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Fall 1981

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TURF
BULLETIN

MASSACHUSETTS TURF
AND LAWN GRASS COUNCIL
INCORPORATED

FEATURED IN THIS ISSUE:

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Lawn Care: Big Potential For Fluids
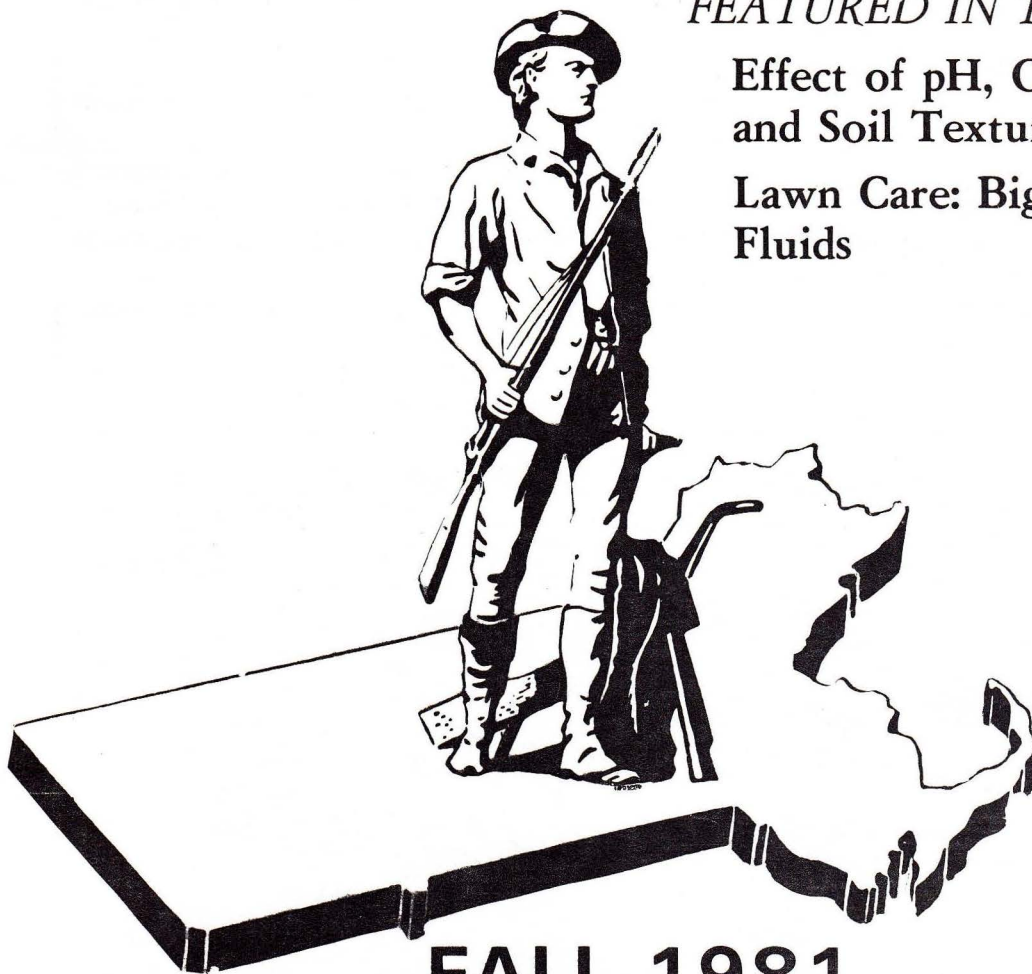
FALL 1981

BETTER TURF THROUGH RESEARCH AND EDUCATION

The Massachusetts Turf and Lawn Grass Council Incorporated is chartered under the laws of the Commonwealth of Massachusetts as a non-profit corporation. The turf council seeks to foster "Better turf through research and education."

More detailed information on the subjects discussed here can be found in bulletins and circulars or may be had through correspondence with the editor.

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Turf Clippings

Turf Research Field Day

Turf Day proved to be very successful this year with over 250 turf specialists attending the research station open house. Golf course, lawn care, and university personnel got a first hand look at the research being conducted at the eight-acre station located in So. Deerfield, MA. James T. Snow from the USGA and Kirk Hurto from U. Mass. were the guest speakers at the "Top of Mt. Sugarloaf" luncheon.

Soil Physics

Dr. Daniel Hillel, Soil Physicist and contributor to the Turf Bulletin shall be releasing three new books in 1982. The books, entitled *Introduction to Soil Physics*, *Advances in Irrigation Vol. I*, and *The Desert Shall Rejoice*, will be published by Academic Press and Praeger Scientific.

Welcome

The Turf Bulletin and Stockbridge Turf Program welcome Dr. William Torello. Dr. Torello comes to us from the University of Illinois at Urbana where his major research was "Ammonia Volitization and Urease Activity in Turf." Dr. Torello is currently teaching Plant Physiology.

Despite the dry weather, Joe Giles, Malcolm Chisholm and Bob Del Vecchio managed to operate the turf research station smoothly this summer. Joe, a Chemistry major, and Bob from Plant and Soil Science are both Stockbridge turf graduates currently working towards their 4-year degree.
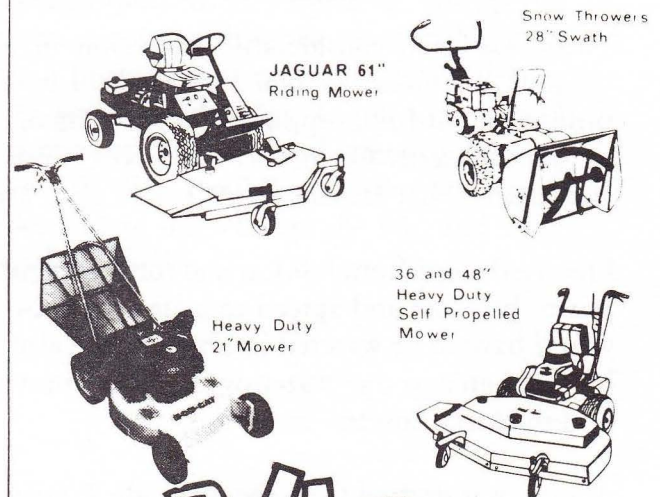
August 17, 1981

TO: Golf Course and other Turf Managers in Massachusetts

FROM: Dr. Patricia J. Vittum

RE: Registration of Oftanol^R (isofenphos)

There has been considerable confusion in Massachusetts recently concerning the status of Oftanol^R, a promising new insecticide. I wrote a letter to the Pesticide Regulatory Board in Boston in mid-July, supporting the issuing of a state (24-C) label so the material could be used in Massachusetts. Connecticut and New York had, by then, already issued 24-C labels, and I was hopeful that Massachusetts would also clear such a label.

I received word from Jeff Carlson (of the Regulatory Board) the last week of July that a subcommittee had met and agreed to issue a state 24-C label with two stipulations. First, the material would have to be watered in immediately after application. Second, Mobay Corporation would have to agree to the 'watering in' stipulation and make the appropriate changes on bags to be sold in Massachusetts.

