MISSISSIPPI STATE UNIVERSITY EXTENSION

Land Manager's Guide to Wildlife Food Plot Herbicides

Sustainable food plot production relies on promoting growth of desired species while reducing competition from undesirable species. Managers typically consider a "weed" to be an undesirable plant that will hinder food plot success. A recent survey of food plot managers revealed the two most important metrics of success were 1) use of the food plot by white-tailed deer and wild turkey, and 2) good establishment of planted species with few weeds.

A manager's tolerance for unplanted species should vary based on food plot objectives. If the objective of a food plot is to maximize pounds of the planted forage, then tolerance for unplanted species will likely be low. However, if the objective is to optimize forage production of planted species with the forage and structural value of naturally occurring plants, tolerance for unplanted species should be greater.

Naturally occurring plants, which might be viewed as weeds by some managers, can add tremendous forage and structural value to food plots. For example, common ragweed, daisy fleabane, and prickly sida, even when relatively dense throughout a perennial clover plot, are commonly eaten by deer and provide excellent structure for turkey broods as they forage on clover and insects. Plants such as these are commonly considered weeds, but they should be viewed as assets that enhance the value of the food plot for deer and turkeys. However, most managers are not aware of the value of many naturally occurring species. Managers should make the decision to control or not control weeds on a case-by-case basis informed by the target wildlife species, competitive tendencies of the plant, and value or detriment of the plant to the overall performance of the food plot.

Figure 1. This food plot was planted in wheat, red clover, and white clover. Naturally occurring black-eyed Susan, common ragweed, Canada goldenrod, and Brazilian vervain are prevalent in this plot. Some managers might consider these species weeds, but deer are grazing them heavily and they enhance the structure of the food plot for turkeys.

Some unplanted species enhance the structure and forage value of a food plot, but many inhibit performance by outcompeting planted species for sunlight, water, and nutrients. Weeds cost food plot managers time and money by suppressing or killing planted species that are expensive to grow. If not controlled, many weeds will produce seed and become progressively more problematic. The foundation of long-term management is an understanding of plant identification, plant biology, value for wildlife, various weed control techniques, and knowing when and how to apply management techniques to achieve desired species composition and structure. Collectively, we refer to this process as integrated weed management, which consists of three primary weed control strategies: cultural, mechanical, and chemical.

Figure 2. This American jointvetch food plot was covered in dense weeds soon after planting. We left part of the plot unsprayed (A), and weeds developed a dense canopy and outcompeted the jointvetch by midway through the summer. In the portion of the plot that we sprayed with a timely herbicide application (B), weeds were eliminated and the jointvetch grew exceptionally well.

Cultural Weed Control

Cultural weed control is a crucial component of integrated weed management. Cultural weed control is the use of plants or planting systems to control weeds without tillage or chemicals. For example, creating a thatch layer with the previous crop to suppress weeds for the incoming planting is a cultural weed management technique. Proper seeding rates and seed placement in the soil are also cultural techniques. Planting the correct rate of pure live seed (PLS) at the proper depth and distribution will suppress weeds and reduce the need for mechanical and chemical weed control. For example, small-seeded species such as American jointvetch are often slow to establish, leaving time and growing space for weeds to colonize. By broadcasting seed uniformly throughout a field rather than planting in rows, American jointvetch seedlings consume more vacant growing space in the first few weeks following planting than they would if planted in rows, thereby reducing growing space available to weeds.

Figure 3. No-till drills are extremely versatile planting implements. No-till drills may be used to drill into the soil, top-sow into thatch, and top-sow into tilled seed beds. Top-sowing with a no-till drill distributes seed more precisely compared with spin-type spreaders. By unhooking the drop tubes when top-sowing, seeds are broadcast uniformly onto the soil surface, reducing available growing space for weeds to colonize.

