AMERICAN LAWN APPLICATOR

May/June 1980
Volume 1, No. 1

Editorial

'It was the best of times, it was the worst of times ..."

Charles Dickens
A Tale of Two Cities
1859

With apologies to Mr. Dickens, I might describe the conditions of our industry something like this: it is the best of times, it threatens to be the worst of times.

On one hand we see the continued growth and maturity of many chemical lawn care companies. There are constant refinements of techniques and equipment. New materials which promise to solve many of the old problems are introduced regularly. Educational programs and professional associations have raised standards and contributed to a widespread "professional" attitude toward this business. And, most importantly, the American homeowner continues to perceive the value of our existence.

However, there is the other hand to reckon with. The opposing forces of inflation and recession put a tremendous strain on the economy. The costs of money, chemicals, labor, and fuel climb at an unbelievable rate. The disappearance of chemicals such as Silvex reduces our effectiveness. Governmental regulations, such as the bill now under consideration in Ohio, complicate and frustrate. Chemical companies talk about the fast approaching day when they won't be able to afford to develop new pesticides for our market. Construction of new homes has slowed to a crawl. And finally, lawn care people have begun to question whether our increased costs can be passed along indefinitely to a consumer who, pressed from all sides, may have to make some difficult choices. Interesting, but nervous, times indeed.

Steve Brown
Editor

Many lawn care businessmen are expressing concern about what the next few years will bring. Should they expand? Buy new equipment? Diversify? What chemicals should they use? Must economics outweigh agronomics? The list of questions is long and serious.

And so we introduce **ALA** at this time in an attempt to make a small contribution toward finding some answers. As someone who has been in the chemical lawn care business for more than a decade told me recently, "We not only have to work harder, we've got to work smarter."

It will be our purpose to present information that will help you "work smarter" in the coming years. If you have ideas about articles you would like to see in **ALA** drop us a line. We'll see that the article gets written.

And one more thing .... remember that **ALA** subscribers use our classified section for free.

In this issue of **ALA** you will find information about an electrostatic spraying system. This device, which is the brainchild of a University of Georgia professor, could someday save lawn care businesses a significant amount of money. The problem is that the FMC Corporation, who is marketing electrostatic sprayers, is not planning to produce that equipment for our industry. At this time they don't think we would buy enough to make it worth their while. We disagree with FMC's assessment of the situation and, as a result, have decided to ask for your opinion. If, after reading the article, you think that the electrostatic system sounds like something you'd be interested in, let us know. We will carry the message to FMC and, maybe, they will change their minds.

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Application to mail at Controlled Circulation Rates pending at Ann Arbor, MI 48106

COMPUTERS

Lawn Care Businessmen discuss Computers

by Stephen Brown

Some ideas die hard. A perfect example is the notion that computers are terribly expensive, totally incomprehensible, and thoroughly impractical for all but a handful of high-powered scientists and businessmen. The facts are that truly sophisticated computers have become quite affordable in the past few years and many lawn care professionals are finding them to be useful, even essential, tools of the trade.

ALA talked with four of these businessmen to find out just how a computer can be used in the lawn care industry. The experiences and insights these men have shared with us should be very useful to anyone contemplating computerization in the near future.

Jim Kelly is the General Manager of Keystone Lawn Spray, Inc., a Wayne, Pennsylvania based company which has used a computer since 1977. Keystone had 3100 customers when they purchased their Sperry Univac BC 8. They have since increased their customer count to 11,000.

Regarding that growth, Kelly says, "It was due to an aggressive marketing program but the computer helped a great deal in directing that program. Our computer was a very valuable vehicle for getting there."

Bob Brown owns Michigan Lawn Spray Service, a Sterling Heights company which had just over 900 active customers in the spring of 1979 when Brown decided to buy a Radio Shack computer. This TRS80 computer, made by the Tandy Company, has helped add about 700 customers in the past year.

Burrough's Model L9000 Computer in use at Atwood Lawn Spray.

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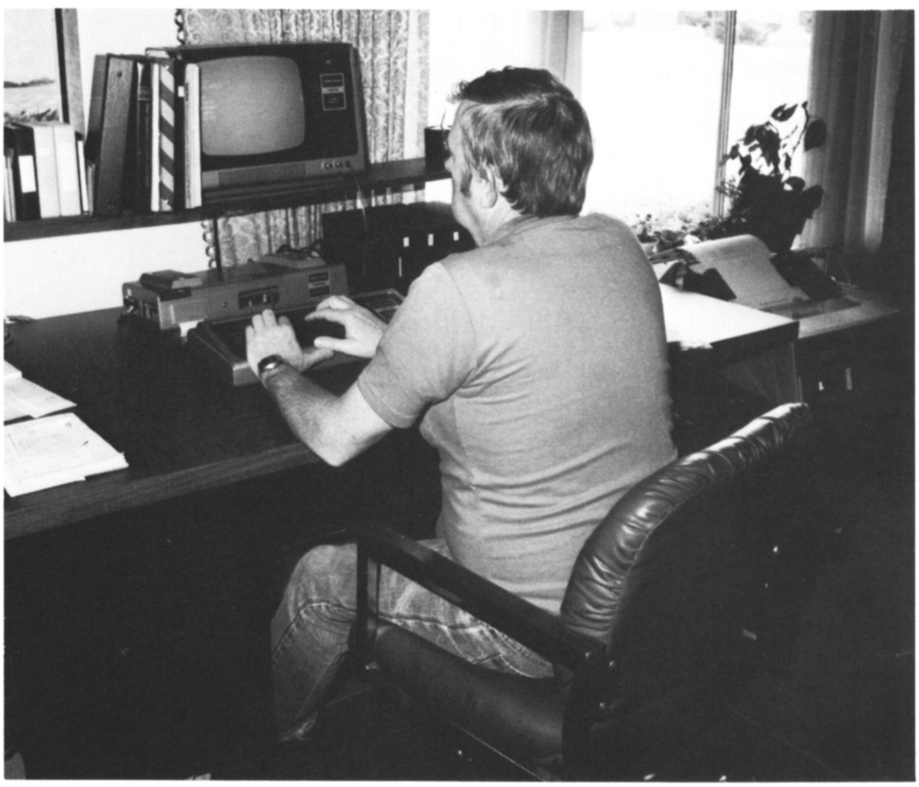

Radio Shack's Model TRS80 Computer eases task of handling large numbers of accounts at Bob Brown's Michigan Lawn Spray Service.

When we asked if this growth was due to a new marketing strategy, Brown replied, "Well, there are probably a lot of things involved. One is that the computer made handling larger numbers of accounts easier. And it helped us justify adding customers. I had intended to be a little more aggressive last year at any rate. The computer made things so easy that we thought nothing of increasing 80 to 100%. And we are considering doing it again this year. We have the capacity to do it, and it doesn't create a real hardship."

Tom Brune is the owner of Atwood Lawn Spray, also of Sterling Heights, Michigan. Brune purchased a Burroughs L-6000 mini-computer in 1975 when he had approximately 1000 customers. Last spring he traded up to a Burroughs L-9000 model. Is there any connection between the use of a computer and the growth of his business?

"I think there is. I've always felt that there is a very definite correlation between business practices and the size of a person's business. I believe there are businessmen around who artificially limit the size of their company by limiting their ability to process paper," says Brune.

Allen Dall, of Lawnco, Inc., bought an IBM 5110 in March, 1979. Lawnco, which operates in the Cleveland, Ohio area, had about 5000 customers at that time. Dall feels that when a lawn care company is servicing 2000 customers from a single location, it is time to computerize.

"There is just so much to be gained in speed and accuracy, not to mention the office space that is saved," says Dall.

(Continued next page)

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"You've got to keep the computer occupied"

For many people the accounts receivable and routing functions will be the computer's most important duties. As Allen Dall says, "You've got to keep the computer occupied with your most important tasks, and keeping track of your money is the most important of those tasks."

Tom Brune's experience in the area of accounts receivable shows what the computer, coupled with some real determination, can do.

Brune says, " My thoughts about a computer began to formulate about 1973 or '74 when we were having a difficult time keeping track of accounts receivable. This was our biggest hassle. When we sprayed a job, we wanted to be paid before we sprayed again. However, we were having a difficult time keeping track of who had paid and who had not because we had two different sets of records. One was the driver's route book and the other was in a master file in the office, and they never seem to be synchronized. It was too time-consuming to make entries in both books and, consequently, we were doing a lot of spraying where people owed us money. So, this was one of the big reasons behind our desire to find a system that could consolidate the information and would also have control over additional applications."

"We have an excellent handle on accounts receivable now."

Brune knows his system works. "I can give you an example that comes to mind, because I know the amounts, we did $73,000 worth of work last April and we lost $23.00. That's one lawn. I feel that we have an excellent handle on accounts receivable now. The bottom line on all of this is that we will lose, as uncollectable monies less than one tenth of one percent of our gross this year. I feel this is due to our attitude about receivables and that we have put in the instruments to keep track of them," says Brune.

And what was Brune able to do with his Burroughs mini-computer?

"Let's take a hypothetical route. If we wanted to know how many people in that route owed us money, the machine would print a list of all names, how much they owed, and for what length of time, with sub-totals for 30 days, 60 days, 90 days, and then a grand total of all monies outstanding in that route. Usually about 15 days after we do a route, we have the machine scan the route and, as it scans, it will give us a print-out. It will also print overdue notices."

"This is a four-part overdue notice which is part of a system we devised. All we have to do is tear off the top notice. which is a very gentle reminder, put it in a window envelope, and mail it off to the customer. The next notice is a bit stronger than the first. Eventually, the fourth or bottom copy goes to the collection agency or small claims court or whatever route we decide to take."

While keeping track of receivables is also of great importance to Lawnco's Dall, he actually bought the IBM 5110 for routing purposes.

Lawnco's computer determines how many customers are done at any time

Dall explains, " By routing, I don't mean looking at the whole town and figuring out the best way to go. That would require a computer with a much larger memory. Our routes are predetermined by area but, within that area, the computer can give you a route by the square footage, by the number of customers, or by the total production. The computer prints the invoices and it won't give you anyone who hasn't paid or who had their last application less than five weeks ago."

In addition, Lawnco's computer is used to determine how many customers have been done and how many are left to do at any one time. By having an accurate picture of the total square footage left to do, Dall can easily monitor the use of chemicals and know when to place an order with his chemical vendors.

Jim Kelly, at Keystone, says that while receivables get a lot of attention from their Sperry Univac BC 8, the computer serves a variety of purposes, one of which is an analysis of the marketing program.

