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The Influence of Spray Water Quality on Herbicide Efficacy

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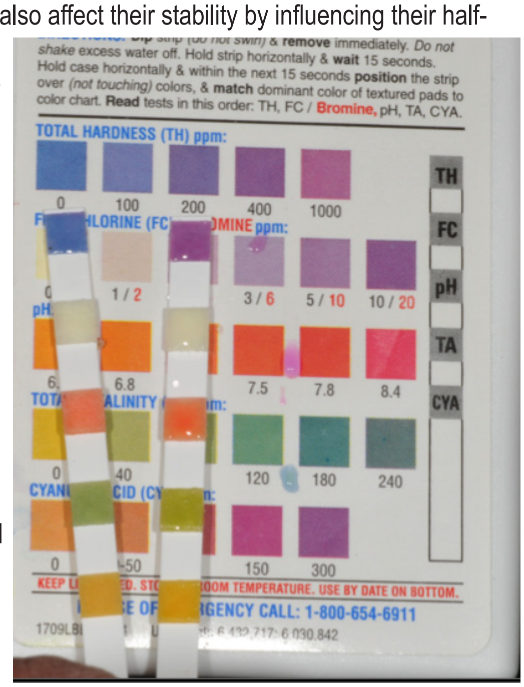
What is Water Quality?

Water is a universal solvent, and it is used as a primary carrier for crop protection products applications, constituting more than 95% of the spray volume. The properties of water used for carrier in spray solutions can greatly influence the performance of herbicides including glyphosate, Ignite, Clarity, 2,4-D, Sharpen, Pursuit, Poast, Accent, and many other herbicides. Therefore, defining the role of water quality on herbicide efficacy is very important. Unlike pure water, water quality of groundwater is variable between sources. Water quality of groundwater is determined by several factors such as pH, hardness, alkalinity, turbidity, and temperature. Presence of dissolved cations like calcium, magnesium, iron, aluminum, zinc, manganese, sodium, potassium, cesium, and lithium can influence herbicide efficacy. The presence of calcium and magnesium carbonate makes water hard whereas carbonate and bicarbonate concentration determine the alkalinity of the water. The presence of soil and/or organic matter particulate leads to the turbidity in water. The temperature of water is another factor to be considered for water quality. All these factors are important in determining carrier water quality and its role on herbicide performance.

Spray Solution pH:

Herbicides can exist in a neutral form or an ionized form depending on the water pH. Weak acid herbicides such as glyphosate, 2,4-D, dicamba, and many other herbicides remain neutral at acidic pH (< 7.0) and become negatively charged at alkaline pH (> 7.0). The leaf cuticle and cell membrane can create barriers for the absorption of negatively charged herbicide. Moreover, the negative charge on the herbicide can attract positively charged ions in the water that can form complexes with the herbicide, ultimately reducing its absorption into the plant. In contrast, basic herbicides such as some ALS herbicides (Accent) remain neutral at alkaline pH levels and become less effective as the spray solution pH becomes acidic. Extreme pH values (< 5.0 and > 8.0) not only affect the charge on herbicides but also affect their stability by influencing their half-life. Extreme water pH levels can reduce the solubility of some herbicides by preventing some of the product from dissolving and leaving some product suspended in the solution. Insolubilized or suspended herbicide precipitates can block the nozzles or screens or deposit on the plant surface, therefore decreasing the delivery of the active ingredient to the target site. If suspended particles of the herbicide settle on the bottom of the spray tank, cleaning of spray tanks can be difficult. When the spray tank is not cleaned properly, leftover traces of the herbicide can contaminate the succeeding spray applications, especially if it is applied to sensitive crops. To overcome the antagonistic effect of water pH, pH adjusters can be used to maintain the optimal carrier pH. Before using pH buffers, consult the product label as some herbicides are already formulated to act as a pH buffer.



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Cations and Hardness:

Another main component of carrier water quality that can dramatically affect herbicide efficacy is the presence of metal cations and hardness level of the water. Cations dissolved in water can interact with the herbicide structure and can form complexes and consequently reduce the absorption of the product into the plant. For example, calcium, magnesium, zinc, iron, and manganese can make complexes with glyphosate and reduce its efficacy in controlling different weeds. Diammonium sulfate (also known as ammonium sulfate or AMS) can be used to reduce the concentration of cations in the water. The sulfate ion of the AMS binds with ions such as Ca2+, Mg2+, Na+ etc. in water wheras ammonium ions of the AMS makes a complex with herbicides and increases herbicide absorption through the leaf cuticle and cell membrane. It also helps to maintain an acidic pH level outside the cell, which is very favorable for weak acid herbicides such as glyphosate.

