds exist and, therefore, cannot withstand low clipping. For this same reason, Kentucky bluegrass and fescue must be cut relatively high (1-1 1/2 inches). If bunch type grasses are cut close, too much leaf surface is removed and the plant can no longer carry on sufficient photosynthetic activity to sustain satisfactory growth.

Frequency of Cut

Frequency of mowing is also an important consideration in the maintenance program. Infrequent clipping allows the grass to elongate to such a degree that any subsequent clipping removes an excessive amount of leaf surface. At no time should clipping amounts in excess of one-third of the total leaf surface be removed at a given mowing on lawns. Removal of large amounts of leaf surface will produce stubbly, unsightly turf, cause excessive graying or browning of the leaf tips, and curtail the photosynthetic production of food with a resultant depletion of root reserves.

In addition, the accumulation of excessive clippings may smother the grass and provide excellent environmental conditions for disease organisms

and insects. The frequency of clipping must be governed by the amount of growth, which, in turn, is related to weather conditions, season of the year, soil fertility, moisture conditions, and the natural growth rate of the grasses, and - most important - the use for which the area is being grown.

Other Considerations

In addition to the mowing practices related directly to habit of growth, there are other considerations that must be taken into account when developing a sound mowing program.

Stage of growth. The stage of growth of turfgrass plays a major role in mowing practices. Young tender growth in the spring is generally soft and succulent. The moisture content of young immature turfgrass is much higher than that of mature grass. Likewise, the fiber content of young grass is much lower than that of mature grass. Such a condition influences mowing practices. Tender young grass must be cut with a sharp, well adjusted mower to avoid mechanical damage, and the early growth must be cut frequently to avoid the problems associated with high moisture.

Mowing practices during the early stages of growth exert a material influence on density of turfgrass. Cutting at heights somewhat lower than normal during early spring will encourage lateral growth which, in turn, promotes density and helps prevent weed invasion.

Washboard effect. Turfgrass areas regularly cut with power mowers or gang mowers sometimes develop a series of wave-like ridges running at right angles to the direction of mowing. If such is not caused by too wide a frequency of clip, it may be prevented or partially remedied by regularly changing the direction of mowing (diagonal or right angles). Alternate directions of cut will partially control runners of creeping grasses and aid in the prevention of grain and thatch. If clip is responsible, the height of cut must be raised or the mower replaced with a unit having more blades or a faster reel speed.

A very similar washboard appearance is often observed on turf areas, but is no fault of the mowing equipment or the operator. Many times land is plowed for seedbed preparation and not properly disked and leveled prior to seeding. Settling then takes place in the plow furrows and unevenness develops. Such a situation may be reduced in severity over a period of years by heavy aeration followed by dragging. The dragging operation generally will remove most of the soil cores from the high areas and deposit them in the low areas.

Wet conditions. Mowing wet grass should be avoided as much as possible, although available labor and time often make it impractical to do so. Dry grass cuts more easily, does not ball up and clog the mower, and gives a much finer appearing lawn. Timing tests show that mowing dry grass requires less time than mowing wet grass.

Uneven terrain. Mowers are not built for grading purposes. Turf areas containing high areas which are continually scalped should be regraded in order that they may be cut properly and to reduce the wear and possible damage to mowing equipment.

Inadequate insect control can become a serious mowing problem. Areas heavily infested with earthworms or ants may have many soil mounds caused

by their activity. Such may cause soil to build up on rollers, or in severe cases simply cause the units to bounce, both cases resulting in an uneven cut. Mounds of earth thrown up by gophers and other soil burrowing animals will have the same result.

Improper operation. Irregular or uneven cutting often occurs due to bouncing of the mowing units when they are pulled at excessive speeds. On specialized areas such as putting greens, bowling greens, lawn tennis, etc. improper handling of the mower on turns will result in turf damage through bruising and wearing of the grass.

Terraces and banks. Terraces and banks offer a difficult mowing problem. Scalping generally will occur if the bank or terrace is mowed across the slope. Up and down mowing generally is the most satisfactory method of cutting these areas.

SUMMARY

Mowing is not a simple operation to be regarded merely as a means of removing excess growth. Mowing practices are related to the species and strain of turfgrass being grown. The inherent physiological, anatomical, and morphological characteristics of a given grass will determine the height and frequency of mowing that will give the most satisfactory performance. Mowing is the most time consuming of all management practices and has far reaching affects on the appearance and longevity of any turfgrass area.

PROFESSIONAL SELF IMPROVEMENT

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Introductory Remarks:

Three men were laying brick.
The first was asked: "What are you doing?"
He answered: "Laying some brick."
The second man was asked: "What are you working for?"
He answered: "$20.00 a day."
The third man was asked: "What are you doing?"
He answered: "I'm helping to build a great University."
Which man are you?

With this as a somewhat unorthodox beginning, you are going to be put to work this morning both physically and mentally. ---------- A "Do It Yourself" exercise on this second day of the Texas Turfgrass Conference. Be warned ---------- you are in for a treatment rather than a treat. However, when it is all over, I hope you will forgive and forget me -- yet retain the experience as a memorable one and perhaps even a profitable one.

If I were to ask you as a turf manager to list - on one of these cards - the central or general difficulties you face as a supervisor today, I'll bet they would fall under two general categories ---------- 'increased costs' and 'intensive turf usage'. It is no surprise to any of us that for every dollar spent on turf maintenance, 65 to 70 cents is spent for labor. Why is it then that so few of us have spent such a small effort in improving ourselves in this area? We are anxious to improve our knowledge of insecticides, fungicides, and fertilizers, but we do little or nothing toward improvement of personnel management. Good supervisors must constantly strive to improve their skills and techniques in handling people successfully. American industry knows that this pays off and they continually train and retrain their supervisors in this area.

A parody on this subject of 'personnel management' recently appeared in the publication of The Northeastern Golf Course Superintendents' Association Bulletin, 'Our Collaborator'. Let me read it to you and see if there is not a familiar ring here for you:

> "A turf manager has practically nothing to do except decide what needs to be done; tell someone to do it; listen to reasons why it should not be done, or should be done by someone else, or done in a different way.
>
> He must then follow up to see if the thing has been done; to discover that it has not; to ask why; to listen to excuses from the person who should have done it; to follow up to see if the work has been done properly at last, only to discover that it was done incorrectly.
>
> He must then point out how it should have been done; to conclude that as long as the work has been done to let it stay as it is; to wonder if it isn't time to get rid of a person who cannot do a thing right, but also to reflect that he probably has a wife and ten children, and that anyway, someone else would be just as bad if not worse.

He must then consider how much simpler and better the work would have been done if one had done it himself in the first place; to reflect sadly that one could have done it right in 20-minutes, and that, as things turned out, one has had to spend two days to find out why it has taken three weeks for someone to do the work the wrong way."

The humor and tragedy of the above is that it is so often true. How often have you heard it said, "You just can't hire the type of men that you use to be able to hire." Now there is always danger in this philosophy of 'looking backward'. You may become so enchanted with where you've come from, that you forget where you are headed. All of us sometimes sigh for "The Good Old Days", but that must not keep us from taking deep breaths in the fresh air of the present.

We are turf managers and supervisors. Constant self improvement is as vital to each of us professionally as an annual checkup with the doctor is physically. Labor management is taking the bigest bite of our budget dollar, and therefore, this is a fruitful field to explore in our efforts of self improvement.

It is a broad field --- Labor Management --- and this morning we are only going to explore a very small part of it. We are going to try to catch an insight to the motivations and feelings of the men on your crew. Never forget that it is your worker's success that is your success.

With this in mind, we are going to attempt some very simple projects and, if the effort is to prove worthwhile, your full interest, co-operation, and participation is needed. Particularly participation. For this reason, let us completely relax and consider this an informal affair.

Each of you have received three of the 5 x 8 cards normally used for office indexing. Now the first project will be for everyone to take one of the index cards and make one of these simple paper boxes exactly like the one I hold in my hand. This is a very simple box made from a flat piece of paper exactly like the one you have before you.

This is an audience of above average intelligence and we will surely have no difficulty in solving a fourth grade problem. Incidentally, the box is leak proof, there are no cracks in the bottom or on any of the box sides. All of the edges of the paper are at or above the top level of the sides of the box. Please take a few minutes now and make one of these boxes. Your co-operation is needed since the rest of my talk depends on you making such a box right now.

(considerable pause)

Well, I can see that things are not going too rapidly on this first project so let's stop our work and have a brief word of explanation. I'll show you very briefly how to make the box so that we can proceed.