A letter was drafted from the Pesticide Regulatory Board to be sent to Mobay notifying them of the decision. However, for some reason, that letter was not actually mailed from Boston until last Wednesday, August 12th, so Mobay is just receiving the news from Boston. According to one of the Mobay representatives in the Northeast, there is 'no way' that Mobay would agree to the stipulations laid down by the Massachusetts Board, so apparently they will not file the necessary paperwork and OFTANOL^R WILL NOT BE CLEARED FOR USE IN MASSACHUSETTS IN 1981. (The label may have national status for 1982, which would remove the need for another 24-C label for next year.)

So, what does all this mean? I asked Lou Wells (also of the Pesticide Board) whether it would be legal for turf managers to use Oftanol^R which had been purchased in another state. He said that any use of Oftanol^R in Massachusetts before Mobay files the paperwork would be illegal. **Even if the material has been purchased legally in another state and has been watered in, any use of Oftanol^R in Massachusetts is in violation of the law** until Mobay files for registration.

Please use discretion. If you have acquired some Oftanol^R this year, dispose of it in an appropriate manner - if possible, return it to the distributor. There is always the possibility that we could fail to get a registration for next year if we abuse the use of the material this fall.

Thank you for your patience!

Patricia J. Vittum,
Extension Entomologist.

Irrigation

A Toro automatic 5-row irrigation system has been installed at the turf research plots in So. Deerfield. The system covers 8 acres with 100% overlap between the 5 lines. This system consists of 40 Toro 690 series heads plus 1 green loop and operates off of unassisted street pressure at 120 psi. The flexibility of the 690 series allows us to interchange the 90° and 180° head ''guts.''

Effects of pH, organic matter and soil texture on herbicides

Industry expert probes into soil interactions that can affect herbicide performance

By Don Paulson, Jr.

In the past few years, a great deal has been written about the effect of pH, soil organic matter and soil texture on herbicides and their performance. This article is on attempt to summarize this information and to take another look at the whole question of those factors that affect herbicide performance.

Herbicides are complex chemicals that are applied in various ways, on many different soil types, under a variety of cultural and environmental conditions. They are expected to do some pretty tough jobs, often under very trying situations. In most situations, herbicides do the jobs expected of them.

Many interacting factors govern the effectiveness of herbicides. Ronald A. Farrell of Brayton Chemicals reported in the May-June, 1980 issue of SOLUTIONS that "weed control is a complex, complicated phenomenon that deals with a variety of variables, some of which we cannot control—such as the weather—but many of which we can control." He went on to list some of these variables such as weed history, cropping history, soil types, soil textures, tillage practices, application techniques (including soil incorporation), soil organic matter and soil pH. Managerial factors such as depth of planting, time of planting, timing of application, seedbed preparation and the rate and type of herbicide used are also important variables that can affect weed control.

As stated by Farrell, the type of herbicide used is, in itself, an important variable. Herbicides are designed for selective weed control in different crops; that is, they are designed to control weeds but not injure the crop. In addition, some herbicides are more selective on grassy weeds while others are more effective on broadleaves. Even though herbicides do the same basic jobs, they are different in their chemical as well as physical properties. Consequently, they are affected differently by pH, organic matter, soil texture and environmental conditions.

Soil

To understand how pH, organic matter and soil texture affect herbicides, we first need to have an understanding of the soil itself.

The soil is a complex, ever-changing system that has a unique combination of properties that are important in determining herbicide rates. Soils are not the same across the country, but each individual soil has properties that are common to all soils. All soils consist of various amounts of solid material and pore space. The volume of an average mineral soil is about one-half solid and one-half pore space (Figure 1). The solid portion of a soil is made

Paulson is a senior technical sales/service specialist with Ciba-Geigy Corporation of Greensboro, North Carolina.

Figure 1. The Volume of an Average Mineral Soil is About ½ Solids and ½ Air & Water.

Organic Matter/Clay

Organic matter is composed of plant and animal remains in various stages of decomposition. Undecomposed organic matter is often referred to as green manure. The addition of moderate amounts of green manure to a soil is not considered a major basis for altering herbicide rates. Humus, on the other hand, makes up the more residual fraction of organic matter. It varies little from year to year and is the portion of the soil organic matter on which herbicide rates are based. Organic matter levels in most mineral soils range from 1 to 5 percent. Much of the humus in soils occurs as a coating on mineral particles, especially clay.

Soil texture and organic matter contribute to what is called the exchange complex of a soil. The higher the organic matter and the finer the soil (higher in clay), the higher the exchange complex. Such soils generally require a higher rate and perhaps a different herbicide than coarse-textured soils (higher in sand) with very little clay and a low organic matter level (Table 2).

Although the amount of clay in the soil plays an important role in herbicide performance, organic matter content is usually more important because of its capacity to
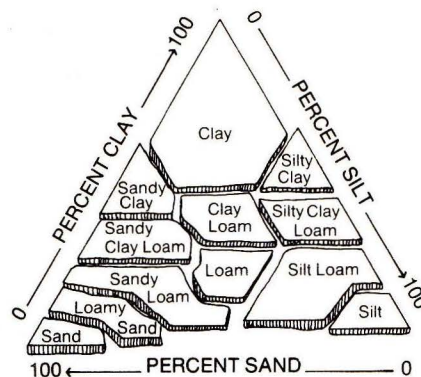

Figure 2. Textural Triangle Used for Soil Textural Classification.

attract and hold a variety of molecules, including herbicides, by a process called adsorption. This is simply a sticking of the chemical to the surface of organic matter (ionic bonding) so that it is not so free to move in the soil solution and, therefore, is less available for weed control, leaching and microbial degradation. Large portions of some herbicides are tied up or adsorbed by organic matter, leaving only small portions in the soil solution. At the other extreme, some herbicides are weakly adsorbed by organic matter and exist predominantly in the solution phase of the soil. Relative adsorption of some common herbicides by organic matter is shown in Table 3.

Because of soil adsorptive effects (or lack of) on certain chemicals, some herbicides are not labeled or recommended on soils high in organic matter. In contrast, herbicides that are weakly adsorbed may only be labeled for application on soils having a specified organic matter content or having a specified texture.

Herbicides establish an equilibrium between the soil solution and soil solids (organic matter and clay) in the same manner as do fertilizers (Figure 3). This equilibrium is established between those herbicide molecules adsorbed to the soil organic matter and clay and those molecules that are in the soil solution or vapor phase. Herbicide molecules present in the solution or vapor phase may be taken up by the weed seedling. In turn, more herbicide will be released from the soil particles. How tightly a herbicide is held by the soil organic matter and clay particles depends

up of various percentages of sand, silt, clay and organic matter. The pore space is filled with air and water or is often referred to as the vapor phase or soil solution.

The relative percentage of sand, silt and clay in a soil determines its texture. The more common soil textural names in order of increasing fineness are listed in Table 1.

The textural name of a soil may be obtained by use of a method called a mechanical analysis which determines the percent of sand, silt and clay present in that soil. For convenience in determining the textural name of a soil from a mechanical analysis, an equilateral triangle was adapted many years ago and is still very useful today (Figure 2). Wherever the three lines intersect on the triangle determines the textural category for that particular soil.

