

INCOMPATIBILITY OF PESTICIDES MIXTURES AND TANK MIXING

James H. Hunter
Agriculture Canada Research Station
Regina, Saskatchewan

There are many factors that can contribute to poor performance of a pesticide in the field. Some of the factors are incorrect selection of chemicals, failure to follow label instructions, incorrect application techniques, poor planting practices, poor weather, and pesticide incompatibility.

Problems with compatibility are difficult to see in an opaque spray tank and may be recognized only as poor performance in the field. Incompatibility of pesticides can be very costly to the farming industry and with the present trend in agriculture toward chemical cocktails tailored for specific problems, the possibilities for incompatibility are bound to increase.

Compatibility problems can occur in the chemical containers, the spray tank or in the plant (the crop or the weed).

FORMULATION ABUSE

A well designed formulation can be abused so that it no longer provides the good services for which it was intended.

TEMPERATURE EXTREMES

Freezing

Storage at low temperatures can cause crystallization, particularly of the active ingredient. The crystals will not be visible in a metal container. Many products when warmed to room temperature (70°F) will go back into solution and are unaltered. In some products, however, the active ingredient may remain crystallized and if such a product were used, the active products would not be applied uniformly. When a pesticide is suspected of having been subjected to cold storage, it should be warmed to room temperature and agitated vigorously before using.

High Temperatures

For the most part, solutions and emulsifiers are stable, however, in some pesticides, especially the chlorinated products, the active ingredient may be chemically degraded at high temperatures. Degradation is usually evidenced by a poor emulsion with water. The temperature on

the inside of a container left sitting in the sun can be considerably greater than the air temperature.

CONTAMINATION

Water

Contamination of an emulsifiable concentrate with as little as 1% water can cause precipitation of the emulsifier. Water contamination in some products results in precipitation of more than just the emulsifier. The water contaminated emulsifiable concentrate will not form a uniform milky white emulsion when added to water.

Water contamination can occur via open vent holes when pesticide cans are left exposed to rain. The result of the contamination is not readily evident until the precipitate at the bottom of the container is noticed.

Rust

Iron or rust contamination can destroy the emulsion characteristics. Iron contamination may occur when the inner lining of the container is ruptured permitting rusting to occur. Physically damaged or dented containers should be carefully examined before being used. A darkening of the concentrate may indicate the presence of rust. When added to water, the herbicide fails to mix properly and a precipitate soon forms. This is one of the reasons why a pesticide should never be transferred from its original container to another container.

Invert Emulsion

Good agitation is necessary to maintain a uniform spray mixture. However, excessive agitation that introduces air into the mixture causes foaming which may reduce the uniformity of the solution. To avoid foaming, fill the spray tank 3/4 full of water before adding the pesticide, then carefully top off the tank.

Excessive agitation also occurs at the air-liquid interface when the sprayer by-pass line returns the fluid to the tank above the surface of the spray mixture. This can lead to an invert emulsion i.e. water in oil instead of oil in water. This produces a layer that has the consistency of cottage cheese and is very difficult to clean-up. By-pass lines should empty at the bottom of the spray tank.

SPRAY TANK ADDITIVES

Adjuvants

"General purpose" spray adjuvants or wetters added with the intention of improving the pesticide activity may be incompatible.

Adjuvants or surfactants are very carefully selected for use in manufacturing emulsifiable concentrates. Indiscriminate addition of surfactant can interfere with the stability of the emulsion.

A chemical reaction can also occur between a pesticide and the adjuvant.

Paraquat is a cationic herbicide, therefore, adjuvants should not be anionic. Paraquat tank mixed with an anionic adjuvant will immediately form a cloudy opaque solution and after only 10 minutes, a precipitate will have formed.

Many farmers are indiscriminately adding a variety of products to formulated pesticides. The previous examples showed how the wrong wetter added to a herbicide may result in a compatibility problem. Random selection of additives should be avoided. They may also result in crop injury.