First, let us take a new sheet of paper and start again. This should be folded into three equal parts. This is done in width as well as in length of the paper.

(Demonstrate)

Now, in the upper left hand square that has been formed by these folds, all you need do is fold from the center of the lefthand margin to the lower righthand corner of this upper lefthand square. Repeat this on all four corners. Very simple ---- a fourth grade project. Now, if you would be good enough to complete the box as rapidly as possible we can go on to the next project.

I am quite surprised that in this room of men who have been most successful in a number of fields, we are having so much difficulty with this simple project. I've given thas talk a number of times before and this has never happened. Now let's get going by applying ourselves and then we can move forward to the next undertaking.

Here is the box. It is made with the same type of paper that I asked you to make yours from. It is a leakproof box with all of the edges at or above the top level. There is no need to tear the paper or maneuver it in any way other than folding as instructed earlier.

(several moments delay)

Well, this project is simply not working out. Let's all stop our work now and see if we can discover what has gone wrong. There is not a great deal of mental or physical skill required to carry this folding operation to completion. But we haven't reached first base. What are some of the reasons the project has failed?

(ask audience)

1. You have never been exposed to this type of work before.
2. The speed of my explanation.
3. The terminology used.
4. The mirror effort.
5. No motivation.
6. Poor physical relationship in this room.
7. There was not a successful environment; I.E. none of your 'co-workers' were succeeding with the project any better than you were.

Alright, let's try to correct as many of these as possible and we will put together one of these simple boxes after all.

First, let me develop your interest or motivation for this undertaking. After all, you should know what this box is good for, if anything. Well, the terminology and correct name for this type of box is a "painter's box." Painters use them quite frequently I am told, when they are doing field work such as painting signs along the road, on store fronts, etc. This simple box holds paint indefinitely, it is leafproof, the paint cannot run out and it gives the painter an opportunity to mix paints for a particular tone or shade that he may desire without having to use a lot of extra equipment. After it has been used, it is easily destroyed and no cleaning or storage problem is encountered.

Now if you are not a painter, the box may still come in handy at a meeting such as this for an ashtray if one is not provided. You could also use it on a camping trip as a cup or small container. If nothing else, you can amaze your friends, and the wife and children by making

a leakproof cup from a flat piece of paper.

Now, let's take the third sheet of paper and we will slowly go through the complete explanation that, in the end, you will find very simple.

As in the beginning, fold the piece into three equal parts in width as well as in length. Then, starting with the upper lefthand square, make a fold from the middle of the left paper margin to the lower opposite corner of the square.
(repeat the explanation slowly until everyone has this step.)

Repeat this folding operation on all four corners. After completion, fold the ends into place and finally fold the flap down to lock the cup together. (repeat explanation)

In the last several minutes, I have tried to reverse tables on you. You have been placed in a subordinate's position. Exactly the same position that your men face each day on the job. You have experienced some of their emotions and feelings. When we first started the project, I'm sure many of you resented me a bit for expecting you to know how to build a box without any explanation. When any of us are exposed to a totally new experience or requirement, regardless of our intelligence, we are in a difficult position and not always "ourselves." If, in the past several minutes, this message has been brought home to you in a forceable manner, then our "do it yourself" visit together has been a successful one.

They say that "the first step in solving any problem is in recognizing that a problem does exist." We must all recognize that one of our major problems is to improve our skills and techniques in handling people successfully. How many times have you heard someone say, "I've told that fellow a dozen times how to do that job, and still he doesn't know how." This shows that someone has done a poor job of training. "Telling" is not instructing.

Instructing is telling, plus showing, plus tryout performance and follow up. Let the worker do the job. Ask him questions. Let him ask you questions. And before putting him on his own, make sure that you know that he knows.

John D. Rockefeller once said, "Good management consists of showing <u>average</u> people how to do the work of <u>superior</u> people." It is not too difficult to be a good instructor. It does require patience, tolerance, tact, and an honest desire to "know your people." Recheck yourself on these points every so often. This is important. Most people want to do a good job and it is up to you to motivate them and to show them exactly what is expected. If you will do this, you will surely succeed as a good supervisor.

As mentioned earlier, we have touched on but one phase of the many duties of a golf course superintendent. There are so many other phases involved that, it seems to me, we must develop a new philosophy ---- a "total philosophy of management" if we are to succeed. With this in mind, I should like to leave this thought with you in closing:

If you think you are beaten, you are;
If you think you dare not, you don't:
If you want to win, but think you can't
It's almost a cinch you won't.
If you think you'll lose, your lost;
For out in the world we find
Success begins with the fellow's will;
It's all in the state of mind.
Life's battles don't always go
To the stronger and faster man.
But sooner or later the man that wins;
Is the man who thinks he can.

HOW GOOD A SUPERVISOR ARE YOU?

Here's a chance to find out. Next to each of the twenty-five questions listed below put a check mark in the appropriate column at the right (Always, Usually, Sometimes, Rarely, Never).

1. Do I know the "Why" of everything I do?
2. Do I do anything above bare essentials for the job?
3. Do I seek help from others when I need it?
4. Do I know how to do all phases of my job?
5. Do I make a positive approach to my job - avoid complaining?
6. Do I plan my work for the day each morning?
7. Do I maintain good communication in three directions? (up-down-sideways)
8. Do I maintain good working relations with others?
9. Do I maintain good team spirit?
10. Do I <u>think</u> <u>with</u> my people?
11. Do I treat superiors as I would want to be treated?
12. Do I always stay on top of my job?
13. Do I delegate work that others can do equally well?
14. Am I training an understudy?
15. Do I find interest in my assignment?
16. Am I alert to ways of improving my job?
17. Do I accept criticism cheerfully?
18. Do I accept responsibility cheerfully?
19. Am I open-minded to suggestions?
20. Do I work to get ahead instead of complaining when I don't?
21. Do I set up standards in order to measure my own performance?
22. Do I follow a plan to develop my own team?
23. Do I give credit for a job well done?
24. Do I listen to my subordinates?
25. Do I do my work in the easiest way?

Number of checks in each column					
Multiplied by	4	3	2	1	0
Column score					
Total score (add columns)					

Follow scoring instructions above.
A score of 90 to 100 is <u>excellent</u> - 80 to 90 is <u>good</u> - 70 to 80 is <u>adequate</u>
60 to 70 is <u>fair</u> - below 60 is <u>poor</u>

> "Money may be the husk of many things, but not the kernel. It brings you food, but not appetite; medicine, but not health; acquaintances, but not friends; servants, but not loyalty; days of joy, but not peace or happiness."
>
> -- Henrik Ibsen, Norwegian poet

HOUSEKEEPING EFFICIENCY ON GOLF COURSES

Grover Keeton
City of Dallas Park Department
Dallas, Texas

Good housekeeping has as many interpretations or definitions as there are individuals. When we say we want to adopt and maintain a good housekeeping program on this golf course, we actually have not explained anything. For example, to one laborman if the floor has been swept clean and the trash piled in a corner outside the clubhouse, this is good housekeeping; to another laborman doing the same thing but piling the trash out of sight of the public is cleanliness; to a third laborman it is not clean until it goes in a trash can, but then is the trash can a neat, painted container. So, we can go on and on. I think the best interpretation of good housekeeping can be explained when we say a place for everything and everything in its place. But with a good daily follow-up schedule and do not forget this word daily because it is a daily responsibility. A responsibility beyond or in addition to turf program responsibility.

Why Good Housekeeping?

Why is housekeeping important? First, you and I can say "this is simple, we all know it is important and I tell my subordinates and associates this all the time". But, just reminding them is not enough - explain to them - not only why, but how, when, and who.

1. We are in a profession which provides relaxation to people who are our customers not only by exercise and competition but by sight or beauty and odor.

2. Good housekeeping will minimize the loss of tools and supplies.

3. Results in a good equipment and tool maintenance program.

4. Eliminates fire hazards. Today, this is more important due to the storage and use of chemicals on golf courses.

5. A good employee moral builder.

6. A combination of these could also result in reduced expenditures.

How

Each organization has its own way of implementating a housekeeping program, but the following could be emphasized.

1. Although this is a daily matter throughout the year, the winter months could be used to "take inventory" of our own conditions. Make an inspection and take notes. It is easy to walk over, around, or not see an unsightly condition which could be corrected with a trash container or rearrangement of storage or a paint brush.