Pure live seed (PLS) is one of the most important and commonly overlooked aspects of cultural weed management and overall food plot success. Seeding rates are based on PLS. Seed coatings, inert material, weed seeds, and germination rates less than 100 percent reduce PLS. For example, a full seeding rate of crimson clover is 20 pounds per acre PLS. A 50-pound bag of crimson clover seed commonly contains 47 percent pure seed with a germination rate of 85 percent. To achieve 20 pounds per acre PLS, use this formula:

$$\frac{\text{Desired rate}}{(\%\text{ pure seed} \times \%\text{ germination})} = \frac{20}{(0.47 \times 0.85)}$$

$$= 50.1 \text{ lb} / \text{ac}$$

This means 50.1 pounds per acre of the material in the bag are required to achieve 20 pounds per acre PLS. If 20 pounds were planted instead of planting the PLS rate, the food plot would contain 60 percent less seed than it should and produce a sparse food plot with excessive vacant growing space for weeds to colonize.

Adequate soil fertility is a cultural weed control technique. When soil nutrients and pH are not limiting for food plot growth, planted species are more likely to outcompete weeds, especially when planting fast-establishing species such as cowpeas, soybeans, cereal grains, and brassicas. Sufficient soil fertility also improves herbicide efficacy by promoting weed growth. Vigorously growing plants uptake herbicide more efficiently than stressed, nutrient-deficient plants.

Food plots naturally suppress weeds when deer density is balanced with forage availability. When deer grazing pressure exceeds a food plot's growth rate, planted species are short, stunted, and leave vacant growing space for weeds to colonize. Conversely, when the growth rate of planted species exceeds deer grazing pressure, planted species will form a vegetative canopy that suppresses weeds underneath. Fast-establishing species such as soybean, cowpea, sunflower, and various brassicas are especially good at suppressing weeds via canopy formation. Species that establish more slowly, such as American jointvetch, alfalfa, and many clovers, take longer to develop a vegetative canopy, leaving more time and space for weeds to colonize. However, even with slowly establishing species, balancing the forage available in food plots, woods, and old-fields with deer density ensures planted species can naturally suppress weeds.

Figure 4. The forage inside the exclusion cage has formed a canopy and is suppressing weed growth. Outside the exclusion cage, deer grazing pressure exceeds forage growth leading to bare ground and space for weeds to colonize.

Mechanical Weed Control

Mechanical weed control involves physical disruption of the root system or growing plant via mowing, cultivation, tillage, or hand-pulling. Mowing clips the tops off weeds to suppress weed growth. Mowing may reduce some annual weeds if done after flowering and before seed maturation. Mowing may limit competition from perennial weeds but does not reduce prevalence.

Figure 5. This food plot was disked twice before planting. Photo A was taken 2 weeks after the first disking and shows many grass and broadleaf weeds that were not killed by disking. Shortly after, it was disked again and planted in a warm-season food plot. Photo B was taken 2 months later and shows complete coverage of crabgrass and little to no persistence of planted species. In most cases, disking alone is an unreliable and insufficient form of weed control.

Tillage or cultivation disturbs the root systems of weeds before planting or after planting if the food plot is planted in rows. Cultivation between rows is much more common in production agriculture than in food plots, but some food plot managers use cultivation in food plots planted to forages, such as corn, sunflowers, grain sorghum, and chufa. Tillage using a disk or rotovator is beneficial for weed control in some circumstances, especially when paired with successive herbicide applications before establishing a perennial food plot to eliminate as many weeds from the seedbank as possible. However, tillage alone is ineffective for long-term weed control. Many of the plants will re-root and continue to compete with planted species unless controlled with herbicide.

Hand-pulling can be an effective means of weed control in some circumstances. For example, various thistle species and Carolina horsenettle can be controlled before seeding via hand-pulling soon after rain. These species are often difficult to control with herbicides without damaging planted species. If the weed is relatively sparse and the food plot is not too large, hand-pulling can be an effective method to rid a food plot of weeds that are otherwise difficult to control.