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"We can monitor the number and the source of leads, and determine how many leads and sales each piece of advertising generates. This gives us an excellent idea of what advertising works well in which areas," says Kelly.

"We can monitor sales leads, inventory, service calls, cancellations..."

Another interesting use of Keystone's computer is the evaluation of technicians. Kelly explains, "We can look at the production done, the amount of product used, the complaints, the cancels, the service calls, everything. When we have all of this information, someone who knew nothing about this business could look at it and tell you who is doing the job and who isn't."

The use of a computer for routing interests Kelly, but he has some reservations about it. One of the problems lies in the definition of the term.

Kelly explains, "Real routing, where the computer determines the most efficient means of going from place to place is a very difficult area. No one really has a handle on it yet."

Kelly shares Allen Dall's opinion that a computer with a very large capacity would be necessary to do a complete job of routing his company's trucks.

"It would take a computer with a tremendous memory and, of course, that's where computers get really expensive," says Kelly.

Does he use the computer to do payroll? "Well, we do and we don't. We have a payroll program that I designed myself that will give us all the data necessary to write a paycheck. The checks then, are manually written. They could be written on the printer but we don't have a high enough volume to justify the time it would take just to put the check paper on the printer," he explains.

Brown is particularly enthused about his computer programs which provide the customer with information. "We have a program that will send out letters when we get requests for quotes, something we didn't do in the past because it was too time-consuming. We might get half a dozen requests for quotes a day, and all we have to do is key in the name, address, city, and the square feet of the lawn of the person who inquired. The computer will then print out a letter, similar to a form letter. However, it is personalized to that individual and gives a recommended program for that lawn, and the cost of each item. It itemizes everything, and that's helped us a lot in making sales," Brown says.

He goes on, "When we do make the sale, the computer sends out another letter thanking the customer for his order, and it outlines the program we have set up for that customer. This gives customers the opportunity to change anything if it's not what they want, and it gives them something to hold onto until we get there, which might be a week or ten days, depending on our backlog. It used to be that we took an order over the phone, thanked them on the phone, and they never heard from us until the truck got there. So, this letter adds a lot more professionalism to the business, and it's very easy to do."

At Michigan Lawn Spray, Bob Brown has his own ideas about how a computer should be used. Brown says, "We're using it for storing all our customer information — name, address, type of service, costs; for sending out our spring mailing to customers, and for doing the invoices and re-billing, plus several other programs we have. We have a program, for instance, where we can add up all of our accounts to see how large we are and compare it to where we were, say, a month or a year ago."

The computer sends out a quote and later a thank-you letter.

SOFTWARE DECISIONS CRITICAL

While finding the right computer at the right price is crucial, it is equally important to obtain the appropriate programs. These programs, which are really a set of directions that enable the computer to perform desired operations, are often referred to as "software". Without software designed for the specific needs of a chemical lawn care company, the most sophisticated computer system will be of little value. Anyone who is looking into the possibility of purchasing a computer should put at least as much time and effort into determining just what software he needs, and where he can get it.

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Today, the lawn care businessman seems to have two options when it comes to software. The first is to hire a professional programmer to write the various programs that are needed. This approach has the advantage of flexibility, as the programmer can obviously tailor the software to fit the individual situations. The disadvantage lies in the fact that a programmer's time is expensive, and getting a program to run exactly the way you want it may take many more hours than you anticipate. On this point, Allen Dall says, "It is extremely important to find a programmer who has worked on lawn care programs before. You will save yourself a lot of aggravation if you get someone who knows exactly what a lawn care business' needs are."

Much time should be spent determining software needs.

Jim Kelly agrees, and continues, "While the basic ideas aren't so difficult, getting the programs exactly the way you want them takes time. Many, many hours of refinement went into our present software."

Bob Brown believes that it is wothwhile to spend time learning to write basic programs yourself. "I studied some books and learned how to do programming myself. However, some of my programs were done by a professional that I hire as I need him. Keep in mind that programming is very expensive. Computers have come down in cost but programming hasn't. And, if you have custom programming done, it can be two or three times the initial cost of the computer", says Brown.

The owner of a new computer has a second option. He can purchase or lease a software package especially designed for the lawn care industry. Two such packages have been developed out of the programming work done for Keystone and Lawnco.

As Allen Dall explains, "When we got the 5110, we went to Mini Systems Group, Inc. in Cleveland, and told them what we wanted to do with our computer. Mini Systems has since developed a modular system which will do all of those things."

Jim Kelly, of Keystone, describes a similar situation. "We went to Mobile Automation in Wayne, Pennsylvania to have our programs written. It is out of their experience with us that they have developed their software package."

And what functions can the packaged softwaare perform? According to Art Tuscany, of Mini Systems, "We have a module that can process estimates. It maintains a file, schedules follow-ups, and transfers 'go-aheads' automatically to the customer file. Another module can build and/or change a basic data file, determine a logical sequence for customer service, and print invoices at the time service is scheduled. A third module can automatically post and print invoices and aging reports, and then print past due reminders. Finally, a module is available which will do customer analysis, route analysis, annual invoice analysis, and print customer labels and spring remider labels."

Tony Ciarlone, a representative of Mobile Automation, says, "Our customized total system can provide the entire range of computer function, including accounts receivable, accounts payable, payroll, general ledger, production, costs and revenue reports, sales and marketing reports, commissions, and special service reports. Our management control programs print invoices, reminders, and over-due notices as well as customer status reports, treatment schedules and analysis, and selective mailing lists with labels."

In the next issue of **ALA**, *our four lawn care businessmen will discuss the cost of computerization, how you can know if your company needs a computer, and what you should consider as you make your selection.*

New Fertilizer Combination

The Andersons Lawn Fertilizer Division of Maumee, Ohio has announced the development and E.P.A. clearance for sale this spring for one of the newest combination lawn care products on the market:

Turf Care 20-4-10 with .92% Balan
& .46% Dursban
40lb. bag treats 8,000 sq. ft.

A free flowing granular fertilizer with slow nitrogen, iron and sulfur, plus crabgrass control and insect control. This 3-way product gives a complete feeding, controls crabgrass and prevents grubs from laying eggs, thereby preventing another grub generation. Manufactured by The Andersons, Lawn Fertilizer Division, P.O. Box 119, Maumee, Ohio 43537.

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Calendar of events:

April 14-15
34th Annual Southeastern Turfgrass Conference. University of Georgia College of Agriculture, Experiment Stations; Tifton, GA. Contact: Dr. Glenn W. Burton; Dept. of Agronomy, University of Georgia, College of Agriculture; Tifton, GA 31794.

September 16-19
National Lawn & Garden Distributors' Annual Convention. Century Plaza Hotel; Los Angeles, CA. Contact: Nancy S. Irving, Executive Director, NLGDA; 1900 Arch St.; Philadelphia, PA 19103.

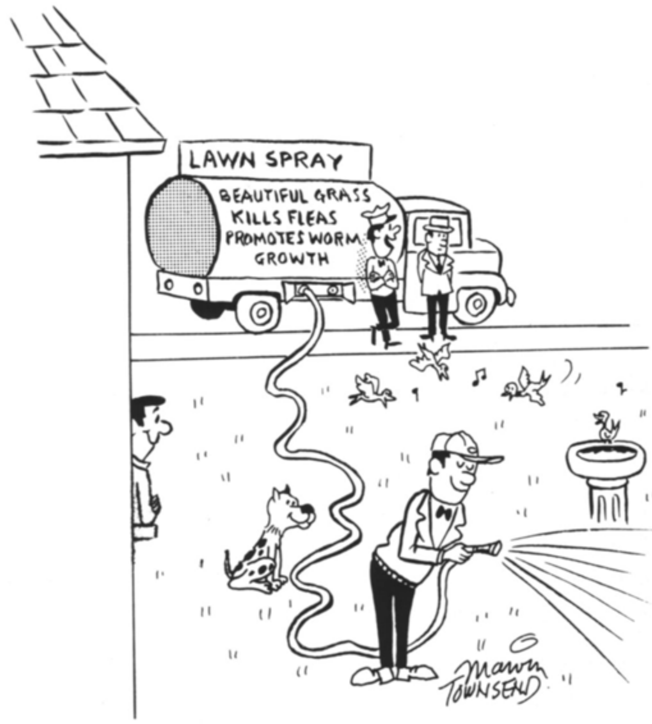
October 14-15
Symposium of Turfgrass Insects. Holiday Inn; Columbus, OH. Contact: Dr. B. G. Joyner, Plant Diagnostic Labs, Chemlawn Corp.; 6969 Worthington-Galena Rd., Suite L; Worthington, OH 43085.

November 12-14
First Professional Lawn Care Association of America Convention, "Lawn Care Business Management in the 1980's." Commonwealth Convention Center; Louisville, KY. Contact: Glenn Bostrom, PLCAA; Suite 1717, 435 N. Michigan Ave.; IL 60611.

December 1-4
National Fertilizer Solutions Association 26th Annual Convention and Chemical/Equipment Exhibition. Los Vegas, Nevada. Contact: Jerry Eisele, NFSA; 8823 N. Industrial Rd.; Peoria, IL 61615.

December 9-11
Ohio Turfgrass Conference. Dayton Convention & Exposition Center; Dayton, OH. Contact: Dr. John Street; 1827 Neil Ave.; Columbus, OH 43210.

Humor:

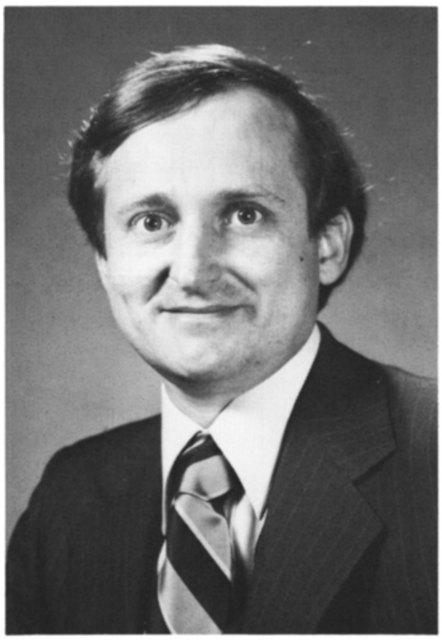


We've learned it pays to keep everybody happy!

A Study of Nutrients

Importance of Potassium in Turfgrass Management

by Nick E. Christians



Nick E. Christians grew up on a farm near Kanawha, Iowa, and graduated from Kanawha High School in 1967. He spent 2 years at Dordt College in Sioux Center, Iowa and then transferred to Colorado State University in Fort Collins, Colorado. Nick received a B.S. degree from the CSU school of forestry in 1972. After graduation he was employed as an assistant golf course superintendent at Flatirons Country Club in Boulder, Colorado for 1 year, and then as a golf course superintendent near Pueblo, Colorado for 2 years.