Liquid Fertilizer

Commercial applicators have considerable interest in the weed and feed idea - applying herbicides and liquid fertilizers together. However, many herbicide formulations that form stable mixtures in water are unstable in liquid fertilizer. Some herbicides may form sufficiently uniform tank mixtures with some of the liquid fertilizers if there is sufficient agitation.

IMPROPER PREPARATION OF SPRAY MIXTURES

Delayed Agitation

The next problem involves the failure to agitate tank mixtures immediately after addition of the pesticide. This situation arises in the field when a farmer dumps pesticide into the water in the spray tank but does not start circulation of the mix until he is ready to start spraying some time later. It also arises when a researcher makes up a series of test treatments but does not agitate them until he is ready to apply them.

Most pesticide formulations are insensitive to the time delay between addition to water and agitation. However, some are sensitive and can cause problems. It is the kind of problem that is easy to avoid.

Incorrect Dilution Rate

Pesticides are formulated to work within a definite range of conditions such as the water hardness and temperature. Similarly they must also be formulated to perform at a specific range of concentrations. Problems may be experienced when the water volume is drastically reduced. The incompatibility is readily discovered by testing in a jar prior to application.

Soluble Powders vs Wettable Powders

Pesticides formulated as powders may be of two types, soluble powders which go into solution much like sugar in tea or wettable powders which form a dispersion in water much like chocolate added to milk.

TCA and dalapon are soluble powders and, therefore, form true solutions. Linuron and atrazine are wettable powders and they will settle to the bottom in the absence of constant agitation.

Soluble powders do not require the same vigorous agitation that is necessary for uniform application of the wettable powders.

Wettable Powder Caking

With good agitation, most wettable powder dispersions will remain uniformly dispersed for extended periods. However, with poor agitation or if agitation is stopped, the wettable powder will settle out. If circulation is started again, a uniform dispersion of the wettable powder may appear to be formed. However, after settling wettable powders will "cake" on the bottom of the tank and are very difficult to redisperse. Even when the return flow rate was increased from 3.5% of the liquid volume per minute (typical of most field sprayers) to 15 to 20% the caked material was not completely redispersed. If this mixture was applied in a field test, the first part of the field would receive an overdose of the herbicide.

The caked powder should be stirred up with a paddle and agitated with circulation at the bottom of the tank. The wettable powder will then be completely redispersed and remain dispersed as long as the agitation continues.

Order of Addition

The compatibility of some pesticide formulations is also dependent on the order in which they are added to the tank. As a general rule, when a liquid or water soluble herbicide is added first and the wettable powder second, a precipitate forms. When a wettable powder is added first, well agitated, then the liquid herbicide added and agitated, they do not separate.

When a wettable powder is added to water the particles are "wetted" by the water and become uniformly dispersed. If the wettable powder is added after an emulsifiable concentrate, the hydrophobic particles of powder become coated with the oily emulsion before they have a chance to be completely wetted. Therefore, the wettable powder fails to disperse and the particles fall to the bottom. The emulsifiable concentrate will affect the soluble powders in a similar manner.

A true solution is formed when TCA, a soluble powder, and an amine or Na salt of MCPA are mixed. However, when MCPA ester, an emulsifiable concentrate, is added to a solution of TCA a precipitate will form. Changing the order of addition does not change the result.

As a general rule when preparing mixtures, soluble powders should be added first, then the wettable powders (preferably as a pre-formed slurry) then the solutions (amines and salts), any additives and lastly the emulsifiable concentrates (esters). Remember to agitate after adding each product.

As with most rules, there are exceptions. For example, when the water soluble herbicide difenzoquat (Avenge) is added first, agitated and then the emulsifiable concentrate, barban (Carbyne), is added, they fail to mix although the order is considered to be correct by the above rule. When the order is reversed, the emulsifiable herbicide first followed by the soluble herbicide, they are compatible.

Salting Out

This phenomenon occurs with some mixtures of water soluble and emulsifiable concentrates.