Chemical Weed Control

Most food plot herbicides pose little human safety risks when used properly. Glyphosate, for example, has an LD50 toxicity rating (lethal dose for 50 percent of test subjects) of greater than 5,000 milligrams per kilogram (mg/kg), whereas the LD50 for household bleach is 1,360 mg/kg. This means household bleach is approximately 3.7 times more toxic than glyphosate.

Chemical weed control relies on herbicides to suppress or kill undesirable plants. There are hundreds of herbicides labeled for use in various agronomic plantings. Herbicides are classified by delivery method to the target weed: preemergence, preplant incorporated, and postemergence.

Preemergence herbicides are sprayed onto the soil surface before weed germination and are soil active. Rainfall incorporates the herbicide into the soil solution, then the preemergence herbicide kills the weed when it germinates below the soil surface. Preemergence herbicides are often applied at the time of planting, but some may be applied over established crops.

The label is the law. Herbicide labels provide the **legal requirements** for safe and effective herbicide use. A herbicide's label specifies the rate, timing, environmental conditions, weeds controlled, necessary surfactants, plant-back interval, rainfast interval, and tank-mix compatibilities legally mandated for herbicide use. No information in this document can replace a thorough understanding of a herbicide's label. Always read and follow the label.

Figure 6. Preemergence herbicides are often sprayed directly on the soil surface after planting and before food plot establishment. Rainfall draws the herbicide into soil solution and kills weed seedlings before they can emerge. Some preemergence herbicides may be sprayed over established plantings, such as a spring application of imazethapyr in perennial clover or alfalfa for spring and summer weed suppression.

Preplant incorporated herbicides are applied at the time of planting and are less mobile in the soil than preemergence herbicides. They require tillage to incorporate the herbicide to the proper depth (typically 2 inches) in the soil profile but otherwise function similarly to preemergence herbicides. For preemergence and preplant incorporated herbicides, it is important to use sprayer nozzles that produce small droplets to achieve adequate coverage on the soil surface.

Postemergence herbicides are applied to the leaf surface of weeds after the weed has emerged from the soil.

In cases where the manager knows which weed species are likely to be problematic before planting, we recommend preemergence or preplant incorporated herbicides where possible. **Controlling weeds before they become problematic is important**. As weeds mature, they become more difficult to control and more detrimental to the productivity of planted species.

Figure 7. This food plot was sprayed during a stretch of warm weather in January. The weeds are small and hard to notice without careful examination, but they covered about 70 percent of the food plot. By spraying when weeds are young, herbicide efficacy is greatly increased and planted species establish with less competition, leading to increased forage production. Do not wait until weeds are a problem to spray; spray before weeds become a problem.

> Do not overlook spot-spray applications with a backpack sprayer or spray wand to control problematic weeds. When weeds are relatively sparse, spot applications of an herbicide such as glyphosate at 2% solution are highly effective. Spot applications often allow use of herbicides that are more effective at controlling weeds than would be permitted in broadcast applications because of unwanted collateral damage to planted species.

Crop rotation combined with herbicide application can be a very effective combination of cultural and chemical weed control strategies. Some combinations of planted species and weed species make it difficult, if not impossible, to achieve satisfactory weed control. For example, perennial clover food plots are often colonized by aggressive weeds such as Carolina horsenettle. There are no effective broadcast herbicide options for controlling Carolina horsenettle in clover. During the first years after the food plot is established, spot-spraying with glyphosate may achieve adequate control, but after several years, coverage may become too dense to justify spot-spraying. In this case, rotating to a different crop that allows use of more effective herbicides or simply allowing the plot to go fallow for a few years are the best options.

Figure 8. Herbicides are sold under trade names and chemical names. Chemical names represent the active ingredient responsible for herbicidal activity. In this example, the trade name is Trust, and the chemical name is trifluralin. Most chemicals are sold under different trade names. For example, trifluralin is sold as Trust, Treflan, Tristar, and others depending on manufacturer.

