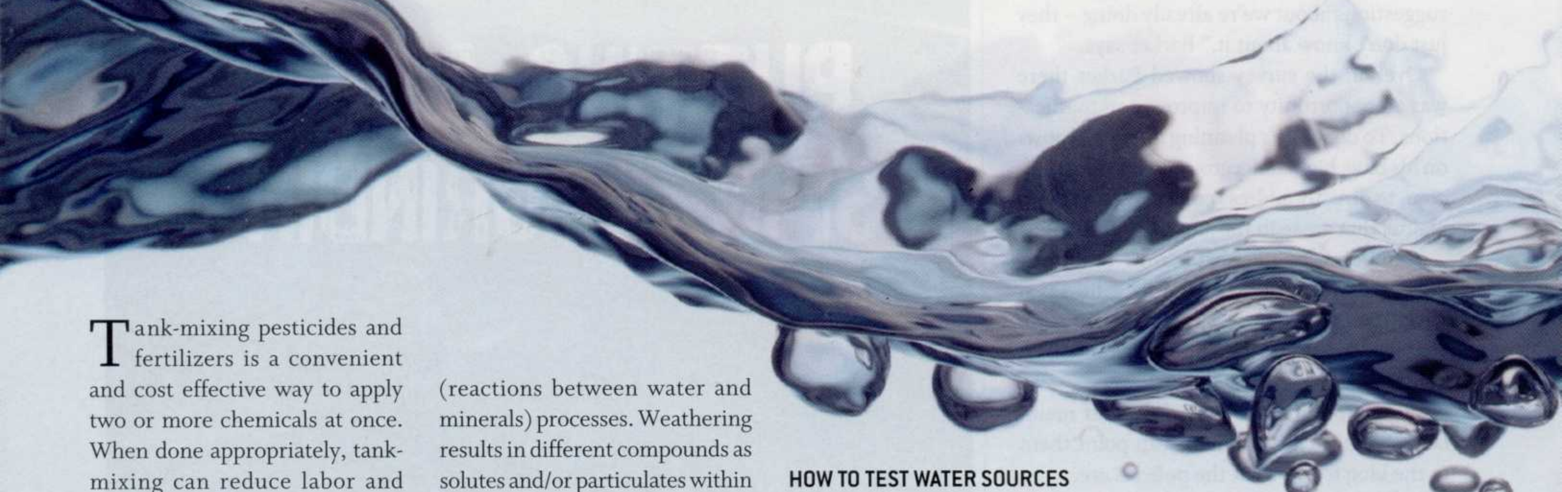
A question of QUALITY

How carrier water quality influences pesticide stability.

By Dara Park, Ph.D. & Juang-Horng 'J.C.' Chong, Ph.D.



CLARKE ROBERTSON

Tank-mixing pesticides and fertilizers is a convenient and cost effective way to apply two or more chemicals at once. When done appropriately, tank-mixing can reduce labor and equipment costs, and save time and energy. Carrier water is the water you put in the tank to dilute your chemicals and to apply them with. Carrier water makes up about 95 percent of what you apply. Certain water chemistry can potentially react with, and change the efficacy of, pesticides in both positive and negative ways. This article will discuss the origins of water chemistry, and how to take a water sample and determine the water quality. This article will also discuss the influence of and the remedies for common problematic water components.

ORIGINS OF WATER CHEMISTRY

The chemical and physical properties of minerals (i.e. mineralogy) and weathering influence water chemistry. Weathering is the decomposition process of rocks, minerals and soils by physical (for example, degradation by microorganisms and cracking by ice formation) and chemical (reactions between water and minerals) processes. Weathering results in different compounds as solutes and/or particulates within the water column.

Here is an example of how mineralogy and weathering may influence water chemistry in South Carolina: Limestone, composed of mainly calcium carbonate ($CaCO_3$), is the underlying bedrock along coastal South Carolina. During each rain event, water combines with carbon dioxide in the atmosphere to form a weak acid called carbonic acid. As rain water passes over and through the limestone, the acid combines with the calcium carbonate to form calcium bicarbonate ($Ca(HCO_3)_2$), which is dissolved in the water. Calcium carbonate and calcium bicarbonate are the two principal causes of hard water.

Water chemistry is also influenced by the sources of water. Saline aquifers, tidally influenced streams and rivers, reclaimed stormwater runoff, and reclaimed wastewater have a considerable amount of salts and other particulates.

