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Understanding Pesticide Toxicity and Human Health Risks

Daniel Frank – Director, VTPP

Pesticides play a crucial role in agriculture and public health by controlling pests that threaten crops, livestock, and human well-being. However, because pesticides are inherently toxic to some forms of life, it is essential to evaluate their potential risks to human health. In the United States, the U.S. Environmental Protection Agency (EPA) is the primary regulatory authority responsible for assessing pesticide toxicity. The EPA's evaluation process relies on a comprehensive review of scientific studies to determine whether a pesticide can be used safely under specific conditions.

How Pesticide Toxicity Is Evaluated in the U.S.

Pesticide toxicity is assessed through a series of standardized studies required during the product registration process. These studies are conducted by manufacturers under strict EPA and international guidelines (such as those from the Organisation for Economic Co-operation and Development [OECD]).

The EPA evaluates both hazard (the inherent toxicity of a substance) and exposure (the likelihood and extent of human contact with the pesticide). This dual approach forms the basis of EPA's risk assessment process, which aims to identify any "unreasonable risk" to human health. Because testing pesticides directly on humans is unethical, risk assessment studies primarily involve rodents and other animals and incorporate conservative

assumptions to protect public health.

Types of Toxicity Evaluated by the EPA

The EPA reviews toxicity data across three main categories, based primarily on length of exposure and potential health outcomes:

1. Acute toxicity – Effects of a single or short-term exposure. Acute toxicity studies are typically quantified according to their LD_{50} (lethal dose for 50% of test animals) and form the basis for toxicity categories used on pesticide labels. Signal words such as DANGER, WARNING, or CAUTION each represent a different toxicity level and are printed on product labels to communicate risk to users.
2. Subchronic toxicity – Repeated exposure over a short-to-intermediate period (usually 30-90 days). Studies on subchronic toxicity help identify which organs might be targeted by a pesticide and if effects build up over time. This information supports setting safe exposure levels and informs decisions about use restrictions.
3. Chronic toxicity – Long-term exposure (repeated exposure lasting for most of the test animal's life span). Chronic toxicity studies assess risks of carcinogenicity, developmental and reproductive toxicity, neurotoxicity, and endocrine disruption. From these studies, the EPA establishes
    - No observed adverse effect levels (NOAELs) – The highest tested dose at which no harmful effects are observed.
    - Reference doses (RfDs) – Daily exposure levels expected to be without significant risk over a lifetime.

These toxicity endpoints are used to establish tolerances (maximum residue limits) for pesticide residues in food, as required by the Federal Food, Drug, and Cosmetic Act (FFDCA).

Estimating Human Health Risk From Pesticides

To extrapolate data from animal studies to humans, the EPA applies uncertainty factors to account for differences between species and variability within the human population. The default is a 100-fold safety margin, broken down as follows:

- 10x uncertainty factor to account for differences between test animals and humans.
- 10x uncertainty factor to account for variability among humans (e.g., sensitivity differences between individuals).

If there are additional concerns, such as limited data on children's sensitivity, the EPA may apply an additional uncertainty factor (up to 10x), thereby increasing the total uncertainty factor to 1,000. For example, if a NOAEL from an animal study is 1 mg/kg/day, the resulting RfD for humans with all three 10x safety factors in place would be 0.001 mg/kg/day (1 ÷ 1,000).

Human health risk assessments also account for real-world exposure scenarios using sophisticated models. These models evaluate

- Applicator exposure – Evaluated using tools like the Pesticide Handlers Exposure Database (PHED), which estimate dermal and inhalation exposure during pesticide mixing, loading, and application.
- Residential and bystander exposure – Based on models that account for contact with treated surfaces such as lawns, garden plants, or carpets.
- Dietary exposure – Calculated using the Dietary Exposure Evaluation Model (DEEM). This model uses national food consumption data to estimate pesticide intake from residues in food.

The EPA compares these estimated exposures to toxicological benchmarks such as RfDs. If estimated exposures are below these benchmarks, the pesticide is deemed to pose no significant health risk for the intended use and is registered.

Conclusion

Pesticide toxicity evaluation in the U.S. is a robust, science-driven process designed to protect human health. Through mandatory testing, conservative safety margins, and sophisticated exposure modeling, the EPA ensures that registered pesticides do not pose unreasonable risks when used according to label directions. While all chemical use carries some level of risk, the U.S. regulatory framework is structured to carefully balance the benefits of pesticide use with the need to safeguard public health.

