

Tips for Identifying Postemergence Herbicide Injury Symptoms in Soybean

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Soybean is the world's largest source of protein for animals and the second largest source of vegetable oil for humans. As of 2015, the United States is the major soybean producing and exporting country in the world. Weed management is an important component of soybean production practices. Soybean growers mostly rely on postemergence herbicides for mid- or late-season control of weeds. After commercialization of the glyphosate-tolerant (Roundup Ready®) corn and soybean, the use of glyphosate increased dramatically, and subsequently became the world's top-selling herbicide.

For the last 20 years, glyphosate has provided excellent broad spectrum weed control in Roundup Ready corn and soybean. However, the repeated application of glyphosate has resulted in selection pressures leading to the evolution of glyphosate-resistant weeds. As of 2015, glyphosate resistance has evolved in six broadleaf weeds in Nebraska: common ragweed, common waterhemp, giant ragweed, kochia, marehail, and Palmer amaranth. Therefore, the widespread occurrence of glyphosate-resistant weeds in Nebraska has compelled growers to use and rotate herbicides with different sites of action.

The herbicide site of action refers to the site at which the herbicide inhibits or restricts a plant's normal physiological processes at the cellular level. This is sometimes referred to as mode of action, although there is a difference between the two, as mode of action refers to how the herbicide actually works. The most commonly used postemergence herbicides in soybean include acetyl-CoA carboxylase (ACCase)-inhibiting (Fusilade DX®, Select Max®, etc.), acetolactate synthase (ALS)-inhibiting (Classic®, Pursuit®, etc.), 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS)-inhibiting (Roundup PowerMax®, Touchdown HiTech®, etc.), and protoporphyrinogen oxidase (PPO)-inhibiting (Cobra®, Flexstar®, Ultra Blazer®, etc.) site of action groups. These can be denoted by the site of action group numbers determined by the Weed Science Society of America; for example, Group 1 for ACCase inhibitor, Group 2 for ALS inhibitor, and Group 9 for EPSPS inhibitor.

Crop safety is an important feature of postemergence herbicides because a high level of crop injury can reduce the crop yield. A few herbicides may sometimes injure crop plants and such injury depends on several factors, including:

Environmental Conditions

- **Environmental conditions.** All herbicides require optimum conditions for maximum efficacy. Variable temperature, relative humidity, soil texture, and soil moisture may play an important role in soybean injury.

Directions for Use

- **Directions for use.** Herbicide labels provide information about herbicide rate, method of application, and adjuvants to add, along with the crop/weed species and plant/weed growth stage to apply herbicide. Any violation to instructions may result in soybean injury.

Herbicide Active Ingredients

- **Herbicide active ingredients.** Some herbicide active ingredients, such as PPO inhibitors, along with the additives, oftentimes cause some level of injuries to soybean, but soybean plants are resilient and usually overcome herbicide injuries in a week or two, often without impacting crop yields.

Off-Target Movement

- **Off-target movement.** Off-target movement of herbicides applied in a nearby field may cause injury, resulting from either physical spray drift or vapor drift. *Physical drift* occurs during herbicide application when small droplets move from the site of application to nearby fields. *Vapor drift* occurs when herbicides evaporate off the target site and are transported by the wind off-target. It is often intensified and can result in greater injury when a temperature inversion exists. Vapor drift is chemical-specific and occurs under high temperatures and low relative humidity. 2,4-D ester is a plant growth regulator herbicide that is more prone to drift due to high vapor pressure, and 2,4-D vapor drift can damage sensitive broadleaf plants far from the site of application.

Tank mixtures

- **Tank mixtures.** Herbicide pre-mixtures, tank mixtures may result in combined symptoms of injury in crops. In *Figure 1*, combined leaf injury (dark red leaf vein and speckling) can be seen when Raptor® (ALS inhibitor) was applied in a tank mix with Ultra Blazer® (PPO inhibitor).

