Heavy growth of Spanish needle weeds in a Collier County citrus grove in Southwest Florida

Herbicide adjuvants in citrus weed control

By Ramdas Kanissery

Adjuvants (derived from Latin, *adiuvare*: to aid or help) are materials added into an herbicide spray solution that improve handling, performance and crop safety. To be effective, an herbicide must overcome certain environmental and biological obstacles before entering and acting in the weeds. For example, environmental conditions like hot and dry weather will result in a thicker than normal leaf wax layer and obstruct the weed's herbicide uptake and transport processes.

Morphological features like cuticular hairs on the leaf surface can reduce herbicide efficacy by interrupting the spray droplets when they contact the leaf surface. Adjuvants modify herbicide's physicochemical characteristics and thus help to overcome these obstacles. Herbicide-adjuvant interactions are not simple processes and depend on factors that include herbicide products, targeted weeds, weather conditions and adjuvant type.

There are numerous types of adjuvants on the market available for use in citrus weed control, including surfactants, buffering agents, drift reduction agents, etc. Growers may have questions about their necessity, significance and interchangeability. Understanding the different types of adjuvants can help with proper selection and use of these products for improving herbicide performance in citrus production.

There are two general types of adjuvants used for tank-mixing with post-emergent herbicides in citrus: surfactants and spray utility agents.

SURFACTANTS

Surfactants are a shortened form of *surf*ace-*act*ive age*nts*. As the name suggests, they are adjuvants designed to improve the leaf surface contact and coverage of herbicide sprays. Surfactant products generally increase retention by reducing the spray runoff from the foliage and enhance the penetration of herbicide sprays into the leaf surface. Several types of surfactants are utilized in herbicide tank mixtures in citrus.

Nonionic surfactants (NIS) are water-soluble compounds that do not have an ionic charge on the molecule. They are composed of alcohols and/

or fatty acids and are compatible with most herbicides. NIS reduce the water molecule's surface tension, consequently allowing the spray droplet to cover a larger leaf surface area. NIS are sometimes referred to as spreading agents or wetting agents. When used in the spray mixture per label directions, NIS generally enhance the weed control efficacy of several post-emergent herbicides (Figure 1). This type of surfactant product's standard use rate is 0.25 to 1% volume per volume (v/v) or 2 to 8 pints per 100 gallons of the final herbicide spray solution.

Crop oil concentrates (COC) are a blend of petroleum oil-based products and a small percentage (up to 20%) of NIS. This surfactant group also improves leaf surface spreading by reducing surface tension and enhancing weeds' herbicide uptake. COC are often known as penetrating agents. The typical rate suggestion for COC in the tank mix is at 1% (v/v) of the final spray unless otherwise instructed.

Methylated seed oils (MSO) are plant-based oils modified through a process known as esterification, where these oils are reacted with an alcohol to form esters. The oil is typically derived from the seeds of sunflower, soybean, corn, canola, etc. This group of surfactants has good spreading and penetrating properties. MSO are generally used at 0.25 to 1.0% (v/v) of spray solution.

Organosilicones are usually a blend of silicone products with other surfactants like NIS. Apart from providing improved effectiveness through

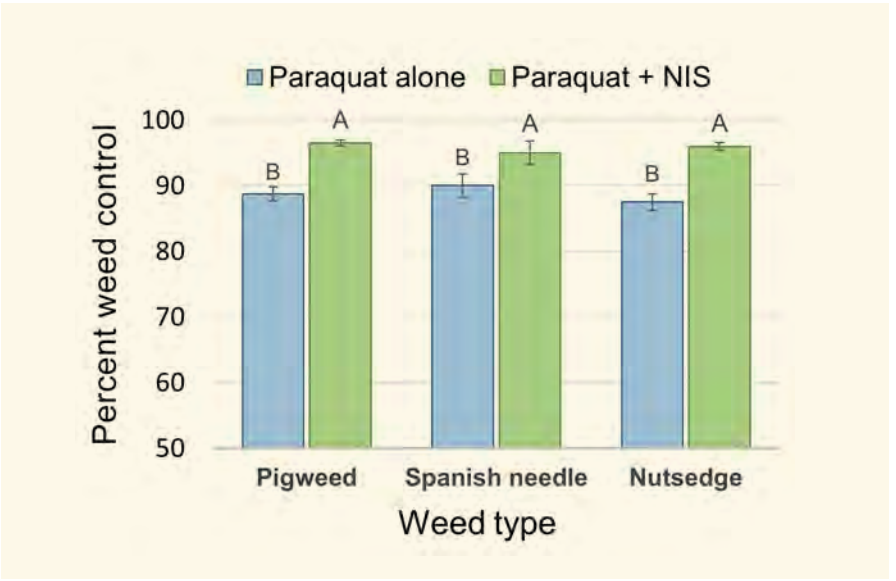

Figure 1. Effect of nonionic surfactant (NIS) on the weed control efficacy of post-emergent herbicide paraquat on different citrus weeds in a greenhouse study conducted at the Southwest Florida Research and Education Center. Observations were made 15 days after applying the treatments. Bars in the graph with the same letters are not significantly different.

herbicide spreading and retention, this surfactant class provides better rain fastness to the herbicide sprays on the foliage.

