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College of Agricultural, Consumer and Environmental Sciences

report on
PLANT
DISEASE

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DEPARTMENT OF CROP SCIENCES
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PROBLEMS OF MIXING PESTICIDES

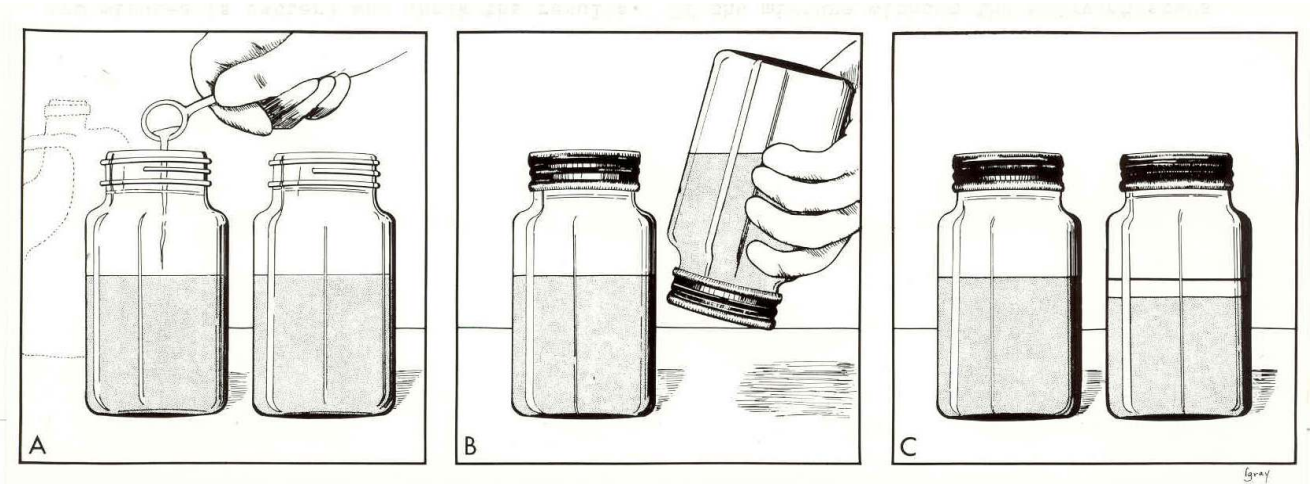

Figure 1. The "jar test" for physical compatibility of pesticides.

A. In one quart jar: Add pesticide or pesticide premix to water or fluid fertilizer. In another quart jar: Add 1/2 teaspoonful of an adjuvant to water or fluid fertilizer then add the pesticide(s). Use 1 pint of water or chosen fluid fertilizer in each jar. Add pesticides in proportion to rates to be used in the field.

B. Close both jars and shake briskly for 30 seconds. Let the jars stand for at least 5 minutes (30 minutes is better) and check the results. If the mixture without the adjuvant stays mixed, use the combination in the spray tank. If the mixture with the adjuvant stays mixed, but the one without the adjuvant does not, be sure to add the adjuvant to the spray tank.

C. Should either mixture separate after 5 minutes, but mixes readily after shaking, the mixture can be used in the spray tank if good agitation is maintained. If a separate oily layer, large oil globules, clumps of solids or sludge forms in the bottom of the jar containing adjuvant, the mixture should not be used.

Combining chemicals to do several jobs with a single spray saves time and labor. In light of the many thousands of pesticides, soluble fertilizers, growth regulators, sticking-wetting agents (surfactants), and other chemicals that can be sprayed on plants, it is surprising that plant injury (or phytotoxicity) does not occur more often. Sometimes sludges will form in the tank, spray nozzles will plug up, and plants will be damaged as a result of the indiscriminate mixing of two or more of these pesticides. An understanding of pesticide compatibilities is essential to avoid these problems.

For further information contact an Extension Specialist in the Department of Crop Sciences, University of Illinois at Urbana-Champaign, or your nearest Extension office.

Compatibility

When pesticides are used in combination or as components in a mixture, they may be either compatible or incompatible. **Incompatible** refers to the reaction of pesticides that cannot be mixed safely without impairing the effectiveness of one or more of the chemicals, developing undesirable physical or chemical properties, or causing plant injury; **compatible** means the chemicals can be mixed together without problems.

There are two basic types of incompatibility: chemical and physical. It is possible to get one or both from the same mix.

Chemical incompatibility involves the breakdown and loss of effectiveness of one or more products in the spray tank and possible formation of one or more new chemicals that are insoluble or phytotoxic.

