A PRACTICAL RESEARCH DIGEST FOR TURF MANAGERS

TurfGrass TRENDS

Volume 6, Issue 4

April 1997

# Insecticide Formulations

*Patricia J. Vittum*
*University of Massachusetts*

Pesticides, including insecticides, are packaged in a variety of forms. The technical grade, or "pure" material, usually is not appropriate for use by a pesticide applicator because the concentrated material might be very toxic, insoluble in water, or unstable in the environment. Specially trained scientists (known as "formulation chemists") work with the technical grade material to determine how best to formulate the pesticide so that it can be applied to the intended target with minimal risk to the applicator or the environment. They use a variety of solvents, diluting agents, or stabilizing compounds to produce a product that can be applied through traditional application equipment.

All pesticide formulations contain some quantity of an active ingredient (the actual killing agent), usually 1 to 80 percent of the total material, while the remainder is inert ingredients. These inert ingredients do not contribute to the pesticidal action of the compound, but they are not necessarily "benign" either. For example, some solvents that are used as inert ingredients tend to be phytotoxic to plants, and others can cause various animal health problems. Some common inert ingredients include talc (used as a base for incorporating the active ingredient into a dust for dry application), corn cob or bentonite clay (used to form granules on which the active ingredient is adsorbed), petroleum-based solvents to retain the active ingredient into solution (technically, into emulsion) in water, or wetting agents to increase the "sticking power" of the active ingredient on the plant foliage.

Micro-Encapsulated Suspension
Emulsifiable Concentrate
Dispersible Granule
Wettable Powder
Soluble Powder
Dry Flowable
Flowable
Granule

Formulations are developed to make the product safer and more convenient to use.

## IN THIS ISSUE

- **Pesticide Formulations . . . . . . 1**
  - Solid vs. Sprayable
  - Calculations for Dry Formulations
  - Calculations for Liquid Formulations
  - Terms to Know
  - Additional Reading
- **Relative Hazards Of Turf and Ornamental Pesticides to Non-Target Species . . . . . . . . . . 9**
  - Methods of Determining Toxicity
  - Toxicity to Birds
  - Toxicity to Fish
  - Toxicity to Earthworms
- **Turfgrass Response to Controlled-Release Fertilizers . . . . . . . . 13**
  - N Release and Quality Response
  - Controlled-Release Urea Sources Evaluated

*TurfGrass TRENDS* •7500 Old Oak Blvd. • Cleveland, OH 44130-3369
Phone: 216-243-8100 • Fax: 216-891-2675 • Internet: turfgrasstrends@en.com

TurfGrass TRENDS

**Publisher,** John D. Payne
*216-891-2786*

**Editor,** William E. Knoop, Ph.D.
*903-860-2410*

**Science Advisor**
Richard J. Hull, Ph.D.

**Production Manager**
Judy Miducki
*218-723-9281*

**Circulation Manager**
Karen Edgerton
*218-723-9280*

**Layout & Production**
Bruce F. Shank, BioCOM
*805-269-9443*

**Group Editor**
Vern Henry

**Group Vice President**
Alex DeBarr

**TurfGrass TRENDS**
**7500 Old Oak Boulevard**
**Cleveland, Ohio 44130-3369**
**Phone: 216-243-8100**
**Fax: 216-891-2675**
**E-mail: turfgrasstrends@en.com**

Abstracts: 800-466-8443 TGIF
Reprint Permission: 216-891-2744
Single copy or back issues:
Subscription/Customer Service
Phone: 218-723-9477
Fax: 218-723-9437

ADVANSTAR
COMMUNICATIONS

**Chairman, President & CEO**
Robert L. Krakoff
**President, Advanstar Publishing**
Robert L. Krakoff
**President, Advanstar Marketing Services**
William J. Cooke
**Vice President, Finance, Chief Financial Officer and Secretary**
David J. Montgomery
**Vice Presidents:** Melinda J. Bush, Kevin J. Condon, Alex DeBarr, Brian Langille, Glenn A. Rogers, Phil Stocker
**Treasurer and Controller**
Adele D. Hardwick

It would be virtually impossible for an applicator to apply one pound of technical material to an acre without inert ingredients. However, for example, by diluting the technical grade insecticide with an inert carrier to create a granular formulation (which functionally dilutes the active ingredient by 90 to 98 percent) manufacturers provide a product that enables applicators to safely apply a pound or less of an active ingredient to an acre. In recent years, advancements in formulation chemistry have provided formulations to enhance the effectiveness of the active ingredient or to increase the shelf life of a commercial product.

Several factors help determine which formulations can be used for a given active ingredient. The most important factor limiting formulation options is the chemistry of the active ingredient. For example, certain active ingredients that are liquid in their technical form cannot be formulated as a powder or an emulsifiable concentrate. The toxicity of the active ingredient also plays a role. Some compounds that are acutely toxic in the pure form can be formulated as relatively dilute granular products, which allows them to be handled by an applicator with reduced risk.

The effectiveness of the product against the intended pest can be enhanced by selecting a suitable formulation. By selecting a suitable formulation, the effectiveness of the product can be enhanced against the intended pest. Certain formulations are more likely to have a detrimental effect on the plants on which they are applied, which certainly can be a limiting factor.

In addition, environmental concerns enter into decisions on formulation chemistry. While a subsequent article will address these concerns in more detail, most turf managers are well aware that some pesticides are subject to leaching (vertical movement through the soil into groundwater) or run-off (horizontal movement to surface water). While the technical grade of some pesticides is highly mobile and more likely to leach or run-off, some formulations (for example, some of the granular materials) increase the persistence in the target zone and decrease the potential for runoff or leaching.

Finally, application equipment available to a turf manager limits the type of formulation he is able to use. The decision between using a granular or a sprayable product might appear to be fairly straightforward, particularly for a turf manager who does not own a sprayer (or perhaps does not have access to a spreader) - but some of the sprayable formulations are better applied by specific kinds of equipment.