HOW TO TEST WATER SOURCES

Use opaque plastic containers to collect your water sample. Rinse out the bottle three times with the water you will be sampling before you take the actual water sample. Place your name, location, and date on the sample bottle with a permanent marker. Place the water sample in a cooler or refrigerator until delivering to the laboratory. Make sure to submit the sample within 24 hours of collection. Regardless of which laboratory you send your sample to, you should receive an interpretation of results as part of your report. Some water components can be determined on site with relatively little expense and will be discussed in the following sections.

COMMON PROBLEMATIC WATER COMPONENTS

PH

What is it?

pH or Potential of hydrogen is the measure of the concentra-

tion of hydrogen ions (H+) and hydroxide ions (OH-) in a solution. It is measured on a logarithmic scale of 1-14 with 1 = acidic (dominated by H+ ion), 7 = neutral, and 14 = alkaline (dominated by OH- ions). Water pH fluctuates diurnally (from photosynthesis and aerobic respiration) and seasonally (from increased rainfall, leaf litter, etc.). Over long periods of time, water pH tends to become more alkaline.

How does it influence pesticide efficacy?
Certain pesticides undergo chemical breakdown in alkaline water (pH more than 7). The reaction is termed alkaline hydrolysis and the severity and speed in which it occurs is dependent on the pesticide, the alkalinity of the water, the length of time the pesticide is in contact with the water and the water temperature. Insecticides, particularly organophosphates and carbamates, are more susceptible to alkaline hydrolysis than other pesticides. In comparison, sulfonylurea herbicides are more susceptible to acid hydrolysis at pH less than 6.0.

How to keep it from becoming a problem?
Check pH regularly and add buffering agents to carrier water whenever necessary. A pocket pH meter is relatively inexpensive and easy to operate. Test the water pH before adding any chemicals. Always read the pesticide label and check the pesticide MSDS for the recommended pH range. If correction is needed, add a buffering or acidifying agent before adding the pesticide. The acidifying agent may include acid-forming nitrogen fertilizers, straight acids and may or may not be used in conjunction with surfactants. Always apply the tank mixture as soon as possible. Buffering agents should not be mixed with fixed copper and lime fungicides; otherwise, plant damage will occur.

SALINITY

What is it?
The concentration of mineral salts (for example, $MgSO_4$, MgCl, CaCl, $NaHCO_3$, NaCl, KCl) dissolved in water. It is measured by electrical conductance (EC) and is commonly reported in either dS/m or mmhos/cm.

How does it influence pesticide efficacy?
Salty water is alkaline and more resistant to pH changes, making adjustments with acids more difficult. Salinity of over 0.75 dS/m can stress sensitive plants and reduce absorption of systemic pesticides through plant roots. Besides what has been mentioned, not much is known about how salinity influences pesticide efficacy, or if it does at all. However, we are aware of instances in which a pesticide failed and the only water problem possible was salinity.

How to keep it from becoming a problem?
Check the salinity in your carrier water if you use water from reclaimed or tidally influenced sources. Pocket EC meters are inexpensive and easy to use. Combination Temperature/pH/EC pocket meters are slightly more expensive but still reasonable. Always read the pesticide label and check the pesticide MSDS

Table 1. Recommendations on the uses of selected fungicides, herbicides and insecticides in carrier water of problematic quality. The effects of water hardness and salinity on fungicides and insecticides are poorly studied; thus, the compatibility should be tested before mixing.

		Water Quality				
Common Names	**Brand Names***	**Acidic (pH < 6)**	**Alkaline (pH > 8)**	**Muddy**	**Hard**	**Saline**
Fungicides:						
azoxystrobin	Heritage	✓	✗	NR		
chlorothalonil	Daconil	✓	✓	Test		
ethazole	Terrazole	✓	✓	Test		
fenarimol	Rubigan	✓	✓	✓		
fosetyl Al	Aliette	✓	✓	✗		
mancozeb	Manzate	NR	NR	Test		
mefenoxam	Subdue Maxx	✓	Test	Test		
PCNB	Terracolr	✓	Test	NR		
propiconazole	Banner Maxx	✓	✓	Test		
thiophanate methyl	Cleary3336	Test	✗	Test		
trifloxystrobin	Compass	Test	Test	NR		
Herbicides:						
2,4-D amine	2, 4-D Amine	Test	NR	✓	✗	✓
atrazine	AAtrex	NR	✗	Test	✓	✗
chlorsulfuron	Corsair	✗	✓	✓	✓	✓
clopyralid	Lontrel	Test	✗	✓	✗	✓
dicamba	Vanquish	✓	NR	✓	NR	✓
diquat (& paraquat)	Reward	✓	✓	✗	✓	✓
glyphosate	RoundUp	✓	Test	✗	✗	✓
halosulfuron methyl	SedgeHammer	✗	✓	✓	✓	✓
MCPA	MCPA	Test	NR	✓	✗	✗
metsulfuron	Manor	NR	✗	✓	✓	✓
sethoxydim	Vantage	✓	✓	✓	✓	✓
simazine	Princep	Test	NR	✓	✓	✗
Insecticides:						
acephate	Orthene	✓	✗	✓		
bifenthrin	Talstar	✓	✓	✗		
carbaryl	Sevin	✓	✗	NR		
chlopyrifos	Dursban	✓	✗	✗		
clothianidin	Arena	✓	✓	✓		
fipronil	TopChoice	✓	✓	NR		
imidacloprid	Merit	✓	Test	✓		
indoxacarb	Provaunt	✓	✗	Test		
λ-cyhalothrin	Scimitar	✓	✗	✗		
spinosad	Conserve	✓	Test	Test		
thiamethoxam	Meridian	✓	Test	✓		
trichlorfon	Dylox	✓	✗	✓		

