# Factors Affecting Pesticide Behavior

**The behavior of pesticides is dependent on many factors, so be sure to consider everything from light and temperature to moisture and pH and recognize that all the factors will impact the active ingredient.**

## By Donald Cress

Pesticides are "formulated" in many ways, each with its own characteristics, to meet a wide array of pest control conditions/needs, application methods, applicator/environmental safety, handling/storage conditions and actual pesticidal characteristics.

Pesticide behavior is important because all pesticides are poisons deliberately introduced into the environment. To maintain minimal non-target exposure, the chemical and physical behavior of pesticides must be taken into account. The following terms and illustrations are meant to provoke thought and understanding of some aspects of pesticide behavior.

### Understanding Formulations

Pesticides contain two groups of chemicals: active ingredient(s) (AI) and inert or inactive ingredients. The active ingredient(s) is that part of the formulation designed to control the target pest. The function of inert ingredients is to enhance application and effectiveness of the active ingredient(s). The combination of active and inactive ingredients is known as the pesticide formulation. The various formulations allow the pesticide to be applied by different means (sprays, dusts, granules) to achieve specific results.

**Emulsifiable concentrate (EC).** These formulations have the active ingredient dissolved in an organic solvent because they have very low solubility in water. Emulsifying chemicals are added to enable mixing with water (resulting in a "milky" solution). Wetting agents, UV light blockers and various other chemicals may be added to perform specific functions.

Microencapsulation is an EC technique whereby the AI is encapsulated as microscopic droplets in a nylon-like material. Microencapsulation reduces dermal toxicity and extends residual time because the amount of active ingredient is limited at any given time to that found on the surface of each droplet.

**Wettable powders.** Wettable powders are formulations in which the AI is not dissolved in petroleum solvents; rather, it is very finely ground and diluted with a powder such as talcum or other inert powders.

**Aerosols.** Aerosol formulations are usually in pressurized containers. By pushing the valve nozzle, a very fine-droplet mist or aerosol is shot into the surrounding air or onto a target surface.

**Fumigants.** Most fumigants are highly volatile. Some are kept as liquids under pressure. When released they go directly into the true gaseous state. Others are formulated as dry tablets or pellets that upon exposure to moisture in the air chemically react to produce gases. Fumigants are not fine droplets like an aerosol but true gases.

**Granular formulations.** Granular formulations are made by placing the active ingredients on a core material such as clay, sand or ground corncob. The core material imparts various qualities (e.g., flowability, dust, release rates) to the formulation. These granular formulations are applied as purchased, i.e., dry. In contrast, water-dispersible granules have a granular form but are mixed with water, similar to wettable powders. Granular formulations generally have less dust than dusts and wettable-powder formulations.

### Understanding Persistence

Persistence is the inherent stability of the pesticide. Another term for persistence is "residual time" — how long it effectively lasts. As represented in Figure 1, below, two pesticides are applied at the same time. In this example, chemical A was more persistent, with six weeks of control, than chemical B, with three weeks. This illustrates the persistence (or residual time) of these two chemicals under identical conditions of temperature, moisture and light.

Now look at Figure 1, below, differently. Imagine that both lines represent the same chemical applied under different light, moisture and temperature conditions. Under existing levels of light, moisture or temperature, curve A represents a 6-week residual time. Now consider that

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**Pesticide Persistence**

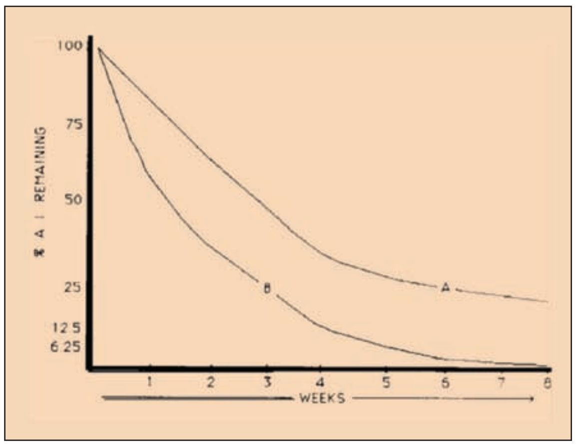


*Figure 1. Most pesticides have different persistence durations because they have different active and inactive ingredients.*

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curve B represents a second application of the chemical later in the season when the factors of light, moisture or temperature are even more favorable for breakdown. The result is only three weeks of residual time. Thus persistence is variable under field-use conditions.