## Solid vs Sprayable Formulations

Most insecticides available to turf managers are available either in a granular formulation that is applied directly to the turf through a spreader, or as a sprayable formulation that is diluted in water in a spray tank, and then applied to the turf in a liquid form. Note, however, that sprayable formulations might be packaged as liquid or dry products.

**Granular Insecticides** - Granular formulations are a mix of dry, relatively large, free-flowing particles to which the active ingredient is incorporated. Most turf insecticides that are available as granular products consist of 1 to 10 percent active ingredient (the remaining material being inert). Most turf managers are familiar with granular products that use ground corn cobs as a base. These granules are relatively large and lightweight, compared to others that have been developed recently. Some of the newer granules have a clay base and tend to be much smaller in diameter and have a greater density, so they drop through much smaller holes in the spreader.

Application chemistry has changed radically in recent years. Ten years ago, a granular material would invariably work more slowly than a corresponding sprayable formulation of the same active ingredient. Today, special solvents can be used to incorporate the active ingredient onto the granule in such a way that it is released almost as quickly as a sprayable formulation might be.

Granular formulations have several advantages over sprayable materials. First, no additional mixing is required. The material that comes out of the bag is the material that will be applied directly to the turf. It is ready to use straight out of the package. Furthermore, most granular products are subject to minimal drift. The granule is usually heavy enough that it drops out of the spreader to the ground, without blowing or drifting to unintended targets.

Granular products have some drawbacks that should be recognized. Some granules break down physically during the mixing or application process and release fine dusts, that can be inhaled by the applicator or anyone else in the vicinity during the time of the application. Granular products must be applied with a spreader and not every turf manager has access to a spreader. On the other hand, spreaders tend to be fairly reliable with fewer moving parts to break down than the corresponding sprayers.

Some granular formulations have almost identically sized granules and can be applied very consistently. Others, however, have a range of particle sizes within the formulation, or some particles might be denser than others. When this is the case, heavier or larger particles can "settle out" resulting in an uneven application pattern. Some corn cob granules could float and run off when flooded. Finally, shipping costs for granular products tend to be higher because there is much more bulk involved (only 1 to 10 percent of the material being shipped is the active ingredient). For some turf managers, storing the large bags of product can also be a problem.

One variation of granular insecticides is the use of fertilizers into which an insecticide has been impregnated. In these cases, the product accomplishes two tasks at once - fertilizing the turf and releasing an insecticide. The most obvious advantage to such an approach is saving labor and time. One drawback is that the combinations that are available might not be ideal for a given situation. The fertilizer part of the combination might not provide an ideal balance of nutrients, or the application timing for the fertilizer might not coincide with the insecticide. The use of water after application might not be compatible with both materials. One part of the combination might need immediate irrigation, while the other might perform better if allowed to remain on the leaf or soil surface for a period of time.

## Sprayable Formulations

Sprayable formulations might be in a dry form or a liquid form when they are received from the manufacturer or the supplier. The dry formulations include soluble powders, wettable powders, dry flowables, and water dispersible granules. Liquid formulations include emulsifiable concentrates, flowables, and micro-encapsulated suspensions.

**Soluble Powders** (often abbreviated as SP on the label) resemble dusts in that the material is a fine clay-like material. However, the formulation is soluble in water, so when the powder is added into the sprayer tank, it eventually goes into solution. Most wettable powders are more concentrated than granular products because they consist of at least 50 percent active ingredient.

Soluble powders have several advantages over other sprayable formulations. First, the container (that is normally a plastic jar or a plasticized bag) usually empties very easily and leaves little or no residue. Soluble powders usually are not absorbed through the skin of the applicator (or the mixer or loader) as readily as emulsifiable concentrates. If a spill occurs during storage or mixing or loading, it is often easier to clean up than a spill involving a liquid concentrate. Soluble powders are less likely to cause phytoxicity (burning of plant foliage) than are emulsifiable concentrates. Finally, because the soluble powder is more concentrated than corresponding granular formulations, shipping costs usually are lower and less space is needed for storage.

Soluble powders are not the answer to everything. They do have some drawbacks. When a soluble powder is added to a sprayer, it often stirs up dust as the material hits the surface of the water. This dust might be inhaled by the person mixing the spray, and can constitute a substantial inhalation hazard. Finally, soluble powders might leave a visible residue on the leaf surface. This residue usually is visible only for a few days, especially if the turf is being irrigated regularly, but turf managers should be aware of the potential for visible residue nonetheless.

**Wettable Powders** (usually abbreviated as WP on a label) are very similar to soluble powders but usually contain additional components, such as a wetting agent and a dispersing agent. Wettable powders differ chemically from soluble powders, because they do not dissolve in water but rather go into suspension. While there is a considerable difference chemically, there is little functional difference to the applicator. Wettable powders also might clog nozzles or wear them out over time. The overall advantages and disadvantages of wettable powders are virtually identical to those of soluble powders. Wettable powders are particularly likely to settle in a tank, so constant agitation during the application is absolutely critical. Most wettable powders have a wetting agent incorporated in the formulation, but some might need a wetting agent added to them.

**Dry Flowables** (usually abbreviated DF on a label) are a relatively new formulation. Some turf fungicides are now available as dry flowables. These formulations are essentially wettable powders (a clay base) that have been converted into small pellets or granule-like particles. When mixing these materials, it is wise to premix them in a jar or similar container to form a "slurry" (a dense mix of the granules and water) before adding the mix to the tank.

Dry flowables are much less dusty than wettable or soluble powders, so the inhalation hazard during mixing is greatly reduced. However, they require greater agitation than do wettable powders and soluble powders. Improper or inadequate agitation results in a deposit of sludge at the bottom of the tank that can be next to impossible to remove. Not surprisingly, dry flowables are more likely to plug nozzles than most other formulations. In addition, they can produce highly visible residues.