Introduction to Adjuvants (Part 2 of a 2-part series)

Kathleen Miller and Stephanie Blevins Wycoff – Extension Associates

This article is the second installment of a two-part series on an introduction to adjuvants. For information on the various types of adjuvants, as well

as when to use them, refer to part one of the series in the Spring 2025 edition of this newsletter.

Choosing an Adjuvant

When used correctly, adjuvants can significantly enhance the performance of pesticide applications. Although adjuvants themselves do not have pesticidal activity, they can improve pesticide efficacy by aiding in mixing, application, and performance. Some adjuvants are added during the tank mixing process to enhance product compatibility, reduce foaming, or improve emulsion stability. Others are used to improve spreading, sticking, or wetting, or to reduce drift and/or volatilization.

Before selecting and using an adjuvant, always consult the labels of both the pesticide and the adjuvant. If a pesticide label specifies a particular brand or type of adjuvant, you must follow it to remain in compliance with federal law. Often, adjuvants are already included in the pesticide formulation by the manufacturer. In these cases, adding more could reduce product effectiveness or even cause phytotoxicity. Consult the Virginia Cooperative Extension Pest Management Guides for a list of recommended adjuvant products for specific crops and applications.

Incorporating Adjuvants Into Your Tank Mix

Tank mixing is the practice of combining two or more crop production inputs (e.g., pesticides, fertilizers, adjuvants) in a single spray application. Tank mixing is widely used and cost effective. It reduces application time, labor, fuel use, and equipment wear. Additionally, applying all products in a single spray pass reduces soil compaction and crop damage. Federal law allows tank mixing unless any of the product labels explicitly prohibit it. Always read each label carefully before combining products.

Managing Adjuvant Incompatibility

Even when labels allow tank mixing, not all products are physically or chemically compatible. Incompatible mixtures can reduce the efficacy of a pesticide, damage crops, or harm equipment. Before preparing and applying a full tank mix, ensure product compatibility by

- Following the correct mixing order (such as W.A.L.E.S.).
- Performing a jar test to observe how the products interact.

W.A.L.E.S. mixing order. W.A.L.E.S. is a recommended mixing sequence for tank mixing pesticides. Each

