PROFESSIONAL APPLICATOR MUST KNOW MIXING BASICS

by Paul A. Sartoretto, Ph.D.

Can a pesticide applicator get by without a knowledge of chemistry and still determine what pesticides are compatible in the spray tank? A knowledge of chemistry is helpful, but not essential if one masters a few basic rules.

A professional must know that the pesticides he mixes in water will retain their own identity and not react with each other. The following four rules and exceptions are helpful in determining tank mixes. However, if there is any doubt, simple tests using a glass jar can be used to check compatibility.

Green Industry applicators are concerned primarily with water mixes. Therefore, the need is to determine how each chemical reacts with water and how each chemical reacts with other chemicals in a water system.

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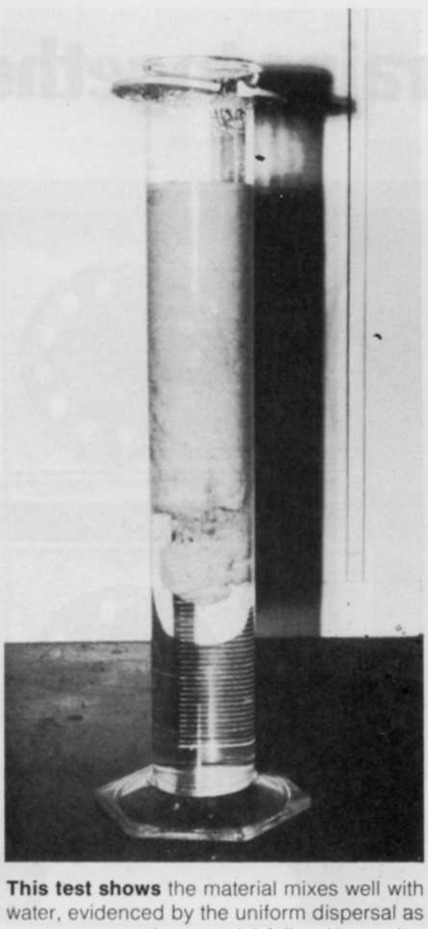

This test shows the material mixes well with water, evidenced by the uniform dispersal as the material falls with gravity.

All chemicals can be classed into three groups; cationic (positively charged), anionic (negatively charged), and nonionic (no charge). Positively charged chemicals (cations) attract negatively charged chemicals (anions). Nonions have no attraction to other chemicals, but their ability to mingle (solubility) with other nonions of similar structure must be recognized. In a water system, nonions that are soluble are termed hydrophyllic, and nonions that are insoluble are termed hydrophobic.

When cations and anions are mixed together they form salts. When large heavy cations and heavy anions come in contact, they form heavy salts which are insoluble and precipitate out of the mix. (Precipitate means to separate out of the solution or suspension, usually a visible solid dropping to the bottom of the container). Smaller cations and anions form smaller salts which can co-exist in solution without precipitating. The specific cations and anions that might cause problems are listed in the "Exception to the Rules" section of this article.

The basic principle of chemical compatibility is the classification of all chemicals, whether they be herbicides, fungicides, insecticides or fertilizers, into two groups: **solubles** and **insolubles,** because it's the physical properties not the chemical properties that determine compatibility 99% of the time.

Having then classified all chemicals into solubles and insolubles, I have devised a set of rules which when followed carefully permits the applicator to tank mix at will without incurring phytotoxicity. E.P.A. has devised key signal letters which alert applicators and inform them whether or not the product they are using is soluble or insoluble. These signal letters are as follows:

S	indicates	solution
SP	"	soluble powder
EC	"	emulsifiable concentrate
WP	"	wettable powder
F	"	flowable

The S, SP, and EC are classified as solubles; whereas, the WP and F are insolubles.

The amount of water sprayed per 1000 sq. ft. is another variable that requires some explanation that will affect the pesticides that should or should not be mixed in the spray tank. For example, an applicator will use 3 to 5 gallons per 1000 sq. ft. on greens and tees, and only ½ to 1 gallon per 1000 sq. ft. on fairways, depending upon whether he is using a mist blower or a spray boom.

By far, the largest group of chemicals are the insolubles. Most technical chemicals are, for all practical purposes, insoluble in water. The

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manufacturer has three options in preparing the pesticide in a sprayable form. (1) He can mix it with a wetting agent and other inerts such as free-flowing and non-dusting agents, and then he will air-mill the mixture to obtain sub-micron size particles so that it will not clog the spray nozzles. He will then call this mixture a wettable powder. (2) He can dissolve the pesticide in an organic solvent (usually aromatic spirits such as xylene or aromatic kerosene), add an emulsifier to it so that it will emulsify in water to give a permanent milky dispersion in water, and will call this solution an emulsifiable concentrate. (3) He can also disperse the pesticide in water or water soluble solvent with wetting agent and stabilizers then sand mill or ball mill this mixture into a flowable.