*Brand names are provided as examples. Mentioning of any products should not be considered as an endorsement.
Key: ✓ = OK. ✗ = Do not use. NR = Not recommended but use soon after mixing if there is no alternative. Test = Test for compatibility.

to see if any precautions should be taken. Sometimes salinity is reported as total dissolved salts (TDS). Most pocket EC meters will give you the option for either an EC or TDS readout. If a saline water source is used, an alternative water source should be identified for permanent use or for blending with the saline water.

Agitators and injection tanks can be installed for water treatment with calcium or sulfur. Ask your extension agent for more information.

WATER HARDNESS

What is it?

Hard water contains a high concentration of magnesium (Mg^{2+}), calcium (Ca^{2+}), and Ferric ions (Fe^{3+}). Water hardness is reported in ppm of $CaCO_3$ equivalent. Water <50 ppm is considered "soft," 50-100 ppm is considered "medium hard," and 100 – 2000 ppm is considered "hard."

How does it influence pesticide efficacy?

Hard water won't lather with soap. The cations in hard water bind with the pesticide molecules (one cations can bind more than two susceptible pesticide molecules) to form insoluble salts and precipitate out of solution. 2,4-D, dicamba, glyphosate and clopyralid are susceptible to binding with hard water. Hard water can also reduce the efficacy of some surfactants and agents added to clear turbid water. Precipitates and scales formed in the sprayer can clog the nozzles and filters.

How to keep it from becoming a problem?

You will have to submit a water sample to a laboratory to test for hardness. Always read the pesticide label and check the pesticide MSDS for any precautions.

If correction of water hardness is needed, add an agent such as those containing sulfate, organic acids and non-ionic surfactants. Sulfate (SO-4) and organic acids are often used to bind with the hard minerals. Non-ionic surfactants are commonly used to enhance herbicide efficacy but it should be noted that these will not correct the problem, and another agent still needs to be used. The agent should be mixed with the carrier water before adding the pesticide. Other options are to decrease the volume of carrier water and to use a higher label rate. Spray the tank mixture immediately.

SOLIDS

What is it?

Particulates of clay, silt and organic matter that are disturbed by water movement and brought into the column. Large particulates will eventually settle to the bottom but small particulates can suspend in the water column. Collectively, the total amount of particulates is known as turbidity and is commonly reported in Nephelometric Turbidity Units (NTU). The small particles that remain suspended are referred to as total suspended soilds and are reported in mg/l.

How does it influence pesticide efficacy?

These particles are both chemical and physical nuisance. Clay and silt can bind with pesticide molecules.

The organic particles not only bind with pesticides but also harbor microbes that naturally degrade pesticides. The particulates can also clog filters and nozzles.

How to keep it from becoming a problem?

To get an actual value of turbidity, a water sample will have to be submitted to a laboratory. The easiest way to test for a problem is to drop a quarter at the bottom of 5-gallon bucket of the water. If you cannot see the coin, then the water must be treated. Always read the pesticide label and check the pesticide MSDS for any precautions on using dirty water. An in-line filter can be installed to remove suspended solids. If the pump is within a surface water body, make sure that the location of the intake is not at the very bottom or close to the top of the water column. Locate an alternative water source for permanent use or to blend with turbid water. Additionally, agents can be added to help precipitate and clear the water.

IRON

What is it?

It is the sixth most abundant element in the universe and is the fourth most abundant element in the earth's crust (although not commonly found in the free metal form). Iron is dissolved as water passes through the underlying rocks. The concentration of iron is reported in mg/l.

