

## Maximizing the Use of Glyphosate

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Glyphosate is the most widely used herbicide in the US. It was discovered in the late 1960's, patented by Monsanto in 1974 and came off of patent in 2000. It kills a broad spectrum of plants and was initially limited to non-crop and fallow use and was expensive. The use of Glyphosate increased significantly around 2000 when it came off of patent and genetically engineered crops with resistance to Glyphosate were being developed.

The popularity of Glyphosate is based on its broad spectrum weed control, lack of soil residual activity which does not limit what can be planted following use, low mammalian toxicity and its currently affordable price. Unfortunately, the heavy reliance on Glyphosate has led to an alarming increase in resistant weeds and shifts to tolerant weeds. Although no weeds in this area have yet to be documented to be resistant, weed shifts have occurred.

Glyphosate is a very broad spectrum, foliar applied and highly systemic herbicide. It is absorbed by the foliage and moves throughout the plant. It works by inhibiting the production of the EPSP enzyme that is needed for many phases of plant growth and development. It uses the same general mode of action as many other herbicides that inhibit amino acid synthesis. Most of these are ALS inhibitors such as Pursuit, Raptor, Express, Affinity, Sandea, Osprey and others. Glyphosate and Sulfosate (Touchdown) are the only ones that inhibit EPSP. It can persist in soil but is so tightly bound that it has no soil activity. Although it kills many weeds, its performance can be greatly affected by many factors. These include application variables and environmental factors as well as characteristics of the weeds. The factors affecting Glyphosate have been intensively studied, are interrelated and can be complex. A brief and simplified review of the most important of these factors follows.

#### **Formulation:**

Glyphosate came off of patent in 2000 and there are now more than 40 products on the market that contain this active ingredient. All of these products are formulated with Glyphosate attached as a weak acid on one of four different salts; ammonium salt, diammonium salt, dimethylammium salt, isopropylamine salt and or potassium. The concentration of active ingredient in most herbicides is listed on the label as pounds active ingredient per gallon. Salts have different molecular weights and it is therefore necessary to look not for the weight per gallon but the acid equivalent(ae) per gallon. Glyphosate products can contain from 3-6 pounds ae per gallon. The use rate must be adjusted accordingly.

The other major difference in Glyphosate formulations is the addition of adjuvants. Some products contain surfactants to improve spreading, sticking and penetration, defoamers, drift retardants and other adjuvants while other products may contain Glyphosate alone. Adjuvants play an important role in the performance of Glyphosate and will be further discussed in the next section.

#### **Adjuvants:**

Glyphosate must be absorbed into the foliage to be translocated to the sites of action. Weeds, especially those growing in the desert regions, often have barriers to this absorption. These barriers include both epicuticular waxes which chemically repel Glyphosate and pubescence that limit physical contact with the leaf surface. Waxes on plant leaves are lipophilic and chemically non-polar and repel water and herbicides like Glyphosate which are hydrophilic and chemically polar. Adding non-ionic

surfactants (NIS) at a rate of 0.25% to 1% will significantly increase how well Glyphosate spreads on and enters leaf surfaces. In general, the addition of crop oil concentrates (COC), methylated seed oils (MSO) and organosilicones are not recommended.

Water in this region often contains excessive amounts of salts including calcium, magnesium, iron and sodium. These salts bind to Glyphosate and reduce its absorption and solubility. The addition of ammonium sulfate (AMS) and water conditioners have been shown to significantly improve weed control with Glyphosate. The sulfate component of AMS is negatively charged and will bind to positively charged salts so that they cannot reduce the activity of Glyphosate. These products should be added to the water before the Glyphosate is added or they may not help.

### **Water Quality:**

Glyphosate binds more strongly to soil, dust and organic matter than almost all other herbicides. When this happens, it is unavailable to be taken up by plants. Soil that is on the plant, in the air, or in the spray tank can reduce activity. Clean water should be used and any practices that reduce dust on the plants or in the air will help.

### **Spray Volume:**

The fact that Glyphosate works best at low spray volumes of 10 gallons or less has been well documented. This is probably because of increased absorption from more concentrated and smaller droplets. Spray volumes of 10 gallons or less are not only difficult to apply by ground but can cause problems with this herbicide. Glyphosate is non-selective and off target drift becomes more likely at low spray volumes. It is also important to get good coverage with Glyphosate and it can be difficult to get through a thick canopy of weeds at lower volumes.

### **Environmental Factors:**

All systemic herbicides work best when the target weeds are actively growing and not under stress. All conditions that cause stress will decrease activity. These can be from drought, high or low air temperatures, pest damage, very low humidity, low fertility and other conditions. Time of day that application is made can have a significant effect on activity. Early morning and evening applications are best during the hot summer months. The weeds are growing more actively at this time. Plants shut down during the hot times of the day in the summer, the herbicide dries out quickly on the foliage and uptake is minimized at this time. The plants are not growing at night and it is better to make application either in early morning or late afternoon. In the winter, best control may change to mid-day applications when conditions are more optimal for plant growth. High humidity and calm winds keep the herbicide in the liquid phase longer and increase absorption.

### **Application Timing:**

Glyphosate works best on small weeds but has no preemergent activity on weeds that have not yet germinated. In this region where weeds continue to germinate over a long time, it is always a tradeoff between treating early enough to kill emerged weeds while they are small but not too early before many weeds have yet to germinate.