Carbonates and Bicarbonates:

The presence of carbonates and bicarbonates can also influence herbicide performance, especially grass herbicides (SELECTMAX, Poast) and plant growth regulators (2,4-D). The levels of bicarbonates higher than 500 ppm can reduce the efficacy of these herbicides in controlling weeds. Diammonium sulfate can be used to help overcome the effect of carbonates and bicarbonates on herbicide performance.

Turbidity and Groundwater Temperature:

Another factor that can affect herbicide efficacy is the presence of soil or organic matter in the water. These particulates suspended in the water can bind to a herbicide and lower its efficacy. Particulates can also block nozzles and screens and reduce the delivery of the product. Applicators must avoid using cloudy or murky water for herbicide applications. Groundwater temperature can also affect herbicide efficacy. For instance, application of herbicides in cold water, particularly in early spring, can decrease the solubility of the product and cause some products to create a sludge in the bottom of tanks.

Additional Suggestions:

Pesticide applicators should analyze their water resources to determine the properties of their spray carrier, especially if inconsistent weed control has been observed with previous herbicide applications. Ammonium sulfate should be added to herbicide applications when cations are present in order to decrease the concentration of cations in the solution. pH adjusters can be used if the pH of the groundwater or pond water is outside the preferred pH range for the product. Lastly, try to mix the spray solutions as close to application as possible, because prolonged storage of spray solution can degrade the product before it reaches to the target site, especially in carrier water having extreme pH values.

Equation to Determine the Amount of Diammonium Sulfate (AMS):

This equation has been developed by North Dakota State University to calculate the amount of diammonium sulfate in pounds for 100 gallons of water.

AMS (lbs/100 gallons) = 0.005*ppm Na^+ + 0.002*ppm K^+ + 0.009*ppm Ca^{2+} + 0.014*ppm Mg^{2+} + 0.042*ppm Fe^{2+}

PARAMETER	RESULT	UNIT	REPORTING LIMIT	MDL	ANALYST	ANALYSIS DATE	METHOD REFERENCE
Alkalinity, CaCO3	317	mg/L	1		SH	3/20/2009	SM-2320B
Conductivity	0.60	mmho/cm	0.01	0.01	SH	3/25/2009	EPA-120.1
pH	7.70		0.01	0.01	SH	3/25/2009	SM(20th)-4500-H+B
Solids, Total Dissolved (est.)	382	mg/L	1.0		SH	3/25/2009	SM(20th)-2510A
Temperature at time of pH reading	14.3	deg. C	0.1		SH	3/25/2009	EPA 150.1
Chloride	6.24	mg/L	3.50	0.67	SH	3/26/2009	EPA-325.2
Nitrogen, Nitrate+Nitrite (as N)	0.17	mg/L	0.05	0.01	SH	3/25/2009	EPA-353.2
Phosphorus, Ortho (as P)	BDL*	mg/L	0.07	0.015	SH	3/24/2009	EPA-365.1 Rev.2.0
Carbonate, CO3	BDL*	mg/L	1		SH	3/20/2009	EPA 310.1
Bicarbonate, HCO3	385	mg/L	1		SH	3/20/2009	EPA 310.1
Boron	BDL*	mg/L	0.1		MTG	3/23/2009	EPA-200.7
Calcium	68.4	mg/L	1.0	0.26	MTG	3/23/2009	EPA-200.7
Iron	0.37	mg/L	0.08	0.016	MTG	3/23/2009	EPA-200.7
Potassium	1.03	mg/L	0.02	0.03	MTG	3/23/2009	EPA-200.7
Magnesium	25.21	mg/L	0.23	0.05	MTG	3/23/2009	EPA-200.7
Manganese	BDL*	mg/L	0.17	0.03	MTG	3/23/2009	EPA-200.7
Sodium	15.7	mg/L	0.36	0.07	MTG	3/23/2009	EPA-200.7
Sulfur (as Sulfate)	14	mg/L	0.5	0.1	MTG	3/23/2009	EPA-200.7

Example:

Water Test Results:

Na^+: 15.7

K^+: 1.03

Ca^{2+}: 68.4

Mg^{2+}: 25.2

Fe^{2+}: 0.37

AMS (lbs/100 Gal) = (0.005*15.7) + (0.002*1.03) + (0.009*68.4) + (0.014*25.2) + (0.042*0.37)

AMS (lbs/100 Gal) = 0.0785 + 0.0021 + 0.6156 + 0.3528 + 0.0155

AMS (lbs/100 Gal) = 1.0645