**Dispersible Granules** (often abbreviated DG or WDG on a label) are formulated on granulated clay. The result is particles that look like tiny beads, which are usually quite uniform in size. The beads disperse readily in water, that means that the material "dissolves" fairly effectively. Functionally they are very similar to dry flowables. They are much less dusty than wettable or soluble powders, and do not produce dust during the mixing process. However, they do require considerable agitation in the tank during the application and can clog or wear out nozzles. Like the dry flowables, dispersible granules can produce visible residues.

Many active ingredients are not soluble in water, and so cannot be formulated readily as wettable powders or water dispersible granules. One formulation that is used to help solve this problem is the **Emulsifiable Concentrate** (usually abbreviated EC or E on the label). Emulsifiable concentrates are petroleum oil-based products that include emulsifying agents and other materials that enable the active ingredient to be suspended in water. The product, when it comes out of the container, is usually transparent (but might be any of several colors), however the final spray solution is often milky.

# Calculations for Dry Formulations

For dry pesticide formulations (granulars, soluble powders, wettable powders, dry flowables, and water dispersible granules), the number in front of the abbreviation for the formulation gives the percentage (by weight of the product) that is active ingredient. A 2.5 G means there are 2.5 pounds of active ingredient in a 100 pound bag. A 75 WP means it is 75 percent active ingredient (there are three pounds of active ingredient in a four pound bag.)

If your information provides the amount of product per unit area, your calculation is very straightforward. Set up the following ratio:

$$\frac{\text{amount of product}}{\text{unit area}} = \frac{\text{amount product needed}}{\text{area you will treat}}$$

**Example:**

The label calls for two ounces of product per 1,000 square feet. You want to treat 20,000 square feet. How much product will you need?

Set up a ratio:

$$\frac{\text{2 ounces product}}{\text{1,000 sq. ft.}} = \frac{X}{\text{20,000 sq. ft.}}$$

Cross multiply (i.e., multiply the top item on the left side times the bottom item on the right side of the "=" sign. Then multiply the top item on the right side times the bottom item on the left side of the "=" sign).

$$\text{(2 ounces) (20,000 sq. ft.)} = \text{(1,000 sq. ft.)}(X)$$

Solve the equation. (Do the same thing on each side of the "=" sign. In this case, divide each side by 1,000 sq. ft.)

$$X = \frac{\text{(2 ounces)(20,000 sq. ft.)}}{\text{1,000 sq. ft.}}$$

$$X = \text{40 ounces}$$

If your information includes the amount of active ingredient per unit area at which the material is to be applied and the percentage of active ingredient in the formulation, your calculation involves an extra step. In this case, calculate how much active ingredient you will need to complete the job, and then set up a ratio.

**Example:**

Assume Insecticide X is available as a 60 WP and should be applied at 4 lb a.i. per acre. How much actual material will you need to treat 20 acres of turf?

Step 1: Calculate how much active ingredient you will need.

$$\text{(4 lb a.i. per acre) (20 acres)} = \text{80 lb a.i.}$$

Step 2: Set up a ratio, using information about the formulation and the amount of active ingredient you have calculated you will need. 60 WP means 60 lb a.i. per 100 lb actual product.

$$\frac{\text{60 lb a.i.}}{\text{100 lb. actual product}} = \frac{\text{80 lb a.i}}{\text{X lb. actual product}}$$

Cross multiply:

$$\text{(60 lb a.i.) (X)} = \text{(100 lb actual) (80 lb a.i.)}$$

Solve the equation (hint: divide each side by 60 lb a.i.):

$$X = \text{133 lb actual product}$$

Emulsifiable concentrates have several advantages over other formulations. First, they are normally quite concentrated, so shipping costs are usually lower than those of bulkier products. Similarly, smaller storage areas can be used to maintain an adequate inventory. Smaller nozzle orifices can be used with emulsifiable concentrates because they are less likely to clog nozzles than other formulations. If all other conditions are equal, emulsifiable concentrates normally will remain active on the surface of plants longer than wettable or soluble powders. An EC application usually will not wash off the leaf surface as readily as a wettable or soluble powder application.

Emulsifiable concentrates have some drawbacks, most of which involve handling concerns. Emulsifiable concentrates tend to be more hazardous, especially during the mixing process, because the oil-based material penetrates skin more readily than any other common formulation. As a result, hazards from dermal exposure can be serious. Also, cleaning up spills of emulsifiable concentrates is more challenging than cleaning up spills of wettable or soluble powders or dry flowables. Some emulsifiable concentrates are relatively flammable, with a low flash point, so it is very important to avoid high temperatures in pesticide storage areas. Finally, ECs are much more likely to be phytotoxic than the other various dry sprayable formulations, primarily because of the petroleum solvent in the product.

**Flowable** formulations (usually abbreviated F on the label) consist of a cloudy liquid composed of solid particles of the active ingredient that are finely ground and suspended in water. The product, when it comes out of the container, is cloudy and can be any of a number of colors, but the final spray solution is milky in appearance. The main difference between flowables and emulsifiable concentrates is that flowable formulations go into suspension in water directly, while ECs go into emulsion (oil mixing with water). The functional difference for a turf manager is minimal - both materials mix well in the tank - but the EC's oil base makes it more likely to burn the intended plant target.

Flowables seem to combine the best of both worlds compared to other formulations. For example, they seldom leave visible residues on the plant surface. They often protect the plant as long as emulsifiable concentrates but are much less likely to burn the plants. Because flowables are water-based and not petroleum-based, they are less hazardous to handle than emulsifiable concentrates (much less skin absorption), especially during the mixing process. At the same time, they are less hazardous to handle than wettable (and soluble) powders because the inhalation hazard is greatly reduced. The only disadvantage of flowable formulations is that the active ingredient might settle to the bottom of the container during storage. This can easily be remedied by vigorous agitation before pouring out the material.

**Soluble Concentrates** (usually abbreviated SC or CS on the label) are very similar in physical structure and performance characteristics to flowable formulations. Unfortunately, while flowables and soluble concentrates seem to provide numerous advantages compared to other formulations, not every active ingredient can be formulated as a flowable or soluble concentrate.