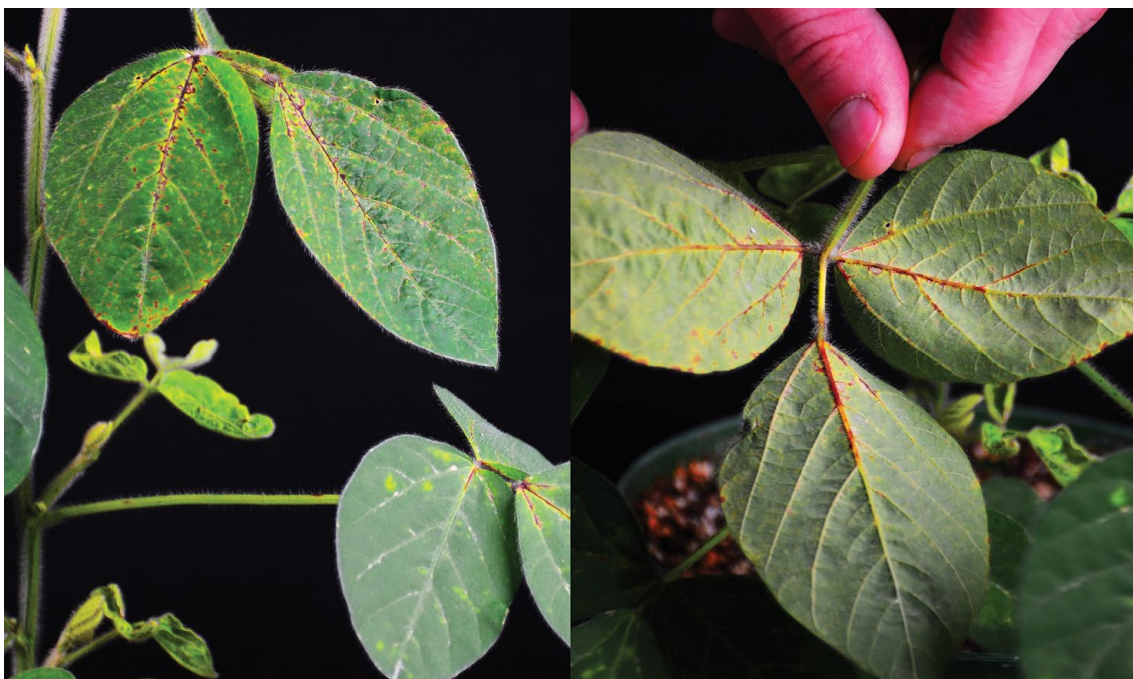


Figure 1. Combined leaf injury (ALS- plus PPO-inhibitor) on Roundup Ready® soybean leaf

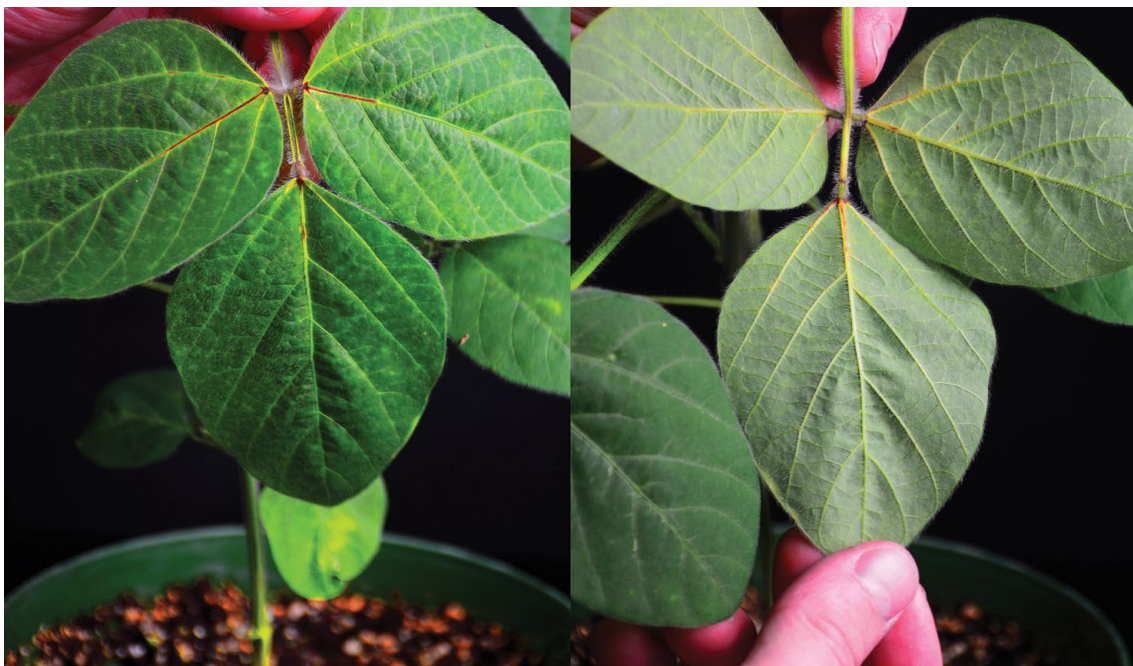


Figure 2. Soybean leaf chlorosis and purple leaf vein due to application of thifensulfuron-methyl (Harmony® SG)