> Herbicides may be referenced by their trade name or chemical name. Trade names, such as Roundup, Liberty, Select, and Pursuit, correspond to the chemical active ingredients glyphosate, glufosinate, clethodim, and imazethapyr, respectively. A chemical may have many trade names when produced by different manufacturers. For example, Buccaneer, Cornerstone, Roundup, Eraser, and Accord are trade names that all include the active ingredient glyphosate.

Broad-Spectrum Non-Selective Herbicides

Herbicides are further classified into three main categories based on which plants the herbicide controls: broad-spectrum non-selective, broad-spectrum selective, and selective.

Broad-spectrum non-selective herbicides control all plants in all plant groups with few exceptions. The most relevant plant groups to food plot herbicide applications include forbs, grasses, and sedges. Broad-spectrum non-selective herbicides are often used to "burndown" a field before planting a food plot and are applied postemergence. Burndown herbicide applications are intended to kill all actively growing plants in all plant groups to eliminate competition for incoming planted species and to improve conditions for tillage. Glyphosate and glufosinate are examples of broad-spectrum non-selective herbicides.

Broad-Spectrum Selective Herbicides

Broad-spectrum selective herbicides exist in preemergence, preplant incorporated, and postemergence formulations. Broad-spectrum selective herbicides control only certain plant species in multiple plant groups. For example, imazethapyr is a versatile broad-spectrum selective herbicide that can be sprayed preemergence, preplant incorporated, or postemergence in various food plot plantings. Imazethapyr controls some forbs, some grasses, and some sedges, but not every species of forb, grass, and sedge. Not all broad-spectrum selective herbicides can be sprayed preemergence, preplant incorporated, and postemergence. Some are labeled for just one or two application methods. Reference the Common Food Plot Herbicides section and the herbicide's label for application methods and timing.

Figure 9. Imazethapyr (commonly sold as Thunder and Pursuit) is a versatile herbicide and can be applied preemergence, preplant incorporated, and postemergence. Imazethapyr controls a variety of grasses, forbs, and sedges, but not every species of grass, forb, and sedge. Imazethapyr does not control most legume species, making it an excellent selective herbicide for some legume food plot plantings.

Selective Herbicides

Selective herbicides control only certain plant groups. For example, clethodim controls grasses but has little or no activity on forbs or sedges, and 2,4-D controls forbs but has little or no activity on grasses or sedges. Selective herbicides are used preemergence in some agricultural settings but are used almost exclusively postemergence in food plots to control problematic grass weeds in forb plots and forb weeds in grass plots.

Incorporate Weed Control into All Phases of the Food Plot Process

Species Selection

Food plot species selection should be considered in a successful chemical weed control program. If a manager plants oats in a field that was dominated by annual ryegrass the year before, there is no herbicide option to control ryegrass without harming the oats. However, if the same field was planted in forbs such as clover, chicory, or brassicas, a grass-selective herbicide such as clethodim or sethoxydim could be applied to control the ryegrass without harming the planting. Alternatively, if a field has a history of aggressive warm-season forb weeds, such as pigweeds or morningglory, planting buckwheat would be a poor decision because both the planted species and the weeds are forbs, leaving no options for chemical weed control.

Figure 10. Seed blend selection is a crucial component of a successful herbicide program. Seed blends that include various grasses, leguminous forbs, and non-leguminous forbs (photo A) often eliminate herbicides as an option unless killing a significant portion of planted species as collateral damage is acceptable. Alternatively, plantings that contain single species or groups of species with similar herbicide tolerance (photo B) will allow more herbicide options.

Some commercial food plot blends contain many species of grasses, leguminous forbs, and non-leguminous forbs. There is no herbicide solution to weed problems with such plantings without killing a significant portion of planted species. Certain tools, such as weed wipers, allow placement of herbicides on taller weeds when planted species are growing underneath, but efficacy of such tools is limited to specific circumstances, and these tools should not be relied upon in lieu of a carefully designed planting.