Although it is rare, one can encounter all three forms of a single pesticide: EC, WP, and F. Wettable powders and flowables are safer to use but not as fast acting as emulsifiable concentrates. The aromatic solvents used in preparing EC's are notoriously phytotoxic. This is why it is important to confine EC's but are rarely used. The EC's used with low gallonage spray invite phytotoxicity.

Rule #1: Never tank mix emulsifiable insecticide concentrates.

Rule #2: All insolubles can be tank mixed without incurring phytotoxicity provided the products are sprayed at recommended rates.

Rule #3: Only one soluble chemical can be tank mixed with any number of insolubles. If two soluble chemicals are tank mixed with or without insolubles, the rate of each soluble should be cut in half to avoid phytotoxicity.

Rule #4: Soluble fertilizers and trace elements can be added individually or mixed, provided the amount will not exceed one ounce solid per gallon tank spray mix.

To guard against such an occurrence we formulate **Rule Number 1. Never tank mix emulsifiable insecticide concentrates.** Not only will you incur phytotoxicity from the aromatic solvent sitting on the grass blade, but the insecticides, according to the labels, must be sprayed with large volumes of water (10 to 30 gallons), sometimes followed up with recommendations to water them in heavily to get them down to grubs. The wettable powder and flowable formulations will not burn but must still require watering for grub proofing. However, they can be used with a limited amount of water for surface treatment and can be treated as insolubles.

As I have said before, the largest category are the insolubles. **Rule Number 2 states that all insolubles can be tank mixed without incurring phytotoxicity provided the products are sprayed at recommended rates.** This permits the tank mixing of a tremendous variety of chemicals. Most important of all, it allows the applicator to spray three, four or more chemicals at the same time. The advantages are unbelievable if he explores the possibilities.

Broad spectrum control, where money is no object, is a must. The applicator should not rely on a single chemical to control a target disease. Follow the example of the pathologists at the various agricultural colleges. Note how they are mixing two and three different fungicides in their experimental plots in an attempt to achieve better control.

The trend that I have tried to pioneer over the last 20 years is precisely in this direction and many competitive manufacturers have joined in. More recently, with the advent of systemic fungicides the broad spectrum mixture has assumed brighter and newer horizons because of the longer residual control attainable with the addition of a systemic along with one or two contact fungicides in the spray tank.

Prior to the systemics, it was an accepted fact that contact fungicides did their job on the grass blade and in the thatch and were dissipated within two to three days. A good contact fungicide will kill germinating spores at a few parts per million. It is usually sprayed on the grass blade at about 5,000 parts per million. With the present-day irrigation and mowing practices, it doesn't take more than two to three days to get down to a dilution below the effective five parts per million.

In hot, humid weather accompanied by sporadic showers, an applicator had to spray twice a week, otherwise his grass would go unprotected the latter part of the week. This is not the case since the advent of systemics. They hydrolyze in the soil to knock down the fungus population, not only in the soil but also within the grass blade by diffusion through the root system, thereby giving extended protection.

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There are soluble fungicides as well. When applying soluble chemicals including fungicides, keep in mind **Rule Number 3. Only one soluble chemical can be tank mixed with any number of insolubles. If two soluble chemicals are tank mixed with or without insolubles, the rate of each soluble should be cut in half to avoid phytotoxicity.** Although they are not numerous, the superintendent is familiar with and has had experience in applying the soluble fungicides such as PMAS, Caddy, Cadminate and Actidione. The latter two are soluble in the spray tank. Coincidentally, three large manufacturers have mixtures of solubles with insolubles presently being marketed.

There is no question that the soluble fungicides have the clout necessary to stop an advanced fungus infection. One can only hypothesize why this is so, and the question resolves itself with the explanation of the difference between fungicidal and fungistatic activity. Fungicides kill whereas fungistats inhibit. But this explanation is too simple. When a spore germinates and sends out a tiny, tender shoot, it is easily killed. Since this is only visible microscopically, the net result determined by sight is that the chemical has prevented spore germination-fungistatic effect. If the spore germinates and the shoot gets a foothold within the grass blade, it takes a more powerful chemical to kill it — fungicidal effect. Some insoluble fungicides possess this advanced stage killing ability to varying degrees; but all of the solubles are immediately fungicidal.