Herbicide Injury on Glyphosate-Tolerant (Roundup Ready) Soybean

Because of the increasing number of glyphosate-resistant weeds, application of other postemergence soybean herbicides is increasing. Tips to identify herbicide injury symptoms on Roundup Ready soybean include:

- **ALS Inhibitors (Group 2):** *Classic*®, *Harmony*®, *Pursuit*®, *Raptor*®. Herbicide injuries include the stunting of soybean plants, leaf chlorosis, and purple leaf veins (Figure 2). Postemergence application injury with these herbicides increases on days with high temperatures and humidity. Due to systemic activity (translocation) throughout the plant, young leaves are the first

Herbicide
Injury on
Glyphosate-
Tolerant
(Roundup
Ready) Soybean

ALS Inhibitors
(Group 2)

Glutamine Synthetase Inhibitors (Group 10)

to be affected after herbicide application (*Figure 3*), although soybean plants can overcome injury symptoms within several weeks due to their rapid growth. Herbicide mixtures of ALS inhibitors with glyphosate (e.g., Tackle®, Extreme®, Touchdown HiTech® plus Scepter®, etc.) may show similar symptoms on Roundup Ready soybean.

- **Glutamine synthetase inhibitors (Group 10): Liberty®.** To combat the increasing number of glyphosate-resistant weeds in the United States, glufosinate-tolerant (LibertyLink®) soybean was introduced as an alternate herbicide-tolerant crop to diversify weed control strategies. Glufosinate (Liberty) can be applied postemergence in LibertyLink soybean, though misapplication of Liberty on Roundup Ready soybean will cause significant injury. Chlorosis and wilting of the soybean plants can be observed within three to five days after application, followed by necrosis (*Figure 4*) in one to two weeks. These symptoms can mostly be observed on older leaf tissues. Bright sunlight, high humidity, and moist soil can increase the intensity of glufosinate (Liberty) injury on soybean plants that are not tolerant to glufosinate.