Physical incompatibility involves an unstable mixture that settles out, flocculates, foams excessively, or disperses poorly and reduces efficiency and causes the clogging of sprayer nozzles and screens. This type of incompatibility may result from the use of hard, soft, or cold water or fertilizer solutions for mixing.

General Rules and Principles

1. Follow label instructions and precautions regarding dosage, method of application (gallons of water to apply to 1,000 square feet or per acre), and all incompatibilities. Practically all pesticide companies and experienced specialists recommend that chemicals be applied **separately** if there is any doubt.

2. If chemicals can be mixed, pour each separately into the spray tank with agitation (shaking). This frequently prevents settling out and nozzle plugging. A common practice is to make up a thin, uniform "batter" or slurry of the spray powder, diluting it with water. Some specialists suggest straining the spray mixture through fine cheesecloth while it is being added to the tank.

3. Never tank-mix emulsifiable insecticide concentrates.

4. Mix only one soluble chemical (such as a soluble or soluble powder formulation) with any number of insolubles (such as wettable powders and flowable formulations).

5. Soluble fertilizers and trace elements can usually be added individually or mixed provided that the amount will not exceed one ounce of solid material per gallon of tank spray mix.

6. Apply spray solutions as soon after mixing as possible. The longer a spray combination remains in the tank, the greater the number of problems that can arise. Some labels specifically warn against premixing a certain number of hours or more before use due to possible breakdown.

7. You can determine the physical compatibility of a tank mix ("check compatibility before getting tanked up"). Two steps are important: (1) Place a mixture of the precise dosage of pesticides plus the proper volume of carrier (water or fertilizer solution) in a quart glass jar, shake it briskly for 30 seconds, and then let it stand for 30 minutes. If the chemical mixture separates or settles out, it is unwise to use the mixture (Figure 1). Regardless of the results in step 1, step 2 should be carried out if the material is at all sprayable.

In step 2 the mixture is applied to a few test plants or an area, preferably during adverse conditions such as heat (above 85° to 90°F or 19° to 32°C) and moisture stress to determine phytotoxicity. A minimum of 48 hours should elapse before you can properly evaluate whether or not injury has occurred.

8. If you are determined to apply a mixture of different pesticides, we suggest this order of adding them to the spray tank: Products which form a suspension (such as wettable powders, dry flowables or liquid flowables [or suspension concentrates]) should be added first and thoroughly dispersed in the spray tank before adding another product. Soluble products, such as solution concentrates or soluble powders should be added second. Surfactants, if used, should be added next, while emulsifiable concentrates should be added last. If emulsifiable concentrates are being added to liquid fertilizer solutions, they should first be mixed with equal parts of water to create an emulsion before being added to the final mix. Always remember that pesticides should be placed in a clean spray tank that has been filled with clean water or fertilizer solution and with the agitator running.

9. Use caution when mixing wettable powders with emulsifiable formulations or a soluble fertilizer. Wettable powders and emulsions both suspend in water. Depending on the concentration and water used, such mixtures may cause a breakdown of the emulsion, the formation of sludges, flocculation, and reduced efficiency. In most cases the active ingredients are not at fault; the emulsifiers, solvents, fillers, and surfactants are responsible. Sometimes, the products of a single company will be compatible but the same active ingredients from two different companies will not be. Yet many (or most) such formations are compatible.

   Plant damage is most common and severe at high temperatures or under low-drying conditions. Soluble fertilizers or nutrient mixes, such as zinc or iron sulfate and chelated compounds, added to a pesticide mix can destroy the emulsification or suspension of other chemicals. However, urea is compatible with most pesticides.

10. Do not mix strongly alkaline and acid materials together. Strongly acid or alkaline materials (sulfur, lime, lime-sulfur, zinc sulfate and lime, ferrous sulfate, and ammonium sulfate) commonly cause acute compatibility problems. The container label should state if the products can be mixed with strongly acid or alkaline materials.

11. The pH and chemical composition of the water can greatly influence how pesticides and other products perform in the spray tank. City water that has been softened may be strongly alkaline (pH 8 to 9+). Hard water from deep wells may cause pesticides to precipitate. Water pumped from a stream or pond may contain organic chemical wastes. These factors can have a great influence on how pesticides perform individually and in mixes.

    Most waters are slightly basic because of the presence of dissolved carbonate and bicarbonate salts. A departure from the norm is caused when acidic or basic industrial, municipal or natural waste discharges enter the water supply.