Table 1		
Soil Textural Names		
Sand (coarse)	Silt loam	Silty clay loam
Loamy sand	Silt	Sandy clay
Sandy loam	Sandy clay loam	Silty clay
Loam	Clay loam	Clay (fine)

Table 2		
Example of the Effect of Soil Texture & Organic Matter on the Rate of Herbicide Required for Weed Control **Dual 8E Alone — Corn and Soybeans**		
	Broadcast rate per acre	
Soil texture	**Less than 3% organic matter**	**3% organic matter or greater**
COARSE: Sand, loamy sand, sandy loam	1½-2 pts.	2 pts.
MEDIUM: Loam, silt loam, silt	2-2½ pts.	2-2½ pts.
FINE: Silty clay loam, sandy clay loam, silty clay, sandy clay, clay loam, clay	2-2½ pts.	2½-3 pts.
Muck or peat soils	DO NOT USE	

Table 3

Relative Adsorption of Some Common Herbicides by Soil Organic Matter.

Chemical		Adsorptivity to Soil Colloids
Common Name or Designation	**Trade Name**	
Dalapon	Dowpon	None
Chloramben	Amiben	Weak
Dicamba	Banvel	"
Bentazon	Basagran	"
2, 4-D	Several	Moderate
Propachlor	Ramrod/Bexton	"
Metribuzin	Lexone/Sencor	"
Atrazine	AAtrex	Strong
Cyanazine	Bladex	"
Simazine	Princep	"
Alachlor	Lasso	"
Metolachlor	Dual	"
EPTC	Eptam	"
Diuron	Karmex	"
Fluchloralin	Basalin	Very Strong
Chlorprophan	Furloe	"
Linuron	Lorox	"
Paraquat	Paraquat	"
Pendimethalin	Prowl	"
Butylate	Sutan	"
Profluralin	Tolban	"
Trifluralin	Treflan	"
Vernolate	Vernam	"
Prometryne	Caparol	"
DCPA	Dacthal	"

on the composition of the herbicide as well as the organic matter and clay content of the soil. Regardless of how they are applied (preplant incorporated or preemergence), herbicide-soil interactions will influence their performance.

On fields where soils are uniform in organic matter and texture, herbicides labeled within soil property limits will effectively control weeds and not result in crop injury. However, herbicide recommendations are difficult to make on nonuniform fields or with soils varying in organic matter. For example, when herbicides that are weakly adsorbed and effective on moderate to high or-ganic matter soils are applied at the same rate to areas of the same field very low in organic matter or with a sandy texture, it may result in injury to the crop. On the other hand, a herbicide that is strongly adsorbed to the organic matter and clay in the soil may result in poor weed control on finer-textured soils that are high in organic matter, *if* it is applied at the lower rate recommended for coarser soils, lower in organic matter.
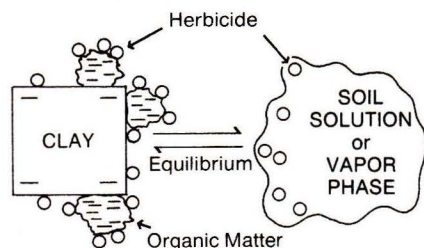
Achieving Weed Control

So what can we do to obtain weed control in fields of varying organic matter content? Here are some possible solutions:

1) Use a highly selective herbicide at the application rate for the high-organic matter areas in the field. The low organic matter areas will get larger amounts of herbicide than needed, but there is no danger of injury to the highly resistant crop.

2) Use a weakly adsorbed herbicide, where appropriate, at the rate for the predominant organic matter content in the field.

3) Calibrate your sprayer for the high-organic matter areas and increase ground speed or reduce sprayer pressure on the areas of low organic matter to reduce the amount applied.

4) Use mixtures of strongly and weakly adsorbed herbicides to hedge on both organic matter and crop tolerance.

5) If a good postemergence herbicide is available for a particular crop, use it and entirely avoid the soil organic matter problem. This could be a disadvantage when timing of application is important for obtaining good weed control.

As previously stated, the soil is a complex, ever-changing system that consists of a combination of properties that affect herbicides and their performance. We've mentioned soil texture and organic matter. However, a discussion of the soil and how it affects herbicide performance

Figure 3.-EXAMPLE of Herbicide Equilibrium Between Soil Solids (organic matter & clay) & the Soil Solution.

Table 4

pH Value Classification

pH	Classification
Below 4.5	Extremely acid
4.5 to 5.0	Very strongly acid
5.1 to 5.5	Strongly acid
5.6 to 6.0	Medium acid
6.1 to 6.5	Slightly acid
6.6 to 7.3	Neutral
7.4 to 7.8	Mildly alkaline
7.9 to 8.4	Moderately alkaline
8.5 to 9.0	Strongly alkaline
Above 9.1	Very strongly alkaline

would not be complete without discussing soil pH.

Soil pH

Soil pH is the degree to which a soil is acid (sour) or alkaline (sweet). It is expressed as a numerical figure, a reading on a graduated scale referred to as the pH scale (Figure 4).

The pH scale runs from 0 to 14. The middle value, 7, is neutral — neither acid nor alkaline. A reading below 7 is acid, above 7 is alkaline.

The pH value reflects the relative number of hydrogen ions (H^+) in the soil solution. The more hydrogen ions present, compared to the hydroxyl ions (OH^-), the more acidic the solution will be and the smaller the pH value. As the number of hydrogen ions (H^+) decrease and hydroxyl ions (OH^-) increase, the soil solution becomes more alkaline or basic and the pH value gets larger. The ratio between hydrogen ions (H^+) and hydroxyl ions (OH^-) changes tenfold for each unit change in pH. In other words, a soil with a pH of 5.0 is 10 times more acidic than one with a pH of 6, and 100 times more acidic than a soil with a pH of 7.0. Most soils used for growing crops have pH values between 5.5 and 7.8. Ranges in soil pH values are usually classified as shown in Table 4.

Soils with pH values below 6.5 are generally considered acidic. Those with pH values from 7.3 to 8.4 are usually classified as alkaline. Where high pH values are due largely to the presence of calcium, the soils are classified as calcareous.

Since hydrogen ions (H^+) have a positive charge, they can be held to the negatively charged clay and organic matter particles in the soil. The more free sites on the clay and organic matter particles, the more hydrogen ions or other positively charged ions (cations) that can be held to these particles. These holding or binding sites are also called exchange sites because a weaker ion can be exchanged for a stronger ion (e.g., hydrogen can be exchanged for calcium). This potential for exchanging of ions or cations is referred to as the cation exchange capacity of the soil (CEC) and is the figure you see listed in soil tests reports. The more exchange sites a soil has, the greater its cation exchange capacity.

A large number of herbicides currently on the market are ionic,
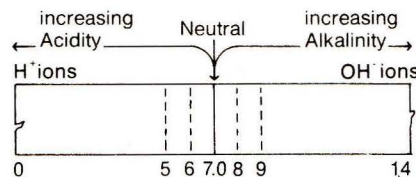

Figure 4. The pH Scale Showing pH of Soil Solutions.

which means they will ionize when dissolved in water. When dissolved in water they can either give off H^+ (act as an acid) or attract H^+ (act as a base), depending on the pH of the solution. Acidic herbicides (negatively charged) include *Banvel-D*, *Amiben* and *2, 4-D*. These herbicides tend to be repelled by the negatively charged organic matter and clay particles of the soil. Herbicides that behave as bases (positively charged) in the soil solution are the triazine herbicides such as *AAtrex*, *Milogard*, *Princep*, *Bladex*, *Sencor* and *Lexone*. These herbicides tend to be attracted to or adsorbed to the negatively charged organic matter and clay particles of the soil.

