Combining herbicides in the spray tank is a common practice and has many advantages. The number of herbicides available for weed control is continually increasing, but most herbicides have limitations in the spectrum of weeds they will control. Some of these limitations might be alleviated by combining herbicides.

Often, when two or more herbicides are mixed, less of each product is required. The possibility of potential herbicide carryover to subsequent crops and the potential risk of crop injury is thereby reduced. When two or more herbicides are applied together, one or more spraying operations are eliminated and field compaction, application time, and expense are reduced.

Many combinations of herbicides or herbicides with fertilizer or insecticides can be used safely and effectively. However, ingredients may be incompatible in the spray tank. Incompatibility often goes unnoticed, and only after poor results are observed are questions asked.

Tank-mix incompatibilities can be placed into two broad categories—chemical and physical. Products are chemically incompatible when they react so the chemistry of one or more of the herbicides is altered. This type of incompatibility is difficult to identify and may not be obvious at the time of application. One or more of the products may be deactivated in the mixture, rendering it less effective; or one or more of the products may become highly phytotoxic. The problem may not be detected until the effects are seen as poor weed control, crop injury, or both.

Physical incompatibility is more common. It is obvious when the products form crystalline solids, a gelatinous mass, or separate components which form layers in the tank. Physical compatibility should be determined before tank-mixes are prepared. Methods to determine physical compatibility will be discussed later in this bulletin.

The purpose of this publication is to alert herbicide users to some of the causes of incompatibility so that the frequency of this problem can be reduced. Preventive measures are outlined to assist in overcoming herbicide mixing problems.

Legal Aspects of Herbicide Mixtures

Herbicide combinations are registered in two ways: tank-mixes where two or more herbicides are labeled to be combined by the user at the time of application, and package mixes where two or more herbicides are combined by the manufacturer into one container and sold under a single trade name. These mixtures have been tested thoroughly before registration, so the user should have few problems with compatibility.

Tank-mixes approved by the Environmental Protection Agency (EPA) or state regulatory agencies are listed on the herbicide label. Tank-mixes prepared by the user that are not specifically labeled for such use will not be deemed inconsistent with the label by the EPA if (1) all products in the mix are registered for use on the crop; (2) all products are applied at a dosage rate not to exceed the label instructions of each product in the mix; and (3) the label of one or more of the products does not explicitly prohibit such mixture. However, the user of the unlabeled herbicide combination assumes the risks and responsibilities of possible adverse effects when using such unlabeled tank-mixes. Always consult the label on the pesticide containers before proceeding with tank-mixes.

Causes of Incompatibility

Incompatibility may result from the sequence in which the products are added to the spray tank. Absorption of one product by another, physical reactions, the use of improper adjuvants for the pesticides being used, or problems with the carrier solution.

Order of Mixing. When one of the formulations in a mixture is a wettable powder, incompatibilities may be avoided by adding the wettable powder to the water in the spray tank first. After thoroughly dispersing the powder, add the emulsifiable concentrate or liquid formulation. If an emulsifiable concentrate is added first, a wettable powder may not mix well because oil in the emulsifiable concentrate binds with the dry wettable powder. Emulsifiable concentrates include an active ingredient, oils or solvents, as a carrier, and an emulsifier. The oil may coat the wettable powder particles and can interfere with their dispersion in water and cause them to stick to the sides and bottom of the sprayer. Adding the wettable powder first will help prevent mixing problems.

Incompatible Mixtures. Two commercial formulations will occasionally be physically incompatible regardless of the order of
addition. In some cases, adding a compatibility agent or more emulsifier may help, if the additives are put into the tank before adding wettable powders, suspensions, or emulsifiable concentrates. Adding additives after “gunk” has started to form may increase the problem. However, compatibility agents do not work in all cases. Some herbicides simply cannot be tank-mixed because two emulsions separate, wettable powders flocculate, or an otherwise good emulsion breaks down.

Absorption of the Active Ingredient. Another type of incompatibility occurs when the active ingredient in a formulation is absorbed (chemical or physical attraction to a surface) onto the inert diluent of another formulation. This happens when a very readily absorbed herbicide such as paraquat or glyphosate is mixed with a wettable powder in the spray tank. Deactivation is never complete, but activity at low rates may be noticeably reduced. The product label is usually the best source of information when mixtures of this type are planned.

Incompatibility due to Adjuvants. An increasing amount of research is being done with adjuvants to alter the biological performance of active ingredients. Some of the adjuvants are mixed with the formulated product and others are added to the spray tank before spraying. The matching of adjuvants, active ingredients, and water is a complicated process even when only one herbicide is involved. For example, physical incompatibility can result between a herbicide emulsion and a wetting agent added to the spray tank to improve herbicide activity. The wetting agent may upset the balance between the emulsifying agent and the active ingredient, resulting in separation of active ingredients in the spray tank.

Chemical reactions may occur between an adjuvant and an active ingredient in the spray tank. A common example is the herbicide paraquat, which has a strong cationic or positive charge. Because anionic wetting agents may precipitate the active ingredient, only non-ionic wetting agents are recommended for paraquat.