Another relatively new formulation is the **Micro-encapsulated Suspension**, often abbreviated ME on the label. This is a suspension of the active ingredient in microscopic capsules, that results in the controlled and slow release of the active ingredient. This approach is similar to that used in pharmacology for cold medicine, which releases the active ingredient over a period of several hours to provide relief.

Micro-encapsulated formulations are similar to emulsifiable concentrates in many ways, including similar shipping costs and storage requirements. They can be sprayed through smaller nozzle orifices than many other sprayable formulations, thereby allowing the applicator to use very fine droplet sizes and the option of using ultra-low volume sprayers. MEs usually provide excellent residual activity. They normally result in reduced potential for exposure hazard during mixing and application, compared to several other sprayable formulations. However, because the technology is still relatively new, micro-encapsulated formulations tend to be more expensive than other formulations, and are not yet widely available on the turf market.

## Calculations

Often a turf manager needs to determine how much product will be needed to treat a given area. Sometimes the information is provided on the container (for example, a bag of a granular product might say, "Treats up to 10,000 square feet."

# Calculations for Liquid Formulations

For liquid formulations (emulsifiable concentrates, flowables, soluble concentrates, micro-encapsulated suspensions, and others), the number in front of the formulation abbreviation gives the number of pounds active ingredient in one gallon of the product. For example, a 2 F is a flowable formulation with 2 lb a.i. per gallon, and a 4 E is an emulsifiable concentrate with 4 lb a.i. per gallon.

If your information provides the amount of product per unit area, your calculation is very straightforward. Set up a ratio similar to the one used for dry formulations.

$$\frac{\text{amount of product}}{\text{unit area}} = \frac{\text{amount product needed}}{\text{area you will treat}}$$

**Example:**

The label says you should apply 1.5 fluid ounces of product per 1,000 square feet. Assume you want to treat 20,000 square feet. How much product should you use?

Set up a ratio:

$$\frac{\text{1.5 fluid oz. product}}{\text{1,000 sq. ft.}} = \frac{\text{X fluid oz. product}}{\text{20,000 sq. ft.}}$$

Cross multiply:

(1.5 fluid oz.)(20,000 sq. ft.) = (1,000 sq. ft.) (X)

Solve the equation (in this case, divide each side by 1,000 sq. ft.):

X = 30 fluid oz. or 0.94 qt. or 0.23 gal.

Just as with dry product calculations, if your information includes the amount of active ingredient per unit area at that the material is to be applied, and the percent active ingredient of the formulation, your calculation involves an extra step. In this case, calculate how much active ingredient you will need to complete the job, and then set up a ratio.

**Example:**

Assume Insecticide Y is available as a 2 F and should be applied at 4 lb a.i. per acre. How much actual material will you need to treat 15 acres of turf?

Step 1: Calculate how much active ingredient you will need.

(4 lb a.i. per acre) (15 acres) = 60 lb a.i.

Step 2: Set up a ratio, using information about the formulation and the amount of active ingredient you have calculated that you will need:

$$\frac{\text{2 lb a.i.}}{\text{1 gallon product}} = \frac{\text{60 lb a.i.}}{\text{X gallons product}}$$

Cross multiply:

(2 lb a.i.) (X) = (1 gallon) (60 lb a.i.)

Solve the equation (in this case, divide each side by 2 lb a.i.):

X =.30 gallons

However, sometimes the turf manager must calculate the amount needed.

The application rate of a pesticide might be given as the amount of active ingredient (a.i.) per acre (for example, 1 lb a.i. per acre) or as the amount of product per unit area (for example, 2 quarts per acre or 1 pound per 1,000 square feet). The label provides an indication of the product concentration.

## Terms to Know

**Abrasive** - capable of wearing away or grinding down another object.

**Active Ingredient** - the actual killing agent in a pesticide formulation.

**Agitation** - the process of keeping a tank mix stirred up and well mixed.

**Emulsion** - a mixture of two or more liquids that are not soluble in one another. One is suspended as small droplets in the other. (Example: oil and water)

**Formulation** - the mixture of active and inert ingredients that forms a pesticide product.

**Inert Ingredient** - a component of a pesticide formulation that is not directly toxic to the target pest.

**Solvent** - a liquid (often water, xylene, or alcohol) that will dissolve a pesticide (or other substance) to form a solution.

**Suspension** - a formulation that contains undissolved (although often very fine) particles mixed throughout the liquid.

ADDITIONAL READING

Bohmont, Bert L. 1990. The Standard Pesticide User's Guide. Prentice Hall Inc., Englewood Cliffs, NJ 07632. pp. 223 - 243.

Environmental Protection Agency. 1991. Applying Pesticides Correctly.

Gaussoin, Roch. 1995. Pesticide Formulations. Golf Course Management (March): 49-51.

# Dr. Bill Knoop Joins TurfGrass TRENDS as Editor

*Dear TurfGrass TRENDS readers,*

I am pleased to announce that Dr. William E. Knoop, extension turfgrass specialist at Texas A&M University for more than 16 years, is TurfGrass TRENDSí new editor.

Knoop, a resident of Mt. Vernon, Texas, is a nationally-known speaker, author and turfgrass expert. During his 30 plus year career, Dr. Knoop has received numerous awards which include the Texas Governor's Award for Environmental Excellence in 1995, Superior Service Award in 1991 from the U.S. Department of Agriculture and the Environmental Excellence Award for Solid Waste Reduction from the Environmental Protection Agency.

Knoop, a graduate of the University of New Hampshire (Ph.D.), the University of Florida (M.S.A.) and Iowa State University (B.S.) will also continue to serve as technical editor on Advanstarís Landscape Management magazine and is the author of the Landscape Management Handbook.

As editor, Bill will be responsible for the coordination and editing of TurfGrass TRENDS, a function that had been handled by, Maria Haber, previous owner of the publication. As such, he will oversee the activities of the editorial and advisory boards and become the hands-on, day-to-day contact for authors and readers alike.