The author has maintained for several years that the ideal tank mix of fungicides is a three-way combination of soluble contact/insoluble contact/insoluble systemic mixture; and, for years has even recommended mixing two soluble contacts, each at half rate to get a broader spectrum than the single soluble at full rate.

Applying rules 2 and 3 in an attempt to get a broader spectrum of control, all of the insolubles can be tank mixed. They can also be tank mixed with one of the solubles or one of the soluble-insoluble combinations. If the solubles and soluble-insoluble combinations are tank mixed, the dosage should be cut in proportion to the number of chemicals added. Because of the soluble portion of the group of soluble-insolubles, they should be treated as if they were solubles. It should be emphasized again that the dosages of two solubles should be cut in half if tank mixed. If three solubles are tank mixed, the dosages should be cut to one-

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third of the recommended rate of each soluble component.

A prime example is the successful combination of MCPP, 2,4-D and dicamba. The recommended rate of MCPP is between 1 and 1½ pounds per acre and the rate of 2,4-D is 1 pound per acre and the rate of dicamba is ¼ - ⅓ pound per acre. However, a successful combination of the three is in the neighborhood of ½ pound MCPP, plus ¼ pound 2,4-D, plus ⅛ pound dicamba. These come premixed in approximately that ratio under the trade names of Trimec and Trex-San.

There are some MCPP/2,4-D combinations in which the rate of MCPP is 1 pound and the rate of 2,4-D is ½ pound. Another example of the synergistic effect of two postemergent chemicals is the combination of DSMA and 2,4-D. In Texas, where 2,4-D is not prevalently used because of its injury to cotton, DSMA anhydrous is recommended for the control of dallisgrass at the rate of 7-10 pounds per acre on bermudagrass. In nearby Louisiana, equally good control has been achieved by the use of 4-5 pounds DSMA plus ½ pound of 2,4-D. This practice has been going on for more than 10 years and, coincidentally, it conforms with rule number 2, which dictates that if two solubles are used together it is a wise practice to cut the dosage of each in half.

Every pesticide applicator knows that fertilizers are usually combinations of insoluble components, and because of the soluble fractions the fertilizers must be watered in to prevent burning. It is not an uncommon practices to add soluble fertilizers to the spray tank in small quantities to attain an immediate greening effect on specific occasions. A more common practice is to add chelated iron for the same reason. But there have been instances of burning because an applicator had a heavy hand in applying these products.

The phenomenon known as salt index comes into play in determining how much of the soluble fertilizer components can be added to the spray tank without incurring phytotoxicity.

Rule Number 4 states that soluble fertilizers and trace elements can be added individually or mixed, provided that the amount will not exceed one ounce solid per gallon tank spray mix. The author has used two ounces per gallon, and has not experienced any burning at the higher rate, but prefers the lower rate. The components that fall into this category are solubles such as urea, ammonium nitrate, ammonium sulfate, muriate of potash, ammonium phosphate, ferrous sulfate, chelated iron, epsom salts, etc.

Exceptions to the rule governing compatibility of solubles is as follows: Heavy cations such as mercury and cadmium fungicides and Paraquat and Diquat are incompatible with heavy anionic herbicides such as DSMA, MSMA, 2,4-D, MCPP, MCPA, and DICAMBA. Precipitation will take place in the spray tank. These combinations are not likely to be used because selective weed control does not involve non-selective weed killers such as Paraquat or Diquat, and the applicator is not likely to use a soluble fungicide such as cadmium or mercury.

There are quick methods to check compatibility. When solubles are mixed with water in the proportion to be used in the spray tank, the solution should remain clear for the number of hours anticipated for spraying.

Emulsifiable concentrates should disperse throughout the water in a stable emulsion without incurring an oily layer separation on standing. The emulsifiable concentrates should be added last, after all solubles and wettables have been added. (However, I strongly urge not to tank mix emulsifiable concentrates).

If three solubles are tank mixed, the dosage should be cut to one-third of the recommended rate of each soluble component.

Thirdly, when wettable powders are components of a tank mix, after standing awhile, the mixture should be sieved through at least a 100 mesh screen. If residue appears on the screen, agglomeration or precipitation has taken place, signaling incompatibility.

These tests can be run in a convenient quart glass jar. The sieve screen should be wet with water with some surfactant added before sieving.

Soluble iron or magnesium salts might remain clear in the glass jar for about an hour and will then begin to hydrolyze in hard water or in water that has a pH of 7 or above. They will decompose to oxide precipitates that are of no value. Whenever possible, use chelated forms of iron and magnesium which will not hydrolyze. They are more expensive, but one can use far less and be able to count on their effectiveness.