Still other herbicides are nonionic — do not react with water and do not carry an electrical charge. These include *Treflan*, *Tolban*, *Lasso*, *Dual*, *CIPC* and *Karmex*. Even though these herbicides are not ionic, many of them are polar (carry a partial electrical charge on part of the molecule) and can be affected by soil pH. However, the effect is generally smaller than with the ionic herbicides.

Some herbicides are so basic that they are positively charged regardless of soil pH values. Paraquat and Diquat fall into this category. They are so rapidly and tightly bound to clay and organic matter particles that they are virtually inactivated as soon as they contact the soil. Glyphosate *(Roundup)* is in a

special category. It is acidic in soils but has both negative and positive charge sites on it, making its pH charge interactions more complex (Table 5).

At this point, it should be reemphasized that, in general, only those herbicide molecules dissolved in the soil solution are available for control of weeds.

The degree of weed control or crop injury that can be obtained from a herbicide depends on the amount of herbicide dissolved in the soil solution. Herbicides should remain in the soil long enough to control weeds in the current crop, but not long enough to harm a sensitive crop the next year. When the soil pH level goes below 7, the herbicidal activity of basic herbicides like *AAtrex* (atrazine) is hampered. Ionic herbicides, especially the triazines, are adsorbed by organic matter and clay particles in the soil. The higher the organic matter and the more clay present, the more herbicide that is adsorbed. The lower the pH value, the greater the concentration of hydrogen ions in the soil solution and, therefore, the more sites that there are available for adsorption of the herbicides. This phenomenon explains why triazine herbicides such as *AAtrex* are not as effective in controlling weeds (and not as likely to injure crops) when the soil pH is low. Conversely, it partly explains why, in alkaline and calcareous or high pH soils such as those in the Southwest, West and parts of Iowa, Minnesota, Nebraska and the Dakotas, there is a high risk of triazine carryover injury to rotational crops such as soybeans.

The whole question of how soil pH affects herbicides is more complex than described here because more than one soil and environmen-

Table 5		
Effect of soil pH on Adsorption of some common Herbicides		
pH Designation	**Examples**	**Adsorption Strongest At**
Ionic:		
Strongly Acidic	Glyphosate	Low pH
Strongly Basic	Paraquat, Diquat	Neutral-High pH
Weakly Acidic	2, 4-D, Dicamba	Low pH
Weakly Basic	Atrazine, Metribuzin	Low pH
Nonionic:	Diuron, Profluralin,	No Significant Effect
	Metolachlor Butylate	From pH

tal factor is in effect at the same time.

Herbicides break down by chemical or physical action and by microbial action. These processes are affected by soil pH. Many triazine herbicides such as atrazine and metribuzin break down by a chemical process known as hydrolysis. Since atrazine is tightly adsorbed by soil organic matter and clay particles, it is necessary for adequate soil moisture to be present, in combination with adsorbed atrazine, for hydrolysis to occur. Atrazine that is in the soil solution is not so subject to hydrolysis and is available for uptake by weeds. As the soil pH increases, atrazine becomes less polar and loses its attraction for the negatively charged organic matter and clay particles. When this occurs, more atrazine goes into the soil solution, breakdown is slower (there is still microbial activity) and potential for carryover injury is increased. This situation becomes more complex in calcareous soils because calcium occupies many of the exchange sites on the soil particles. Calcium is stronger than hydrogen and atrazine molecules and is not as easily displaced. Breakdown of atrazine is then further reduced and potential for carryover is even greater.

Soil pH also affects the microbial life in the soil. Fungi predominate in acid soils and bacteria predominate in alkaline soils. The greatest number of microbial life exist in soils where the pH is near neutral (pH 7). The decomposition of acidic herbicides, like 2, 4-D, is mainly by microbial activity and since microbial activity in the soil is greatest at a neutral pH, these herbicides tend to lose their activity fastest in a neutral soil.

Soil microoganisms serve as the primary means by which most of the nonionic herbicides are degraded. Consequently, they also break down most rapidly in soils with a near neutral pH.

Management practices that influence soil pH will also influence herbicide activity. Recent work done in the New England states, North Carolina and elsewhere on fields where minimum tillage or no-till is practiced has shown that the top one inch of soil in a field under minimum or no-till was substantially more acidic than the 0 to 6-inch depth measured in standard soil testing procedures. Results have shown reductions as great as 1.3 pH units in the surface layer.

This change appears to be the result of surface applications of ammonium forms of nitrogen such as urea and ammonium nitrate that increase soil acidity as they break down into usable forms of nitrogen. Since little or no tillage occurs, acidity of the surface layer increases. This becomes more apparent where nitrogen fertilizers have been applied to the soil surface for two or more years without lime or tillage. Those herbicides that are strongly adsorbed to soil particles at a low pH will not work as well or last as long as they would under normal soil pH conditions. In fields under minimum- or no-till, adding lime on a regular basis will offset buildup of surface acidity. When soil sampling fields suspected of having reduced soil surface pH values, sample just the top one inch of soil and keep separate from other samples.

Low soil pH values affect herbicide performance in yet another way. Crops growing under such conditions are weaker due to poor nutrient availability to the plant. Consequently, these crops are stunted and provide less shading of the soil surface. This results in greater weed pressure, especially later in the growing season, and shortens the effective life of the herbicide.

Studies have also shown that long-term use of no-tillage or heavy manure application results in increased organic matter content of the surface soil. Normal tillage mixes crop residues with the soil, but in reduced tillage systems plant residues remain at or near the soil surface and decompose more slowly. After several years of no-till culture, the surface inch of soil may contain twice as much organic matter as the tilled soil. Since many herbicides are quite sensitive to soil organic matter content and are applied in the top 1-2 inches of the soil, herbicide rates must be increased enough to compensate for this increase in organic matter content.

As we can see from this summary, organic matter, soil texture and soil pH do have an effect on the activity of herbicides in the soil. These are not the only factors that can affect herbicide activity, but they are very important. The more we understand these factors and their effects on herbicides, the better job we will do in recommending or using herbicides.
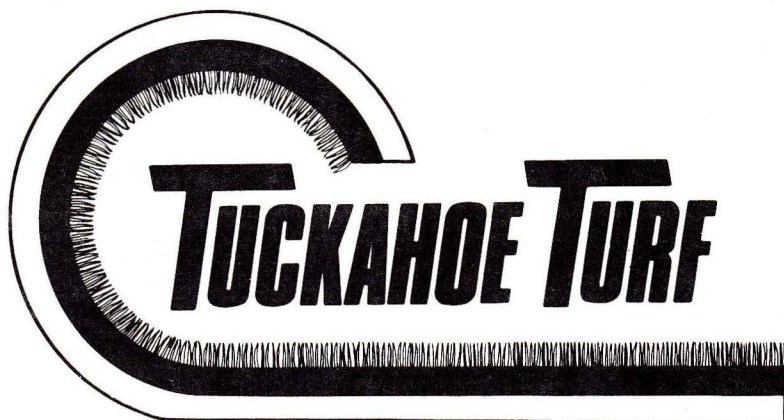
Lawn Care: Big Potential For Fluids

Survey shows fluids take about a 30 percent bite out of total $100 million pie
reported in readership study conducted by trade publication
circulated within lawn care industry

By Bob Early

Can a fluid fertilizer dealer — who normally serves agricultural customers who raise crops on huge acreages — shift gears to take advantage of the supply needs of the growing lawn care industry and make money at it?