    Physical or chemical incompatibility can arise from the salts and other inorganic or organic compounds dissolved in the water, the chemicals discharged from an industrial or municipal plant, or from products applied to plants. When the pH of the water and/or the spray mix is strongly acidic or basic, you can expect problems. For example, the organophosphate insecticides, which include such products as Diazinon, chlorpyrifos (Dursban), and trichlorfon (Dylox or Proxol) do not persist in the environment. These products gradually or rapidly break down into two or more

smaller, inactive chemicals when mixed with water that is alkaline. The higher the water's alkalinity (or pH), the more rapidly these insecticides lose their effectiveness. In one study the half-life of Proxol in water with a pH of 8.0 was 63 minutes, at 7.0- it was 6.4 hours, while at a pH of 6.0 it was 3.7 days. In the same study Dursban had a half-life of 1.5 days at a pH of 8.0 and 35 days at a pH of 7.0 (when a phosphate buffer was added). Diazinon was much more stable, having a half-life of 36 days at a pH of 9.0 and 185 days at a pH of 7.4.

Carbamate insecticides, which include the widely used carbaryl (Sevin), are also affected by the pH of the water. The half-life of Sevin was 24 hours at a pH of 9.0, 2 to 3 days at pH 8.0, 24 to 30 days at 7.0, and at a pH of 6.0 its effective half-life was 100 to 150 days.

If the pH is high (alkaline), there are commercial buffering agents available (such as Buffer-X, Multiplex, Sorba Spray, and Zip) to adjust the pH of water solutions. Another possibility is adding vinegar to lower the pH to slightly acidic (pH 6.0 to 6.5). Most pesticides that are sensitive to pH will state this on the label.

12. Do not experiment with new combinations. If you must try out a new mix, apply it on a small area or to a few test plants first. Whenever possible, spray in an out-of-the-way area with each product alone alongside an area sprayed with the test mixture. Apply these sprays several times at various strengths and different air temperatures. Check to see if the mix performs as well as when the materials are applied separately. Write your findings in a record book–do not trust your memory. Remember, no chemical company can possibly test all its products and those of its competitors in all possible combinations. The product bought today may have different "fillers", emulsifiers, solvents, or surfactants than the same product bought a year or two ago.

13. As a general rule, insoluble and wettable powder fungicides do not produce chemical injury when used as recommended. Many soluble fungicides can be phytotoxic, should be applied within their safety ranges, and should not be combined with other chemicals unless the package label states otherwise.

14. Plants in a low state of vigor are more easily injured than vigorously growing ones by chemicals and mixes. Plants may be predisposed to damage by winter or herbicide injury, drought, waterlogging of the soil, poor soil, disease or insect damage, or an imbalance of nitrogen, potassium, phosphorus, or other elements.

15. Do not mix a foliar fungicide, herbicide, or insecticide with fertilizers or other chemicals that require watering in. Incorrect placement of pesticides sometimes explains poor pest control. For example a combination of a "Helminthosporium" leaf spot fungicide and an insecticide drench to control grubs applied at the same time to turf.

16. Use caution when mixing chemicals that may be toxic by themselves with other materials. Such combinations commonly injure sensitive plants at considerably lower concentrations than individual products in the mix.

17. Plant injury can sometimes be avoided by spraying when temperatures are between 40°F (4°C) and 85° to 90°F (29° to 32°C). Emulsifiable materials are more likely to cause injury than wettable powders.

18. Buy pesticides only in amounts you expect to consume in the current year. Different products, especially in combination, vary greatly in their shelf life, particularly once the container has been opened. The same basic chemical, manufactured by different companies, may vary in stability because of differences in formulation. Storage temperature and humidity can also have important effects. Many pesticides last indefinitely if kept dry with the container sealed.

19. Store chemicals only in their original, tightly closed containers so that contamination cannot occur. Clean up sprayers, hose lines, nozzles, and mixing containers thoroughly after each use. Numerous cases of plant injury can be traced back to the contamination of equipment with potent weedkillers or to carelessness.

20. Be sure of the identity of the material. It may seem incredible, but whole towns have actually been "fogged" with 2,4-D (instead of with an insecticide) for mosquito control. Liability damages amounting to hundreds of thousands of dollars could have been avoided by simply reading the label–if the old container still had one.

Commercial products that contain a mixture of ingredients are the result of many years of testing under a wide variety of environmental conditions. Many such mixes (tested by company representative, the USDA, state experiment stations, consultants, and Extension service specialists) are never sold, because of reduced efficiency, short shelf life, or other problems. Yet many "practical" people, with limited time and facilities, think they can come up with an even better mix. The odds are not good.