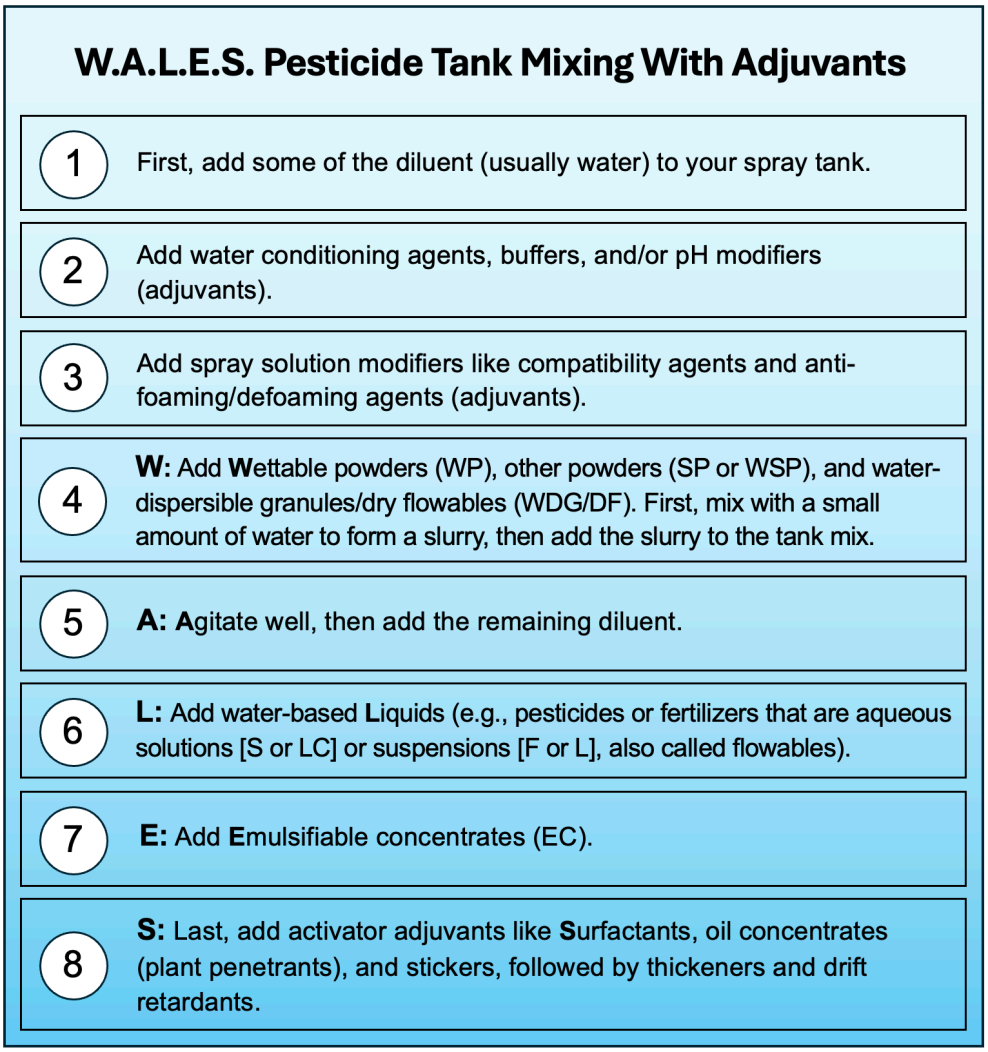

Figure 1. The W.A.L.E.S. pesticide and adjuvant mixing order can be used when jar testing products before tank mixing. It also helps prevent incompatibility during actual tank mixing (Stephanie Blevins-Wycoff, VTPP).

letter corresponds to a specific type of additive and can help you remember when to add each item (fig. 1). Adjuvants are generally added at the beginning and end of the W.A.L.E.S. sequence, grouped by their function into three categories: water conditioning agents, spray solution modifiers, and activator adjuvants. Adjuvants that condition the diluent (typically water) are added immediately after the diluent is introduced into the tank. This group includes water conditioning agents, buffers, and pH modifiers, which help optimize the solution for pesticide stability and performance (step 2 of fig. 1). Once the diluent has been conditioned, add any spray solution modifiers. These adjuvants assist in the mixing process and include compatibility agents and anti-foaming/defoaming agents (step 3 of fig. 1). The last adjuvants added to the tank mix are activator adjuvants, which enhance pesticide performance. These include oil concentrates, surfactants, stickers, thickeners, and drift retardants (step 8 of fig. 1). As always, read pesticide labels carefully prior to any type of handling, including mixing. If the product label recommends a different mixing order than what is outlined here, the label instructions take precedence and must be followed.

Jar testing. To evaluate the compatibility of tank mix components before a full-scale application, it is essential to conduct a pesticide jar test. This process requires a large and clean glass container, water from the same source you will use for your finished spray, and accurate, scaled-down proportions of the products you plan to apply. Agitation is a key component throughout the mixing process. Make sure to agitate the mixture (such as shaking the jar or stirring) for 10 seconds after adding each component.

Once all components have been added in the correct order and mixed thoroughly, let the mixture stand for 15 to 30 minutes. During this resting period, observe the mixture closely for signs of incompatibility. Examples include layering, separation, color change, or production of heat (fig. 2). Other indicators may be formation of a gas, precipitate, surface scum, foam, or gel. If any of these signs appear, add a compatibility agent (step 3 of fig. 1) and repeat the jar test to see if it resolves the issue. If the mixture still shows signs of incompatibility, do not combine the products in a single tank mix. Instead, divide them into separate mixes — testing each with a jar test — or apply the pesticide products separately, using appropriate adjuvants for each application.

If a jar test shows no signs of incompatibility, test the mixture for both efficacy and phytotoxicity on a small portion of the intended crop or treatment area. If no adverse effects are observed, the tank mix can be safely scaled up and applied broadly to the treatment area. Always follow the W.A.L.E.S. mixing order with appropriate agitation to maintain product compatibility throughout the mixing process.

Disposing of an Incompatible Mixture

All incompatible jar test mixtures must be handled and disposed of properly. If the jar test shows signs of incompatibility, contact your local Extension agent for information about hazardous waste disposal in your area.