Nick resumed his education in 1975 at Ohio State University, where he majored in agronomy with a specialization in turfgrass management. He received a M.S. Degree in 1977 and completed a Ph.D. degree in 1979. Both of these degrees were obtained at Ohio State.

Increased cost and decreased availability of fertilizer materials are becoming serious problems in the turfgrass industries. The use of proper amounts and ratios of nutrients is no longer just good management, but is a necessity. This is particularly true in the lawn care industry where the efficient use of fertilizers can mean the difference between profit and loss.

The fertilizer materials used in the greatest quantity on turfgrasses are nitrogen (N), phosphorus (P), and potassium (K). Micronutrients, usually iron (Fe) or zinc (Zn), are used to some degree, but basically it is N, P, and K which become limiting to turfgrass growth and which are usually included in lawn fertilizer recommendations.

These three elements are often referred to as macronutrients because they are required in relatively large quantities by the plant. Of the three, N is required in the greatest quantity by the grasses, followed in order by K and P. The reason for the important status of nitrogen lies in the chemistry of the plant. Nitrogen is an important constituent of many of the organic molecules, including chlorophyll. Deficiencies of this element readily show up as 'chlorosis', or yellowing, of the tissue and by a decrease in the rate of growth. Severe nitrogen deficiencies will eventually have an effect on every attribute and function of the plant.

Phosphorus is likewise a constituent of a number of organic molecules. One of its most important functions is its involvement in the transfer of energy within cells. Phosphorus has been linked to the formation of reproductive primordia, seed formation, the growth of roots, and the strengthening of stems in the grasses (7). The importance of this element at the time of establishment is also well known in the turfgrass industry. Foliar symptoms of Kentucky bluegrass deficient in phosphorus have been described in the literature (3) but they are rarely seen under field conditions. These symptoms include very very dark green foliage in the early stages, followed by an intense tan coloration of the leaves in later stages. Rapid response of the type which normally follows the application of N to grasses generally do not occur following fertilization with phosphorus materials. Only on soils with extremely low levels of available P, would any visible response of Kentucky bluegrass to applications of P fertilizer be expected.

Potassium, unlike N and P, is not a constituent of any organic molecules in the plant. Yet, most plants use relatively large quantities of this element. The grasses in particular are heavy users of K (6). Potassium has been linked to a number of biochemical processes within plants; however, the mechanisms involved in these processes are still somewhat of a mystery to plant scientists. Among the functions known to be affected by K are (a) carbohydrate metabolism, (b) synthesis of proteins, (c) enzyme activation, (d) promotion of

A Study of Nutrients

meristematic growth, and (e) adjustment of stomatal movement (7). It is known that K deficient turfgrasses have a difficult time translocating carbohydrates from leaves to roots, and that they are less drought resistant and more susceptable to disease (5). Potassium has also been linked to rooting, to tolerance of temperature extremes, and to wear tolerance of the turfgrasses (1).

Deficiencies of potassium do not always cause visible symptoms. Potassium deficient plants may undergo a phenomenon known as 'hidden hunger'. Grain crops which exemplify hidden hunger show no other symptoms than a decrease in yield. W.L. Nelson of the potash institute (5) states that foliar symptoms of potassium deficient turfgrasses are difficult to discern, especially on the mown turf of golf course greens, and that these plants may exhibit hidden hunger.

Foliar deficiency symptoms have have been observed on both bentgrasses grown on potassium deficient nutrient solutions in the laboratory (3). The symptoms described include (a) soft drooping leaves, (b) a tendency toward excessive tillering, (c) moderate chlorosis of interveinal areas, and (d) rolled and withered leaf tips.

Nitrogen is unquestionably the most important element for the fertilization of turfgrasses. This is the nutrient most likely to be limiting to growth, and grasses will usually show very rapid visual responses to its application. In recent years, however, an increasing amount of attention has been given to K and its importance to the maintenance of quality turfgrass areas. The balance between N and K seems to be of particular importance to the grasses. In 1969, Monroe, Coorts and Shogley (4) published an excellent paper which demonstrated the importance of this balance. Their work was performed using Kentucky bluegrass grown under carefully controlled conditions in the green house. The grasses were grown on pure, silica sand to remove the variability found in soil. Their results indicate that K plays a very important role in the maintenance of Kentucky bluegrass. At moderate levels of N, best growth and development was observed at high levels of K. They also demonstrated that the response to increasing levels of K depended on the level of N. In other words, N and K 'interact' in their combined effects on Kentucky bluegrass.

The balance between N and K seems to be of particular importance to the grasses.

Whenever the response to an experimental treatment varies with the levels of another treatment, the two are said

of another treatment, the two are said to interact. Few things in nature are truely independent and interactions are commonly observed in experimental work.

N and K 'interact' in their combined effects

There are other references in the scientific literature which indicate that nutrient elements interact in their effects on the grasses. For instance, it is known that the increase of N in the blades of Kentucky bluegrass in response to increasing levels of N fertilization is dependent upon the level of K fertilization (8). Basically, though, our understanding of these interactions is very limited. We know that they exist, but the key to understanding them and then to using that understanding in a practical way is yet to be found.

There have been two factors which have prevented extensive study of these relationships among nutrient elements. The first is the large number of experimental units (the objects being studied) required in investigations of this type. The second is the tremendous number of mathematical calculations which are required to thoroughly study the interactions.

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The first problem was partially overcome in the 1950's by a group of statisticians headed by a man named Box. Box and the others developed statistical methods by which the interrelationships among experimental treatments— the interactions— could be studied with far fewer experimental units than had previously been required. These methods were originally developed for use in the field of chemical engineering, but were readily adaptable to agronomic studies.

The second problem has been overcome by the computer industry. In the last 15 years, there have been many advances in computer science. Calculations which once took days to perform now take seconds. The use of the computer itself has been greatly simplified through the development of computer programs. Computers are now used in nearly all fields of study. The statistical methods developed by Box and more recently available computer programs were used in a study on Kentucky bluegrass and creeping bentgrass at Ohio State University. The results of that study are the subject of the remainder of this article.

The main objective of the investigation was to study the ways in which N, P, and K interact in their effects upon the two turfgrasses. The initial stages of the work were conducted under controlled environmental conditions in the laboratory using sand culture methods similar to those of Monroe and his co-

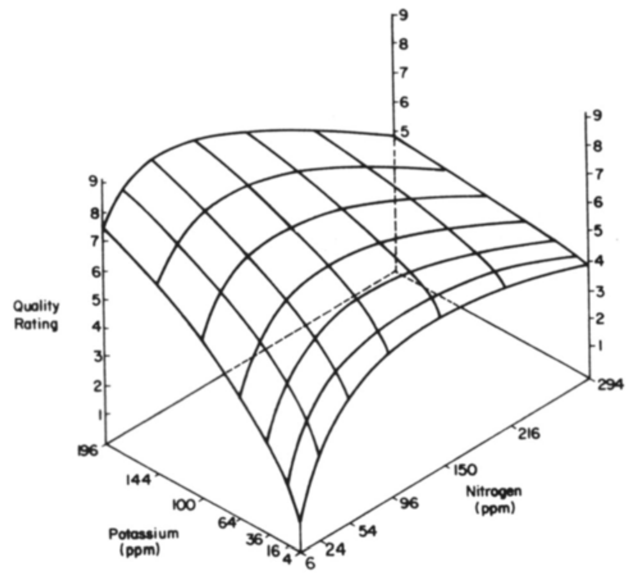

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Fig. 1. Response surface showing the affect of nitrogen and potassium on the quality of creeping bentgrass.

workers. The information gathered in that phase of the study was then used to design experiments in the field.

The treatments which were used in the laboratory study were based on parts per million (ppm) of N, P, and K in a liquid nutrient solution. The varying quantities of N, P, and K were applied to a series of pots containing the grasses, with an automatic watering system designed for laboratory use. The number of ppm of the elements cannot be readily converted to field fertilizer recommendations. What is of importance in the results that are to be discussed is not the number of ppm involved, but the relative quantities of each element required.

Some interesting results were found in the laboratory phase of the study. For instance, very small quantities of P in relation to N and K were required for the maintenance of these two grasses on sand. The lowest P treatment included was 2 ppm. No sign of P deficiency was observed at that level, and no response was observed when the quantity of P included in the nutrient solution was increased sequentially from 2 up to 98 ppm..

The response to N and K and the relationships between the two were of most importance. More K than N was required to reach maximum growth and quality for both species. The best overall quality (based on visual evaluations) of Kentucky bluegrass was observed on those pots which were treated with solutions containing 96 ppm N and 196 ppm K. For creeping bentgrass the best quality was observed at 54 ppm N and 196 ppm K. In both segments of the study, 196 ppm K was the highest treatment. There may well have been response to higher levels of K had they been included in the study.

The quality ratings of creeping bentgrass in response to N and K are shown in Fig. 1. The graph in Fig. 1 is called a

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response surface. Response surfaces are based on mathematical equations which are in turn based on the data collected from certain types of experiments. The response surface is a very effective way of demonstrating the interactions between 2 treatments; in this case N and K. The response surface appears to be complicated at first, but if you look closely at it you'll see that it is quite easy to understand. Notice in particular the response of quality to increasing levels of N. There are 7 separate response lines to increasing levels of N, one at each level of K. Nitrogen and K interact. That is, the response to increasing levels of N varies with the amount of K in solution. The nature of this interaction could potentially be very important to turf management. At very low levels of K, high levels of N are required to reach the highest observed quality. As the amount of K is increased there is a gradual shift in the nitrogen response curves. With each increment of K, less N is required to reach the maximum observed quality. The results of this segment of the study indicate that K fertilization can, to some degree, decrease the N requirements of grasses.

Fig. 2 is the quality response surface for Kentucky bluegrass. The decrease in the N requirement observed with increasing levels of K for creeping bentgrass do not appear in this graph, although it should be pointed out that trends of that type did appear in some of the data collected from the Kentucky bluegrass study. The importance of K to the maintenance of Kentucky bluegrass is still very evident, however. At all levels of N, the observed quality increased in response to addition of K consistently to the highest level, 196 ppm. The results of the laboratory investigation did substantiate the previous indications in the literature that the balance between N and K is quite important.