Please join me in welcoming Bill to TurfGrass TRENDS. You can reach him by telephone at 903-860-2239 or e-mail at knoop@mt-vernon.com.

*John D. Payne, Publisher*

PO Box 1637, Mt. Vernon, TX 75457
903-860-2239 (tel)
903-860-3877 (fax)
e-mail: knoop@mt-vernon.com

# Relative Hazards of Turf and Ornamental Pesticides to Non-Target Species

*Whitney Cranshaw*
*Colorado State University*

One of the more publicly visible issues involving pesticide use in turfgrass and landscape plant protection involves harm to desirable 'non-target' species, such as birds, fish, earthworms, and other wildlife. Pesticide applications do have the potential to harm these organisms - as well as the intended target pest species (grubs, webworms, billbugs, chinch bugs, etc.).

Inadvertent wildlife kills can draw intense scrutiny to the applicator of pesticides. Federal laws protecting wildlife have caused further regulation of pesticide use in the landscape. Landscape practices, such as gardening to attract wildlife and the expanding popularity of fish ponds, are increasingly bringing fish and birds into close contact with landscape plantings which may need pest protection.

Potential hazards of some turf pesticides to fish and birds are sometimes not well communicated on the pesticide label. A generic warning is used, but too often the warning doesn't reflect the seriousness of the potential hazard. It is in the interest of the turf care professional to be aware of these potential special hazards associated with pesticide products so that problems can be minimized.

## Methods of Determining Pesticide Toxicity

The relative toxicity of various chemicals, including pesticides, is often evaluated in terms of their LD50 value. This is the lethal dose of the chemical which kills 50 percent of the test animals. The figure is adjusted for body weight of the animal and expressed as a number based on milligrams (mg) of pesticide required per kilograms (kg) of body weight (This is equivalent to parts per million of body weight). Using this approach, lower LD50 values indicate greater toxicity.

LD50 values can be developed for various types of pesticide exposure. The LD50 values most easily developed - and most widely available - are those based on a single exposure applied either orally (ingestion) or to the skin (dermal). These are often called acute exposure values.

Pesticide toxicity to fish and other aquatic organisms is measured somewhat differently. Instead of a lethal dose (LD) value, a lethal concentration (LC50) value is given, based on the concentration of the pesticide diluted in water that will kill 50 percent of an exposed fish population. Studies on fish are usually run over a four-day period (96 hours) and LC50 values are expressed in parts per million (or parts per billion) of the pesticide in water.

For both LD50 and LC50 values, the technical (i.e., unformulated) pesticide is almost always tested. The values given in Tables 1 and 2 reflect this. Formulated pesticides may have different values because the other ingredients added during formulation can affect uptake by fish or birds. Inert ingredients found in the formulated product can also affect toxicity.

Toxicity of pesticides to earthworms, a group of animals important for lawn health, is not routinely determined in laboratory trials. Information on this subject is based on field trials conducted by turfgrass researchers, often entomologists.

**Toxicity of turf and ornamental insecticides and miticides to birds.** The insecticides most toxic to birds (Table 1) are primarily organophosphate insecticides such as diazinon, Cygon, and Mocap. Bendiocarb (Dycarb, Turcam) is the lone carbamate among the higher risk insecticides. Most of these insecticides are considerably more toxic to birds than to mammals. Diazinon, for instance is 100 times more toxic to birds (LD50 value 3.5 mg/kg) than for mammals (about 350 mg/kg). A few granules of the 14G formulation of diazinon would be considered a lethal dose to many birds. This insecticide typically carries a label indicating only moderate toxicity (Warning) but would be in the highest risk category if risk to birds was the basis for assigning label warnings. Concerns about toxicity have recently resulted in more restrictive diazinon-product labels.

**Toxicity of turf and ornamental insecticides and miticides to fish.** Fish show a very different spectrum of susceptibility to insecticides and miticides. The newer insecticides, pyrethroids (Talstar, Mavrik, Tempo) and avermectins (Avid), dominate the insecticides of high risk to fish. These are extremely toxic to fish, at least in the clear water tanks in which most studies have been conducted. For example, bifenthrin, the active ingredient in Talstar has an LC50 value equivalent to 1 teaspoon per 8,680,560 gallons of water.

**Table 1. Acute avian (bird) toxicity of insecticides and miticides used in tree and turf care.** *LD50 values for single feed acute toxicity of mallard ducks are given unless otherwise indicated.*

| *Pesticide (Trade name)* | *LD50 value* | *Pesticide Class* |
|---|---|---|
| **Highly toxic to birds** (equivalent to Category I-Danger/Poison label-pesticides for human exposure, oral LD50 0-50) | | |
| bendiocarb (Turcam, Dycarb, Ficam) | 3.1 mg/kg | Carbamate |
| diazinon | 3.5 mg/kg | Organophosphate |
| ethoprop (Mocap) | 4.2-61 mg/kg | Organophosphate |
| dimethoate (Cygon) | 7-22 mg/kg | Organophosphate |
| **Moderately toxic to birds** (equivalent to Category II-Warning label-pesticides for human exposure, oral LD50 51-500) | | |
| isazophos (Triumph) | 61 mg/kg | Organophosphate |
| chlorpyrifos (Pageant, Dursban) | 76.6 mg/kg | Organophosphate |
| avermectin (Avid) | 84.6 mg/kg | Avermectins |
| fonofos (Crusade | 128 mg/kg | Organophosphate |
| imidacloprid (Merit, Marathon) | 152 mg/kg (quail) | Chloronicotinyl |
| acephate (Orthene) | 350 mg/kg | Organophosphate |
| **Lower toxicity to birds** (equivalent to Category III-Caution label-pesticides for human exposure, oral LD50 501+) | | |
| fenpropathrin (Tame) | 1089 mg/kg | Pyrethroid |
| malathion | 1485 mg/kg | Organophosphate |
| spinosad (Conserve) | > 2000 mg/kg | Naturalyte |
| biphenthrin (Talstar) | > 2150 mg/kg | Pyrethroid |
| fipronil | > 2150 mg/kg | Phenyl pyrazole |
| carbaryl (Sevin, Chipco Sevimol) | > 2179 mg/kg | Carbamate |
| lambda-cyhalothrin (Scimitar) | > 3950 mg/kg | Pyrethroid |
| fluvalinate (Mavrik) | > 2510 mg/kg | Pyrethroid |
| hexythiazox (Hexygon) | > 2510 mg/kg | |
| cyfluthrin (Tempo) | > 5000 mg/kg | Pyrethroid |
| halofenozide (MACH-2) | > 5000 mg/kg | Growth regulator |
| permethrin (Perm-X, Astro) | > 9,900 mg/kg | Pyrethroid |
| **Pesticides of low toxicity to other birds but data for mallards unavailable. Data on LD50 values, if given, is for bobwhite quail.** | | |
| dicofol (Kelthane) | 3010 mg/kg | Chlorinated hydrocarbon |
| dienochlor (Pentac) | 4319 mg/kg | Chlorinated hydrocarbon |