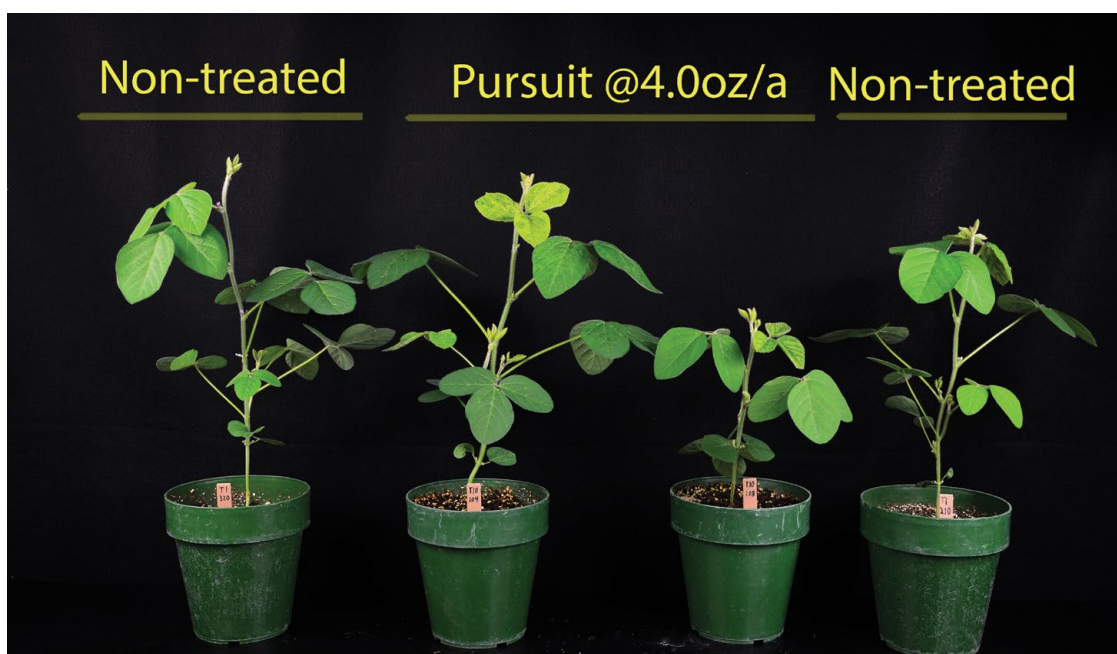


Figure 3. Leaf chlorosis on the younger leaf of soybean at 14 days after imazethapyr (Pursuit®) application



Figure 4. Roundup Ready® soybean leaf at 14 days after glufosinate (Liberty®) application

- **Long-chain fatty acid inhibitors (Group 15):** *Outlook®*, *Warrant®*, *Zidua®*. Herbicides from this site of action group are registered for residual control of grass and small-seeded broadleaf weeds. Few herbicides from this site of action are also labeled for postemergence application in soybean. Cold and wet weather during herbicide application increases the possibility of injury to soybean leaves, with symptoms including shortening of the mid-vein with crinkled and heart-shaped leaves (*Figure 5*).
- **Photosystem-II inhibitors (Group 6):** *Basagran®*. Few herbicides from this site-of-action group are registered for postemergence use in soybean. Bentazon (Basagran) is believed to be safe on soybean foliage (*Figure 6*), but under certain conditions may cause bronzing or necrotic spots starting from the leaf margin, or chlorosis of the leaves.

Long-Chain Fatty Acid
Inhibitors (Group 15)

Photosystem-II
Inhibitors (Group 6)



Figure 5. Soybean leaf injury due to application of acetochlor (*Warrant®*)



Figure 6. Soybean leaf as no injury can be seen here at 14 days after bentazon (*Basagran®*) application

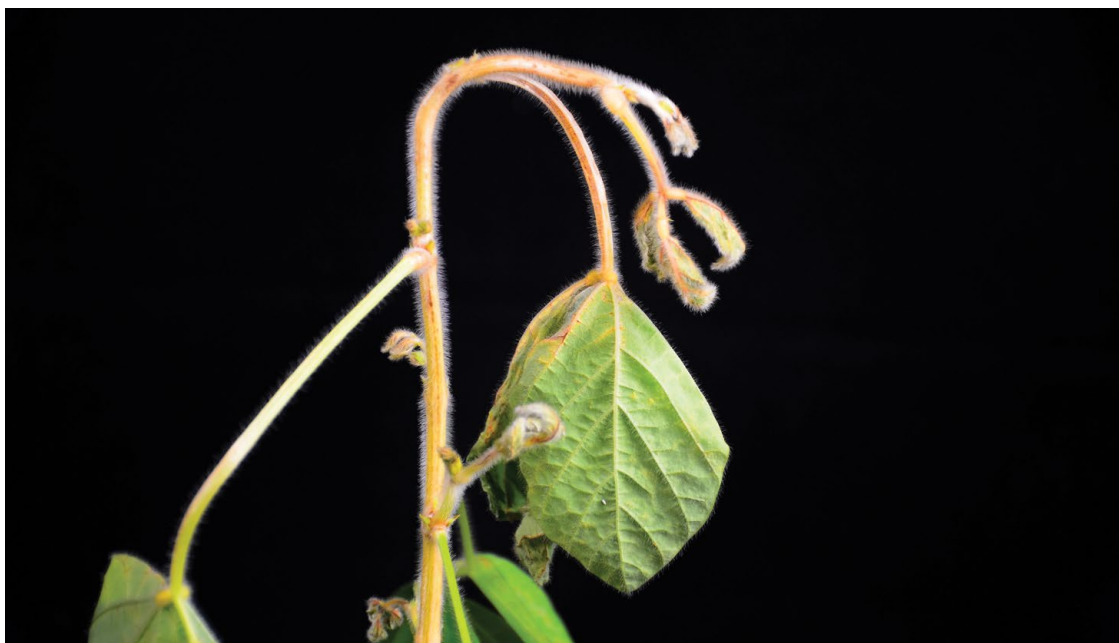


Figure 7. Twisting of Roundup Ready® soybean stem and petiole followed by the application of dicamba plus glyphosate (Roundup Xtend™)