The field study was conducted during the 1977 and 1978 seasons at the Ohio State University turfgrass research facility at Columbus, Ohio. This study was again performed on Kentucky bluegrass and on creeping bentgrass. The results of this study are yet to be published in a scientific journal and will not be discussed in detail at this time. There were some very important similarities between the field study and the controlled environment study. First, both in the lab and in the field, phosphorus requirements of the two species were met at very low application rates of that element. No response to applied P was observed even though soil test levels as low as 14 lb. P/Acre* were measured in some of the plot areas.

Again, the effect of applied N and K were not independent. The nature of the interactions between applied N and K were somewhat different in the field than they were in the laboratory on pure sand, as would be expected. Differences in the interactions were also observed in the field on irrigated and non-irrigated areas, and on the different soil types included in the study, but still the fact remains that N and K do interact in their combined effects on the growth and quality of turfgrasses. They are not independent.

So, where do we go from here? The experimental methods used in these studies are very efficient techniques for looking at the interactions among a number of widely spaced treatments, such as a series of N, P, and K application rates. They are less useful

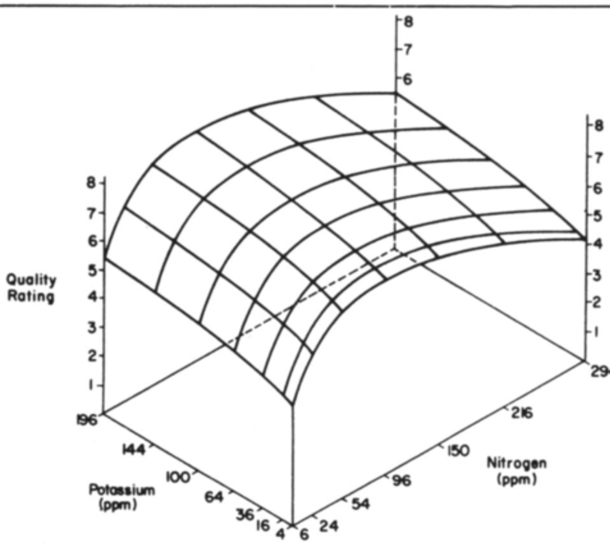

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Fig. 2. Response surface showing the affect of nitrogen and potassium on the quality of Kentucky bluegrass.

Based on the Bray 1 phosphorus test.

A Study of Nutrients

when it comes to making specific recommendations. For that reason, investigations of this type usually serve as preliminary studies. They are used to search out the relationships which exist and to point the way to more detailed work. The studies at Ohio State produced some very interesting information on the importance of K to the maintenance of turfgrasses and on the way in which N and K interact, but to make specific recommendations on the quantities of these two materials to use on lawn areas, based on these results alone would not be possible. The next step in this work will be to use what has been learned to design very specific studies directed at the N and K interaction and from which more detailed recommendations can be made.

From the standpoint of plant chemistry, less is known about K than is known about either N or P. There is still much to be learned, both about the function of K in the plant and about its relationship to, and interactions with, other elements.

What does this mean to the lawn care professional? The amount of K you apply is a management decision. That decision must be based on your knowledge of the species you are working with and on a knowledge of the characteristics of the soils on which that species is being grown. But don't be afraid to experiment. It takes very little time to mark off a few plots in your back yard and to apply a set of treatments. Try some higher rates of K and compare that to your present application rates and to an area receiving no K. If you want to spend a little more time and tie up a little more space, try cutting back somewhat on N, while increasing levels of K. Of course, you'll have to include examples of your existing program for comparison purposes. Chances are, on many soil types you'll see little difference, but I believe the results may surprise you on some areas; particularly on the sandier soils. One word of caution, do not expect striking results in a short period of time. The grass is not going to respond to K in the same way that it responded to N. It may be the second season before noticeable differences begin to appear. If you do see some important results from home tests of this type, I would appreciate a letter from you explaining what you observed and the type of soil you were dealing with.

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Weed Control Correspondence Course

The University of Guelph in Ontario, Canada has announced the development of a new correspondence course, *Weed Control in Turf.* This course, which is part of the Turf Management program, was authored by Dr. C.M. Switzer, Dean of the Ontario Agricultural College. Dr. Switzer has taught courses in plant physiology, plant nutrition, and weed control. Along with his administrative duties, he continues to be involved in both teaching and research in the area of weed control. Dr. Switzer is the Chairman of the Ontario Weed Committee, a member of the Educational Advisory Committee of the Golf Course Superintendents of America, and President of the International Turf Grass Society.

Weed Control in Turf provides a thorough coverage of weed biology, control of broad-leaved weeds and weedy grasses, and the application and safe use of herbicides. The course consists of the following seven units:

Weeds and Weed Biology— Weeds are defined and their identification explained. Weed life cycles are considered and methods of weed reproduction are investigated. Weed ecology and factors influencing the invasion and growth of weeds are included in this unit.

Controlling Weeds in Turfgrass— The reasons behind and the history of weed control serve as an introduction to a discussion of current methods. Cultural, mechanical, biological, and chemical means are explained. Herbicides are divided into selective and non-selective categories. The unit concludes with herbicide formulation and recommended times of treatment.

Control of Broad-Leaved Weeds— This topic is introduced by an explanation of the methods of removing broad-leaved weeds. A more detailed discussion of such herbicides as 2-4D, MCPP, Dichlorprop, and Dicamba follows. Several recommendations are included.

Control of Weedy Grasses— Eradication of weedy grasses by cultural, mechanical, and chemical means is discussed. Weedy grasses are divided into groups as perennials and annuals, and the chemical control of annual types is considered. Chemicals such as Bensulide, Chlorthal Dimethyl, Trifluralin, and Siduron are studied.

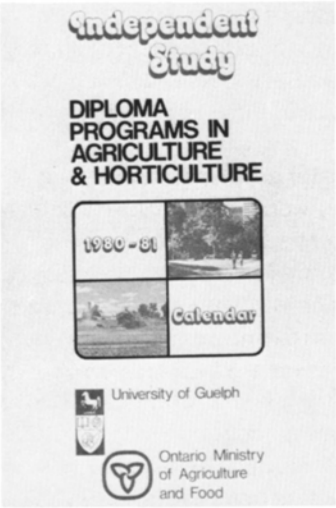
Other Weed Problems— This unit deals with areas other than lawns which have weed problems. Chemical and cultural control of unwanted vegetation in flower beds and basal plantings are presented as well as short and long term weed control in waste areas, parking lots, and driveways. The maintenance of bare areas is also explained. Paraquat, Diquat, Bromacil, and other herbicides are recommended. Problem vegetation such as clover, moss, poison ivy, and nutsedge is discussed.

Application of Herbicides— A detailed explanation of the use and maintenance of various pieces of equipment is presented. Also included in this unit is the determination of appropriate amounts of herbicide and methods for its application.

Safe Use of Herbicides— This section concentrates on various hazards which arise from the incorrect use of herbicides.

These include the effects to the sprayer operator, turfgrass, non-target plants, livestock, and wildlife. Legislation pertaining to herbicide usage is discussed to acquaint the prospective operator with restrictions and regulations.

Course evaluation consists of three written assignments. In addition to the illustrated printed material, the course package contains 18 filmstrips (equivalent to 378 color slides), a small hand viewer, and cassette taped commentary. These materials are the student's to keep as a reference.



This course can be used for individual study, in-service training of personnel, or seminar and classroom presentations. An inexpensive adaptor may be purchased for most slide projectors so that the filmstrips may be presented to groups.

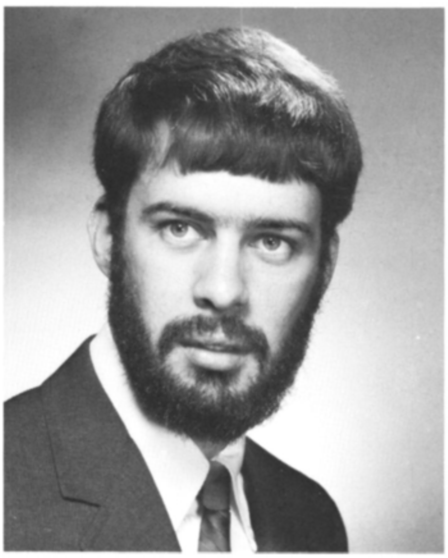
The cost of *Weed Control in Turf* is \$75.00 for Ontario residents and \$85.00 for those residing outside of that Canadian province. Those who wish to purchase the course for reference or in-service training only and not submit assignments can purchase the entire package for \$50.00. The text portion only can be purchased for \$20.00.

Inquiries should be directed to: Independent Study, University of Guelph; Guelph, Ontario, Canada, N1G 2W1.

A New Perspective

Chemical Lawn Mowing

by John E. Kaufmann



John E. Kaufmann is an assistant Professor of Turfgrass Management and Physiology at Michigan State University. He received his B.S. degree from Goshen College and both his M.S. and Ph.D. degrees from Michigan State University. Dr. Kaufmann previously taught at Cornell University in Ithaca, New York. His current research is in the area of chemical and environmental growth regulation.

Professional turfgrass managers and homeowners alike have long dreamed of the day when the lawn would grow only to the desired height and would thus eliminate the need for mowing. Turfgrass researchers have contemplated the possibilities and have concluded that the only feasible methods are the use of chemical growth retardants, of which there are some available, or dwarf-type turfgrasses, of which none are available. Use of dwarf-type turfgrasses will likely not occur in the near future, while chemical growth regulators have been marketed with marginal success to date. In the near future, however, it is certain that chemical lawn mowing will move closer and closer to becoming a reality.

In making the decision whether or not to use a growth retardant, the goals to be accomplished must be clearly defined. One goal may be to use the chemical to treat areas that are normally not mowed or are difficult to mow because of excessive slopes or frequent obstructions. The intent, then, is to improve the over all appearance of an area without the economic intent of reducing costs of mechanical mowing. The use of chemical growth retardants currently on the market can be justified in obtaining this goal.

"the chemical must replace three mowings before it pays off"

The other goal would be the use of these chemicals to economically replace mechanical mowing on fine turfs. Rough estimates suggest that the cost of the chemical would equal one mowing and the cost of application another mowing. Thus the chemical must replace three mowings before it begins to pay off. These kind of calculations may be important for the park, cemetery or roadside turfgrass manager but not necessarily for the professional lawn sprayer.

Since the lawn sprayer is already applying chemicals in liquid form, the cost of application could be negligible. Also, since the homeowner is usually mowing the lawn, the out-of-pocket cost of mowing is not as critical as the homeowner's interest in reducing his time spent on maintaining the lawn. The questions that need to be answered for the professional lawn sprayer are not just of economics but also of customer satisfaction. Will presently available chemical growth regulators give customer satisfaction? The following review outlines and discusses questions that you should ask the chemical growth retardant salesman when he knocks on your door.