2. Involves

   A. Maintenance buildings
   B. Parking area - employees and customers

C. Walkways
D. Bridges - service and foot
E. Trash cans
F. Clubhouse area
G. Trees - underbrush, dead trees, etc.
H. Paint
I. Curbs and gutters
J. Service Drives
K. Fence row
L. Equipment - storage and cleaning
M. Hard surface areas

3. A written plan on what you plan to do this fall and winter and cannot do during the growing season is a good plan. For example, the following is a plan received on one golf course for this fall and winter - not all may be classified as housekeeping.

Fall and Winter Work Program

1. Watering System
   a. Repair all leaks
   b. Replace worn out coupling valves
   c. Check sprinkler heads, parts may be obtainable

2. Painting
   a. Tool barn
   b. Caddie house
   c. Benches
   d. Signs
   e. Tee markers
   f. Flag poles
   g. Trash cans

3. Trees, Planting, and Woodlands
   a. Trim and raise branches along Coombs Creek
   b. Remove dead wood from trees that were trimmed last year
   c. Regroup the 100 cedar trees that were planted along fence line of #10 fairway last year. (Contact landscape architect for re-grouping plan).
   d. Plant abelia hedge along street side of #6 tee.
   e. Put in several flower beds along Hampton Road and run water lines to these locations.
   f. Clean woodlands of trash, sticks, and mulch leaves as they fall from frost.

4. Tees
   a. Level and repair
   b. Several need to be enlarged

5. Fairways
   a. Improve watering system as much as material as available
   b. Continue Dallis grass control
   c. Put top soil on thin rocky areas when material is available

6. Construction replacements
   a. Four wooden doors on tool barn
   b. Resurface yard around tool barn

Conclusion

1. I think housekeeping must be on a high priority as one of our responsibilities along with our turfgrass program.

2. Create and instill in our organizations a desire for good housekeeping not only because the boss wants it clean but because he, the laborman, wants it clean.

3. Establish a policy - how we keep it clean through daily checking. The Navy at one time had a policy - if you can't clean it, paint it.

4. Establish a policy any laborman can understand - who is responsible, where is it stored.

PRESCRIPTION ROOTZONES WITH CALCINED CLAYS

Dr. W. H. Daniel
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Penncross bentgrass was seeded on 26 different rootzone mixtures in a total of 66 plots in September 1959. Section A. - DEPTH OF ROOTZONE - included 0, 1, 2, 4, 8, and 12" of 5 parts Turface, one part peat by volume over existing soil with drain tile. Section B. - 24 plots - SOURCES AND HARDNESS - included varying rates of calcined clays, sand, soil, and peat to an 8" depth. Section C included four replicates of six entries - LYSIMETER STUDY - for leachate studies - 12" of rootzone over 2" of sand, over 4" of gravel over tile in plastic lined pits.

In 1960 the area was topdressed three times; in 1961 three times, in 1962 only one time. The area was power spiked once in 1961 and once in 1962. The entire area has had a normal to heavy fertilization, including the ureaforms, Milorganite, and trace element complete fertilizers.

Various data on root depth, top growth, color, water holding capacity, wilting, foot-printing, and recovery from wilting have been recorded. Generally all mixtures will support good turf. Those that hold little available water may wilt readily; those high in soil tend to be very hard and compact. Rapid water penetration and freedom from weeds continues to be the outstanding characteristic of the calcined clays.

One of the leading questions on calcined clays concerns their durability. Freeze and thaw test under controlled conditions showed stability varied from 98 to 61%. Those 94% stable and above in this severe test were considered satisfactory. In one of the better materials the number of aggregates above 1 mm has dropped less than 3% in two full years under putting green conditions which indicates good stability.

Due to their porosity (up to 80%) the calcined clays handle water very fast. Infiltration rates after three years of putting green management without cultivation provide infiltration times of less than two minutes for 1" of water for some of the mixtures.

Initially we had hoped that the high percentage of large pores within clays would favor ample aeration and deep rooting; thus, reduce the need for hand-rinsing during hot weather. This has not proven the case. If anything, the east end of the putting green needs more attention to hand-rinsing during hot weather. This has not proven the case. If anything, the east end of the putting green needs more attention to hand-rinsing than the center portion composed of only 50% sand.

Many people ask about using straight calcined aggregates on topdressing along with repeated Greens-aire, or aerifier use. Layers of materials (sand, peat, etc.), which would change or affect capillary movement of water, are to be discouraged. Since calcined aggregates have ample capillary action in them, straight topdressing with mixing of old plugs seems quite practical.

On athletic fields we use a vertical slicer (subsoiler blade without base and with hopper attacher) to place calcined clay aggregates into vertical

slits into a tight soil. It required 8 - 50 lb. bags to go the length of the field. Such trenches greatly increased infiltration - from less than 0.5/hr. to 5.0" for first 15 minutes and 2.5 continuous after this. After placing slits on 3' centers, no water stood or ran off field in two years of observance. Such use on existing turf areas may reduce troublesome surface drainage problems in intense use area.

AUTOMATIC IRRIGATION SYSTEMS

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Moist O'Matic, Inc.
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There are numerous combinations of equipment and various types of controls that might be used in an automatic sprinkler system. Valves may be actuated hydraulically or electrically and may control one or a number of sprinkler heads. No matter what the method of operation, the same principles apply. Water when and where you need it.

One or all of the following reasons are usually given for the installation of an automatic sprinkler system.

1. Labor saving
2. Water saving
3. Better turf
4. Increased turf use

Let's examine each reason briefly:

Labor saving: No water personnel, which also eliminates seasonal labor demands and the problems of absenteeism. In the well-designed system, head maintenance will be reduced, since handling of sprinklers each night is eliminated.

Water saving: May be as high as 40% with proper design for the following reasons:

1. Correct amount of water applied each time on time. There is no chance for human error. Thousands of gallons of water can be wasted by just a few minutes overtime operation;
2. Irrigation at night loses much less water to evaporation;
3. A properly designed system has a set precipitation rate, which matches the soil intake rate, which prevents runoff waste;
4. Each small area has individual control so there is no need to overirrigate one area to apply sufficient water to another.

Better turf: The accurate control of water allows more accurate control of fertilizers. Both leaching and runoff are minimized.

Since head pressure can be accurately controlled, optimum sprinkler performance with smaller droplets can reduce the incidence of soil compaction and poor water distribution.

Sudden water demands from extreme weather can be quickly satisfied.

Better irrigation will give deeper and stronger root system.

The efficiency of an automatic sprinkler system depends on design. I must emphasize the importance of the initial design. The better the design, the longer and more obvious the savings when in operation. Each system must be custom designed to consider the soils, terrain, water availability and quality, winter temperature ranges, summer water requirements, wind conditions,

and time available for operation. Automatic systems cost somewhat more than a quick-coupling system and, therefore, must be efficient to be economical.

On the subject of costs - there are basically two cost factors to consider:

1. Initial cost
2. Operating cost

Adding both together over the probable life of the system will give the total cost. Automatic systems initially cost more than some other types of irrigation, but the operating cost is substantially less. On the average, the reduced operating cost of automatics makes up the difference in initial cost after about five years. The savings would accrue from this point on through the life of the system, perhaps another 15-20 years.

Initial costs vary with the type and size of system and types of materials used. This cost would also vary somewhat in different areas of the country.

Generally speaking, and at best these are rough figures, automatic sprinklers will cost up to $2,000 an acre on small areas and up to $1,500 an acre on a golf course -- many times considerably less. Total costs are decreasing every year as newer and more efficient equipment becomes available.

Tests are now in progress with the University of California Turfgrass Advisor in Los Angeles using tensiometers connected to automatic sprinkler controls, which promise to reduce still further the water consumption for irrigation.

Automatic irrigation has come a long way and this progress is accelerating. The past few years have proven many new products and materials. A great deal more lies in the future.

PRINCIPLES IN MAINTAINING ATHLETIC TURF

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We would agree that turf managers are constantly facing an increased use of athletic areas. Currently the professional teams schedule fifteen regular games; most colleges schedule nine or ten. However, our stadium areas, with their needed seating capacity, are receiving the brunt of this. I have heard that famous areas, such as the Cotton Bowl and Rose Bowl, have approximately fifty games per season. We have one high school field in Indianapolis with more than forty scheduled. However, these are not our major concern. Most of you are concerned with a regular schedule on an ordinary field with a limited budget for maintenance.

In my opinion the major thing that must be accomplished on athletic areas is to have rapid infiltration of water wherever it falls. It is unfortunate if water must run off the surface during use.

The second major requirement is that the area be smooth enough for running without looking both for high speed travel and safety.

Third, it is desirable to have the area covered with a dense turf for safety, beauty, and ease of play. Notice, however, that the turf cover is third in importance. Let's take these apart.