Fluid fertilizers have fast become the modern method of fertilizer application in the commercial lawn care industry. Currently, it is estimated from market studies that over 60 percent of the industry is using the fluid fertilizer technique.

In the United States, overall consumption of fluid fertilizers now accounts for nearly 30 percent of all fertilizer tonnage applied annually — and a significant part of the dramatic increase in fluid fertilizer usage can be attributed to the lawn care industry.

The reasons for the large and still growing usage of fluid fertilizers by the lawn care industry are basically four:

- Uniform distribution
- Prescription formulation
- Agronomic advantages
- Handling and application efficiencies

Thirty Percent Fluids

Lawn Care Industry has a circulation of more than 10,000 lawn care businessmen across the United States and did a survey recently of its readers. To get a feel for the industry, let's look at some numbers.

More than 7,000 *Lawn Care Industry* readers are actively involved in chemical lawn care application. The average number of chemical application accounts these readers service is about 500 per company, which projects out to 3.6 million chemical application accounts serviced by our readers. We, of course, do not reach every lawn care businessman in the United States, but I think this figure can give you a ball-park figure as to how much work is being done in the chemical lawn care field. Our readers also service about 700,000 mowing/maintenance accounts, for a total of 4.3 million home lawns serviced.

Average gross receipts for our readers in 1979 were $117,089. This projects out to gross receipts of $1.1 billion. We then asked them: "After subtracting all your costs from your 1979 receipts, approximately what percentage of gross receipts was pre-tax profit?" The average response was $16,442, or about 14 percent pre-tax profit.

When we asked them how they expected their year-end 1980 gross receipts would compare to 1979 receipts, they answered that they expected a 17 percent increase. Our past surveys of our readers have indicated that the lawn care industry has been growing at a rate of between 20 and 25 percent since the early 1970s.

More than 88 percent of our readers purchased dry-applied fertilizers in 1979. Average purchase was $8,331, for a *Lawn Care Industry* readership projection of $71 million.

Almost 36 percent of our readers purchased liquid-applied fertilizers in 1979. Average purchase was $9,438, for a readership projection of $33 million.

In total, our readers purchased about $100 million worth of fertilizers in 1979, about 30 percent of which was liquid-applied. Even though our survey shows that our readers are purchasing more dry-applied fertilizer than liquid-applied, it is known that most of the large chemical lawn care companies in the United States are using liquid-applied fertilizers. This figure is growing, and will continue to grow.

Bob Earley is editor/associate publisher of Lawn Care Industry magazine published in Cleveland, Ohio.

Many of our readers that own smaller companies are purchasing dry-applied fertilizers because they do not have enough accounts to warrant liquid application of fertilizers. As these companies grow, they will most likely convert to liquid application.

In the same survey, we asked our readers where they purchased fertilizers and chemicals. About 51 percent said they purchased from a local distributor other than another lawn care company. About 26 percent said they purchased from a regional distributor of another company's product. About 17 percent said they purchased from a regional sales office of a manufacturer. About 11 percent said they purchased directly from a national sales office of a manufacturer. And about six percent said they purchased from another local lawn care company.

Potential

Is the potential there for the fluid fertilizer dealer? Using the purchasing figures above, all but 11 percent of the buyers surveyed purchase their fertilizers either locally or regionally. This indicates that most buying is done in areas that the fluid fertilizer dealer could service. Most application is done, of course, in the highly populated metropolitan areas. But at least in the Midwest, Southeast and Southwest, most metropolitan areas are not that far from agricultural regions. Thus, it would seem that the logistics could be worked out.

More and more of the larger chemical lawn care companies have also installed tank farms to hold their bulk chemicals and fertilizers. It would seem that it would be a logical next step for fluid fertilizer dealers to use these already existing tanks or newly installed tanks to service the needs of the larger chemical lawn care companies.

> "Our readers reach perhaps only 10 percent of the total number of home lawns being serviced."

While most of our readers are small (500 lawns would be the equivalent of about 100 acres times four applications a year, or 400 acres of application), a survey in the January '80 issue of our magazine turned up a number of companies doing in the vicinity of a million dollars worth of business a year or more. A partial listing follows:

ChemLawn Corp., Columbus, Ohio, heads the list. It grossed about $86.6 million in 1979 with service to 694,000 customers. It has more than 100 branches and employs close to 2,000 persons.

Lawn Doctor, Inc., Matawan, New Jersey, has about 250 franchise outlets employing 1,200 persons. Gross sales were estimated by the company at more than $17 million on service to 115,000 customers.

Lawn-A-Mat Chemical & Equipment Corp., Westbury, New York, has about 150 franchise outlets employing 800 persons. Gross sales were estimated by the company at $13.5 million on service to 75,000 customers.

Lawn Medic, Inc., Bergen, New York, has about 92 franchise outlets employing 276 persons. It also has a company-owned division. Gross sales were estimated at $6.4 million on service to 43,400 customers.

Davey Lawnscape Service, Kent, Ohio, has 10 company-owned outlets employing 110 persons. Sales were estimated at $4.5 million on service to 37,000 customers.

> "Fluid fertilizers have fast become the modern method of fertilizer application in the commercial lawn care industry."

Perf-A-Lawn Corp., New Carlisle, Ohio, has eight company-owned outlets and 18 franchise outlets. The company employs 175 persons. Sales were estimated at $4 million on service to 45,000 customers.

Barefoot Grass Lawn Service, Worthington, Ohio, has 12 outlets, both company-owned and franchise. Sales were estimated at $3 million.

R.W. Collins, Inc., Satellite Beach, Florida, has 17 company-owned outlets, employing 125 persons. Sales were estimated at $3 million on service to more than 20,000 customers.

A-Perm-O-Green-Lawns, Inc., Austin, Texas, has 13 franchise outlets, employing 65 persons. Sales were estimated at $3 million on service to about 25,500 customers.

Leisure Lawn, Inc., West Carrollton, Ohio, has four company-owned outlets employing 80 persons. Sales were estimated at $3 million on service to more than 20,000 customers.

Liqui-Green Lawn Care Corp., Peoria, Illinois, has 26 franchise outlets. Sales were estimated at $2 million on service to 13,000 customers.

Lawn King, Inc., Fairfield, New Jersey, has more than 80 outlets. The company estimates sales of more than $2 million. It is a franchise-based operation.

Excelawn, Inc., Louisville, Kentucky, has three outlets and estimated sales in excess of $2 million.

Hydro Lawn, Inc., Gaithersburg, Maryland, had two company-owned outlets in 1979, employing 37 people. Sales were estimated at $1.75 million on service to more than 12,000 customers.