It is regularly emphasized by manufacturers of pyrethroid insecticides that organic matter in natural ponds binds to and inactivates most of the insecticide. Even though this greatly reduces the risk hazards of these products, they still remain inherently toxic to fish and need to be used with special caution in and around fish-bearing waters. Concerns about these compounds has greatly affected their progress of registration in recent years, particularly where endangered aquatic species occur.

Many of the miticides (Pentac, Kelthane) also show considerable toxicity to fish, but they are of much lesser risk to mammals and birds. Organophosphates, which are highly toxic to birds, are generally at the bottom among insecticides that are ranked for their toxicity to fish.

**Toxicity of turf and ornamental insecticides and miticides to earthworms.** Earthworms are essential to lawn health, in that they are macrodecomposers that help recycle organic matter such as thatch and they naturally aerate soils. Destruction of earthworms can disrupt a healthy soil ecosystem, contributing to other problems, notably build-up of thatch layers. Older insecticides in the chlorinated hydrocarbon group, such as chlordane, devastated earthworms and created unhealthy lawn environments. Pesticides currently in use apparently have considerably less effects on decomposers inhabiting turf. However, even among current products some can have a potentially serious impact on earthworms.

The most recent data on the impact of lawn care pesticides on earthworms was produced by Dr.

**Table 2. Acute toxicity of insecticides and miticides used in tree & turf care to rainbow trout.** *LC50 (lethal concentration in water) values for 96 hour exposure.*

| Pesticide (Trade name) | LC50 value | Pesticide class |
|---|---|---|
| biphenthrin (Talstar) | 0.15 ppb | Pyrethroid* |
| cyfluthrin (Tempo) | 0.68 ppb | Pyrethroid* |
| fluvalinate (Mavrik) | 2.9 ppb | Pyrethroid* |
| avermectin (Avid) | 3.6 ppb | Avermectins |
| isazophos (Triumph) | 6.3 ppb | Organophosphate |
| fenpropathrin (Tame) | 10.3 ppb | Pyrethroid* |
| permethrin (Perm-X, Astro) | 12.5 ppb | Pyrethroid* |
| dienochlor (Pentac) | 50 ppb | Chlorinated hydrocarbon |
| fonofos (Crusade) | 50 ppb | Organophosphate |
| dicofol (Kelthane) | 53-86 ppb | Chlorinated hydrocarbon |
| lambda-cyhalothrin (Scimitar, Battle) | 240 ppb | Pyrethoid* |
| fipronil | 248 ppb | phenyl pyrazole |
| diazinon | 635 ppb | Organophosphate |
| ethoprop (Mocap) | 1.02-1.85 ppm | Organophosphate |
| dimethoate (Cygon) | 1-10 ppm | Organophosphate |
| bendiocarb (Turcam, Ficam, Dycarb) | 1.55 ppm | Carbamate |
| carbaryl (Sevin, Chipco Sevimol) | 1.95 ppm | Carbamate |
| malathion | 2.00 ppm | Organophosphate |
| chlorpyrifos (Dursban, Pageant) | 3.0 ppm | Organophosphate |
| halofenozide (MACH-2) | > 8.6 ppm | Growth regulator |
| spinosad (Conserve) | 30 ppm | Naturalyte |
| imidacloprid (Merit, Marathon) | > 128 ppm | Chloronicotinyl |
| hexythiazox (Hexygon) | > 300 ppm | |
| acephate (Orthene) | > 1000 ppm | Organophosphate |

*ppb = parts per billion; ppm = parts per million.*
** Note: These values indicate hazards under laboratory conditions. Hazards under field conditions might differ greatly. For example, most pyrethroid insecticides appear to have greatly reduced hazard in field situations because they have a high attraction to organic matter particles in water.*

Dan Potter at the University of Kentucky. In field trials (Table 3), out of all the products tested, only a few significantly reduced earthworm populations two weeks after treatment. These primarily included the carbamate insecticides (carbaryl, bendiocarb) and fungicides (benomyl), along with the organophosphate insecticide ethoprop (Mocap). Most other commonly used insecticides and fungicides had little, if any, impact on earthworm populations.

This data indicates the variable effects that pesticides can have on different types of organisms. Becoming aware of these differences can allow the applicator to use them with greater care and avoid harming susceptible species. This will help in the avoidance of hazardous pesticides in areas where highly sensitive species occur.

However, how the pesticide is applied will be the most important factor in determining the hazard of a pesticide. Turf managers should always attempt to make applications in a manner that best avoids exposure to any non-target species. Time of application, limiting the area treated, control of drift, rates applied and formulation are all important factors which can greatly affect the severity of unintended impacts of a pesticide on valuable, non-target organisms.