Is the chemical compatible with my present chemical program?

The manufacturer should be able to provide information on the chemical compatibility of the product with common post emergence herbicides such as 2-4D, MCPP and dicamba. For spring applications, compatibility with the preemergent herbicides such as Dacthal, Betasan, and Balan must be considered. Information on compatibility with fungicides, insecticides and liquid fertilizers is also important.

What are the application procedures?

Many of the growth regulators have special timing recommendations. A growth retardant should be applied so that growth inhibition coincides with the period of maximum turfgrass shoot growth. For the cool season grasses this would likely be the spring season. For warm season grasses, the summer months.

CHEMICAL LAWN MOWING

The time of application is often limited relative to mowing height. Some chemicals may require tall foliage during application, to be mowed the following day, while others may require a normal mowing height during application with no subsequent mowings.

Is the chemical absorbed by foliage or roots?

When the chemical is primarily absorbed by the foliage, the time needed for uptake is critical. For instance, the activity of some chemicals could be severely reduced if rainfall or irrigation occurs less than 6 hours after application, and some reduction in activity could occur up to 12 hours after application. However, if the chemical is root absorbed, the length of time until rainfall or irrigation is not as critical. Here the concern would be whether there is enough water to set up the activity of the chemical or whether rain falls in such quantity that it rinses the chemical out of the turfgrass rootzone before it is absorbed. The use of a root absorbed growth retardant would be more effective for the lawn sprayer because of the high gallonage of water per 1,000 square feet found in most liquid programs. Foliar absorbed chemicals are most effective when applied at 1 gallon of water or less per 1,000 square feet.

Will the chemical have undesirable effects on the desirable lawn grasses?

A growth retardant is used to reduce growth, which is one of many physiological processes of the plant. It is not surprising that such a chemical will alter other processes such as synthesis of pigments. Very often early effects of a growth regulator include yellowing or discoloration of the leaves. A low level of discoloration can be tolerated, for a short period. However, it becomes unacceptable if the loss of color persists for the duration of the inhibition period or is extremely severe at any one time. On the other hand, some growth retardants have actually resulted in a darker green color compared to a non-treated check.

How will growth patterns of the lawn be affected?

The ideal objective of chemical lawn mowing is to reduce or eliminate vertical shoot and seed head growth without reducing or adversely affecting tillering, or root and rhizone growth. If the horizontal and below ground growth is inhibited, stress tolerance and recuperative potential are greatly reduced. In addition shoot growth reduction should be uniform among all species of plants (including persistant weeds) that are growing in the lawn. If they do not respond alike, a very unsatisfied homeowner finds himself mowing the lawn regularly for a few scattered patches of grass.

The search for the perfect growth retardant will continue

The search for the perfect growth retardant will continue. In the meantime, it is important to find how the individual plant reacts and which grasses respond to the growth regulator being considered for use.

How long will the effect last?

The seasonal considerations taken into account for application timing must be weighed relative to the expected duration of effect of the chemical. For areas not receiving any stress such as traffic, heat, cold or drought, a season long retarding effect would be desirable. However, if the chemical is to be used to reduce the spring flush of growth of cool season grasses in an area that may have increased traffic during a hot dry summer, season long growth inhibition would not be desirable. Yet the duration must be a minimum of 3 to 4 weeks where the chemical is expected to economically reduce mowing costs. A period of 8 to 12 weeks then becomes the most desirable duration of chemical effect.

For best results, should lawn culture be altered in any way while under the effects of a retardant?

When the chemical begins to take effect, mowing usually is terminated. What about irrigation and fertilization? Should the level be increased or decreased? Experience and research have shown that it is more critical to avoid wilt and drought while the lawn is under the influence of a growth retardant. This is primarily due to the lack of recuperative potential when the dry period is over. Data from Michigan State University does not suggest that a grass will either increase or decrease its water use rate due to growth regulator influence. Additional fertilizer applications to turfgrasses generally have not been successful in overcoming discoloration that may be associated with the chemical. However it does not appear that fertilization should be stopped just because the grass is no longer actively growing. Be sure to ask for cultural recommendations while the lawn is under the effects of the chemical, and remember that irrigation as needed to prevent drought is important.

"critical to avoid wilt"

(Continued on page 16)

CHEMICAL LAWN MOWING

Is there a chemical or cultural antidote?

Suppose that after the chemical has just taken effect, plans for use of the area are changed and growth is again desirable. For growth regulators presently on the market there is no known chemical antidote. As growth regulator chemistry becomes more sophisticated it is likely that an antidote could be made available along with the retardant.

"cultural antidoting is not possible."

The question about cultural antidoting needs to be asked of the growth regulator salesman. Suppose you have an unsatisfied customer and you need to "push" the grass out of the retarding effects with frequent mowing, high fertilizer applications, or frequent irrigation. Could it be done? For some chemicals, mowing has been an effective cultural antidote since the chemical is translocated to the leaf tip and once mowed off, has no more effect. For most of the growth regulators, however, cultural antidoting is not possible.

Is the lawn more succeptable to environmental stresses?

This question can be answered, "yes." Again the effects of stress environments are much more visible because of reduced turfgrass recuperative potential. Pest invasion that requires one or more weeks for plant symptoms to appear, (such as with the rust fungi) are often completely obscurred by an actively growing plant. However symptoms of pest or environmental stress damage will have time to appear on the aging leaves.

With fewer young leaves being developed to replace the old ones, the lawn may appear to age while under growth retardant effects.

The perfect chemical will need to be specific for reducing shoot elongation of existing leaves above a certain height while allowing the initiation and development of young leaves. Most chemicals available today inhibit initiation of new leaves as well as elongation of older leaves.

Are there any unusual growth effects after the retarding period is over?

Many people have reported that a burst of growth occurs as the lawn comes out of the effect of a growth regulator, and that this burst necessitates the expensive mowing that the chemical was designed to avoid. Turfgrass researchers have explained that this phenomenon is due to a high level of stored energy in the form of carbohydrates in the plant. Thus, when the plant is released from the effects of the chemical, the growth rate is very rapid.

Seasonal and cultural considerations will minimize this effect. It is important to not over-fertilize or overwater during the period of retardation. Additionally, the application should be timed so that a cold, hot or dry environment will limit the growth rate as the chemical effects are terminating. For a cool season grass, a spring application should be terminating as the hot, dry environment begins to slow growth, and the effects of a fall application would terminate as cool weather limits growth in late fall.

Many professional lawn sprayers are currently being encouraged to buy the chemical growth regulator, *Embark*. Of all the chemicals that have been on the market for turfgrass growth regulation, Embark is undoubtedly the most effective in reducing growth.

The following information is an attempt to answer the questions listed above relative to Embark's use. These conclusions have been derived from data and observations at Michigan State University.

Embark has been shown to be compatible with 2-4D. Because of similarities in chemistry to 2-4D, MCPP would likely also be compatible. Tests for compatibility with dicamba or pre-emergent herbicides have not been conducted. Make sure enough green tissue is available for foliar absorption. Mowing may be done once, 24 hours after application to make the lawn uniform. Plan the application so the chemical is on the leaves for 12 hours prior to rainfall or irrigation.

Some yellowing of the turfgrass plant should be expected during the second week after application. However, by the fourth week the treated grass may appear darker green than adjacent lawns which have not been treated. An environmental stress during the second week may result in a longer period of discoloration.

Both seed head development and shoot initiation and elongation will be retarded. For the cool season grasses, Kentucky bluegrass will show the greatest response, while red fescue and perennial ryegrass will respond to a lesser extent. Homeowners having a mixture of species may be less enthused with the chemical than those with a pure bluegrass blend. The effect should last from eight to ten weeks.

As is typical for most growth regulators, it is critical to avoid a drought when the lawn has been treated with Embark. The lawn should be mowed only once after the application of the chemical, and fertilization practices should not be altered.

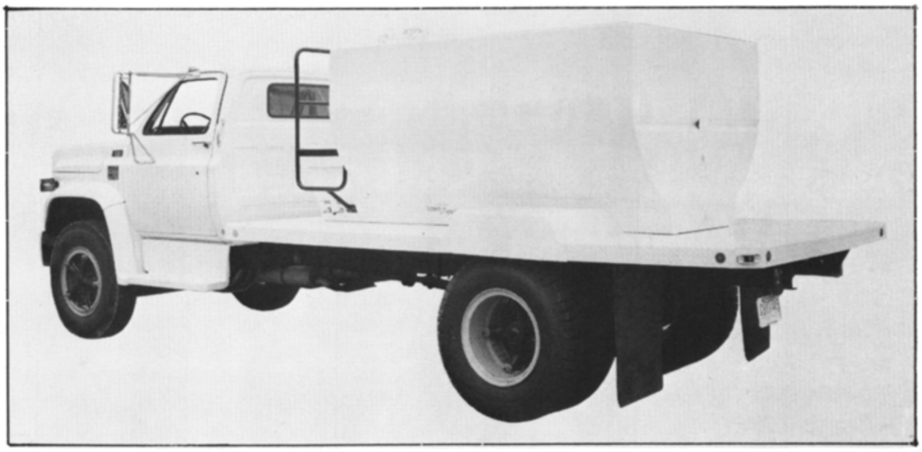
CHEMICAL LAWN MOWING

There is no known chemical or cultural antidote for Embark. Therefore, given a pest invasion or environmental stress that damages the lawn, nothing can be done to encourage new growth until the effect of the chemical wears off.

Since Embark retards initiation of new leaves, the lawn will be more suseptible to pest injury symptoms, traffic, and drought. Close examination will often show aged or infected leaves by the end of the retarding period. The evaluations at MSU all terminated at a time when growth was slowed by the environment, and the post-retardant burst of growth was not evident.

Plant growth regulators will play an important role in the future of lawn maintenance. An understanding of the effects of these chemicals will be critical to determine proper use. The questions listed above, when asked about each and every chemical growth retardant, will greatly enhance proper use and, ultimately, greater customer satisfaction.

NEW PRODUCT



The Finn Model LF-30

An applicator for spraying a mixture of water, liquid chemicals, screened dry chemicals and other materials, liquid or dry (screened), as required for lawn applications.

SIZE:	800 Gallon	1200 Gallon
Length	107½" (273 cm)	120½" (306 cm)
Width	57" (145 cm)	73½" (187 cm)
Height	57" (145 cm)	55" (140 cm)
Weight	1800 lbs. (816.5 kg)	2100 lbs. (952.5 kg)

TANK:

Capacity 860 gallons (3255 1), 800 gallon (3000 1) working or capacity 1200 gallon (4542 1) 1100 gallon (4164 1) working.
Removable top.
400 sq. in. (2580 cm^2) raised loading hatch with bagcutter guard and sealed cover.
Level gauge.

