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Effect of Water and Spray Solution pH on Pesticide Activity

Many factors can influence pesticide effectiveness — spray coverage, application frequency, interval between applications, pesticide type and age, application rate and timing, and the pH of the water or spray solution. Greenhouse producers understand pH in relation to water quality and growing medium but may not know the effect of pH on pesticide activity. The pH scale is a measurement of the acidity or alkalinity of a substance and ranges from 1 to 14. A pH of 7 is neutral. A pH less than 7 is acidic, and a pH greater than 7 is alkaline. The scale is logarithmic, which means pesticide sensitivity to water pH increases by a factor of 10 for each pH unit. For example, a pH of 6 is 10 times more acidic than a pH of 7, and a pH of 5 is 100 times more acidic than a pH of 7.

Chemical Changes

A pesticide may lose effectiveness when mixed with water. A chemical reaction known as hydrolysis causes pesticide molecules to break apart, releasing individual ions (electrically charged atoms) that reassemble with other ions. New combinations have no insecticidal or miticidal properties, which compromises the overall effectiveness of the pesticide application. Alkaline hydrolysis may occur when a pesticide is exposed to water with a pH above 7. Certain pesticides may undergo acid hydrolysis at a pH less than 7.

The rate of alkaline hydrolysis increases as water pH increases. The speed with which a pesticide breaks down depends on chemical properties of the pesticide, the temperature of the water, and the amount of time a pesticide mixture remains in the sprayer. In general, the effectiveness of a pesticide diminishes over time when the water pH is greater than 7. As a result, the spray mixture emitted early in the application may be more effective than the spray solution emitted later. In addition, the decomposition rate of a pesticide can double as temperature increases.

Pesticide manufacturers keep data associated with the effect of water pH on the half-life of their pesticides. Half-life is the time required for 50 percent of the active ingredient to hydrolyze or break down, or the amount of time required for pesticide strength to decrease by 50 percent. In most cases, the half-life is based on the active ingredient and not the formulated product. For example, adjuvants used in various formulations may increase the stability of a pesticide in solution. Insecticides tend to be more susceptible to alkaline hydrolysis than fungicides or plant growth regulators. Insecticides in the chemical classes organophosphate (acephate, chlorpyrifos, and malathion), carbamate (carbaryl and methiocarb), and pyrethroid (bifenthrin, cyfluthrin, fluvalinate, and lambda-cyhalothrin) are most sensitive to alkaline hydrolysis or "high" pH solutions; however, certain pesticides, such as fenbutatin-oxide, are not affected by water pH.

To maximize pesticide effectiveness, be prepared to monitor spray solution pH and adjust if necessary. For most insecticides and miticides, the ideal pH is between 5 and 7. Many insecticides perform better at a pH of 7 or higher. For the optimum pH range of common insecticides and miticides, see Table 1.

Adjusting Water pH

Water pH can be adjusted, but must be done carefully. Although not accurate for precise monitoring, pH paper (litmus paper) can be used for insecticides and miticides where a reading between 6 and 7 is acceptable. To reduce the pH, add acetic acid (vinegar) to the spray solution in small increments. Check the pH regularly to avoid adding too much vinegar and to maintain the spray solution pH around 6.5. To increase pH, add household ammonia. Adjust pH before adding any pesticides to the container.

Water pH varies by season and fluctuates throughout the year. To prevent alkaline hydrolysis, monitor water pH. Adjust with buffers or water-conditioning agents to keep the spray solution within the 5 to 7 pH range. Buffers or water-conditioning agents are safer than sulfuric acid, which may be used to reduce the pH of a spray solution. Pesticides may degrade on contact with an alkaline solution, so always add buffers first.

Follow the proposed guidelines to prevent water pH from reducing pesticide effectiveness:

1. Read and follow pesticide label directions regarding proper water pH.
2. Test water pH routinely to monitor changes throughout the growing season. Collect samples in a clean, nonreactive container, such as a glass jar, making sure they are representative of the water in the spray solution or mixture. Allow the water to flow long enough to flush any water left in the spray hose. Determine the pH immediately after collection using pH paper.
3. Apply pesticide spray solutions as soon as possible after mixing. The spray solution or mixture should be used within 6 hours to avoid any problems.
4. Adjust water pH with buffers or water-conditioning agents to prevent alkaline hydrolysis and maintain the pH within the desired range.

Table 1. Optimum water pH of insecticides and miticides registered for use in greenhouses. Common name is the same as active ingredient.

Common Name	Trade Name	Optimal Water pH
Abamectin	Avid	6.0 to 7.0
Acephate	Orthene	5.5 to 6.5
Acequinocyl	Shuttle O	6.5 to 7.0
Acetamiprid	TriStar	5.0 to 9.0
Azadirachtin	Azatin/Ornazin*	5.5 to 6.5
Bacillus thuringiensis	Dipel/Gnatrol	5.0 to 8.0
Bifenazate	Floramite	6.5 to 9.0
Bifenthrin	Talstar	5.0 to 9.0
Buprofezin	Talus	5.5 to 6.5
Chlorfenapyr	Pylon	5.0 to 7.0
Chlorpyrifos	DuraGuard	5.0 to 9.0
Clofentezine	Ovation	5.0 to 8.0
Cyfluthrin	Decathlon	5.0 to 9.0
Cyromazine	Citation	6.5 to 7.0
Diflubenzuron	Adept	5.0 to 9.0
Dinotefuran	Safari	5.0 to 8.0
Etoxazole	TetraSan	6.0 to 8.0
Fenpropathrin	Tame	5.5 to 6.5
Fenpyroximate	Akari	5.5 to 6.5
Flonicamid	Aria	4.0 to 6.0
Fluvalinate	Mavrik	5.0 to 7.0
Imidacloprid	Marathon	5.0 to 7.0
Insecticidal soap**	M-Pede	6.5 to 7.5
Methiocarb	Mesurol	6.5 to 7.0
Neem oil***	Triact	5.0 to 7.0
Novaluron	Pedestal	6.5 to 9.0
Pyriproxyfen	Distance/Fulcrum	5.5 to 6.5
Pymetrozine	Endeavor	7.0 to 9.0
Pyridaben	Sanmite	5.0 to 8.0
Spinetoram + sulfoxaflor	XXpire	5.0 to 9.0
Spinosad	Conserve	6.5 to 7.5
Spiromesifen	Judo	5.0 to 7.0
Thiamethoxam	Flagship	6.5 to 9.0

* Additional trade names include: AzaGuard, Molt-X, AzaSol, Azatrol, and Aza-Direct.

** Active ingredient=potassium salts of fatty acids.

*** Active ingredient=clarified hydrophobic extract of neem oil.

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