There is a detectable amount of active ingredient that is less than the lowest level required for effective control. In the previous example, curve B provided three weeks of residual control. However, though declining, it is still detectable for at least eight weeks (curve A lasts even longer). These "post-control residues" may affect subsequent crops and are referred to as "carry over."

If a soil sample containing deactivated chemicals is taken into the laboratory for analysis, the amount of pesticide present may be chemically detected in the soil sample even though it does not control the target pest from a biological standpoint.

### Pesticide Degradation

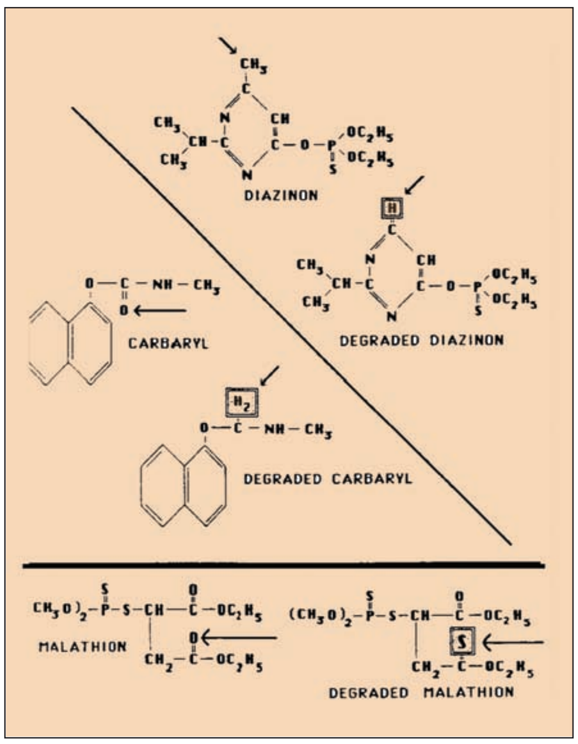



*Figure 2. Degradation is the chemical breakdown of AI in a pesticide, as seen here when an oxygen atom in carbaryl is replaced with two hydrogen atoms.*

## Understanding Degradation

Degradation is the AI breakdown process. It is strictly a chemical breakdown, as illustrated in Figure 2, left. In chemical degradation, for purposes of illustration, the methyl group ($CH_3$) at the top of the diazinon molecule has been replaced in the degraded state by a hydrogen (H) atom (as seen in Figure 2, right).

This form of degradation is a chemical reaction between the pesticide AI and the various chemicals in the soil, on the leaf surface or wherever the pesticide happens to be. The rate of chemical degradation is governed largely by temperature, that is, for every 50° F rise in temperature, the chemical reaction rate will double.

The importance of chemical degradation is the faster the pesticide compound degrades, the less time it is available for pest control. In some cases the breakdown product(s) can be more toxic than the original AI. Therefore, when the U.S. Environmental Protection Agency registers any pesticide, it must also be concerned about the degradation products.

## Understanding Deactivation

Some deactivation occurs when some of the pesticide adheres so tightly to a soil particle, organic matter in the soil, leaf surface or some other compound in the environment that it is no longer available. For example, a root hair growing in soil where glyphosate is bound to the clay may not be affected by the glyphosate molecule.

## Understanding Photodecomposition

Ultraviolet (UV) light is a very high source of energy that promotes the breakdown of many chemicals. Most of the pesticides we use today are somewhat subject to photodecomposition. Some pesticide formulations contain UV light blockers that lessen the amount of photodecomposition.