POWER:

Truck P.T.O. powered hydraulic pump or independent gasoline engine w/electric start powered hydraulic pump.
Oil cooler built in to hydraulic system.

PUMP:

2½" (6.4 cm) intake and 1½" (3 cm) discharge delivering 30 GPM (114 1/m) at 35 psi (2.5 kg/cm^2).
Clearance for ¼" (.65 cm) solids.
Diaphram pressure gauge.
Adjustable for wear.
Hydraulic variable speed controlled.

AGITATION:

Dual-hydraulic, variable speed controlled mechanical paddle type agitator in conjunction with liquid recirculation.

LOADING AREA:

Grouped controls for easy operation.
Independently operated variable speed pump control.
Independently operated variable speed agitator control.

DISCHARGE:

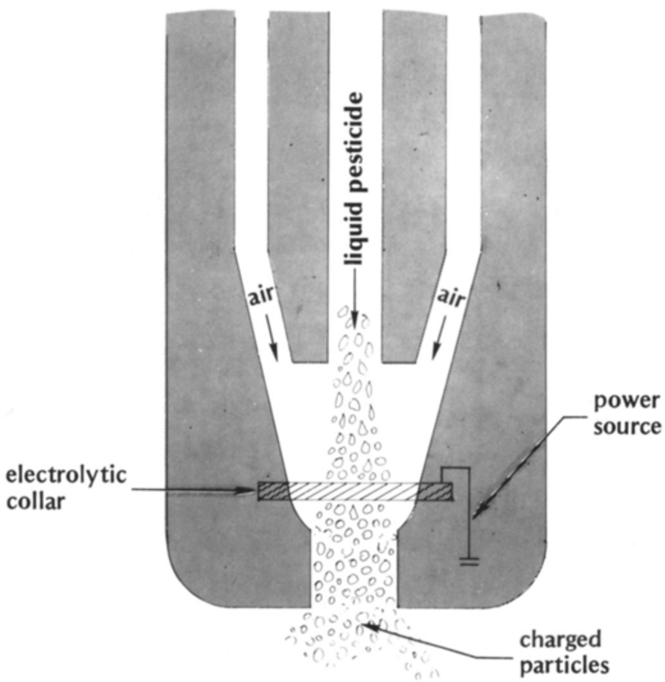
On/off valve and quick connector for attaching hose reel or hose.
Spray wand with on/off valve and nozzles for applying up to 4 gallon (15 1) per minute.
Adaptable for up to 400' (122 m) of hose (sized for flow desired up to 4 GPM (15 1).

Unit furnished with polymetal phosphate coating prior to painting.
For further details contact Finn Equipment Company, P.O. Box 8068, 2525 Duck Creek Road, Cincinnati, Ohio 45208.

The Process

Electrostatic Spray System Shows Promise

Actual application with electrostatic system.



The development of an electrostatic pesticide application system has important implications for lawn care professionals. This system, which was devised originally for agricultural crops, could allow you to use one half to one third the pesticide you are now using. At the same time, it would virtually eliminate drift problems.

The electrostatic system was invented by Dr. S. Edward Law, an Agricultural Engineering professor at the University of Georgia. Dr. Law had found that conventional spray systems deposit only about 20% of the pesticide spray on the target plant. Feeling that there must be a more efficient method, Law designed a system which has increased that accuracy to better than 80%. With electrostatic spraying, application rates can be reduced significantly because so much of the pesticide comes in contact with the plant.

Pesticide rate is about half that used by traditional methods.

The heart of the electrostatic system is an epoxy nozzle into which a small, round electrode is placed. This electrode puts negative electrical charges into each of the pesticide droplets as a spray cloud is produced. The negative charges or "electrons" in the spray

Electrostatic Spraying System

momentarily drive electrons out of the target plants, just as one negatively charged magnet repels another. At this point, the plant has been given a positive charge while the spray remains negatively charged. Since, electrically speaking, opposites attract, the spray is immediately pulled to the plant just as iron filings are pulled to a magnet.

A regular 12-volt battery is used to power the electrostatic system. A miniature, built-in circuit box steps up the voltage to about 1000 volts as it goes to the charging nozzle. Although the voltage may seem high, the current is less than 10 microamperes and the system is designed so that there is no danger to the operator.

An interesting aspect of Law's device is that it uses a very small amount of water as a carrier for the pesticide. The experimental model, used at the University of Georgia, requires only one gallon of water per acre. And, since the pesticide rate is about half that used in more traditional methods, the total amount of liquid to be transported is extremely small.

Although Dr. Law's original work with electrostatic spraying focused on cotton and other agricultural crops, he has recently completed research on the application of pesticides to turf. He is now satisfied that his system is just as effective on grass plants. Dr. Law explains, "Of particular importance is the fact that not only is more pesticide deposited on the plants but it is distributed more evenly. Where previously droplets were often transported around and away by air slip-streams, pesticides sprayed electrostatically are pulled back onto the side of the plant opposite the spraying device."

The spray is pulled to the plant as iron filings are pulled to a magnet

The FMC Corporation in Jonesboro, Arkansas has received the exclusive rights to produce Dr. Law's electrostatic spraying system. However, according to FMC representive Mike Lane, the company has no plans at present to market the electrostatic systems for the turf industry.

"Our priorities at this time are cotton, vegetables, and vineyards. I don't think we are aware of a demand from the turf industry for this type of equipment," says Lane.

Lane says further that his company might be persuaded to produce electrostatic sprayers for the chemical lawn care industry if they could identify a strong interest in the product.

For more information on Dr. Law's electrostatic spraying system, the following publications should be available in your public library:

"Agrichemical Age"; Jan/Feb, 1976; p. 11.
"Agri-Fieldman and Consultant"; May, 1977; p. 22.
"National Geographic"; February, 1980.
"Popular Science"; July, 1977; p. 10.
"Progressive Farmer"; February, 1977; p. 30, and October, 1979; p. 34.
"Research and Invention"; Spring, 1976; p. 1.
"USGA Green Section Record"; Nov/Dec, 1979; p. 1.
"World Farming"; January, 1978; p. 32.

Study shows little danger from inhalation

Pesticide Exposure to Applicators

by J. R. Vaccaro

NOTES ABOUT THE AUTHOR

James R. Vaccaro received his A.B. in Chemistry from Hope College, Holland, Michigan in 1965. He is certified by the American Board of Industrial Hygiene in the Comprehensive Practice of Industrial Hygiene, 1975. Currently a Research Specialist in the Industrail Hygiene Laboratory, Health and Environmental Sciences U.S.A., Dow Chemical U.S.A., Midland, Michigan.

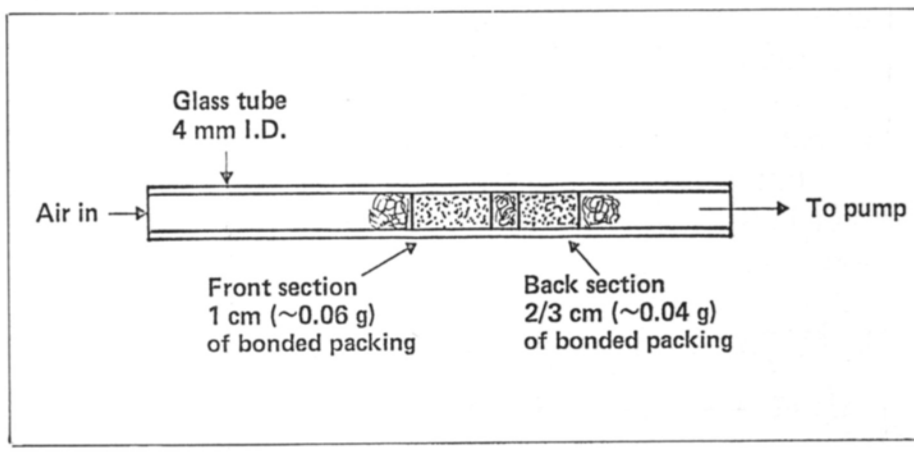


Figure 1: Sampling tube

One of the fastest growing small businesses in the United States in recent years is the lawn care industry. This industry includes the care of trees and shrubbry, sometimes referred to as ornamental spraying. The target pests in the turf application are chinch bugs, sod webworms, ants, brown dog ticks, crickets, cutworms, earwigs, grasshoppers and certain white grubs. In ornamental spraying the target pests are aphids, bagworms, caterpillars, scale crawlers, leaf-hoppers, mealybugs, mites, spittlebugs, thrips and whiteflies.

Lawn care involves the use of not only insecticides but also herbicides. Herbicides, in general, have relatively low mammalian toxicity, however, organophosphate insecticides generally have greater mammalian toxicity. The use of organophosphate insecticides has grown with the industry and, in 1978, 4.1 million pounds of organophosphates were used for insect control in this industry.

With this increased use came the increased responsibility to ensure that applicators were properly handling the organophosphates – in this case Dursban formulations is an organophosphate of moderate toxicity with an acute oral LD50 in the male rat of 163 mg/Kg and female rat of 135 mg/Kg. Organophosphates inhibit a series of enzymes collectively known as cholinesterase. When this inhibition occurs there is an abnormal accumulation of acetylcholine which disrupts the transmission of nerve impulses at nerve synapses and neuromuscular junctions. This may or may not manifest itself in the form of symptions. In nearly all cases of exposure, symptoms are not noticeable, even when there is extensive blood plasma enzyme depression.

The two major routes of exposure to organophosphate pesticides are inhalation and skin absorption. Skin absorp-

Pesticide Exposure

tion appears to be the major route especially from contact of liquid spray on the lower extremities. It was the purpose of the studies reported here to determine the contribution of the inhalation exposure to the total exposure.

In turf application, the nature of the spray can vary anywhere from a coarse droplet to a fine mist, depending on the applicator "gun", trigger position and the type of nozzle. Coarse droplets do not present as much of a problem as the fine mist does because of greater particle size. In ornamental spraying the liquid is released under a relatively high pressure (greater than 1200 psi) in order for the spray to reach inaccessible locations; sometimes overhead, as in trees. In this case, the mist generated would be expected to contribute more significantly to an applicator's exposure than the mist generated in turf application.

The following four surveys described were conducted in the Midwest. The work was completed by a company in the turf care business and currently using Dursban insecticide for insect control. Normal spray routines were followed. Each pesticide applicator was instructed to use the same application techniques each day.

The final spray, an emulsion, contained a herbicide, fertilizer and an insecticide, chlorpyrifos. The insecticide concentration was approximately 700-1000 parts per million.