How does it influence pesticide efficacy?

In the air or water, iron reacts with oxygen to form rust (oxide and hydroxide forms of iron). Rust forms faster in the presence of salt (as in certain pesticides or within the carrier water). The rust can cause reddish-brown staining. Iron also combines with organic materials and bacteria to produce slimes. Rust flakes and slimes can clog nozzles, filters and lines.

How to keep it from becoming a problem?

A water sample will have to be submitted to a laboratory to get an actual value of iron concentration. Stains can appear at concentration as low as 0.3 mg/l. Treatment for excessive iron will depend on the type of problem that exists (stains, deposits, or slimes). The most common techniques include aeration followed by filtration, the use of a water softener (caution: these usually use sodium), and the use of potassium permanganate and chlorination followed by filtration. Contact your extension agent to help decide which is best for you.

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TAKE PRECAUTIONS

Always check your pesticide label and MSDS for recommendations and guidance. If you still have a question, contact the company representatives or county extension agents. Table 1 summarizes the effect of water quality on the most commonly used and more recent pesticides.

If the irrigation source exhibits one of the above-mentioned water problems, and the pesticide requires water-in after application, the irrigation water should be treated as well. This can be done by installing inline injection tanks. **GCI**

Dara Park, Ph.D., and Juang-Horng 'J.C.' Chong, Ph.D., are assistant professors at Clemson University's Pee Dee Research and Education Center in Florence, S.C.

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Tank-mixing tactics

To get the most mileage out of your pesticides and fertilizers, follow these tank-mixing principles.

by Dara Park, Ph.D. and Juang-Horng 'J.C.' Chong, Ph.D.

Tank-mixing pesticides and fertilizers is a convenient and cost effective way to apply two or more chemicals at once. When done appropriately, tank-mixing can reduce labor and equipment cost, and save time and energy. However, chemicals can potentially react with each other and/or change the characteristics of the carrier water. These interactions can change the efficacy of pesticides in both positive and negative ways.

POSITIVE EFFECTS

Enhancement occurs when an additive is mixed with a pesticide to provide a greater response than if the pesticide was applied alone. Adjuvants are common enhancements added to tank-mixes. Adjuvants include spreaders, stickers and other materials.

Additive effects result from the addition from each chemical added. The additive effect simply equals the sum of the effect if the chemicals would have been applied alone.

Synergism is when the product of two chemicals interacting with each other provides increased efficacy (control). This may allow for lower rates of chemicals to be used.

NEGATIVE EFFECTS

Antagonism is the opposite of synergism. The components react chemically with each other so one or both chemicals are rendered less effective than if they were applied separately. In addition to poor performance, an increase in plant phytotoxicity may occur.

Incompatibilities can occur from chemical reactions as mentioned above, or as the physical product of mixing chemicals. For example, if flocculants form, screens and nozzles may be clogged and the desired rate of chemical may not be applied. Flocculants and precipitants also can leave a residue on leaf surfaces. Other chemical incompatibilities occur from mixing chemical(s) with inadequate carrier water. Also, carrier water that is too low or high in pH and temperature, contain salts, or organic particulate can chemically alter the compound that is to be applied.

Pesticide resistance to two or more chemicals within a tank-mix may develop if the same chemical combination is used repeatedly over a long period of time. Pests may develop resistance faster when the chemicals used in the same tank-mix are of the same mode of action (for example, cyfluthrin and bifenthrin are both synthetic pyrethroids and target the activity site in an insect's nervous system). Resistance also may occur when the chemicals are of different modes of action if they are used frequently.

To make sure that only positive effects occur when tank-mixing, follow these guidelines for developing new tank-mixes:

1 Know the temperature, pH and salinity of your carrier water. Adjust your carrier water temperature and pH to the optimal range of each chemical before mixing in a tank or for a jar test.

2 Read the label of all chemical products considered to be tank-mixed. The product labels will give you information on what type of chemical and carrier to avoid and potential problems that may occur. If you are still unsure about a mix, contact the manufacturer.

3 Perform a jar test following proper mixing procedures (see sidebar). This will determine physical incompatibilities.

4 Many chemicals require constant agitation; be sure to follow all label instructions. Many labels will instruct you in the sequence for adding products to the tank mix.

5 Tank-mix enough to make a test application on part of the target site (preferred) or on a non-target site. Schedule the application to allow enough time for any negative effects (chemical incompatibilities) to be apparent before the actual application is made.

6 When making an actual application, spray as soon as possible. Do not use a spray solution that has been sitting for a long time. Some chemicals may degrade in spray solution after several hours. **GCI**

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