

# Tank Mixing Fungicides for Better Control

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My article, "Compatibility in the Spray Tank," was first published in February of 1977. In that article, I described four simple rules, which when followed would permit one to successfully tank mix pesticides without incurring phytotoxicity. This present article deals with one specific aspect of tank mixing, namely fungicides, to obtain a broader spectrum of disease control for the turfgrass professional.

## A Question of Solubility

As the world of fungicide products shrinks due to slower new product introductions and faster old product retirements, I get an increasing number of phone calls asking about the compatibility of pesticides in the spray tank. I welcome the calls, but if one were to truly understand a universal principle of tank mixing and its relationship to phytotoxicity, one could pigeonhole any new product by knowing if it is soluble or insoluble. The manufacturer will use key letters after the name of the product that can indicate whether it is soluble or insoluble. Examples of such letterings are as follows:

### Solubles

S: Solution  
SP: Soluble Powder  
E: Emulsion  
EC: Emulsifiable Concentrate

### Insolubles

WP: Wettable Powder  
F: Flowable  
WDG: Water Dispersible Granule

For quick and easy reference, I have categorized in table form the commonly known pesticides currently used for turf disease control. Should a new pesticide appear on the market, just determine whether it is water soluble or whether it is insoluble, then proceed using the following information. A large number of pesticides are insoluble, and before they can be used, they must be milled down to submicron size so that they will disperse in water; whereas, solubles dissolve in water and when in solution are molecular in size. Submicron-size particles are thousands of times larger than molecules. Therein lies the difference. A solution, when sprayed on a grass blade, will move in and out of the blade at ease by the process of osmosis. In other words, molecules of water and molecules of soluble pesticide will easily move in and out of the grass blade through the stomates. Too high of a concentration of soluble pesticide or soluble beneficial fertilizer will burn the grass. The insoluble submicron particles of pesticide or organic fertilizer are too large to pass through the stomates. If they can't enter the grass blade they won't burn the grass.

Understanding this universal principle, one can conclude insolubles are not phytotoxic when tank mixed together up to the labeled rates for each product. However, solubles could be phytotoxic at or below labeled rates in the tank mix. Label rates of soluble pesticides must be respected and carefully followed. If you were to mix full rates of soluble pesticides, you would undoubtedly exceed the safety factor and encounter phytotoxicity. That is why it is necessary to back off and use half rates or even third of the rates when

mixing soluble pesticides. A classic example is a premixed herbicide product which contains a combination of three soluble herbicides: 2,4-D, MCPP, and Dicamba. These products generally contain 1/3 lb. of 2,4-D, 1/2 lb. MCPP, and 1/9 lb. of Dicamba per acre, which are actually one-third rates of each if you were to use them separately. Many other examples of this concept exist both in pesticides and fertilizers.

Also discussed in my previous article is the treatment of emulsifiable concentrates (ECs). Some manufacturers will take water insoluble pesticides and dissolve them in hydrocarbons, then add emulsifiers. Most ECs are insecticides. Treat them like solubles because the hydrocarbons can penetrate the grass blade through the stomates. Since the pesticide is now soluble in the hydrocarbon, it is no longer submicron size but is molecular in size and can also penetrate the grass blade.

## Tank Mixing

Tank mixing fungicides is not new. There must have been someone advocating tank mixing before me, but I started with the classic tank mix of PMAS - Thiram forty-five years ago. That popular tank mix was used for almost thirty-five years. PMAS was a powerful soluble contact fungicide with both preventive and curative properties, but its solubility was its shortcoming. It was sprayed at 500 ppm, and within two or three days, the normal irrigation practices would wash it off the grass blades; whereas, Thiram was an insoluble contact sprayed at 10,000 ppm, and it took at least four to five days to wash off the last traces of it. Had PMAS

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been sprayed twice a week, there would have been no need to add Thiram to it because the grass blade would have been protected at all times. Therefore, insolubles were added so that the superintendent would only have to spray once every seven- to ten-day intervals.

To appreciate the value and importance of insoluble contact fungicides, one has to understand how they work. First, understand that they are truly not insoluble, but for all practical purposes they are referred to as insolubles with solubilities in water in the range of 10 to 100 ppm, low enough to be regarded as non-phytotoxic when sprayed at heavy rates. Their action is preventive, not curative. They act very similar to preemerge crabgrass killers as opposed to postemerge crabgrass killers. One puts down a heavy rate of preemerge crabgrass control which has only a few parts per million solubility, sufficient to kill the tender crabgrass seedlings which have germinated. But if crabgrass has germinated when the seedling has rooted and slightly matured, that few parts per million solubility is insufficient to kill the plant.

Insoluble contact fungicides act in a similar manner. They are applied at heavy rates, and as long as there are a few parts per million of insoluble fungicide left on the grass blade, it is sufficient to kill the spore when it sends out its tender shoot; but the insoluble contact doesn't have sufficient solubility to kill the more mature mycelia. That's the job of the soluble contact.