Keystone Lawn Spray, Wayne, Pennsylvania, has three company-owned outlets, and employs 30 persons. Sales were estimated at $1.65 million on service to about 14,500 customers.

No-Risk Exterminating Co., Inc., Fort Meyers, Florida, employs 60 persons out of its one office. Sales were estimated at $1.5 million on service to 20,000 customers.

Easy Lawn Corp., Piqua, Ohio, has seven company-owned outlets employing 42 persons. Sales were estimated at $1.5 million on service to 17,000 customers.

Spring-Green Lawn Care Corp., Naperville, Illinois, has 23 franchise outlets. Sales were estimated at $1.5 million on service to 10,000 customers.

Lawn Beautiful, Wheeling, Illinois, has two company-owned outlets employing 40 persons. Sales of $1.5 million were estimated on service to 13,500 customers.

Chemical Applicators, Pearland, Texas, has two company-owned outlets employing 22 persons. Sales were estimated at $1.2 million on service to 700 accounts, most of them industrial weed control accounts.

Super Lawns, Inc., Rockville, Maryland, has 10 franchised outlets employing 20 persons. Sales were estimated in excess of $1 million on service to 4,000 customers.

In addition to these companies, we have identified another 40 companies that are approaching $1 million dollars in gross receipts, many of whom might cross that mark by the start of this year.

Marketing

As for advertising of their lawn care services, average expenditure in 1979 was $3,394 or about 2.9 percent of gross receipts. Breakdown of media used was:

Yellow pages	67%
Newspapers	44%
Personal calls	35%
Phone	32%
Direct mail	31%
Door hangers	16%
Radio	16%
Television	4%

Nine percent of those surveyed said they used no advertising at all.

Summary

The potential is certainly there for the fluid fertilizer dealer. Our readers service 4.3 million lawns, representing about 860,000 acres of turf. Multiplied by four applications a year, this would be 3,440,000 acres of turf treated a year. Multiplied by an average of four pounds of nitrogen per 1,000 square feet per year applied, that totals more than 75,000 tons of nitrogen fertilizer applied in a year by our readers. This is perhaps only 10 percent of the total number of home lawns being serviced.

Which spells potential with a capital P for the fluid fertilizer dealer!
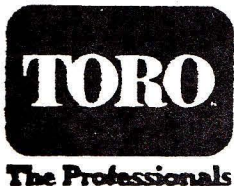
Chemistry of Insecticides

Elmer E. Fleck[2]

It is my purpose in this paper to discuss the stability of insecticides and some of the chemical reactions that cause these materials to be degraded and removed from the environment.

First, I should point out that there is a fundamental difference between the organic insecticides and the inorganic ones that were used extensively until the last 20 years. Figure 1 will refresh your memory with regard to the inorganic materials. Note that they are based on such toxic elements as mercury, selenium, arsenic, and lead. The fundamental difficulty with these materials is that they are permanent. Once applied to a soil, they are there to stay unless they are leached away with water. Most of these compounds have very little solubility in water, so they stay where they are applied.

On the other hand, the organic compounds are relatively transient materials. Those organics that have been singled out for use as insecticides range from the very unstable to those that remain in our environment for several years. Students in organic chemistry soon learn that all organic compounds can be oxidized and that the end products of such oxidation are CO_2 and water. There is, therefore, a well-traveled route by which even the most toxic substances may be rendered harmless and removed from the environment over a period of time.

This instability of the organic insecticides has another feature that probably is not widely understood. If a stable inorganic insecticide is applied yearly to soil, the percentage of this material that is present will continue to increase every year. This property is not characteristic of organic insecticides. Because they decompose they will reach a concentration dependent not only on the rate of application but also on the rate of decomposition. They will remain at this level no matter how many years their application is continued.

Let us illustrate this principle of decomposition by a simple example. To make the mathematics easy, assume that 1 pound of insecticide is applied to an acre each year. Also, assume that this particular insecticide decomposes at the rate of 50% each year. At the end of the first year, one-half pound of insecticide will remain in the soil and the addition of a second yearly application of 1 pound

Mercuric Chloride	$HgCl_2$
Selenium Compounds	$(KNH_4S)_5Se$
	Na_2SeO_4
Lime Sulfur	CaS_x
Paris Green	$3Cu(AsO_2)_2.$ $Cu(C_2H_3O_2)_2$
Lead Arsenate	$PbHAsO_4$
Calcium Arsenate	$Ca_3(AsO_4)_2$

Figure 1. Earlier inorganic insecticides.

will make 1-1/2 pounds. At the end of the second year there will be one-half of the 1-1/2 pounds, or 3/4 pound. The third year will start with 1-3/4 pounds. If we project this treatment over a number of years, we will find that the highest level attained will be 2 pounds per acre. This will be so, because at the 50% rate of decomposition, 1 pound will decompose in a year's time, and this amount just balances the amount of new insecticide applied. Hence a stable level of the material in the soil is reached.

A little thought indicates that when yearly application is stopped or we change to another insecticide, the original insecticide will automatically disappear from the soil over a period of time.

We might find it profitable to look at some of the ways organic insecticides are destroyed. The most important of these is by oxidation. Oxygen in the air combined with the catalytic action of sunlight makes a very powerful oxidizing agent. Few, if any, organic compounds can stand unchanged against it indefinitely. Thus insecticides that evaporate in the air are soon destroyed. A rule of thumb to follow in understanding chemical reactions is that the speed of the reaction is approximately doubled with each 10-degree rise in temperature; so the hot, sunny summer days tend to make short work of oxidizing organic materials exposed to this combination.

Oxidation will also be rapid when deposits are exposed to sun and air (10) on the ground and on leaves or solid surfaces. On the other hand, materials that are mixed deep in the soil or in muddy river bottoms are shielded from this combination of sun and air and may be expected to last longer.

A second general reaction of many pesticides is their hydrolysis or reaction with water. This reaction is influenced markedly by pH and in general proceeds more rapidly at both high and low pH than in the neutral range. The carbamate (9) and the phosphate insecticides (8) are subject to this type of reaction as are some of the chlorinated hydrocarbons, particularly in alkaline solutions (5).

Many of the insecticides undergo catalytic decomposition. Iron compounds have very marked catalytic properties, particularly against the chlorinated hydrocarbons (6).

In addition to the chemical reactions noted, there are other means by which organic insecticides may be removed from the site of action. One of these is a physical phenomenon known as adsorption. Certain materials in the soil will adsorb some of the organic compounds so strongly that their insecticidal action is nearly destroyed. Witness the adsorption of DDT on the mud walls of some huts in Africa (7).

Microbiological action affords another pathway for the destruction of organic insecticides, but an explanation of this procedure is outside the scope of this paper.

Let us review the various types of organic insecticides to see how their reactions affect their stability.