Soaps and household detergents are sometimes used as surfactants, but this is generally not a good practice. Soaps and detergents can combine with hard water to form precipitates or scums that can interfere with the performance of spray equipment. Good agricultural surfactants do not form precipitates and can be used equally well in hard and soft water. Also detergents and soaps may foam too much for use in a spray tank. Most liquid detergents have a fairly low concentration of surfactant (10 to 20%) compared to 50 to 90% for agricultural surfactants.

Mixtures of Herbicides and Liquid Fertilizers. Herbicides and liquid fertilizers are often applied simultaneously. Several herbicides are registered for use with liquid fertilizer as the carrier, but physical incompatibility is a common problem. Many herbicides that form good mixtures in water do not mix well with liquid fertilizer. Always mix a new combination on a small trial basis (as explained under Conduct a Small-Scale Test) before mixing in the spray tank. Good agitation and the addition of compatibility agents will often allow successful use of marginal mixtures.

How to Avoid Compatibility Problems in the Spray Tank
Tank-mix incompatibility often is not noticed until it is too late. It is, therefore, important that the operator take the necessary precautions to prevent incompatibility.

Read the Product Label.
Whenever mixtures of herbicides—or a single herbicide mixed with other ingredients—are planned, consult the instructions on the label. Considerable effort goes into preparation of a product label, and a few minutes given to reading it is time well spent. It is not possible to cover all conditions on the label and special caution is advisable in these situations.

Conduct a Small-Scale Test.
When in doubt about a planned mixture, conduct a simple small-scale test. Mixing small quantities of the materials in small containers using appropriate proportions and observing the results can often help avoid problems. This can be done using two clear 1-quart containers. First place 1 pint of the carrier—water, oil, or liquid fertilizer—in each container. In one container add one-half teaspoon of a compatibility agent to the carrier. Then add the herbicides one at a time in the appropriate amounts to each container.

When more than one herbicide is used, unless label directions specify otherwise, add the wettable powder first, followed by flowable formulations, water-soluble concentrates, and emulsifiable concentrates. Thoroughly mix ingredients after each addition. Watch for any interaction that forms precipitates.
or a thickening of the mixture. Let the container stand and watch for separation of ingredients. The tolerable separation will depend on the intensity of agitation in the sprayer. Should the mixture separate after 30 minutes, but remix readily with container inversions, the mixture can be used if good agitation is maintained in the tank and mixtures are not prohibited on any of the labels. A mixture should not be used if non-dispersible oil, sludge, or clumps of solids form. If a mixture with an adjuvant stays mixed or readily remixes but one without an adjuvant does not, be sure to use the adjuvant in the spray tank.

Proper Mixing in the Sprayer. Using the small-scale test as a guide, fill the spray tank about half full with clean water. First add the compatibility agent, if required; then add the wettable powder while agitating to ensure adequate wetting of the powder. Better yet, take time to make a slurry of wettable powder and water in a bucket to pour into the tank. "Flowable" products often act the same as wettable powders and should also be mixed well before adding the emulsifiable concentrate. Then fill the tank about three-fourths or more before adding the other products in the order described in the small-scale test above.

It may sometimes help to pre-emulsify an emulsifiable concentrate by mixing one part of the chemical with two or three parts of water, then add this to the spray tank. Follow the same mixing procedures when liquid fertilizers are used as the carrier.

Thoroughly mix all herbicides in the tank before spraying. Otherwise, excessive concentrations sprayed from part of the tank may injure the crop, and diluted spray from the other part of the tank may not control weeds. Maintain good agitation at all times until spraying is completed.

In the spray tank, excessive agitation may sometimes cause an invert emulsion. (An example is mayonnaise in which water particles are surrounded by oil.) Don’t use excessive agitation. Check to be sure the bypass line is at the bottom of the tank and that hoses are secure. Do not pull air into the system.

Try to finish with an empty spray tank before refilling and this is especially important at the end of the day. If a wettable powder and an emulsifiable concentrate mixture is left to stand in the tank, the powder may settle to the bottom while the oil floats to the top. If more wettable powder is added on top of the oil, a serious problem may develop. Be sure to mix the material left in the tank well before adding more herbicides. Occasionally, products will not mix again once they separate in the tank and must be discarded. Some products such as Glean must be used within 24 hours after being mixed or product degradation may occur.

Examples of Incompatible Mixtures

Some tank-mixes in which the effectiveness of at least one product is reduced because of chemical incompatibility are listed below:

| Hoelon+2,4-D | Poast+Basagran |
| Hoelon+MCPA | Poast+MCPA |
| Hoelon+2,4-DB | Poast+Betanex |
| Hoelon+ | Fusilade+ |
| Basagran | 2,4-DB |

1Assuming volume to be sprayed is 25 gallons per acre:

a. Add 1 1/2 teaspoons of wettable powder or flowable to the pint of carrier for each 1 lb. of the product that is required per acre.

b. Add 1 teaspoon of emulsifiable concentrate or water-soluble concentrate to the pint of carrier for each 1 quart of the product that is required per acre.

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