Many people have been concerned with the crowning of fields. Basically 2% slope is most ample. A 1% slope (10" crown over sidelines) is ample if the original surface is smooth. Now, if we accept the principle that water must penetrate where it falls, then surface drainage is relatively unimportant and flat surfaces may be just as satisfactory. Yes, this is almost heresy, but isn't it true?

I do believe that the day of extreme slopes on athletic fields will soon be passing. We have several stadiums (Ohio State, Notre Dame) where, if you stand outside one side of the field, you cannot see the feet of the players at the other side. This is a real disadvantage for patrons sitting on the lower seats.

A Uniform Surface

Consider an end running at full speed, trying to catch a pass, slight changes in unevenness can disrupt his stride, cause undue danger, as well as reduce the refinement in the game. For this reason, very uniform grades are desired and to achieve these, uniform soil preparation and ample settling is desired during construction. For established fields, surface topdressing may be the best way to correct minor irregularities. For a few fields, particularly in the south where newer grasses are being introduced, plowing and regrading may be the preferred solution.

In developing a field I personally like to use deep tines on cultivating bars, rather than rotating blades, so that there will be more uniformity at the surface after settling. Also, to give surface grading and uniformity, good wide drags, which can be angled, are preferred for finishing the surface.

The third item is a dense turf cover. We know this is last - the coaches tell us so. Look at their practice fields. Where they are not concerned with crowd observation they tend to wear out the middle, even though good turf is nearby. They tend to start plays in the middle rather than from a sideline or edge, or a point where good turf exists, so in the coaches mind turf is a luxury. Perhaps there are exceptions, but look around.

It is a desired luxury, however. You and I recognize that a uniform turf can mean much in safety to players, as reduction in injury, reduction in skin abrasions, etc. Also, a good turf cover helps to modify varying soil conditions - less dust, less mud, less wind, more uniform cleanliness, better line identification, etc.

Fertilization

Within the limits that the grass you are growing will respond favorably, I am a strong believer in using fertilizer on athletic areas. For bluegrass this means fertilizing in early spring, lightly in late spring, heavy in mid-August, and again heavy in mid-October - four times a year.

For Bermuda four applications a year would be needed to start growth in the spring, to push growth in the summer, to maintain excellent color in early fall, and to force some growth in late fall as soil temperatures drop. If the soils are cold, soluble nitrogen may give much more initial response. If the soils are warm, organic fertilizers and slow release materials seem to work well and give more uniformity in release.

Basically the key in management is to fertilize most heavily to produce growth during the period of most use. Thus, on a minimum budget you may skip on fertilizing in early summer, even in the spring, but do put on plenty in the fall period prior to use and during use.

As a rule newer varieties of grass being used, both cool and warm season, are those that tolerate and respond to ample nitrogen.

Mowing

Bluegrass management in its zone seems to be best when it is mowed high during the summer, 2-3", then gradually reduced in the fall back to near 1.5" for play. The extra high mowing permits more energy reserve, tends to reduce summertime weed infestation, and favors a deeper root system. Then, with the closer cut in the fall, you have a firmer, better turf with less divot damage. In Bermuda the height of cut may be more uniform throughout the season. There seems to be little reason for neglect in mowing any grass at any time.

Rootzone Improving

Over the years you have been encouraged to use sandier, more-porous soils, We have tested the calcined clay aggregates in slits by attaching a hopper to a sub-soiler and removing the sub-soiler shoe. This permitted the application of vertical slits of calcined clay so we were getting an open, porous channel from the surface downward. This favors rapid removal of excess water from the surface.

Based on this principle first used at the Purdue stadium in 1961, we have had three seasons without any surface runoff at any time. Actually the soil present is a heavy silt loam which is almost impervious to water. In our experience with our equipment it took eight bags of calcined clay to make one slit the length of the field. Such treatments are rather long lasting unless the surface is reworked, or sod is re-laid. Eventually new slits might be needed which could be done during any season as desired. The point is such techniques do give greater water infiltration into established areas.

Other techniques, of course, help a great deal. All of you know the benefits of aeration to reduce compaction. My preferred use of these is intensely once a year; perhaps going over an area four to six times with an aerifier, if needed, to completely loosen the soil during one day's operation.

Plugging and Repairing

Plugging and repairing becomes most important in the cool season grasses where stadium turf receives high levels of maintenance. Currently we are unable to grow dense enough cool season grasses that cleats will not remove plugs of turf under ordinary conditions. However, the key to plugging and repairing is to be prompt. There is always paper to pick up, other maintenance to be done, but give plant life priority in every operation possible. With warm season grasses repair may not be needed during the season, but may be needed more in spring if there has been winter damage, or winter kill. Again, earliness is the key.

How Much Wear Will Turf Stand?

Not only in athletic areas, but under many conditions there are areas which receive such constant or intense use that turf fails in ordinary management. The first question then to ask is - how much can you improve management? If, with good management, you are unable to grow turf around schools, parks, even on some athletic areas, you may have to resort to loose, bare surfaces. Perhaps it is just plain soil, or pea gravel, or sand mixed with soil, tanbark, or sawdust. These, of course, also present problems. For areas where people do not fall as part of a game, hard surfaces are the final resort. You may have heard of some of the newer materials - stabilized ground rubber, or the new material from the 3M Company, which may greatly upgrade hard surfaces for athletic use.

Frankly, I am optimistic. We have much better grasses, calcined clays, better equipment and easier-to-use fertilizers.

Looking ahead we are now testing the use of electric cable for soil warming. It offers much promise. As an adjunct to that we are considering developing athletic areas without surface drainage, all of which will further upgrade the use of athletic areas in the future.

LANDSCAPING COORDINATED WITH TURF

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First, let us clarify a point of work useage. Generally, when we speak of landscaping, we consider the complete planting, including the grass. Landscaping will include the planting of grass, trees, shrubs, annual flowers, and other miscellaneous ornamental plantings. Within the scope of landscape architecture will also fall such improvements as sidewalks, steps, retaining walls, parking areas, and other miscellaneous structural facilities.

To bring us back around to a point of beginning, let us consider that our subject or coordination is divided into two parts. One is the establishment of turf, and the other is all of the other above-mentioned phases of landscape architecture. We here, as turf men, will consider the coordination of grass and other plantings. Such things as topography and irrigation systems, which are closely common to both parts of the overall development, will not be discussed to any degree.

It is apparent that where ornamental plantings are to occur within or adjacent to turf areas there must be someone qualified at a higher level to decide when the various stages of the over-all development will take place. We can readily forsee the anxious moments which would transpire when a truck load of shrubs and trees drives across a newly seeded or sodded area to a spot where an ornamental bed is to be planted. This situation could exist in any ordinary park, golf course, or school area. Some organizations are such that different groups are responsible for different phases of the work that is to be done. Private golf courses may be less subject to this diversity of phases but would still have it to a certain extent. It is vital that all the parts of the development be ultimately responsible to one authority for coordination.

General landscape designers usually emphasize all the stages of a complete development with impartiality. Having been formally exposed to the specialized field of turf grass management for a number of years, I must admit that I have come to place a slightly greater emphasis on turf in my overall park operation. When I look at a landscaped turf area, I often compare it with a carpet in a room. Furniture in the room complements the carpet. If the carpet is worn, or has holes in it, it detracts from the furniture, which we can compare to ornamental shrubs. If there is no carpet, and an unsightly floor is showing, then the furniture has little meaning. Of course, the reverse of this situation is also true.

In developing a turf area we know that once the area has been prepared and planted, nothing except footsteps are welcome in the area, and sometime, not even those. So, if ornamental planting is planned for the area, it should be planted beforehand. When the final grade has been established in an area, then trees and shrub beds should be planted beforehand. When the final grade has been established in an area, then trees and shrub beds should be planted with the final seedbed preparation and planting of grass to follow as soon as possible, thereafter. With initial heavy watering of the shrubbery and trees, the watering of the turf area will, if properly planned, be sufficient to provide enough water to carry the shrubs and trees through their initial growth requirements.

In some cases, sufficient funds are not available for the simultaneous planting of ornamentals, and the planting may be deferred for a period of time. The turf may be fully developed, at this point. Where does our coordination fit in? Now, it is a matter of how can we minimize the damage to our turf? This now becomes a matter of simple judgement. If there is sufficient notice, we can hold off on watering, to minimize compaction; and postpone fertilization to minimize physical damage directly to the grass from repeated vehicular or foot traffic. Planning so as to reduce the amount of traffic is also very desirable.