**Table 3. Effects of pesticides on earthworm populations.**
*Based on data from Dr. Dan Potter, University of Kentucky.*

**Pesticides that affected earthworm populations two-three weeks after treatment**
(percent population reduction)

| | |
|---|---|
| Dursban 4E (-32.3) | Diazinon 14G (-58.4) |
| Triumph 4E (-59.4%) | Benomyl (Tersan 1991) (-60.0)* |
| Thiophanate-methyl (Cleary's 3336) (-88)** | Sevin SL (-89.8)* |
| Fonofos (Crusade) (-96)** | Mocap 10G (-96.8)* |
| Turcam 2.5G (-99.0)* | |

**Pesticides that did not have significant effects on earthworm populations**

| | |
|---|---|
| 2,4D | Triclopyr |
| Dicamba | Senariol (Rubigan) |
| Triademephon (Bayleton) | Isofenphos (Oftanol) |
| Pendimethalin (Pre-M, etc.) | Trichlorfon (Proxol) |
| Chlorothalonil (Daconil 2787) | Propaconazol (Banner) |
| Iprodione (Chipco 26019) | Isoxaben (Gallery) |
| Prodiamine (Barricade) | Dithiopyr (Dimension) |
| Mycobutanil (Eagle/RH3866) | Bifenthrin (Talstar) |
| Cyfluthrin (Tempo) | Fluvalinate (Mavrik) |
| Flurprimidol (Cutless) | Mefluidide (Embark) |
| Metalaxyl/Mancozeb (Pace) | Fosetyl-al (Alliete) |
| Cyprocanazole (Sentinel) | Tebuconazole (Lynx) |
| Azadirachtin (Margosan-O) | *Steinernema carpocapsae* (Savior) |
| Halofenozide (MACH-2) | |

** Pesticides that had significant effects on earthworm populations 20 weeks after application. Reduction of earthworm populations at 20 weeks ranged from 79%-40%.*
*** 20 week evaluations not made.*

# Turfgrass Response To Controlled-Release Urea Fertilizers

*By John L. Cisar, Ph.D.*
*University of Florida*

Nitrogen (N) is the nutrient element required in greatest quantity by warm-season turfgrasses. Turfgrass managers often prefer to use soluble N sources on turfgrasses due to their relatively low cost, their rapid response, and with some sources, soil acidifying effect.

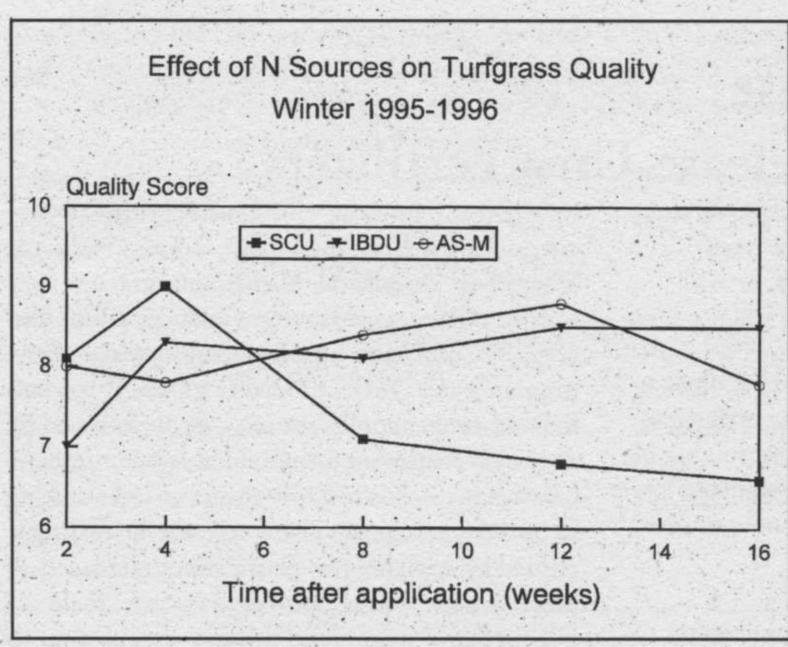
On highly permeable, sandy soils, applications of large amounts of soluble N can result in appreciable N leaching and reduced N utilization by turfgrass. Sandy soils, along with irrigation and clipping removal, make it difficult to provide the grass with an even supply of N. Slow- and controlled-release N sources have been shown to provide a longer lasting, more uniform supply of fertilizer N. In addition, these materials reduce nitrate leaching under adverse climate and soil conditions and offer benefits such as minimum burn potential, reduced application frequency, and lower labor costs.

Water-soluble urea can be coated to provide a controlled-release N which can extend the duration of turfgrass response. The first coated-urea material, sulfur-coated urea (SCU), has become a standard in the turfgrass industry. Developed by the Tennessee Valley Authority in the 1960s, the SCU production process consists of coating urea prills with layers of sulfur, wax, and conditioner. Nitrogen release occurs by water penetration through micropores and imperfections in the sulfur coating and microbial degradation of the wax layer. Unreleased N from a certain percentage of heavily-coated prills (coined "lock-off"), has been a concern with users of SCU.

Recent technological advances in polymer chemistry have led to a number of new controlled-release ureas (CRU). SCU can be coated with a thin layer of polymer (e.g., available as PolyS and Tricote) to to control N dissolution more uniformly. Other new sources include saran film (e.g., V-Cote), and an ethylene-propylene diene monomer (EPDM). EPDM (e.g., ESN) is a sulfonated-rubber applied from a solvent followed by a mineral coating to form a durable outer layer. A fourth approach is to apply a reactive layer coating to urea (e.g., Polyon). The reactive layer coating is created by applying two plastic monomer layers to urea which then polymerize to form a polyurethane membrane around the urea prill. Water penetration through this coating and the subsequent release of soluble N is governed by diffusion across the semi-permeable polymer membrane.