SPRAY UTILITY AGENTS

Spray utility agents improve the mixing and delivery of herbicide sprays. Once added to the spray mixture, they will modify the spray solution characteristics (e.g., droplet size, viscosity, pH, etc.). Examples of spray modifiers include:

Drift reduction agents (DRA) make the sprays easier to aim at the targeted weeds, subsequently reducing the herbicide's drift into the trees or non-targeted areas in groves. They modify sprays to reduce drift, usually by increasing the droplet size. They are chemically polyacrylamide, or polyvinyl polymer compounds made up of large chain-like molecules that help to break the surface tension of spray solution, thereby restricting the formation of driftable tiny spray droplets (e.g., less than 150 microns). Although very effective in reducing drift and associated crop injuries, if not used according to the product label suggestions, DRA can make the spray droplets too large, potentially resulting in clogging the spray nozzles or even poor spray coverage.

Antifoam agents (also known as defoamers) usually are added to suppress the formation of foam in the tank during agitation and mixing. Foaming and the resultant air entrapment in the spray tank can potentially cause pump and sprayer problems. Antifoam agents are often made from silicone-based products.

Buffering agents (also known as water-conditioning agents) are added to change the spray solution's pH to improve the herbicide dispersion and thereby stabilize its activity. Most herbicides will have a better activity when the spray solution's pH is between 4.0 and 6.5. Buffering agents are used particularly when hard water is utilized in making an herbicide tank mixture. When water is high in dissolved minerals, mainly calcium and magnesium, it is referred to as hard water.

Spray utility agents improve the mixing and delivery of herbicide sprays.

Ammonium-based fertilizers like ammonium sulfate (AMS) can also be added to the spray solution to reduce the effects of hard water and improve herbicide efficacy. Ammonium salts ($NH4^+$) are believed to be the active component of these fertilizer solutions to improve herbicide performance. Glyphosate is an example of an herbicide that appears to benefit from the use of such adjuvants. Certain glyphosate products (e.g., Roundup) have a recommendation on the label for the addition of AMS for hard water, cool air temperatures or drought conditions. Check the specific herbicide product label, hardness of the water source for herbicide mixing, and environmental conditions to determine the need for AMS. The typical AMS rate is from 8.5 to 17 pounds per 100 gallons of water. AMS always should be added to the tank-mix water and agitated well before adding herbicide products.

Table 1. Adjuvants used in citrus weed management

Adjuvant type		Example product(s)[a,b]	Remarks on usage[b]
Surfactants	Nonionic surfactants	LI 700 Activator 90 Zandar Induce	Used with most herbicides except a few products like saflufenacil
	Crop oil concentrate	Crop Oil Plus Agri-Dex Prime Oil	Used primarily with selective grass herbicide products like fluazifop, sethoxydim, etc.
	Methylated seed oils	Hasten Meth-oil	Used with herbicides like saflufenacil
	Organosilicones	Kinetic Sylgard 309 Sil-Fact	Used as an all-purpose surfactant for improving spray retention
Spray utility agents	Drift reduction agents	Grounded Crosslock	Used for improving spray delivery by reducing spray drift
	Antifoam agents	Unfoamer No-Foam	Used for reducing the mixing issues of the herbicide product in the tank
	Buffering agents	Quest Buffer-75	Used for maintaining the tank mix water pH in a desirable range for optimal herbicide activity
	Ammonium-based fertilizers	Ammonium sulfate Urea ammonium nitrate	Used for managing water hardness for improving herbicide efficacy

[a]Including but not limited to these products.
[b]Read and follow the specific product label before usage.

SELECTION CONSIDERATIONS

The selection of an adjuvant should be based on several factors, including the herbicide product requirement, mixing and application condition, cost of the adjuvant and availability. A great source for deciding whether an adjuvant is required or getting more information on compatibility with various adjuvant types is the herbicide product label.

With some herbicides, a specific adjuvant may work better than others. The adjuvants suggested on the label of an herbicide product should not be interchanged with others. For instance, saflufenacil requires the use of

MSO-based adjuvants; utilizing NIS as a substitute would result in poor weed control performance. Similarly, the performance of adjuvants may also depend on the type of weeds. For example, COC should be considered for grass weed control if labeled to be used with the intended herbicide product.

Some herbicides are compatible with more than one type of adjuvant, like paraquat, which is compatible with NIS, COC and MSO. There are some general tips to consider to get the best out of the herbicide and surfactant in such circumstances. For instance, if both NIS and COC are listed on the herbicide product label, consider using NIS under normal weather conditions or when weeds are young. Use COC in the tank-mix for a herbicide if weeds are stressed due to extreme weather or when they are in a mature growth stage. If crop injury potential for the herbicide is high, then use NIS instead of COC.

SUMMARY

An adjuvant that will best complement an herbicide's active ingredient and formulation type should be selected for specific mixing and spraying situations. Different types of adjuvants used for improving herbicide performance in citrus weed management are summarized in Table 1 (page 18). Using the appropriate adjuvant ensures maximum weed suppression while minimizing the herbicide-related injuries to trees, whereas incorrect adjuvant use will reduce the weed control efficacy and crop safety.

It is necessary to follow the herbicide product label guidelines and select the appropriate adjuvant for its spray mix. Moreover, tank-mixing the herbicides and adjuvant products in the right order is very important for a successful herbicide spray. For more information about the correct mixing order of components, refer to EDIS publication PI285 (edis.ifas.ufl.edu/pi285) and a previous Citrus Industry article (crec.ifas.ufl.edu/extension/trade_journals/2014/2014_July_proper_mixing.pdf) on this topic.

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