The natural insecticides such as rotenone and pyrethrins (Figs. 2 and 3) are characterized by complex structures. They contain ester groups that make them susceptible to hydrolysis, and/or unsaturated chemical bonds and strained ring systems that provide excellent sites where the oxygen and sun may attack. Hence we should expect that these compounds would have limited stability, and they do. The problem is to provide them with enough stability to prolong their action so that they will kill insects.
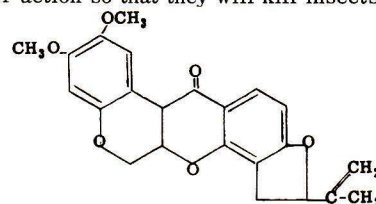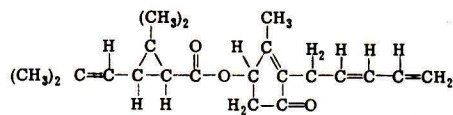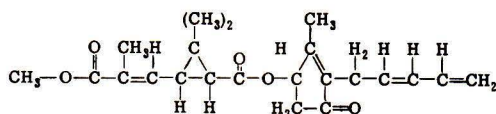

Figure 2. Structure of rotenone.

Pyrethrin I

Pyrethrin II

Figure 3. Structure of pyrethrins.

Chemists have attempted to modify the structure of the pyrethrins, as the structure of allethrin demonstrates (see Fig. They have also prepared other esters of chrysanthemumic acid achieved some increase in stability. Recent developments indicate that they may be able to make esters that will be as effective as the pyrethrins, yet have simpler chemical structures (3).
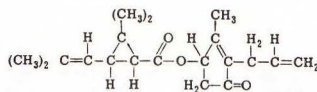
Figure 4. Structure of allethrin.

The carbamate insecticides are exemplified by carbaryl (Sevin) (Fig. 5). The ester group present in insecticides of this class indicates that they should be subject to hydrolysis, and they actually are. An analytical method for carbaryl is based on the alkaline hydrolysis of the compound to naphthol (9) and this is indicative of the instability of this type of compound in alkaline media.
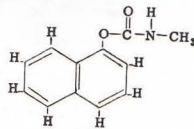

Figure 5. Structure of carbaryl. (Sevin)

The organophosphorus insecticides are chiefly phosphate esters, as exemplified by tetraethyl pyrophosphate (tepp) (Fig. 6) and parathion (Fig. 7). The double ester groups of tepp indicate that it should be subject to attack by hydrolysis, which it is. Parathion, on the other hand, is much more resistant; but alkaline solutions speed up this reaction.
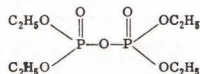
Figure 6. Structure of tetrethyl pyrophosphate.
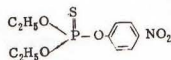
Figure 7. Structure of parathion.

Note that in parathion a sulfur atom replaces the oxygen atom on the phosphorus. Chemists can make similar substitutions for other oxygen atoms in this type of compound and they have prepared many variations and tested them as insecticides (8). The introduction of sulfur in this manner sometimes leads to complications when oxidation takes place, because a first step in the reaction can replace the oxidizable sulfur atoms in the molecule, which can lead to an oxygen analog that may be more toxic than the original insecticide.

Another widely used organophosphorus compound is malathion (Fig. 8). On the basis of the discussion in the preceding paragraph, we will readily see that it should be oxidized at the sulfur atoms. Since it has both phosphorus and carbon ester groupings, it should also be subject to hydrolysis. In addition, its decomposition is catalyzed by iron salts. So we are not surprised to find that malathion is not a persistent insecticide. Malathion itself is not very toxic to mammals and does not yield oxidation products that are toxic, so we can understand readily why this compound is widely used.
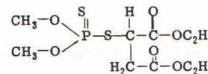
Figure 8. Structure of malathion.

Chlorinated hydrocarbons as a group have been regarded as stable insecticides, but they too are subject to reactions which destroy their effectiveness. In the presence of an alkali, chlordane (Fig. 9) readily loses hydrogen chloride and forms nontoxic products. Iron catalyzes this reaction.
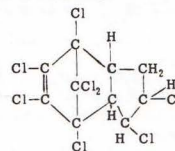
Figure 9. Structure of chlordane.

Heptachlor, closely related to chlordane, is one of the more stable chlorinated hydrocarbons. It is not affected by acid or alkaline conditions and is stable against hydrolysis. It is one of the more volatile compounds of this group and its loss to the air is appreciable. It is, however, subject to catalytic decomposition; and when it is formulated as a dust or wettable powder many inert diluents that might be used must be deactivated to prevent such a reaction from occurring. When inert diluents have not been deactivated, formulations of dusts have been known to become hot because of the heat given off in the decomposition reaction.

Aldrin and dieldrin (Fig. 10) are likewise subject to catalytic decomposition produced by some inert diluents for dusts (2). Dieldrin, of course, is the epoxide of aldrin; this is a case where the first step in the oxidation of aldrin leads to dieldrin, another insecticidal chemical, rather than to a harmless product of oxidation.

Benzene hexachloride (Fig. 11) represents a type of compound that is also sensitive to alkalies. Three moles of hydrogen chloride
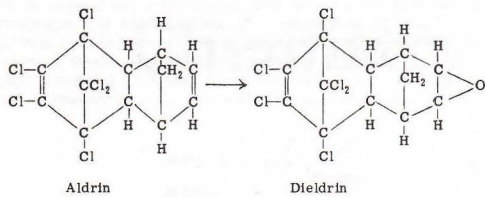
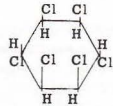Figure 10. Structure of aldrin and dieldrin.

Figure 11. Structure of benzene hexachloride (Lindane).

are removed under alkaline conditions, and the insecticidal action is destroyed.

The last compound we will discuss is DDT (Fig. 12). This compound seems to undergo most of the reactions we have previously mentioned, and yet under certain conditions it is a very stable compound. In the presence of an alkali it readily loses hydrogen chloride to form dehydrochloro-DDT that in turn is readily oxidized to p,p'-dichlorobenzophenone. This same dehydrochlorination takes place in the presence of catalysts. A tiny speck of anhydrous ferric chloride dropped into melted DDT will cause hydrogen chloride to boil off and completely dehydrochlorinate the DDT in a matter of minutes (5). Even at ordinary temperatures other iron salts will cause this reaction to take place but at a much slower rate. A solution of DDT exposed to sunlight and air will follow the route of dehydrochlorination to p,p'-dichlorobenzophenone mentioned previously in a matter of $\overline{ours}$ (4). Solid DDT exposed to sun and air is very much more resistant to this reaction, and in darkness and exposed to air it is almost completely stable. DDT, which is very nearly completely insoluble in water, is not subject to hydrolysis.
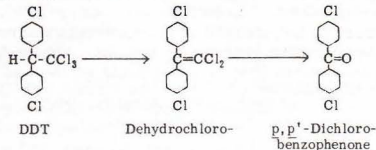
Figure 12. Structure of DDT, dehydrochloro-DDT, and p, p'-dichlorobenzophenone.

Because DDT is so extremely hydrophobic, it is involved in some interesting phenomena. DDT molecules in water tend to migrate to the side of the container, where they may be adsorbed, or to the air surface. At this water-air surface a process known as codistillation (1) takes place. The DDT is evaporated into the air along with water molecules at a much greater rate than would be predicted from its extremely low vapor pressure. Once the DDT is in the air, the catalytic action of sunlight promotes its destruction by oxidation.