Figure 8. Roundup Ready® soybean plants at 14 days after application of 2,4-D choline and glyphosate (Enlist™ Duo)

- **Plant growth regulators (Group 4):** 2,4-D, Clarity®, Weedone®. Soybeans are sensitive to plant growth regulator herbicides if not tolerant to 2,4-D (Enlist™ Soybean). Several herbicides from this site of action group are volatile, and the misapplication or drift of these herbicides may cause injury to soybean plants or other sensitive plants. As these herbicides are systemic in nature, soybean injury can be observed on newly developed tissues or leaves. Injury symptoms include epinastic (downward) bending or twisting of the stems and petioles (Figures 7 and 8), along with leaf cupping and curling (Figure 9). Leaf shape and venation are often abnormal after exposure to plant growth regulator herbicides, followed by chlorosis of young leaves, and wilting. It may take two to four weeks to kill soybean plants after an application of a plant growth regulator herbicide. The newly developed Enlist soybean is tolerant to the 2,4-D choline and glyphosate (Enlist Duo™) herbicide, which can be applied post-emergence in Enlist soybean. Similarly, the upcoming Roundup Ready 2 Xtend™ soybean will be tolerant to dicamba plus glyphosate (Roundup Xtend™).



Figure 9. Dicamba (Clarity®) drift on the Roundup Ready® soybean under field conditions

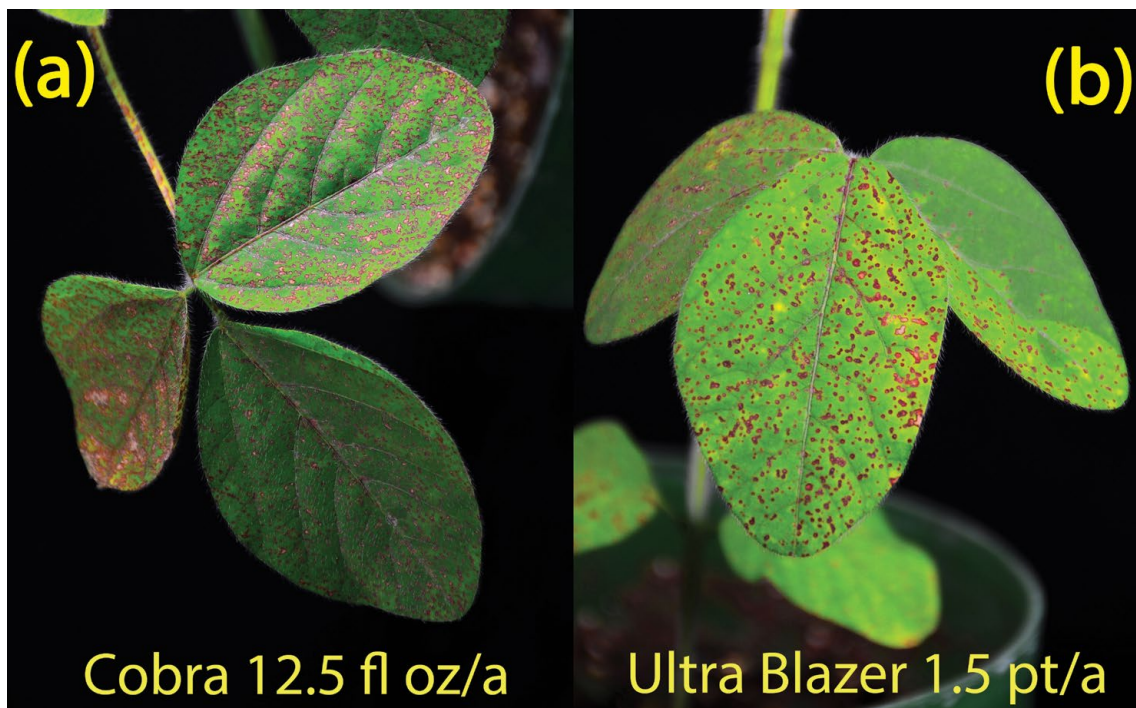


Figure 10. Bronzing and speckling on soybean leaves due to (a) lactofen (Cobra®), and (b) acifluorfen (Ultra Blazer®) application