Figure 11. Weed wipers are useful when no selective broadcast herbicide options are available and weeds are taller than the planted forage. Weed wipers apply a concentrated herbicide solution directly to the foliage of the tallest plants and don't contact shorter plants.

Timing and Type of Herbicide Application

Preemergence applications should be made based on the forecasted weed profile. For example, imazethapyr is a commonly used preemergence herbicide in warm-season legume plots such as soybean, cowpea, and American jointvetch. Imazethapyr provides preemergence control of a broad variety of weeds, but some species, such as smooth pigweed, are poorly controlled by imazethapyr. If pigweeds are forecasted to be problematic, a preemergence application of S-metolachlor or pendimethalin may provide better control. Some herbicides, such as S-metolachlor, are prone to rapid photolysis. Photolysis occurs when sunlight degrades the herbicide and reduces efficacy. If S-metolachlor is sprayed more than one or two days before a rain, photolysis will occur, and efficacy will be reduced.

Mature weeds are more difficult to control with herbicides than younger plants of the same species. When postemergence herbicide applications are necessary, **it is generally best to spray when weeds are very young**. For example, an application of 2,4-DB controls buttercup in alfalfa food plots when the buttercup is 1–2 inches tall. If buttercup matures to more than 4 inches tall, efficacy will be reduced, and some of the buttercup will persist and continue to compete with planted forages.

It is not always necessary to achieve complete control of a weed via herbicide application. Some herbicides will suppress, but not kill, the target weed. In cases where the weed is suppressing growth of planted species, an herbicide application that stunts, but does not kill, the target weed often allows planted species to outgrow and outcompete the weed. This difference in growth rate between the weed and the planted species effectively kills the weed with competition rather than herbicide. For example, butyrac often suppresses, but does not kill, pigweed. If pigweed is aggressively colonizing an American jointvetch food plot, butyrac can stunt the pigweed enough to allow the American jointvetch to develop a canopy and outcompete the pigweed, if the American jointvetch is not heavily grazed.

Spraying weeds when young also minimizes the competition between weeds and planted species. For example, purple deadnettle is an aggressive weed in cool-season food plots. If purple deadnettle is sprayed several weeks before the onset of spring green-up, planted forages will fill in the vacant growing space previously occupied by the purple deadnettle, and the food plot will enter spring green-up in excellent condition for maximum production. If purple deadnettle is sprayed too late, not only will herbicide efficacy be reduced, but the planted species will enter spring green-up at a deficit, with less above- and belowground biomass, leading to less production and more growing space for additional weed seeds to germinate.

Environmental Conditions

If environmental conditions do not support active plant growth, herbicide efficacy will be reduced and planted species may be damaged. The ideal temperature range for herbicide application is 60–85 degrees, with 50 degrees generally recommended as the minimum and 90 as the maximum. If the temperature is outside this range, plant metabolism slows down and herbicides may not translocate well in weeds. Herbicide metabolism is one of the primary mechanisms by which plants resist herbicidal effects. For example, if imazethapyr is sprayed for yellow rocket control in a clover or alfalfa plot on a 45-degree day, yellow rocket control will likely be poor; the clover or alfalfa may not be able to metabolize the herbicide, and injury and stunted growth could result. Similar effects occur during drought and flood events.

The ideal relative humidity range for herbicide application is 50–70 percent. If humidity is too low, the herbicide droplet may evaporate before reaching the plant or before the herbicide can penetrate the plant cuticle. If humidity is too high, drying may take too long and herbicide uptake into the plant may be too slow, increasing the chance of leaf runoff.

The ideal wind speed for herbicide application is 3–6 miles per hour. When wind speed is too low, risk of temperature inversions increases, which can lead to off-target herbicide drift. When wind speed is too high, herbicide droplets may not reach the weed before drifting off-target. Larger herbicide droplets are less prone to wind drift. When wind, temperature, and relative humidity are outside the ideal range, risk of herbicide volatilization and off-target movement increases. Volatilization increases the risk of the herbicide killing other plants outside the intended application area.