Coincidentally, herbicides also fall into two classes— solubles and insolubles. The soluble herbicides are postemergent in nature whereas the insolubles are preemergent in activity. The insoluble preemergents are safe to apply because by their very nature they slowly release the active toxicant by hydrolysis in the soil (although certain preemergents exhibit some phytotoxicity on certain species and cultivars; however, these cautions are covered on the labels).

The rate of release of active toxicants is sufficient to kill the germinating weed seedling and, strangely enough, insufficient as a rule to kill the mature weed plant. The rate of release will determine the length of residual activity of the product. Each individual preemergent has its own time release schedule. The residuals range anywhere from 45 to 90 days, with an average of about 60 days.

It should be noted that one important factor which will materially alter the residual is oil structure. Adsorption of the hydrolytic toxicant by soil particles dictates different rates for different soils. Label directions must be carefully followed. But

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the parent pre-emergent compound is an insoluble, thus nonburning.

Pre-emergents should be applied before the weed seed germinating season begins, which is usually in March, April or May depending upon that portion of the country. Preemergent chemicals can be tank mixed and sprayed as a wettable powder or can be applied with a granular carrier as a spreader.

It is obvious that wettable pre-emergent powders will not present a phytotoxic problem at the time of application. However, some preemergents will release the toxicant rapidly and pose a phytotoxicity to certain types of grasses such as bentgrass. Some applicators will split the rate of application of a preemergent wettable powder in half when treating bentgrass greens and put on two applications a month apart.

The tank mixing of two or three soluble postemergent herbicides is becoming more and more prevalent.

The problem of phytotoxicity is an important factor when dealing with soluble postemergent herbicides. As a general rule, the phytotoxicity index (safety factor) is narrow for all postemergent chemicals. Yet they are used rather extensively and effectively, provided the rates of application are followed closely. The tank mixing of two or three soluble postemergent herbicides is becoming more and more prevalent. This practice is useful because the applicator has found a synergistic effect with combination; but, in doing so he must again apply rule number 2 which states that whenever solubles are added to the spray tank the dosage rate should be cut proportionately, depending upon the number of solubles.

Surfactants or wetting agents should be treated as solubles. Wetting agents are usually added to the spray tank in order to reduce the surface tension of water so that the spray comes out as finer droplets and wets the blades of the weeds or grasses giving a more uniform coverage. This also reduces the safety factor of soluble herbicides and promotes phytotoxicity. If a wetting agent is used, apply Rule No. 3. Cut the rate of the soluble herbicide. When used with insoluble fungicides, it is not necessary to reduce the rate.

Finally, there are two classes of chemicals which are infrequently used by applicators and by their very nature cannot be tank mixed. They are nematicides, such as Dasanit and Nemagon, and general weed and grass killers such as Phytar, Paraquat and Roundup.

When the applicator embarks on a new formula it would be wise for him to practice on small areas, preferably his nursery.

Also, according to the federal Environmental Protection Agency, if a chemical applicator willfully uses more than the recommended amount on the label and destroys turf, he is technically criminally libel.

But we are addressing ourselves to applicators who are faced with multiple diseases and multiple weeds. In this situation, one single product is inadequate, and it becomes costly and somewhat ridiculous to spray each individual product separately. But never apply more than the amount recommended on the label, and following the rules outlined in this paper, it is necessary to split dosages of solubles.

Solubility and Formulation

	EC, S, SP Solubles		WP, F Insolubles		Soluble-Insoluble Combinations
FUNGICIDES					
	PMAS		Tersan 75	Fore	Calo-Clor
	Caddy		Tersan LSR	Maneb	Kromad
	Cadminate		Tersan SP	Zineb	Actidione RZ
	Actidione TGF		Spotrete	Captan	Actidione Thiram
			Bromosan	Daconil 2787	Thimer
			Spectro	Dyrene	Cadtrete
			3336	Fungo	
			1991	RP26019	
INSECTICIDES					
	Dursban	Malathion	Diazinon		
	Diazinon	Proxol	Dursban		
	Chlordane	Dylox	Sevin		
	Sevin		Malathion		
HERBICIDES					
	2,4-D	DSMA	Dacthal		
	2,4,5-T	MSMA	Tupersan		
	MCPP	AMA	Balan		
	dicamba	Betasan-EC			
FERTILIZERS					
	urea		ureaform		
	ammonium nitrate		IBDU		
	ammonium phosphate				
	ammonium sulfate				
	potassium nitrate				
	muriate of potash				