- **PPO inhibitors (Group 14):** *Cadet™*, *Cobra®*, *Flexstar®*, *Ultra Blazer®*. Postemergence herbicide applications with PPO-inhibiting herbicides may result in soybean injury, specifically during hot and humid weather. Sometimes, tank contamination and drift will also result in PPO inhibitor herbicide injuries to soybean. Injury symptoms range from bronzing and speckling of the leaves (Figure 10) to necrosis of the leaf tissue. PPO inhibitors are contact herbicides, and symptoms can be observed on the fully opened leaves at the time of herbicide application. Lactofen (*Cobra*) is one of the postemergence herbicides widely used by soybean growers to control glyphosate and ALS-inhibiting herbicide-resistant weeds, including common waterhemp. It may injure soybean 7 to 14 days after herbicide application, but soybean plants can usually overcome injuries in 21 to 30 days after herbicide application without yield loss (Figure 11).

PPO Inhibitors (Group 14)

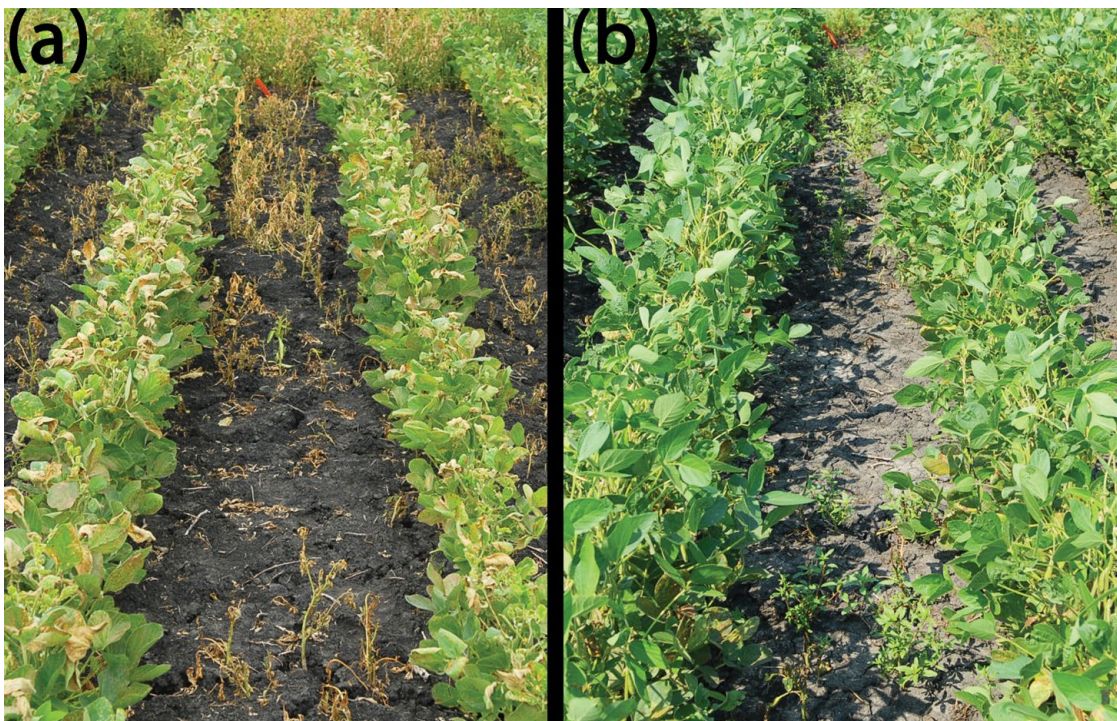


Figure 11. (a) Soybean injury at 14 days after lactofen (Cobra®) application, (b) soybean plants recovering the injury at 30 days after lactofen (Cobra®) application under field conditions

Soybean plants are usually resilient to overcome herbicide injuries when the herbicide is registered for use over the top of the soybean canopy and applied per label directions. To combat increasing herbicide resistance issues in weeds, it is essential to rotate herbicides with different sites of action and to include residual, preemergence herbicides in a weed management program. It is also important to read the herbicide label and follow the application instructions.

Resources

Resources

For more information about the efficacy of herbicides on specific weed species and crop tolerance, refer to the Guide for Weed Management in Nebraska (EC130), available for purchase online at <http://marketplace.unl.edu/extension/ec130.html>.

Practical Weed Science for the Field Scout. University of Missouri Extension. Available online to download at <http://extension.missouri.edu/explorepdf/agguides/pests/ipm1007.pdf>.

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