It was this philosophy that set a trend in the fifties, and other manufacturers followed shortly thereafter. Each had excellent soluble contacts with good curative power which never had to be used above the rate of one oz. per 1000 sq. ft., as phytotoxicity could be

encountered above that rate. This group of products was efficient and economical and was mostly used in conjunction with insoluble contacts. Mallinekrodt had Caloclor and Cadminate and also mixtures with Thiram. Upjohn had the excellent Actidione, and sold it straight or mixed with PCNB or Thiram. Cleary also added soluble Caddy to its line. Believe it or not, DuPont also had a soluble organomercury in its line. Tersan OM was a combination of mercury

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and Thiram. If you were a superintendent in the fifties and sixties, I'm sure you would have been tank mixing or using tank mixed products. The mixtures were always a soluble with an insoluble contact.

However, the seventies ushered in a new era: the advent of the systemics and the phasing out of those great soluble contacts. In the 1970s, three great systemics were introduced: DuPont's 1991, Cleary's 3336, and Rhone-Poulenc's 26019. They were awesome when first used commercially. One or two oz. per 1000 sq. ft. gave excellent broad spectrum control for six or seven weeks! It appeared there was no further need for soluble or insoluble contacts.

Then strange things began to happen. The rates had to be upped, and the intervals were shortened; still disease was coming through. The grass plant which was supposed to be rendered immune was succumbing to resistant strains of the diseases, just as we had experienced resistance in the past with insects and insecticides. In medicine, antibiotic drugs were performing similarly. Repeated use of the same antibiotic developed resistant strains of the infectious organism. Obviously, the answer was simple: switch to different systemic or a different antibiotic which would control the dominant resistant strain. It worked, but for how long? Until another resistant strain developed?

Fortunately, several good systemics were developed during the late seventies and eighties, and the practice of alternating systemic pesticides has reduced the resistance problem somewhat, but not completely. A few years' experience with the new systemics made us realize that the contact fungicides, far from becoming obsolete, had to fill in the gaps of disease control created by the deficiencies of the systemics. Therefore, it was logical to add 3336 to the near perfect mixture of PMAS+Thiram. The residual control of PMAS+Thiram was tailing off at the ten-day interval; adding 3336 did extend the control. Ultimately, in the late eighties, all soluble contacts came under scrutiny by EPA; and as a result they were all canceled: PMAS, CADMINE, CADDY, ACTIDIONE, AND CALOCLOR.

They were all so powerful and economical products to use. They have been sorely missed and have made the job of replacing them expensive and complicated. Personally, if I had to choose between systemics or soluble contacts, I would prefer the latter.

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### Fungicides Are Different

Although there appears to be a fairly large number of systemic fungicides, these fungicides are limited to a small number of chemical families. Competitive factors have led to the development of new materials; however, these products are the result of structural changes to the molecules within a similar chemical group. Research has shown that the fungicidal activities of these groups are similar, normally disrupting one distinct function within the fungal organism. When tank mixing, it would not be wise to mix two systemics within the same group. No synergism or broader spectrum of activity is achieved by doing so. This is so beautifully explained by Professor Patricia Sanders, Penn State plant pathologist, in her article: "USE SENSE and Be Skeptical." The article is a classic and should be read, studied, and thoroughly understood by anyone who wishes to begin tank mixing. She explains there are three groups of broad spectrum systemic fungicides:

**BENZIMIDAZOLES:** Cleary's 3336, Fungo-50, Tersan 1991 (discontinued)

**DICARBOXIMIDES:** Chipco 26019, Vorlan

**STEROL INHIBITORS:** Bayleton, Banner, Rubigan

Ms. Sander's research has shown that any fungus that is resistant to one member in a group will become resistant to all the members in that group. Therefore, it is futile to mix systemics within the group. "Broad spectrum systemics must be mixed between but not within groups." Example: Don't mix 3336 with 1991, but you can mix 3336 with Bayleton or 26019. She also points out that there are three *Pythium* systemics: Subdue, Banol, and Aliette. They each have

different modes of actions; they can be mixed as either two-component or three-component systems, using half rates, or in the later case, using one-third rates to avoid resistant strains. Ms. Sanders has found that reduced rates of fungicides in the mixtures are not only economical and environmentally sound but produce a broader spectrum of control and have been found to have a synergistic effect. I have also found the same results in all my tank mixing.

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### Fungicide Mixtures

Since most all systemics have been found to be somewhat deficient in the control of some diseases, it is necessary to add contact fungicides to the mixture to make up for this deficiency. A good example is brown patch. I have found by adding Daconil 2787 and a Mancozeb product, such as PROTECT T/O or PCNB or Thiram, to the systemic mixture, brown patch does not occur; but without them, it will eventually persist.

In other research, Dr. Bruce Clarke at Rutgers University has done some remarkable work in controlling summer patch with 4 oz. per 1000 sq. ft. rates of the

sterol inhibitors such as Banner, Bayleton, etc., and also 8 oz. per 1000 sq. ft. rates of benzimidazoles such as 3336 or Fungo 50 at monthly intervals.