> Volatilization occurs when herbicide vapors or particles move off-target after the herbicide has been applied. High temperatures, low humidity, and low winds increase the chance of volatilization. Certain herbicides are more prone to volatilization than others, especially ester formulations such as 2,4-D ester and dicamba.

Plant-Back Intervals

Some herbicides are soil active, meaning they remain in the soil solution and can provide residual weed control for extended periods after the initial application. **Residual activity** is a benefit in some situations because it can provide full-season weed control, but if not planned carefully, residual activity can be detrimental to future plantings. Different crops have varying plant-back intervals for different herbicides. Plant-back intervals represent the amount of time required between an herbicide application and planting to avoid crop damage or failure because of residual soil activity. Managers should consider future plantings when applying herbicide. For example, if warm- and cool-season food plots are planted on the same acreage each year, you must take extra caution with certain herbicides. Imazethapyr may be sprayed preemergence in a cowpea food plot in May, but most clovers and cereal grains require a plant-back interval of at least 4 months after imazethapyr is sprayed, whereas oats, sunflower, and sorghum require 18 months and brassicas require 40 months. See the Residual Activity table on page 24 for specific plant-back intervals.

Preventing Herbicide Resistance

Some weeds, such as horseweed, common ragweed, lambsquarters, annual ryegrass, and several species of pigweed, have developed resistance to a variety of herbicides because of repeated and widespread use in agricultural landscapes. Herbicide resistance develops as weed species are repeatedly sprayed with the same herbicide or different herbicides with the same mode of action. An herbicide's mode of action refers to the physiological pathway acted upon by the herbicide to kill the plant. The best way to deal with herbicide-resistant weeds is to use herbicides with varying modes of action and ensure all aspects of the herbicide application follow label guidelines, including herbicide rate, plant growth stage, and environmental conditions.

> More herbicide is not always better. Herbicide labels list the rate required to control a given weed. If more herbicide is applied than required to control the weed, herbicide is wasted. If less herbicide is applied than required, weed control will be sub-optimal, herbicide is wasted, and the chance of promoting herbicide-resistant weeds increases.

Adjuvants

An **adjuvant** is any substance that modifies herbicidal activity or application characteristics. Adjuvants perform many functions, including reducing surface tension, solubilizing the plant cuticle, increasing herbicide penetration into the plant, defoaming the spray solution, reducing drift potential, and adjusting solution pH. Some manufacturers include necessary adjuvants in the herbicide formulation, but some herbicides require the user to add adjuvants to the spray solution. For example, most glyphosate products include necessary adjuvants in the formulation, but clethodim and 2,4-DB require addition of an adjuvant to the spray solution. Preemergence and preplant incorporated herbicides typically do not require additional adjuvants because they are applied to the soil instead of the plant. Food plot managers use three primary types of adjuvants: surfactants, oil concentrates, and nitrogen fertilizers.

> Mixing order is critical for spray solutions to avoid gelling, incompatibility, and ineffective applications. Most herbicide labels recommend adding 50 percent of the water to the tank, then the herbicide, then necessary adjuvants, and the remaining water last. Refer to the label for herbicide-specific instructions.

Surfactants

Non-ionic surfactants (NIS) are the most common and versatile surfactants. Surfactants reduce surface tension of the spray droplet and help spread the herbicide on the plant surface. Surfactants are required for most postemergence herbicide applications and are most often used for selective applications because they do not compound the damage caused by the herbicide. Most herbicide labels require surfactants at 0.25–0.5 percent solution. For example, if a herbicide label requires the solution to contain 0.5 percent surfactant and you plan to spray 25 gallons (3,200 ounces) of solution, then 16 ounces of surfactant should be added to the spray tank (3,200 ounces × 0.005 = 16 ounces). 0.005 is one-half of 1 percent and represents a 0.5 percent solution.