Something should also be said about planning for maintenance. Sometimes the turf maintenance man is left with a number of mowing problems which have developed from poor planning of the location of beds and other plantings. Narrow strips and short turns have reduced many aesthetic masterpieces to maintenance nightmares. Simplicity in design and careful forethought can just as easily bring about an attractive area with simplified maintenance.

As you can see, coordination has several sides, but good planning and scheduling of work is necessary for us to derive the greatest benefit from the least expenditure over the whole broad picture of landscaping and turf management.

INSECT ECOLOGY

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Stauffer Chemical Company
College Station, Texas

The subject of insect ecology or the reasons for insect populations varying from one year to another or one generation to another can be quite involved, and actually it is pretty difficult to put your finger on one or two specific causes for this variation. Before getting involved with the subject, however, I would like to take just a moment to consider the seriousness of the relationship between insects and man and some of the consequences thereof.

The animal kingdom has more than one million species or types with approximately 750,000 of these being insects. This means that there are three times more types of insects than all the other animals put together. These figures alone let us know that we are outnumbered and that certainly insects are an important factor in the world.

The annual losses to insects in the United States run into the billions of dollars each year. It is very difficult to put a dollar value on damage that is caused by diseases as malaria, yellow fever, typus, and others that are carried or transmitted by insects.

The conflict between man and insects is often referred to as a war and I'm sure that many of you will certainly agree with this. It sometimes seems impossible, using the best weapons available, to rid turf areas, ornamentals, or possibly homes of insects. The reason for this war is that man and insects want the same things at the same time, and certainly the things that we each want are important to both insects and man. There is no sure-fire method of keeping insects out of our various crops; turf areas; ornamentals; and animals, both livestock and pets, which they damage in various ways. There is hardly any plant or animal that is not attacked in some way by insects. Termites undermine our homes and other buildings causing tremendous damage and expensive repairs and control measures. Insects such as flies and mosquitoes are constantly annoying us by their presence, yet we cannot even keep them out of our homes entirely or keep them from attacking our very own bodies.

Insects are very well distributed since they are found from the Arctic to the Antarctic, from the mountain tops to the bottom of our deepest caverns, even in our lakes and rivers. They have the ability to survive under adverse conditions of many kinds and of many different environments. Insects have even developed the ability to resist our potent insecticides. With the advent of DDT we thought that we had insect problems generally whipped; however, it wasn't long before they had developed a tolerance, and DDT no longer effectively controls many pests. Man has never been able to exterminate completely even one insect species and possibly never will.

Scientists tell us that insects have inhabited the earth for some fifty million years while man has been here but 500,000; therefore, they had advantage of possession of the fields, and they have fought every step of our invasion. In some cases partnerships have been worked out with advantages to both parties as with the case of the honeybees and silk worms; but where their interests and ours are opposed, the struggle continues and will continue as long as civilization continues to exist.

Yes, insects are well adapted for their existence on earth. They wear their skeleton on the outside which serves as a suit of protective armor for them. This exoskeleton also gives them remarkable mobility and smallness of size. Their food is taken in by a variety of ways such as chewing, piercing sucking, grasping sucking, lapping, sponging, and variations of these type mouth parts. Some even bore holes in lead telephone cables causing much concern to the telephone and telegraph companies.

Man has subdued or turned to his own use nearly all kinds of living creatures. There still remain the bacteria and protozoa that cause diseases and the many injurious insects. If we continue to exist, we must be able to master insects and diseases. Insects have and are causing famines throughout the world. History tells us that many crops have been destroyed in Europe and America throughout the years by insects.

Fortunately, not all insects are harmful. Their value in the U. S. alone runs into millions of dollars each year with products such as honey, bees wax, silk, shellac, dyes and inks, and even fish bait. Insects pollinate the flowers of many plants, thus increasing the set of fruit, seeds, vegetable crops, etc. They serve as food for many animals and birds, while some even destroy other harmful insects or act as scavengers. Insects have been used quite extensively in scientific investigations such as working out genetics problems, using their secretions as drugs, etc.

Today, however, we are interested in insect populations that affect turf and why they vary so much from one time to another. First, let's consider the reasons for the rapid insect buildups - basically it all depends on temperature, soil, and moisture.

Arctic regions are not too favorable for general insect development, however, during the brief warm periods amazingly large numbers of mosquitoes and a few other species develop. Tropical areas are certainly more favorable for more species of insects and that is where the largest variety and population of insects are found; therefore, temperature limits distribution of many insects. Generally speaking, insect activity stops at 40° F on the lower range and 95-100° F on the upper range.

Food supply is very important in determining insect population. Fertile soils with adequate moisture grow many different plants and an abundance of them serve as a food supply for insects. In arid areas, plants are quite limited and therefore insects are limited.

Insects have the ability to reproduce very rapidly. This is possible because of the great number of eggs or young produced by the female in one generation. Each female will usually produce from 100 to 1,000 offspring which, of course, when compared to humans is fantastic. This ability is certainly increased by the short life cycle and the rapidity with which each generation succeeds the other. In higher animals, it is a few months to 30 years per generation while an insect reproductive cycle may be as short as ten days. Many of them have the ability to reproduce themselves within a 25 to 35 day period with a few taking one or more years to complete their life cycle. Let us use as an example one pair of house flies starting on the first day of April and assume that all of their offspring live and reproduce. By August the number of flies would have increased to 191,010,000,000,000,000,000. Allowing 1/8 cubic inch per fly, this number would cover the earth 47 feet deep. Of course such a

situation is impossible as natural control and food supply would prevent it from happening, but this is the potential from just one pair of insects in a relatively short time.

Let us look a little closer at some of the factors that cause variations in insect populations.

Food Supply: Like humans, insects increase when the food supply is adequate and decrease when it is inadequate. You grow good nutritious turf; thus, turf insects will be there and should be expected to be one of your problems.

Enemies: Insects have certain enemies that are constantly killing them off and when these enemies are plentiful, insect populations will be small. These enemies consist of predators, such as animals, birds, reptiles, insects, and even cannibalism. Parasites such as nematodes and other insects feed in or on the bodies, thus weakening and usually eventually killing their host insect. Diseases of bacterial, fungus, and virus causes are always present and when conditions are favorable, they take a very heavy toll on insect life.

Climate: Adverse weather conditions of various kinds affect the build-up of insects. Excessive rainfall will often drown insects, especially when they are very young. Soil insects are often forced to the surface because of too much moisture where they are open prey for predators and parasites. Dry weather will often delay or even entirely prevent adults from emerging from their pupa cases in the ground. Extremely hot or cold temperatures greatly affect insect numbers by decreasing the number of eggs that hatch and killing the ones that are not properly protected.

The above factors, and combinations of them, are the ones that determine the increase or decrease of insect populations. You can readily see that the conditions you would prefer to grow good turf would also be very suitable for insect development. Therefore, you should always be on the lookout for insects and control them before they have an opportunity to cause extreme damage.

Many of you, because of past experience, realize the damage that soil insects can do and are carrying out very good and sound preventive control measures. Most soil insects can be controlled with a spring or fall application of Heptachlor, Chlordane, or Dieldrin in granular spray or dust form or in combination with fertilizers every two to three years. For above ground insects you have to depend on specific timing with their development for preventive control or be ready to use adequate chemicals at the first sign of their appearance.

Lets consider briefly some of the turf pests and their life cycle. White grubs - adults are May or June beetles which are brown or blackish-brown. They appear in April through June with a few emerging in the fall of the year. These adults feed on pecan, elm, and other trees at night. Eggs are laid in the soil during the day and are pearly white in color. These eggs hatch in two to three weeks. The larvae or grub worms are white with brown heads and the hind part of the body is smooth and shiny with dark body contents showing through. They usually lie in a curled

position. These grubs will live in the soil from one to several years depending on the species with the most common ones remaining in this larval stage for two to three years. They feed on the roots and underground stems of grasses and other plants and in warm weather usually stay within one to three inches below the soils surface. In winter they will move as deep as necessary to stay below the frost line. In the final year of the larval stage the larva changes into the pupa or resting stage in the early summer and by the latter part of the summer it becomes an adult but stays in the soil until the following spring.

Wire worms - Adults are hard shelled, brown, grey, or black in color, somewhat alongated streamlined bodies. The head fits close to the body. The adult will flip when placed on its back until it lands on its feet; therefore, they are often called click beetles, snapping beetles, or skip jacks. Eggs are laid in the soil or around the roots and underground stems and hatch in a few days to a few weeks. Larvae are very hard and tough, light to dark brown, or yellowish in color, are very smooth with the joints not too prominant. They will range in length from 1/2 to 1 1/2 inches long and remain in the soil for 2 to 6 years depending on the species. The pupae look very much like the larvae, however, they are soft and essentially naked and stay in a cell they have built in the soil for a few weeks in the late summer or fall of the year they mature. Adults usually stay in the soil until the next spring.