TESTING PROCEDURE

Airborne samples of atmoshpere containing chlorpyrifos were collected by drawing air through glass tubes filled with a chemically bonded sorbent gas chromatographic Durspak/Carbowax 400/Porasil F. These tubes were 3" long and about 4 mm in diameter (see Figure 1). The air was drawn at approximately 100-200 cc/min using small, battery operated pumps. The pump was connected to the tube by a piece of either surgical tubing or Tygon tubing. The tube was then clipped onto the lapel of the pesticide applicator (see Figures 2 and 3).

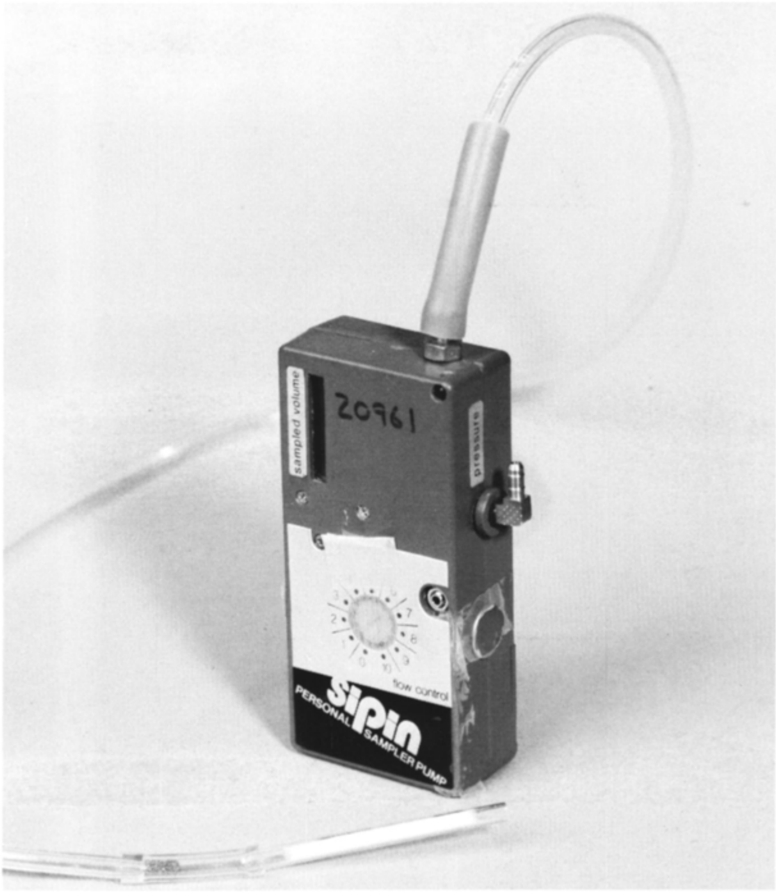


Figure 2: Sampling pump

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MAY 1980 ISSUE

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Pesticide Exposure

The applicator carried out his normal duties with the pump running. The pump was calibrated using a soap bubble meter and the flow rate recorded. These pumps were also equipped with digital scales which allowed calculation of the total volume per pump stroke, a constant. The flow volume was calculated by multiplying the total strokes by the constant, representing volume per stroke.

Once the sampling period was completed, the tubes were removed. The contents of each tube were later desorbed in diethyl ether and analyzed on a gas chromatograph equipped with a poly 1-100 column and an electron capture detector.[1]

In addition to sampling for chlorpyrifos with solid sorbent, 47 mm diameter Whatman No. 2 filter papers were placed on various parts of the uniform of the applicator to discern the pattern of fallout of the sprayed material. Some papers were placed in the breathing zone, near the sternum; others were placed on the uniform covering the extremities. After use, each paper was removed and placed in a vial and later desorbed with solvent and analyzed by gas chromatography, as was described for the air sample. The amount of chlorpyrifos found was reported in micrograms per sample.

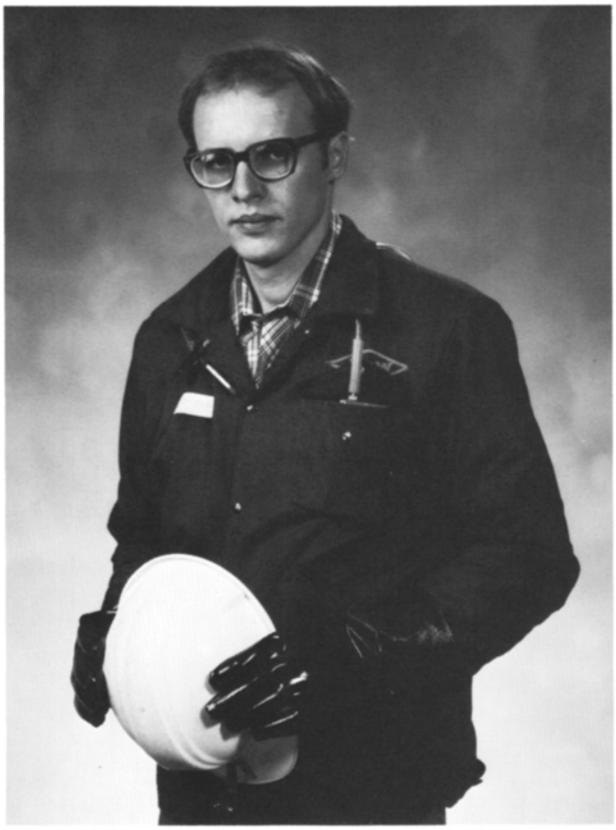

Figure 3: Sampling tube clipped to lapel of applicator.

EXPOSURE GUIDELINES

In order to determine if an individual's exposure to a substance is excessive, exposure concentrations must be compared with acceptable exposure guidelines. The current guideline for chlorpyrifos, established by the American Conference of Governmental Industrial Hygienists (ACGIH), is 0.2 mg/m^3 (0.2 milligrams of chlorpyrifos per 1000 liters of air or roughly equivalent to 14 parts of chlorpyrifos per billion parts of air). This exposure guideline was established to ". . . prevent measurable decreses in plasma cholinesterase activity and provide a wide margin of safety in preventing cholinergic symptoms. . ."[2] However, this guideline carries a skin notation with it which means that when considering the total exposure, skin absorption may make a significant contribution to the total exposure. The chlorpyrifos guideline is defined as the airborne time weighted average (TWA) concentration to which most individuals may be exposed for 8 hours a day, 40 hours per work week, throughout a working lifetime without suffering adverse effects.

Pesticide Exposure

It is possible for an individual to be exposed to a relatively high airborne concentration for a short time interval during which he may suffer ill effects, such as headache, dizziness, nausea, etc., and still maintain an exposure below the guideline. To prevent such exposure from being considered acceptable, a short term exposure limit of 0.6 milligrams of chlorpyrifos per 1000 liters of air was established. This means that an employee may be exposed to 0.6 mg/m^3 for approximately 15 min in every 2 hours as long as the TWA exposure does not exceed 0.2 mg/m^3 for the 8 hour day. For a 10 hour work day, a suggested guideline would be eight-tenths of the guideline, or 0.16 mg/m^3.

The guidelines established by the ACGIH are arrived at based on current knowledge of the toxicity of a given substance.

SAMPLING RESULTS

Air sampling was completed at several locations thoughout the Midwest. In August of 1975, three pesticide applicators were monitored for airborne exposure to chlorpyrifos. The spraying lasted 30 to 55 min. The measured TWA exposures ranged from 0.002 to 0.02 milligrams per 1000 liters of air. This monitoring was completed during the application of a dilute liquid spray containing approximately 0.1% chlorpyrifos to private lawns. During this survey, the Whatman filter papers were also placed on various parts of the uniform worn by the applicator. Of 16 samples taken, 4 showed values of 11 to 25 microgram filter paper. All of these filters had been placed on the uniform below the knee. None of the filters located above the waist, e.g., on the sternum, contained detectable levels of chlorpyrifos.

In August of 1976, a similar study was conducted where three pesticide applicators were monitored for airborne chlorpyrifos exposures. Two TWA exposures were determined on each of the three applicators. The following table summarizes the results.

TWA Exposures, mg/m^3

1st EXPOS.	2nd EXPOS.
Sprayer 1	
0.005 (95 min)	0.002 (110 min)
Sprayer 2	
0.001 (85 min)	0.002 (75 min)
Sprayer 3	
0.006 (85 min)	0.005 (60 min)

The average TWA exposure for the times indicated was 0.004 mg/m^3. Again, Whatman filter papers were placed at various parts of the uniform worn by the applicators to detect any fallout reaching that part of the uniform. Eight papers placed in the breathing zone ranged from 0.23 to 2.5 milligrams per paper. The average was 1.0 milligrams per paper. Six papers placed on the uniforms below the waist ranged from 1.6 to 135 milligrams perpaper. The average was 40 milligrams per paper.

Highest exposure was a factor of ten below guideline

A third study was conducted in June, 1979, where eight pesticide applicators were monitored for 4 to 6.5 hours. Chlorpyrifos exposures were monitored during normal application. The TWA exposures for the 4 to 6.5 hour periods ranged from 0.006 to 0.013 mg/m^3. No filter papers were used in this study.

Pesticide Exposure

A fourth study was conducted during ornamental spraying. Two applicators' exposure were evaluated. The first applicator's TWA exposure over a 2.5 hour spray period was 0.0007 mg/m^3. The second applicator was monitored for 2.3 hours and his TWA exposure was 0.023 mg/m^3. There was a decided increase in wind speed during the exposure monitoring of the second pesticide applicator. This probably accounts for the higher exposures to this employee.

None of the filters above the waist contained detectable levels

In none of the four studies was a pesticide applicator exposed above the acceptable guideline of 0.2 mg/m^3. In fact, the highest exposure noted was a factor of almost ten below the guideline.

CONCLUSIONS

Airborne chlorpyrifos, and organophosphate, were measured in the air during applications of the insecticide to turf and during ornamental plant spraying. The highest TWA exposure during four separate surveys was 0.023 mg/m^3, about one-tenth of the established ACGIH guideline of 0.2 mg/m^3, for airborne exposures to chlorpyrifos. The 47 mm Whatman No. 2 filter papers, used to determine the area's fallout onto clothing, indicated that very little chlorpyrifos found its way into the applicator's breathing zone, verifying the Porasil sampling tube data. The highest levels of chlorpyrifos were found on papers located below the knees.

For these reasons, it was concluded that airborne exposures to chlorpyrifos during routine turf application and during routine ornamental plant spraying are well below the current ACGIH guideline and provided a wide margin of safety for the pesticide applicator from exposures by the inhalation route.