The objective of this study was to determine the effect of new controlled-release sources on turfgrass growth and quality as compared to standard soluble and slow-release N forms. Twelve controlled-release ureas and a coarse (0.7-2.5 mm diameter) IBDU were evaluated in each of two experiments. For the first experiment, these N fertilizers were applied on November 13, 1995 and for the second experiment on May 24, 1996 to provide either 1.5 or 3 lbs. N per 1,000 sq. ft. to established "Tifgreen" bermudagrass plots. Soluble N as ammonium sulfate (AS) was applied at the same rate to other plots. A second set of plots received AS each month at 1 lb. N per 1,000 sq. ft. In addition, three IMC Vigoro products (V-Cote and two experimental products coded S-1 and S-3) were applied as split 50/50 CRU/AS at the above rates to determine the effectiveness of blended, controlled and soluble N sources. The plots were arranged as a randomized complete-block design on a Hallandale fine sand soil at the Ft. Lauderdale Research and Education Center, University of Florida.

The plots were also fertilized at the beginning of each experiment with phosphorus (P) and potassium (K) at a rate of 0.5 and 1.5 lbs. per 1,000 sq.




The figure on the left illustrates the typical quality response obtained from standard controlled-release N sources, SCU and IBDU, as compared to AS applied monthly. Note the expected more rapid but shorter duration quality response from SCU compared to the slower and longer turfgrass response from coarse IBDU. The turfgrass quality response was consistent with the observed N release rate from prills placed in the field.

This example reflects the typical patterns observed for CRU sources. In general, sources releasing N over a longer duration did not always promote as high initial turf quality as did sources with shorter expected duration. However, manufacturers often supplement controlled-release N with soluble N to compensate for this lag in N response, and we too observed greater initial turf responses with the 50/50 (IMC Vigoro products/AS) blended experimental products.

ft., respectively. The area was mowed as needed at a 0.5-inch height. Irrigation maintained adequate soil moisture for turfgrass growth. Turfgrass quality ratings were determined and turfgrass clippings were harvested beginning two weeks after N application. Nitrogen release from controlled-release urea prills placed in the field was also determined.

## N Release and Quality Response

Ideally, controlled-release N fertilizers should provide acceptable turfgrass quality responses similar to those obtained from frequent "spoon feeding" applications of soluble N fertilizers. In addition, the materials should release predictably, so that a turfgrass manager can time applications efficiently at rates sufficient to achieve suitable quality and growth responses.

All of the controlled-release N sources generally provided acceptable turfgrass quality and clipping yields consistent with their estimated release duration under both winter and summer conditions of sub-tropical South Florida. Furthermore, these products generally provided turfgrass quality and growth that was equal to or better than that achieved from the application of soluble N. However, no single source consistently out-performed other sources.

Based on the results of this study, turfgrass managers in Florida and elsewhere have numerous controlled-release N options from which to choose. Among the many criteria for selecting a N source, turfgrass managers could base their decisions on material and labor costs, convenience of application, safety, and duration of N release.

*John L. Cisar, Ph.D., is an associate professor of turfgrass management and water, FLREC, University of Florida, 3205 SW College Ave, Ft. Lauderdale, FL 33314. He received his Ph.D. in Biological Sciences from the University of Rhode Island, M.S. from Cornell University and B.A. from Rutgers University. Cisar has been with the UF since his appointment in 1986. He is active in turfgrass research, extension, and resident instruction at the University. His current activities include efficient agrichemical resource utilization, water conservation and protection of water quality in turfgrass systems.*

**Table 1. Controlled-release urea sources evaluated.**

| Designation | Description/ Estimated Release | % N | Manufacturer |
|---|---|---|---|
| S-1 (expmtl.) | Saran-coated/ 3-4 months | 43 | IMC Vigoro, Winter Haven, FL |
| V-Cote | Saran-coated/ 2-3 months | 44 | IMC Vigoro, Winter Haven, FL |
| S-3 (expmtl.) | Saran-coated/ 2-3 months | 44.5 | IMC Vigoro, Winter Haven, FL |
| Polyon 42 | Reactive-layer coated/3-4 months | 42 | Pursell, Sylacauga, AL |
| Polyon 43 | Reactive-layer coated/2-3 months | 43 | Pursell, Sylacauga, AL |
| Polyon 44 | Reactive-layer coated/2-3 months | 44 | Pursell, Sylacauga, AL |
| S-4 (expmtl.) | Saran-coated/ 3-4 months | 44 | IMC Vigoro, Winter Haven, FL |
| PolyS | Polymer + Sulfur-coated 2-3 months | 40 | Scotts, Marysville, OH |
| TriKote | Polymer + Sulfur-coated 2-3 months | 44 | Pursell,Sylacauga,AL |
| SCU | Sulfur-coated 2-3 months | 39 | |
| ESN 2003 | Sulfonated rubber-coated/ 2-3 months | 40 | Veridian, Redwater, Alberta, CAN |
| ESN 2004 | Sulfonated rubber-coated/ 3-4months | 40 | Veridian, Alberta, CAN |
| IBDU | Isobutylidene diurea 3-4 months | 31 | |
| Ammon. Sulfate | Soluble | 21 | |

*TurfGrass TRENDS* is published monthly. ISSN 1076-7207.

Subscription rates: One year, $180 (US) $210 (all other countries.)



Postmaster: Send address changes to TurfGrass TRENDS, 131 West First St., Duluth, MN 55802-2065.

ADVANSTAR COMMUNICATIONS

# In Future Issues

- Nutrition Series: Phosphorous Uses by Turfgrasses
- New Buffalograss Cultivars



## Use of TGT articles

Permission may be granted on request for TGT articles as course material and for reprints in publications.
For course material: We can group articles by subject for you.


Please send request to:
*TurfGrass TRENDS*
7500 Old Oak Blvd.
Cleveland, OH 44130-3369
Phone: 216-243-8100
Fax: 216-891-2675
E-mail: turfgrasstrends@en.com


Index and abstracts are available electronically through: Michigan State University, TGIF 800-466-8443; PLCAA, at http://www.plcaa.org. TurfNet at http://www.turfnet.com

ADVANSTAR COMMUNICATIONS


TurfGrass TRENDS

131 West First Street
Duluth, MN 55802-20


FIRST CLASS
US POSTAGE
PAID
DULUTH, MN
PERMIT NO. 1900