Sod Webworms - Adults are whitish, grey, or pale brown moths which fly in a zig-zag pattern when disturbed and wrap their wings around them when at rest. Their mouth parts appear to be a snout protruding from their head. Eggs are laid in the early evening or night at the base of grass stems or quite often they are dropped while the adult is flying over grass areas. The larvae work at night and stay in silk-lined tunnels in the day just barely under the soil surface. This makes preventive applications as previously discussed not too effective on this insect, especially on greens, because the insecticides have a tendency to wash or move downward in the soil. These larvae feed on grass blades and cut them off and take them into the tunnel to feed on them often. They will range in size from 1/2 to 1 1/2 inches. They overwinter as partly grown larvae and go through the pupal stage in this protective tunnel. Most species have three to four generations a year. The first signs of Sod Webworm damage are regular brown areas in the turf and upon examination by breaking the turf apart the webworms can be found. Sprinkling one gallon of water with one tablespoon of pyrethrum extract in it over one square yard of the suspected area will cause the larvae to come to the surface.

Army worms and cut worms are somewhat similar in appearance and length of cycle so I will take them together. Adults are usually a dirty brown or dirty grey in color and are attracted to lights at night. With heavy populations of these moths that are about 3/4 inch long with the wing span of about 1 1/2 inches long, you should begin to watch for an infestation of cutworms or army worms. The adults lay their eggs on weeds and grasses and they hatch in two days to two weeks. The larvae feed continually and if not stopped promptly, they will cause damage in a very short time. Normally the larva stage is two to three weeks and the entire life cycle can be carried out in about 30 days. Several generations occur each year; however, the most damage is usually done in the spring or early fall of the year.

Rhodesgrass scale - This insect appears as a white mass usually in the axle of the leaf of St. Augustine, rhodesgrass, or similar turf plants. When mashed, a reddish brown substance will come out of the scale body if it is alive. The eggs are retained within the body of the mother until they hatch at which time they crawl over the plants and at this stage are called crawlers. They move around until they mate and find a place to locate. After locating themselves, they lose their legs and form the white covering for protection. It takes this insect 60 to 70 days to go through this life cycle and in the southern parts of the state it is continuously reproductive. From about San Antonio northward, it probably would stop reproducing through the winter, spend the winter in the egg stage, and hatch as the weather warms up in the spring. The best methods of control are to get the first or second generation in the spring of the year in the crawler stage at which time they can be controlled with Malathion or Trithion.

Lawn chinch bugs have developed into a major turf pest. Adults are 1/5 inch long, blackish in color, with snowy white marks on the wings. The adults tend to hibernate in the winter, however, on warm days they will move about and mate. In the spring of the year after the temperature reaches about 70 degrees, they are ready to move to good feeding areas and start reproduction. The female lays from three to five hundred eggs on the lower stems or roots of the grass plants and these eggs hatch in 7 to 10 days. These nympths begin to feed on the roots or lower stems with their piercing, sucking mouth parts, thus sucking the plant nutrients from the plants. Forty to fifty days are usually required for the completion of the life cycle with four to five generations occurring during the year. The young or nympths are pink to red with a white band across their middle. They are about 1/16 inch long when first hatched, and as they grow they shed their skins five different times gradually turning darker each time and losing the prominant white stripe, wings being formed as they reach maturity.

A preventive application of spray or granular Trithion, ASP51, Ethion, or Diazinon in the latter part of April or first of May can do a lot to prevent chinch bug build-ups. Time prevents further study of turf insects, however, I would like to say that the U. S. Department of Agriculture has Home and Garden Bulletin No. 53 entitled "Lawn Insects - How to Control Them" available through your county agents. Also, the Texas Agricultural Extension Service has published "Texas Guide to controlling Insects on Ornamental Plants" L 199, which has a section on lawn insect control and is also available through your county agents office. Thank you very much for the honor and privilege of appearing on your program.

IMPORTANCE OF TURFGRASS IN TEXAS

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1. Complete accounts of sampling procedures and detailed analysis of the data obtained will be published as soon as possible.

2. Home lawns represent the greatest use of turf in Texas.

3. Bermudagrass is the species used on 41 per cent of the home lawns; St. Augustine on 56 per cent; and 3 per cent of the lawns are in other grasses. These other grasses include buffalograss, carpetgrass, centipede, Zoysia, and mixtures.

4. Home owners spend approximately twice as much for lawn maintenance as do non-owners.

5. In the Gulf Coast, 96 per cent of lawns are in St. Augustinegrass. No St. Augustine lawns were reported in the Panhandle region and only 10 per cent of the completed questionnaires from West Texas reported St. Augustinegrass.

6. Labor is the greatest item of expense in turf maintenance, except in the case of home lawns. In municipal parks labor accounts for 85.3 per cent of the total turf maintenance expenditure; in colleges and universities, 75.6 per cent; in public school ground maintenance, 73.1 per cent; and on golf courses it is estimated to be about 70 per cent.

   On home lawns the value of labor was reported to be 22.2 per cent of the total maintenance cost.

7. The cost of water for home lawns accounts for 36.23 per cent of the total.

8. The golf courses of Texas have a total of 4,641 holes. The national average cost in 1962 according to published surveys is $3,307 per hole. A figure of $3,204 per hole is used in this study. Thus, a total maintenance cost estimate of $14,869,764 is probably on the conservative side.

9. No accurate figures are available relative to costs of maintaining roadside turf. Right-of-way maintenance cost the Texas Highway Department $10,201,500 in 1961. This included other costs such as shoulder re-shaping and grading.

   The total area in roadside turf is 595,098 acres. It is estimated that a total of 1,218,832 acres are mowed annually.

10. It is difficult to compare the value of turf with other important agricultural crops. Turf represents a permanent investment in better living, but its value cannot be calculated in monetary units.

However, the maintenance of turf costs money, and these costs may be compared to the economic value of other agricultural production. The total value of agricultural production in Texas in 1962 has been estimated at 2.5 billion dollars. If we estimate the cost of turf maintenance at 225 million dollars (a conservative figure), we see that it is almost equivalent to one per cent of total agricultural production.

Cotton (our biggest cash crop) is estimated to have had a total production value of $742,000,000 in 1962. Thus the cost of maintaining turf was 30 per cent of the total production value of cotton. It appears that we may safely say that the net income from the Texas cotton crop will not maintain the home lawns of the state.

MAINTENANCE COSTS OF TURF IN TEXAS

Home lawns	$189,199,660
Public school lawns and athletic fields	2,512,085
Colleges and universities	1,032,900
Municipal parks	3,593,716
Golf courses	14,869,764
Roadside turf	No figures
Military installations	No figures
Airports	No figures

Lawns

Number of lawns	2,536,576
Annual total cost	$189,199,660
Acres in home lawns	820,836
Cost of maintenance per acre	230.50
Average size of lawn	14,099 sq. ft.
Cost of maintenance per lawn	$74.59

Table 1. Totals of various home lawn maintenance expenditures within regions and for the state[1/]

Region	Number of households with lawns	Maintenance items: Compost	Commercial fertilizers	Chemicals	Water	Equipment	Labor	Region total
Panhandle	187,384	$ 282,950	$ 1,247,977	$ 386,011	$ 4,412,893	$ 3,575,287	$ 3,773,914	$ 13,679,032
West Texas	254,552	1,359,308	1,573,131	236,733	16,324,420	3,780,097	2,311,332	25,585,021
North Texas	664,436	1,674,379	3,893,595	1,023,231	16,272,038	10,943,260	8,225,718	42,032,221
East Texas	293,489	2,242,256	2,007,465	868,727	5,353,239	6,348,167	6,955,689	23,775,543
Central Texas	455,405	2,099,417	1,525,607	833,391	19,782,793	9,299,370	9,262,938	42,803,516
Gulf Coast	518,245	1,730,938	2,280,278	1,150,504	2,378,745	12,956,125	6,389,961	26,886,551
South Texas	163,065	924,579	774,559	344,067	4,412,539	3,396,644	4,585,388	14,437,776
State total	2,536,576	$10,313,827	$13,302,612	$4,842,664	$68,936,667	$50,298,950	$41,504,940	$189,199,660

1/ Calculated from average expenditures per lawn x the number of households in the region with lawns. Number of households was derived from 1960 census and adjusted for the percentage of households within each region reporting no lawn.