REFERENCES

1. Melcher, R. G., et al., "Analytical Chemistry" 50:251, Feb. 1978.
2. American Conference of Governmental Industrial Hygienists: "Documentation of the Threshold Limit Values", Third Edition, pg. 304, 1971.

ACKNOWLEDGEMENTS

The author wishes to thank R. G. Melcher of the Michigan Division Analytical Laboratories, Dow Chemical U.S.A., for completion of all of the analytical work associated with the studies reported.

Reprinted from the 1980 Urban Pesticide Dealers and Applicators Clinics, University of Illinois.

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A Guideline

Timing for Turfgrass Disease Control

by Dr. M. C. Shurtleff

Extension Plant Pathologist and Professor of Plant Pathology, University of Illinois.

All important turfgrass diseases in the Midwest are caused by fungi, which react to changes in temperature, humidity, nutrition, and the general vigor of their grass hosts; distribution and amount of rainfall or irrigation; length of the dew period; and other factors in the air and soil environment.

Fungi are much more common and damaging to grass plants in a moist or overly fertilized turf than in a dry or moderately fed turf. Free moisture is essential to the rapid reproduction, spread, and infection of grass plants by all fungi except powdery mildew. Examples of damaging fungi include snow molds, Rhizoctonia brown patch, Sclerotinia dollar spot, Pythium blight, and Helminthosporium diseases.

Most of the fungi (over 100) that casue disease in turfgrasses feed on both living and dead plant material in the soil, on the soil surface (thatch), or in the living green "carpet." A pound of topsoil contains 4.5- to 225-million fungi, most of which are benficial in breaking down organic matter into useful humus. A few are even parasitic on the fungi that attack turfgrasses.

Fungi enter grass plants through mowing and other wounds, through pores (stomates), and by forcing their way directly through a plant's protective epidermis. After growing for

Fungi enters through mowing and other wounds

several days or weeks at the expense of a grass plant, most diseases-causing fungi give rise to spores or spore-producing bodies (e.g., sclerotia). Under favorable conditions of temperature and moisture, the spores and sclerotia germinate by sending out filaments (hyphae) that enter plants and establish a parasitic relationship, thus completing the disease cycle. A fungus may pass through a number of disease cycles in a single growing season.

Free moisture is essential to spread and infection of fungi

Fungus spores are easily transported from one grass plant or turfgrass area to another by air currents, splashing or flowing water, insects and mites or other animals, mowers and other turf equipment, shoes, and grass parts.

Proper timing for turfgrass diseases (and their control) into four groups based on the average temperature when symptoms *first* become visible.

COLD WEATHER DISEASES

(average temperatures between 32 and 45° F.)

Fusarium patch or pink snow mold and Typhula blight or gray snow mold attack all types of turfgrasses from November to April, expecially under a blanket of snow when the soil is unfrozen. The longer snow stays on the ground, the more likely it is that snow mold damage will be severe. To control Fusarium patch and Typhula blight, make the first fungicide spray or granule application – where problems have occured in the past – just *before* the first heavy snowfall is forecast in late fall or early winter. A second application of a suggested fungicide (see Table 4, Extension Circular 1076) should be made during a midwinter thaw in January or early February.

Turfgrass Disease Control

COOL WEATHER DISEASES
(average temperatures between 45 and 60^{o} F.)

Helminthosporium leaf spots and blights, Septoria leaf spots, leaf smuts, powdery mildew, and fairy rings are evident from late winter to early or midspring and again in the autumn. Control measures should start as the grass is becoming green in the spring and should be repeated in the fall. Septoria most commonly attacks the tips of the first green leaves in the spring, with the early Helminthosporium leaf spots and blights being evident a week or so later. Susceptible grass plants need protective fungicide applications against Helminthosporium diseases at 5- to 14-day intervals during periods of rainy weather from spring "green-up" through late spring. From a practical standpoint, two or three well-timed applications is all most homeowners and park boards are willing to pay for.

Leaf smuts are best controlled by two soil drenches spaced two to three weeks apart as the grass is going dormant in late autumn. A systemic fungicide is needed (See Table 4, Extension Circular 1076) because the fungicide must be taken up by affected plants and be translocated in an active state to where the smut fungi overwinter in meristematic tissues within the rhizomes and stolens. It is important to drench the fungicide into the soil.

Powdery mildew is a problem in shady Kentucky bluegrass areas when nights are cool (between 40 and 60 degrees), days are warm (between 60 and 80 degrees), and the weather is dry. Usually two or three spray applications are sufficient when spaced one or two weeks apart. Applications should start when mildew is *first* evident.

Control of leaf spot should start in early spring

There is no fungicide control for fairy rings short of stripping the sod and fumigating the soil beneath. Masking the symptoms by fertilizing the turfgrass area and pumping large quantities of water into the rings, using a root-feeder attachment on a garden hose, is usually all that is required. A brand-new method is to strip the sod, rototill the affected areas, and collect a bushel or so of the dry soil underneath containing the white mycelial spawn of the fairy ring fungus. The spawn of several rings is then blended together and placed back on the soil where it came from, and the sod is replaced. Fairy ring fungi are antagonistic to each other, and this treatment provides excellent biological control.

Fairy ring fungi are antagonistic to each other

WARM WEATHER DISEASES
(average temperatures between 60 and 75^{o} F.)

To control Helminthosporium leaf blights and crown rots, Sclerotinia dollar spot, and Corticium red thread or pink patch, fungicides are applied to susceptible grasses *just before* warm, rainy periods when and where disease has appeared in the past. Applications of protective contact fungicides are made at 7- to 14-day intervals. The newer systemic chemicals give four- to six-week control of dollar spot and red thread. To control Helminthosporium diseases it is important to check the disease while it is still in the leaf blight stage and *before* the fungus attacks the crown tissues.

HOT WEATHER DISEASES
(average temperatures *over* 75^{o} F.)

These diseases include Helminthosporium crown and root rots, Rhizoctonia brown patch, Pythium blight, Fusarium blight, anthracnose, and rusts.

Rhizoctonia brown patch and Pythium blight are active in hot, wet weather with frequent showers, heavy dews, and night temperatures generally above 70^{o} F. It is critical to have maximum fungicide protection on the grass during these periods. Anthracnose attacks plants weakened by disease, insects, and unfavorable weather. Fungicides are secondary to improving general turf health. Attacks of Fusarium blight can be expected during a summer drought (mid-May to early October) after an extended period of rainy weather. When the weather suddenly turns hot and no rain or irrigation has occurred for 10 days, watch out for Fusarium. One or two applications of a systemic fungicide are usually needed (see Table 4, Extension Circular 1076, spaced two to three weeks apart. It is important to drench the fungicide into the root zone and to have the turf watered thoroughly the day before treatment.

Rust diseases are a problem only when the grass is growing slowly, if at all, in hot weather. Instead of your making two or more applications of a fungicide, we suggest that you water and fertilize to keep the grass growing steadily – about an inch of new foliar growth per week. If fungicide applications are desired, the first spray should be made when rust *first* appears, with subsequent applications at 7- to 14-day intervals until the grass is growing steadily once again.

MISCELLANEOUS PROBLEMS

Seed rot and seedling blights (damping-off) cause damage in seedbeds that are overly wet and poorly drained. The grass seed should be treated with a captan or thiram seed protectant fungicide plus Koban or Tersan SP (for *Pythium* control) before planting. Fungicide sprays over the soil surface at about the time of seedling emergence, and again 7 to 10 days later, are often beneficial in obtaining denser stands of more vigorous seedlings.

Although algae, moss, and slime molds do not technically cause disease, they are unsightly. A fungicide application when the problem first appears is sometimes suggested. Correcting the underlying cause for having moss or algae, however, is much more important than applying a fungicide to check the problem once it appears.

KEY TO TURFGRASS DISEASES

by M. C. Shurtleff, PhD

Cold Weather Diseases (first visible at temperatures between 32° and 45°F)

- Round patterns of dead grass; often follows melting snow

  Patches usually less than 1 ft. across . . . Fusarium patch (Pink snow mold)

  Patches up to 2 ft. or more across. . . . . .Typhula blight (Gray snow mold)

Cool Weather Diseases (first visible at temperatures between 45° and 60°F)

- Round to arc-shaped dark green patterns in turf after grass greens up. Mushrooms may appear in rings following wet periods. . . . . Fairy rings

- Irregular patterns in turf; grass thin or bare; seedings affected, wilt and die . . . . .Seed decay, damping-off, and seedling blights

- Surface of grass blades with POWDERY mold

  Black streaks; leaves split into ribbons and curl. Grass dies out in irregular areas. . . . . . Leaf smuts

  Milky-white to gray, found in shade; easily wiped off. Grass thins out . . . . Powdery mildew

- Leaves spotted; leaves wither and die back

  Mostly at or near tips of first leaves; resembles damage from a dull mower. . . Septoria leaf spot (Tip blight)

- Spots with dark reddish-brown to purplish-black margins . . . . Helminthosporium leaf spot diseases

Warm Weather Diseases (first visible at temperatures between 60° and 75°F)

- More or less round, bleached straw-colored spots, 1 to 6 inches across. . . . . Sclerotinia dollar spot

- Leaf spots present; leaves may wither and die in large irregular areas; leaf sheaths may rot . . . . Helminthosporium leaf spot diseases

- Surface of grass blades if POWDERY; leaf spots not usually present

  Bright yellow-to-orange or reddish-brown pustules; occur during dry periods . . . . Rusts

  Milky-white to gray, found in shade; easily wiped off. Grass thins out . . . . Powdery mildew

  Bluish-gray, ash-gray, creamy-yellow, or black; easily wiped off; appear "greasy" at first. . . . . Slime molds

Hot Weather Diseases (first visible at temperatures over 75°F)

- Irregular patterns of weak, thinned and dead or dormant grass. Crowns and roots reddish-brown to black. . . . . Helminthosporium crown and root rots

- Leaves spotted to blighted and reddish-brown in irregular areas. Black-spined bodies on grass blades visible with hand lens. . . . . Anthracnose

- Round patterns of dead grass

  Patches usually 1 to 6 inches across; grass blades matted. May occur in streaks . . . . .Pythium blight

  Straw-colored patches up to 2 feet across; develop green centers. Appear during droughts . . . . Fusarium blight

  Light brown, usually without green centers; grass blades not usually matted . . . . Rhizoctonia brown patch

- Surface of grass blades becomes POWDERY

  Bright yellow-to-orange or reddish-brown pustules; occur during dry periods . . . . Rusts

  Bluish-gray, ash-gray, creamy-yellow, or black; easily wiped off; appear "greasy" at first. . . . . Slime molds