In this brief review I have attempted to point out that because organic insecticides are less persistent than the inorganic ones, their use offers very real advantages. However, the normal decomposition of the organics may be retarded under certain circumstances. For this reason we must conduct studies to determine whether their residues persist on our edible crops to make sure that any remaining residue is below the level at which it could be hazardous. We must find out more about what happens to the insecticide that is left in the field after the crops have been harvested. It is, however, a comforting thought that organic insecticides do have their Achilles heel and that they can be and are destroyed in nature. We must learn to take better advantage of the stable or unstable properties of insecticides so as to control the time these materials remain in our environment. We also must learn how to retain the stability of a compound for as long as its action is needed, and then how to alter this property at the right time to promote its instability so it may be removed from our environment.

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This Putter Widens The Cup

The STX putter, with a face of "Adiprene", is the golfer's new ally
in that never-ending battle with bogies

Almost everybody can learn to putt well, said golfing great Arnold Palmer.

Maybe so, countered weekend golfer Dick Tucker, but I'd still like my putter to help me do some of the work. So Tucker set out on a 15-year odyssey in search of the perfect putter to help him overcome the vagaries of putting.

"We're the kind of people who always are tinkering, looking for a better way to make things," says Tucker, president of Baltimore's STX, Inc., the world's largest producer of lacrosse sticks and related accessories. "Week after week, I three-putted my way around the course in frustration. Like most duffers, I had neither the time nor patience to practice the problem away. So I hoped a new putter might give me an edge. I sketched out ideas and the people in the shop would machine a new head for me to test the next weekend."

The shop to which he refers is the production area of STX. Machinists obviously were kept busy, for numerous boxes of putter heads scattered throughout Tucker's office attest to his trial-and-error style of inventing.

"We came to the conclusion that we had to contend with two basic problems. First, a golfer must establish the correct alignment with the cup and be able to hold the line throughout the putting stroke. Second, the golfer has to 'feel' the ball in order to put the correct speed on the putt time after time.

"We found that a more versatile putter helped solve the alignment problem," continues Tucker. "Most golfers don't have a perfect textbook putting stance, so we designed a putter that's adaptable to any golfer's style. It doesn't matter if it's conventional or sidesaddle, open or closed."

STX also tackled the alignment problem by concentrating weight directly behind the "sweet spot," with a low center of gravity. By placing the weight right at the end of the shaft, the putter becomes a natural extension of the golfer's hands.

In an effort to impart more feel to the putter, STX tried numerous elastomeric materials as putter faces. "Usually, they were too resilient, or they absorbed too much of the impact and the ball wouldn't reach the hole," he adds. "Luckily, during a visit to Du Pont's Chestnut Run Laboratory, we were shown samples of a new, tougher formulation of 'Adiprene'. I brought some back to Baltimore, glued a piece on my putter face, and took it out for a round. It felt terrific."

Thus, the STX putter was born. "Adiprene" urethane elastomer now is molded onto the club head to help the golfer get maximum distance out of a minimum stroke. It's axiomatic in putting that an accurate putt results from a short backswing, since there's less opportunity for a golfer's miscue.

"This new putter face of 'Adiprene' has a higher coefficient of friction than traditional metal faces, so it's more forgiving. The extra feel for the ball produces more accurate putts—fewer balls roll by or come up short of the cup."
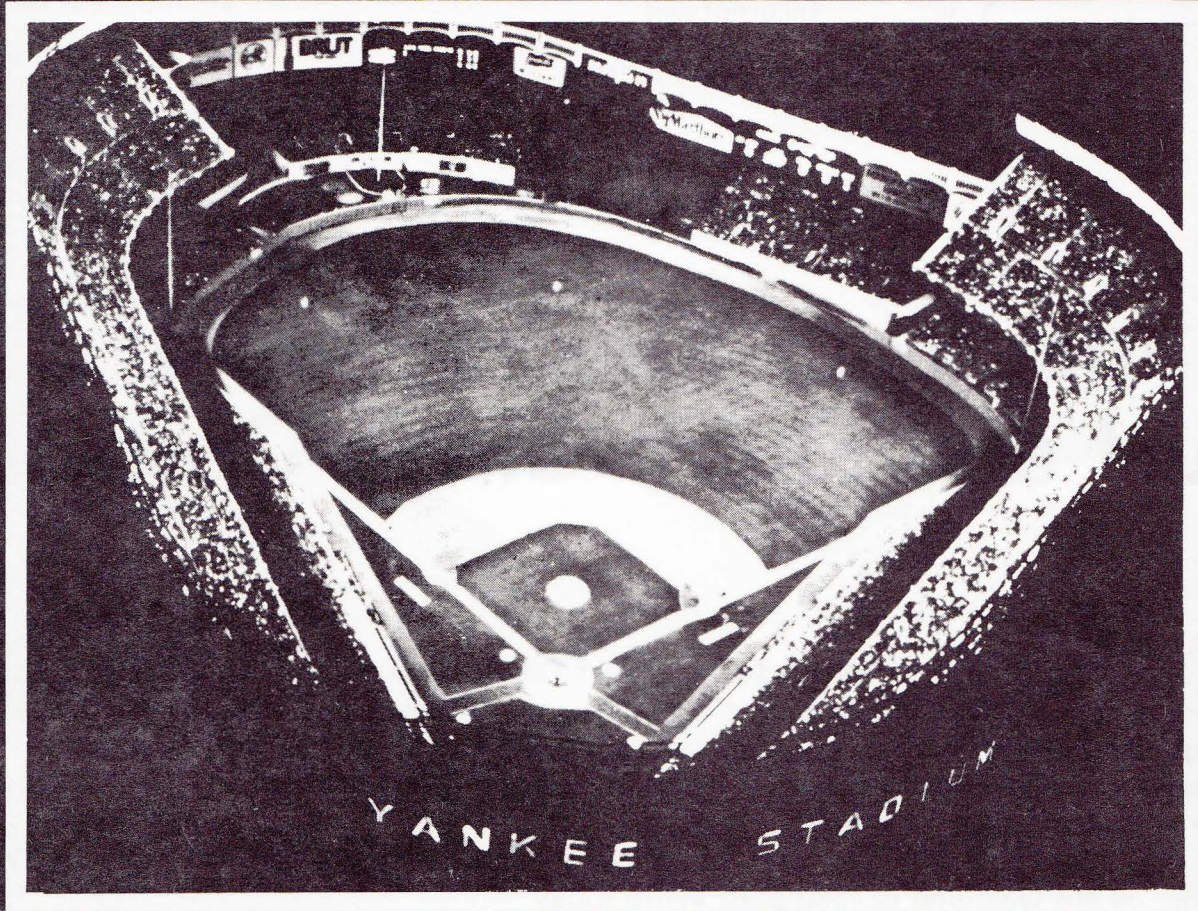
Adds Tucker: "We didn't set out to make just another gimmick. We want to add to the game. The putter conforms with USGA rules, so I think we've made a contribution. I know it's helped my game. I've seen my handicap drop by several strokes."

"Adiprene" certainly is playing with no handicap when it takes on the rigors of golf. Since its 1957 debut, it has scored with distinction when tested for load-bearing capacity, hardness, and abrasion resistance. Away from the golf course, it commonly is found in industrial tires, shock mounts, wear parts for the mining industry, and power transmission belts. As a versatile liquid polymer, it can be cast and cured in intricate shapes or very large parts. ∎

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