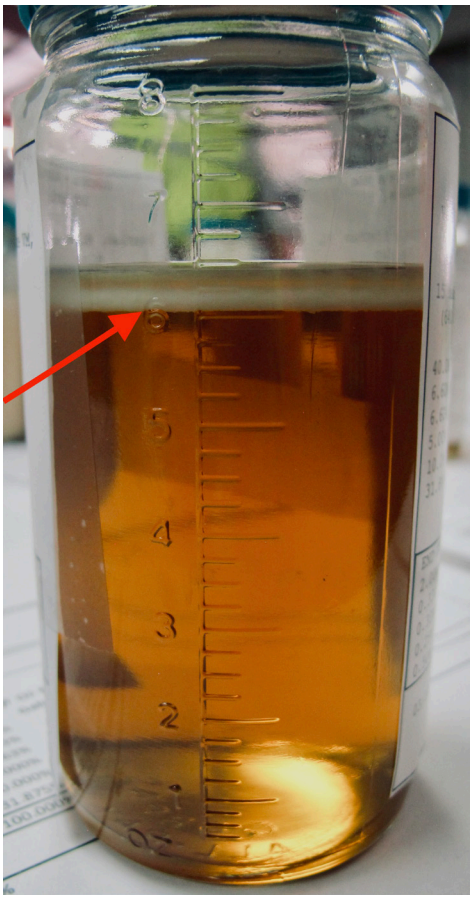

Figure 2. This jar test shows separation of products (denoted by the red arrow), which is a sign of incompatibility (Stephanie Blevins-Wycoff, VTPP).

Blast From the Past

Stephanie Blevins Wycoff – Extension Associate

Willson Dust and Spray Masks

The advertisement below (fig. 3) shows the Willson Dust and Spray Masks, which were marketed to protect pesticide applicators and other trades during the early 1900s. It was recognized very early that protection was needed to shield the respiratory system from particulate exposure. The masks were manufactured by Thomas A. Willson & Co. in Reading, Pennsylvania, which was founded in 1871. In addition to protective masks, the company manufactured a variety of products like goggles, safety glasses, and gloves for many occupations including agricultural and factory workers, coal miners, aviators, and military personnel. T. A. Willson & Co. manufactured personal protective equipment until the late 1980s when the company was sold.

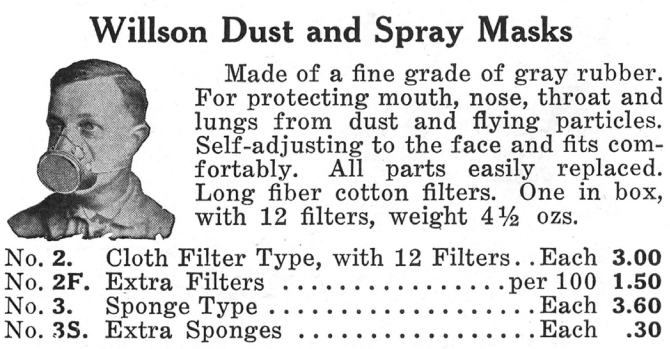

Figure 3. An advertisement for Willson Dust and Spray Masks in the early 1900s.

Program Updates

VTPP Updates

2025 IPM and PSEW Workshops

Registration is now open for the 2025 Integrated Pest Management (IPM) Workshop and the Pesticide Safety Educators Workshop (PSEW). These events are open to all Virginia Cooperative Extension (VCE) Agriculture and Natural Resources (ANR) agents.

The IPM Workshop is designed to help VCE faculty stay current with the latest IPM strategies and techniques, ensuring they can provide accurate, timely, and practical information to their clients. PSEW will feature important updates from Virginia Tech Pesticide Programs (VTPP) and the Virginia Department of Agriculture and Consumer Services (VDACS) that you won't want to miss. PSEW has been approved for private applicator recertification and is currently under review for commercial applicator recertification in Category 10.

Both workshops will be held back-to-back at the Hotel Roanoke & Conference Center from September 3-5. The registration deadline for both events is **August 29**, but please note that the deadline to reserve a hotel room is **August 8**. There will be no virtual attendance option. An email with conference and registration details was emailed on July 2 to all VCE ANR agents, VDACS–Office of Pesticide Services personnel, and other constituents. If you did not receive the email and would like more information, contact Rachel Parson at rparson@vt.edu. To register, please visit

- IPM Workshop registration: pears.io/events/vce/196/
- PSEW registration: pears.io/events/vce/191/
- Hotel registration: book.passkey.com/e/50907848

VDACS Updates

Virginia Plastic Pesticide Container Recycling Program

The VDACS Plastic Pesticide Container Recycling Program offers pesticide dealers and applicators a convenient, cost-effective, and environmentally friendly way to dispose of properly rinsed plastic pesticide containers. This free service is available to all pesticide applicators and dealers in Virginia and supports a nationwide initiative by chemical manufacturers to reduce plastic waste from pesticide packaging. More than 20 cities and counties across Virginia host collection sites for the program. For additional information, or to find a collection site near you, visit: vdacs.virginia.gov/pesticide-container-recycling.shtml.

2025 Pesticide Collection Program

Do you or does someone you know need help disposing of unwanted or outdated pesticides? Location dates and times have been announced for the 2025 Pesticide Collection Program. Information about the program, as well as the 2025 Pesticide Collection Program brochure, can be found at: vdacs.virginia.gov/pesticide-collection.shtml.

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