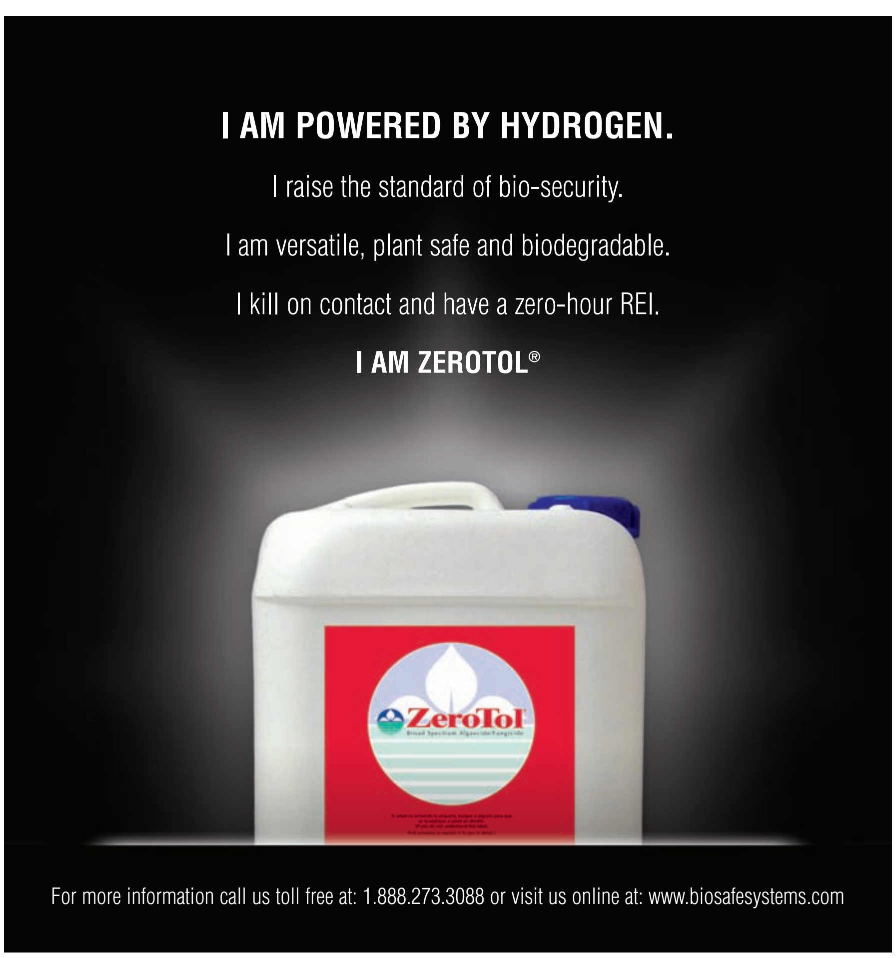
Ultraviolet light is an extremely destructive source of energy and plays a very important role in terms of the persistence of pesticides that are exposed to it. Some pesticides are packaged in brown-colored glass. This cuts out the light and thereby stops the photodecomposition of the pesticide ingredient while it is on the shelf.

## Understanding Hydrolysis

Hydrolysis is the combination of a water molecule with another molecule that results in the splitting of the larger molecule. Hydrolysis in combination with photodecomposition is often involved in the breakdown of various pesticide active ingredients.

Hydrolysis can take place in the container before the pesticide is ever applied. Once the container seal is broken, moisture in the air moves in and out of the container with each atmospheric pressure change, and the small amount of moisture (water vapor) in the air combines with the active ingredients in the container. When this occurs, the shelf life of that particular product is reduced.

Hydrolysis is an important mechanism in ➧



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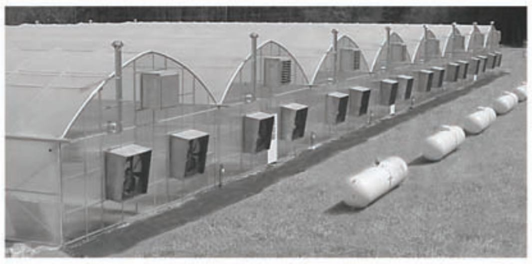

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pesticide breakdown. The faster the hydrolysis reaction takes place, the less time the pesticide is available in the environment for pesticidal activity, leaching or other movement.

**Effects Of Temperature On Pesticides**

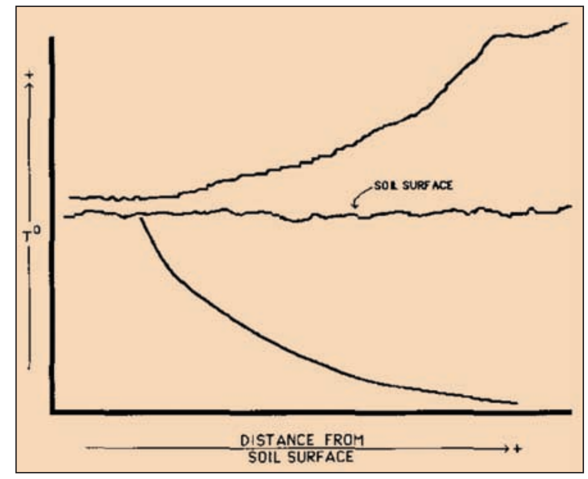


*Figure 3. Temperatures above and below the soil surface can affect a pesticide's reaction rate. Warmer temperatures speed reaction rate; cooler temperatures slow reaction rate.*