The results are phenomenal and when combined with proper soil chemistry management indicate that the turf manager may finally get the upper hand on this disease. Best results occur when they are watered in. They have long residuals in the soil, and these heavy rates give one full month protection before the next application.

Unfortunately, some superintendents are using this application solely for disease control on greens and could be in danger of getting resistance or also the occurrence of other diseases such as brown patch for which systemic control is weak. I reason that it would be just as sensible to supply the grass plant with incremental amounts of systemic through weekly or ten-day interval applications; and in these incremental applications, contact fungicides are added to the mixture so that they can do their job. Contact fungicides fail when they are not present on the grass blade but succeed when they are. To spread the interval of application beyond ten days is not a good idea for contact fungicides. Also, watering in the mixture is bad because the contact must stay on the grass blade as long as possible. Your irrigating practice will suffice in getting the systemic into the soil. It has a long residual. I have had excellent control by spraying a mixture of 1/2 oz. Bayleton, 1 oz. 3336, 1 oz. Daconil, and 1 oz. Thiram at weekly or ten-day intervals; and when stressful disease weather approaches, I increase the contact fungicides to 2 oz. each yet keeping the systemics at the low rate. Other substitutions can be made, such as substituting 26019 or Banner in the mixture; but always making sure that one is not using two systemics within the same

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group. The example I gave you had two Cleary products in the four-way mixture, and that is not academically fair to the reader. You could get equally good results with a non-Cleary mixture such as 1/2 oz. Banner, 1 oz. 26019, 1 oz. Daconil, and 1 oz. PCNB, or 1 oz. Mancozeb per 1000 sq. ft. at seven- to ten-day intervals. Remember, the short interval is important so that you can get the full benefit of the contact fungicides.

It is easy for a well-educated plant pathologist to criticize the use of such mixtures, but pity the superintendent whose job is on the line because he has had chronic disease problems and has occasionally lost a few greens. The ecologists are insisting that he spray less, and the pathologist wants him to target the fungicide to a specific disease, when actually he is not that knowledgeable in anticipating what disease might show up and what would be the likely preventive spray. Skipping sprays because there are no visible symptoms of

disease is economical but risky business. I have found this sort of practice is why most superintendents fail. They might get by for two or three years, but eventually they get hit hard and lose their jobs. Call my program for what it is: a shotgun treatment, but I look at it differently. I tell the superintendent, "You're on automatic pilot." Instead of coming in every Monday morning trying to devise a spray program for the anticipated disease based on the weather forecast, you start on this broad spectrum program in the spring and stay on it, defying any disease to break through that barrier. Believe it or not, I have many successful converts, most of whom are on it because they were in trouble and after being put on the program have been successful.

**I must stress one last time the importance of the intervals of sprays. Monthly intervals defeat the whole program. Remember that contact fungicides are only active for about four days. What good are they in**

**a monthly spray program? They are not too efficient even in a two-week interval program. The perfect program is a weekly interval. A near perfect program is a ten-day interval. Many successful superintendents have adopted the compromise of a ten-day interval. All of the university field trials are either two-week or monthly intervals. That is too bad, because it has impacted the mind of the superintendent into thinking these are the proper intervals. Not so. The universities don't have the money or the personnel to test weekly or in ten-day intervals. But therein lies the secret of success. ■**

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## TURF FUNGICIDES IN USE TODAY

PRODUCT	FORMULATION	CHEMICAL NAME	SOLUBILITY
Chipco 26019	50 WP/2 F	iprodione	insoluble
Cleary's 3336	50 WP/4.5 F	thiophanate-methyl	insoluble
Aliette	80 WG	fosetyl-Al	soluble
Banner	1.1 EC	propiconazole	soluble
Banol	6 EC	probamocarb hydrochloride	soluble
Bayleton	25 WP	triadimefon	insoluble
Cleary's PCNB	75 WP	pentachloronitrobenzene	insoluble
Curalan	4.17 F	vinclozolin	insoluble
Daconil 2787	4.17 F/90 WDG	chlorothalonil	insoluble
Defend	2 F	pentachloronitrobenzene	insoluble
Dithane T/O	75 WP	mancozeb	insoluble
Domain	4.5 F	thiophanate-methyl	insoluble
Fore	80 WP/4 F	mancozeb	insoluble
Koban	30 WP	etridiazole	insoluble
Prostar	50 WP	flutolanil	insoluble
Protect T/O	80 WP	mancozeb	insoluble
Rubigan	1.1 F	fenarimol	insoluble
Sentinal	40 WG	cyproconazole	insoluble
Spotrete	4 F/75 WDG	thiram	insoluble
Subdue	2 F/25 WP	metalaxyl	soluble
Terrachlor	75 WP	pentachloronitrobenzene	insoluble
Terrazole	35 WP	etridiazole	insoluble
Thalonil	90 DF/4 F	chlorothalonil	insoluble