Table 2. Public school annual expenditures for turf maintenance by regions

Region	Maintenance classification					
	Labor	Fertilizers	Chemicals	Equipment Upkeep	Miscellaneous	Total
Panhandle	$ 121,416	$ 15,735	$ 5,347	$ 32,298	$ 3,657	$ 178,453
West Texas	568,784	63,785	3,997	109,387	10,423	756,376
North Texas	95,755	68,030	5,673	14,255	23,450	207,163
East Texas	315,743	46,408	7,412	61,256	0	430,819
Central Texas	133,337	19,402	3,480	31,690	3,259	191,168
Gulf Coast	453,482	18,744	6,032	63,206	21,488	562,952
South Texas	148,004	5,753	738	28,568	2,091	185,154
Totals	$1,836,521	$237,857	$32,679	$340,660	$64,368	$2,512,085
Per cent of state total	73.12	9.46	1.30	13.56	2.56	100

Table 3. Estimated annual expenditures for turf maintenance by colleges and universities

	State colleges & universities (16 total)	Independent colleges & universities (37 total)	State junior colleges (36 total)	Independent junior colleges (11 total)	State total
Labor	$239,943	$441,139	$ 92,405	$ 7,792	$ 781,279
% of total	69.8	78.1	83.5	57.2	75.6
Fertilizer	26,304	13,209	3,698	275	43,486
% of total	7.6	2.3	3.3	2.0	4.2
Chemicals	910	1,954	795	46	3,705
% of total	.3	.4	.7	.3	.4
Equipment upkeep	75,672	102,727	13,608	5,166	197,173
% of total	22.0	18.2	12.3	37.9	19.1
Miscellaneous	686	6,061	163	348	7,258
% of total	.2	1.1	.2	2.6	.7
Total	$343,515	$565,090	$110,669	$13,627	$1,032,901

Table 4. Estimated annual expenditures for turf maintenance in municipal parks in Texas

Maintenance Item	City population (thousands) 10 to 25 (51 cities)	25 to 75 (29 cities)	75 or more (13 cities)	State total
Labor	$155,040	$248,054	$2,971,036	$3,374,130
% of total	76.6	88.3	85.6	85.3
Fertilizer	3,060	5,646	57,709	66,415
% of total	1.5	2.0	1.7	1.7
Chemicals	3,570	1,305	15,136	20,011
% of total	1.8	0.5	0.4	0.5
Equipment upkeep	35,700	22,022	409,389	467,111
% of total	17.6	7.8	11.8	11.8
Miscellaneous	5,100	4,060	16,889	26,049
% of total	2.5	1.4	0.5	0.7
Total	202,470	281,087	3,470,159	3,953,716
% of total	5.1	7.1	87.8	
Number of parks per city	6.2	9.2	68.0	
Acres per city in parks	22.9	75.2	1,379.1	
Total number of parks	316	267	884	1467
Total acres in parks	1,168	2,181	17,928	21,077

PRINCIPLES OF CHEMICAL APPLICATION

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Principles of chemical application represents a broad subject area and one that cannot be covered to any detail in the time alloted on this program. Perhaps a survey of this subject area, singling out certain aspects that most frequently function as limiting factors in the application of chemicals for disease, insect and weed control, would offer the best approach.

Principles of chemical application encompass a number of factors which include:

1. Diagnosis of the pest problem.
2. Selection of the chemical pesticide.
3. Distribution of pest control chemicals.
   a. Release point to target
   b. Behavior at target surface.
4. Adjuvant influence on pest control chemicals.

These factors are reviewed below in some detail with the thought that they will reveal to some extent the complexity of application of chemicals for pest control.

Diagnosis of the pest problem

Proper diagnosis of the pest problem whether it be a disease, insects or weeds is the first important principle that influences the performance of chemicals. Several examples which indicate the magnitude of proper diagnosis are given.

Confusing symptoms of insect damaged turf with disease damaged turf has frequently been reported. Recently a golf course superintendent, after making several fungicide applications to a putting green showing turf damage on a golf course in the mid-South with no success in lessening the problem, called in a turf consultant. After careful examination of the damaged putting turf, the consultant reported finding a high population of sod webworms. This was the key to the problem. Proper selection of a pest control chemical was then made. Improper identification of weed plants in lawn areas often provides the answer to customer dissatisfaction when a given herbicide is used. Tall fescue, a perennial bunch grass, often is commonly assumed to be crabgrass. The presence of established plants of tall fescue in lawns and identified as crabgrass, after properly applying a pre-emergence crabgrass herbicide, serves as another example of improper diagnosis. Dallisgrass, a perennial bunch grass of the Southern region, again often is identified by the inexperienced as annual crabgrass with paralleled results expected when pre-emergence grass type herbicides are used. Many other common examples can be cited, some that you have experienced in your turf maintenance operations.

Selection of the chemical pesticide

Selection of chemicals has been touched upon briefly above in relation to proper diagnosis, yet it should be emphasized that if the right chemical is not selected, then diagnosis is not of much value.

With the increased development of pesticides of a rather nannow range of selectivity, the right choice becomes increasingly important. The use of any fungicide for the control of brownpatch disease in St. Augustinegrass does not hold. Here one perhaps would choose PCNB or another fungicide specifically selective for this pest. In another use situation such as Bermuda putting greens, results of research have shown that many fungicides will control brownpatch in St. Augustinegrass. Perhaps the problem is one of fungi race differences. Again the use situation will very definitely influence the selection of the chemical regardless of the pest involved. Atrazine, a very effective pre-emergence and post-emergence herbicide could not be successullly used for controlling clover in a bentgrass putting green because of phytotoxic effects of the chemical on bentgrass turf. The use of this chemical for clover control in St. Augustine lawns would be satisfactory.

The severity of the pest problem will influence chemical selection. With respect to plant diseases on turf, if the disease has done a lot of damage to the turfgrass and is still highly active, then the use of a protectant fungicide would not be as satisfactory. The selection here should be a fungicide of the eradicant class.

Distribution of pest control chemicals

If you all are satisfied that you have diagnosed the pest problem and have selected the proper chemical pesticide, then the next step is distribution to the target. Often this is considered a minor factor in the applicator of materials for pest control, however, improper distribution often will result in failure to overcome a given pest problem.

Distribution of chemicals to the target, whether one employs conventional sprayers or dry applicators, exhibit similar behavior patterns. Available data indicates most optimum coverage of plants is obtained with liquid aerosols or dry ornamental type dusts with a particle size of 5 microns. For visual comparison of a 5 micron drop to something we are familiar with, a group of these drops would appear as oil fog or sea fog. If optimum coverage is gained with the 5 micron drop or particle size, then should one consider applicators to provide this size for application of materials as DMA or 2,4-D? Probably not because of the behavior of such particles from the point of release until target contact. The following table shows data on the behavior of drop or particles of varying sizes.

Drop or particle size	Fall rate in 10 feet (secs)	Drift in 3 mph wind (feet)
5 micron	4,050	18,000
100 "	11	48
500 "	1.5	7

The above points up problems that may develop for application of materials with drop or particle size approaching 5 microns. You may be interested to know that many aerosols and dusters used around the home have a particle size ranging from 4 to around 50 microns. The above data suggest some caution might be in order where chemicals of a toxic nature are used, particularly from the standpoint of time the material is suspended in air.

Spray applicators that operate at excessively high pressures combined with small nozzle orfice size would be expected to yield a spray distribution pattern made up of very small drop sizes subject to lengthy suspension in air or be moved by light winds. Properly adjusted sprayers should produce the major proportion of drops in the range of 100 to 500 microns. For visual comparison, this would be equivalent to light mist to light rain.

Some of the commercial pesticide granular materials used for application on turf areas deliver in the area of 70 percent of the particles in the 200 to 700 micron size range. Distribution of dust or finely ground dry pesticides with particle size below 100 microns would be expected to behave similarly to liquid distribution.

For liquid applications other variables also influence distribution. Evaporation of liquids in sprays has been evaluated to some extent. An example is given to show the evaporation aspect. At 68^{o} and with a relative humidity of 50 percent the life of a 50 micron diameter water drop has been found to be 4 seconds in free air. For a 100 micron drop, evaporation from liquid drops in free air is of interest from another aspect in relation to concentration of toxicant. If 50 percent of a drop consisted of water and 50 percent an involatile toxicant and with a 50 micro drop size, it would be at a 100 percent concentration after 4 seconds under climatic conditions listed above. What effect would this have on performance of chemicals? Increased discoloration of turf with certain type chemicals may be expected under certain conditions. Wettable powders carried in liquid drops under certain conditions could reach the plant surface as a dry particle.