## Understanding Temperature

Temperature is another very significant factor in the breakdown of pesticides. As Figure 3, right, shows, temperature can be divided into two categories: above the soil surface and below the soil surface. Above the soil surface the air temperature is highly variable, fluctuating radically, but in general, it increases with height above the soil surface. For every 50° F rise in temperature, the chemical reaction rate doubles. Thus, if a pesticide is applied close to the soil surface versus the top of a crop canopy, the rate of chemical breakdown may increase up through the canopy due to higher temperatures at the top.

Below the soil surface, the soil temperature drops at a rather steady rate. For every 50° F drop in temperature, the chemical reaction rate is cut in half. As the pesticide moves further below the soil surface, the temperature is cooler, slowing chemical breakdown reaction to the extent it is dependent on temperature. Therefore, if a chemical gets below the root zone, the soil temperature (along with oxygen level and microbial activity) will often be such that breakdown will be relatively slow.

## Understanding pH

A measure of the acidity of any substance, including where the pesticide may be applied and the pesticide mixture itself, is known as pH, and it affects pesticides in many ways. If a slightly acidic pesticide is applied to a basic (alkaline) surface, the pesticide may break down more rapidly. Similarly, slightly basic pesticides applied to acidic surfaces will break down fairly quickly.

Pesticide reactions in the soil or on the leaf surface are not violent because the acids and bases are so weak, but the principle of breakdown or neutralization is the point. In some cases, buffering chemicals are included in pesticide formulations to help stabilize the pH and, in turn, reduce breakdown of the pesticide.

Soil is a mixture of many organic and inorganic bases and acids, all of which react with each other to form a soil pH. If the pH of the soil is such that the pesticide is neutralized (broken down) relatively rapidly, the pesticide is unavailable for pesticidal activity or adverse environmental effects.

## Summary

Half-life is referred to in terms of how long a pesticide will last. As shown


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## Theoretical v. Actual Decomposition

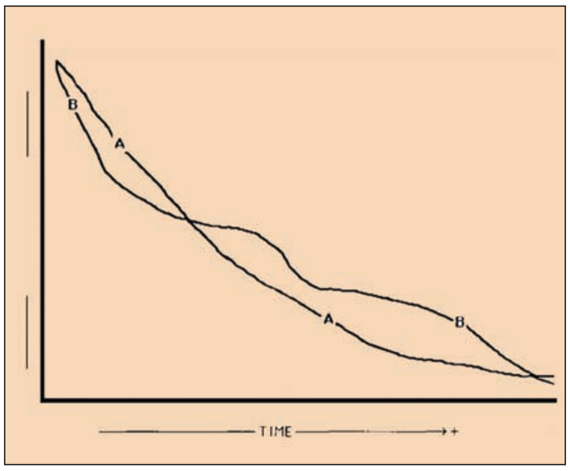


*Figure 4. Line A represents the theoretical decomposition of a pesticide under laboratory conditions. Line B represents the actual decomposition of the same pesticide under actual field conditions. The difference in decomposition is due to the variability of decomposition factors in the field.*

in Figure 4, left, pesticide A is decomposing at the theoretical rate under controlled conditions. The other line indicates that pest-icide B, under field conditions, decomposes rather rapidly then levels out. It then breaks down rapidly again only to slow down and level out again. In fact, these two breakdown curves can indeed be the same chemical but under a different complex of factors.

Temperature, light, moisture, bacteria, pH, etc., all affect pesticides in different ways and cause them to break down at varying rates. The point is, pesticide breakdown, thus half-life, is dependent on many and varying factors when applied under normal use conditions. Some pesticides are more stable than others under the same conditions. For this reason, half-life is not a single number (five days or 20 days, etc.). Half-life should only be used as a guide to pesticide residual time.

The behavior of pesticides is dependent on many factors, all affecting the pesticide at the same time. The net result is that any given pesticide under the various field situations can last for a short, intermediate or even long period of time.

When applying any pesticide, it is important to recognize that all the factors (light, temperature, moisture, pH, bacteria, etc.) will impact the active ingredient. The breakdown rate affects the time the pesticide is available for pest control, off-target movement and environmental contamination. GPN

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