When the water soluble 2,4-D amine was added to a solution of the water soluble dicamba, they formed a true solution. When the emulsifiable 2,4-D ester was added to the dicamba solution, a milky white emulsion was formed but after 30 minutes, the emulsion breaks down and particles were suspended in the mixture. After two hours, the particles, which resemble rust, had grown in size and begun to settle out. After 24 hours, there was considerable precipitation, and reconstitution by agitation was impossible. The explanation for the incompatibility lies in the ionic nature of the water soluble material.

Chemical Incompatibility

Initially the water soluble cationic herbicide paraquat (Gramoxone) and the water soluble anionic 2,4-D amine will form a clear solution. However, after only 15 minutes the solution became cloudy and dark. After 2 hours particles appear throughout the solution and they begin to settle out.

With sufficient agitation, many of the incompatibility problems can be reduced. The incompatible mixtures of dicamba plus 2,4-D ester and paraquat plus 2,4-D amine could be successfully sprayed if they were well agitated and sprayed immediately after mixing.

BIOLOGICAL INCOMPATIBILITY

So far, only interactions that occur in the chemical containers or in the sprayer have been discussed. Interactions may also occur in the crop or weed plants and are, therefore, called biological interactions.

This may be an increase or a decrease in the uptake of a herbicide by the plant and/or its translocation out of the treated area, a change in the mode of action of the herbicide or its selectivity. The tolerance of the crop may be decreased or the efficacy may be reduced or nullified entirely on one or more of the weed species.

A biological incompatibility may occur even when the two herbicides are applied several days apart. Normally the level of incompatibility decreases as the interval between application of the two products is increased.

When 2,4-D amine and barban (Carbyne) are tank mixed, they appear physically and chemically compatible in the jar test, however, the effectiveness of the barban has been nullified and the control of the wild oats will be drastically reduced. The control of broad-leaved weeds with 2,4-D remains unaffected. If the two products are applied separately rather than in a tank mix, there is no time interval required between the application of each product.

Similarly, benzoylprop ethyl (Endaven) and 2,4-D amine also appear compatible in the jar test but when applied on the weed, the tank

mixture fails to control the wild oats. When the two products are applied one right after the other as two separate applications, the results are similar to the tank mixture. The chemicals are biologically incompatible in the plant. The incompatibility decreases as the interval between application of the individual products increases. When the applications of benzoylprop ethyl and 2,4-D are separated by a seven day interval, there is no biological incompatibility and the control of wild oats is unaffected.

RECOMMENDATIONS

Jar Test

The physical and chemical compatibility of two pesticides can be determined by performing the "jar test".

- 1) Calculate the amount of each chemical to add.
 $T = R/A \times 25$
T is teaspoons of chemical added to a quart jar
R is desired rate in ounces of active material per acre
A is activity in ounces of active material per imperial gallon
- 2) Fill 4 quart jars to the neck with water.
- 3) To jar 1 add chemical A, to jar 2 add chemical B and agitate both jars.
- 4) To jar 3 add chemical A, agitate, add chemical B and agitate.
- 5) To jar 4 add chemical B, agitate, add chemical A and agitate.
- 6) After 30 minutes if no separation has occurred in one of the mixtures, jar 3 or 4, it should be possible to mix the two herbicides in the same order and obtain a uniform application in the field.

The jar test does not determine the biological compatibility and although the mixture may be compatible in the sprayer tank, the two pesticides may be incompatible on or in the plant resulting in a loss of activity of one or both of the chemicals.

Recommendations for Reducing Compatibility Problems

1. Use only mixtures recommended on the labels.
2. Follow label instructions on preparation.
3. Provide good spray tank agitation.
4. Do not delay agitation after pesticide addition.
5. Add chemicals in the proper order: soluble powders, wettable powders, suspensions or flowables, solutions, spray additives, emulsifiable concentrates.

6. Agitate often adding each chemical.
7. Avoid water contamination, contact with iron or temperature extremes.
8. Use only recommended mixtures or evaluate on a small scale before using in the field.

Conclusion

The safest way to avoid compatibility problems is to use only registered mixtures and prepare them as recommended in the current provincial weed control bulletin.