The second aspect of distribution in relation to application principles and pesticide performance for review is related to behavior of chemicals at the target surface (plants, fungi, insects). Based on research carried out on surface tension phenomena of liquids, considerable variation perhaps may be expected as one uses different type chemicals in different ways. Surface tension of liquids is expressed quantitatively as dynes per centimeter. Surface tension of water is around 70 dynes per centimeter. Water drops of 100 micron size when applied to leaves of peas resulted in 100 percent retention. When the drop size was increased to 250 microns, the result was 100 percent reflection. A water solution with certain additives which lowered the surface tension from around 70 to around 40 dynes per centimeter with a droplet size of 250 microns, the result 100 percent retention on leaves of peas. Adjusting another water solution to approximately the same surface tension with different additives resulted in 100 percent relfection from leaves of peas. This suggests that as one shifts from one type chemical to another, in water solutions that considerable variation may be expected.

Although pesticides carried on, granular carriers perhaps have not been considered as being influenced by surface phenomena, this perhaps is not true. After the granular carrier reaches a given target, surface phenomena no doubt comes into play as the toxicant moves off the granular particle in to a liquid system. Little attention has been given this aspect by researchers in the past, however, more attention should be given this aspect regardless of the type carrier involved.

Vapor pressures of pesticides in liquid systems, particularly in the case of application to plants also may materially effect chemical performance. Toxicant vapor pressure that favors rapid evaporation from surfaces no doubt contributes to the loss of the toxicant from such surfaces. Vapor pressures may vary with kind of chemical used, surfactants, and concentration.

Adjuvents

The behavior of the chemical when it reaches a given target may be influenced by such factors as additives or materials added to the basic active chemical and carrier to do a specific job. Although these factors were reviewed above to some extent, it may be of interest here to briefly review terminology in regard to adjuvants for orientation purposes.

Adjuvants are classified generally as inert materials added to insecticides, fungicides, and herbicides to improve physical characteristics of the toxicant and carrier. Some of the common adjuvants are:

1. Adhesives - materials that increase adhesion of the chemical pesticides to plant foliage, insects, and fungi. Tenacity of the deposit is increased which lessens removal of the deposit from such factors as sun, wind, rain, dew, etc. Removal by rain, irrigation, and mowing represent the major ways residue are lost. Certain adhesives function as spreading and wetting agents.

2. Spreaders - are classed as materials that improve spreading or "creeping" of materials over a surface. Spreaders are used more commonly in contact sprays where maximum coverage is essential. The principle of spreading action is now incorporated into granular pesticides to improve the spread of the active ingredient as it "bleeds out" or diffuses from the carrier.

3. Wetting agents - include materials that reduce surface tension of solutions which lessens the chance of a layer of air occurring between a solid and a liquid. The cuticle of plants is made up of a crosslinked polyester produced by the condensation of polyhydroxy fatty acids. Common terminology describes this as a wax layer which possesses characteristics of little or no affinity for water.

4. Solvents - represents materials that do not necessarily fall in the classificaton of adjuvants, but their action in the performance of pesticides is quite important. Such materials are usually essential to solubilize chemicals not soluble in water. The solvent-chemical system if not directly soluble in water then may be emulsified for liquid application or application to granular carriers. The action of solvents on plant cuticles is of considerable interest. Certain kinds of solvents have been found to cause a swelling of the cuticle which subsequently aids in the penetration of the active toxicant.

5. Emulsifiers - include the class of compounds employed to facilitate dispersion of one liquid within another and to retard settling of a solid within a liquid. The sequence here might be the chemical is solubilized in a solvent and thendispersed in water by employing an emulsifier. The oil-water is one commonly used in most of your spray applications.

LIQUID INJECTION OF FERTILIZERS

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Interest in automation of turfgrass production has increased. With an automatic irrigation system management has control over the all important water application factor. It appears then, that another step is fertility control. Various producers of plants have observed that an efficient method of fertilizing is by injecting fertilizers into irrigation water. This method works well in automatic systems and is receiving great interest. It might be further mentioned that other chemicals can also be introduced into water systems through injection.

Equipment suitable for injecting fertilizers into large area irrigation systems is available. The most important step, however, in an injection fertilizer program is an efficiently designed and operating automatic irrigation system. Good designed systems just don't happen. Automatic irrigation is a specialized field as is turfgrass production. It requires experience, plus, engineering know-how to design a hydraulically efficient automatic system. Such a design must, however, receive good installation to produce a successful system. In seeking water and chemical control, design an automatic system for this purpose and them see that proper installation is obtained.

Since fertilizer and other chemicals will go where the water goes, good uniform distribution of the water is important. Published data is available on the performance of sprinkler types which have been in use for several years. This is especially true of the agricultural type sprinklers. The distribution pattern of sprinklers should be checked. Uniformity of water application varies with:

Type of sprinkler head
Amount of water discharged per sprinkler
Water pressure at sprinkler
Spacing of sprinklers in rows and between rows--mutiple row systems give higher uniformity than single row systems.
Length of operating time
Wind velocity and angle of wind with respect to sprinkler rows and
Precipitation rate--inches per hour.

High precipitation rates applying more water than a soil can absorb will result in poor uniformity. Runoff will result in deficient amounts of fertilizer in some areas and excessive amounts in others. Where possible it is advisable to design for application rates of water less than the infiltration rate of water into the soil. If such is not possible automatic controls of the system should be flexible enough to overcome the poor infiltration rate of the soil.

One of the simplest methods of injecting fertilizers into irrigation systems is by taking the solution through pumps on the suction side. A pipe is extended from the solution container to the suction pipe of the pump with a shutoff valve for regulation. The addition of another line from the discharge pipe to a closed pressure solution container improves this type of system. Allowing corrosive solutions to go through pumps is a disadvantage for this method.

Small high pressure pumps as gear pumps or spray rigs may be used to inject fertilizer into main lines or the discharge side of pumps. This and the previous method are cumbersome and are not as accurate as the use of the following types or equipment.

Types of Equipment Available for Fertilizer Injection

Type of Equipment	Fertilizers	Features
Eductor	Liquid and Water Soluable Drys	Pressure gradiant by venturi or enlargement in pipe creating suction Simple and free of moving parts Need valves to regulate flow Injection proportional to water flow Water flow should be constant Small pressure drop in water line
Metering Pump	Liquids	Electric, gas, or water motor needed Accurate metering of fertilizer Water flow needed nearly constant No pressure drop in water line Fertilizer rate constant with time
Proportioner	Liquids	Fertilizer exact ratio to water -- proportions fertilizer to flow of water Useful where water flow is variable Water motor driven from system Small pressure drop in water line Fixed volume ratio from 1:100 to 1:2,000, etc.

Three time intervals are generally used in applying fertilizer through sprinkler systems. The systems operates normally through the first interval to wet the turf and soil. Fertilizer is injected into the system during the second period. This period should be as long as convenient to keep the solution in the system diluted and to improve the distribution pattern. Proper timing of this period will eliminate any possibility of turf burn and decrease corrosion of sprinkler system. The last period should be long enough to completely rinse the system and remove all fertilizer from the turf. It is also used for moving the fertilizer down into the proper root zone.

Fertilizer types which have been used in sprinkler systems are ammonium sulfate, ammonium nitrate, calcium nitrate, urea, potassium chloride or sulfate, phosphates, and iron sulfate. Losses of ammonia to the air may be kept to a minimum if the irrigation water pH is near neutral. If the irrigation water has a pH above 7.5 or 8.0 ammonia losses can be reduced to a minimum by applying the fertilizer in the safest smallest amount of water. The choice of fertilizers should be based on soil or plant analysis, personal experience, or the advice of the fertilizer industry.

The amount of fertilizer injected will depend on the area covered, the type of fertilizer, and the desired rate. Time required for the fertilization is a function of the amount to be applied, size of area and precipitation rate.

The following has been suggested as one method of fertilizing putting greens. One inch of water weekly was suggested or 40 irrigations per year. Nitrogen used was 20% ammonium nitrate solution.

Material	Amount / Irrigation per acre	Amount / Irrigation per 1,000 square feet
Nitrogen	14 lbs.	.32 lbs.
Fertilizer pounds	70 lbs.	1.61 lbs.

Material	Amount / Year per acre	Amount / Year per 1,000 square feet
Nitrogen	560 lbs.	12.8 lbs.
Fertilizer pounds	2800 lbs.	64.2 lbs.

The potentials of automation are now being recognized. Programs of fertility and water control have been outstandingly successful. Never before has management had an opportunity to use such tools for environmental control. The proper tools are at hand to be used wisely.