Figure 12. Non-ionic surfactant (NIS) is a versatile adjuvant that improves efficacy of many herbicides. NIS reduces herbicide droplet surface tension, leading to greater coverage on leaves, solubilizes leaf cuticle for increased herbicide penetration, and promotes herbicide translocation within the plant. NIS is ideal for many postemergence selective herbicide applications because it does not cause additive damage to plants, unlike crop oil concentrate and methylated seed oil.

Figure 13. Crop oil concentrate (COC) is a more potent adjuvant than non-ionic surfactant. COC is often used in burndown applications where the objective is to kill all plants. COC can lead to increased injury of target and non-target plants relative to non-ionic surfactant.

Oil Concentrates

Oil concentrates perform similarly to surfactants but are more effective penetrants into waxy or hairy leaves. The most common oil concentrates include crop oil concentrates (COC) and methylated seed oil concentrates (MSO). Unlike surfactants, oil concentrates can compound plant tissue damage caused by herbicides by destroying cell membranes. This additive damage is a benefit for some herbicide applications and a detriment to others. Oil concentrates are often used in burndown herbicide applications where the objective is broad-spectrum control of all actively growing plants because oil concentrates compound herbicidal damage. However, if grass weeds are sprayed with a grass-selective herbicide in a forb food plot and COC is used, especially at a high rate or when plants are stressed, planted species may be damaged because COC can damage non-target plants independent of the herbicide. Non-ionic surfactants will not damage the plant when used properly.

Nitrogen Fertilizers

Nitrogen fertilizers, such as ammonium sulfate, reduce negative effects caused by hard water in spray solutions. Hard water is a primary reason creek water should not be used to fill spray tanks. Hard water contains salts, such as calcium, magnesium, and sodium, that can bind to herbicide molecules and reduce efficacy. The sulfur in ammonium sulfate binds to these salts, reducing the salt's ability to interfere with herbicide activity, and the nitrogen stays in solution and fertilizes the food plot. Adding ammonium sulfate to the spray solution also improves weed control by improving plant absorption for some herbicides, especially during stressful environmental conditions such as drought or cold temperatures. Refer to the herbicide label for specific rates and instructions.

Ammonium sulfate is a useful addition to spray tanks to treat hard water, and acidifiers and basifiers may be added to treat pH-imbalanced water. Reference the herbicide label to determine if a specific pH range is required for effective weed treatment. If the water used in your spray tank is outside the labeled range, an acidifier or basifier can bring pH into the ideal range.

Common Food Plot Species and Herbicide Options

All seeding rates are listed in pounds of pure live seed (PLS) per acre for broadcast monoculture stands. If drilling, decrease rate by approximately 25 percent, depending on the species. Herbicide rates are listed per acre and are based on the product trade name in bold in the Common Food Plot Herbicides section. This list represents some of the most popular plantings and herbicide options, but there are many others.

Reference the herbicide label for application rates specific to your weed profile and soil type. Soils with high-percentage clay and organic matter often require greater rates for preemergence and preplant incorporated herbicides and may require longer plant-back intervals.

Volume Conversions

1 gallon = 4 quarts

1 gallon = 8 pints

1 gallon = 128 ounces

1 quart = 2 pints

1 quart = 32 ounces

1 pint = 16 ounces

Warm-Season Species

Soybean (*Glycine max*)

Seeding rate: one bag

Seeding depth: 1 inch

Preemergence herbicides

- Broad-spectrum selective:
  - imazethapyr (4 ounces)
  - S-metolachlor (1–2 pints)
  - pendimethalin (2–3 pints)
  - trifluralin (1–2 pints)

Postemergence herbicides

- Broad-spectrum selective:
  - imazethapyr (4 ounces)
  - imazamox (4 ounces)
  - bentazon (1–2 pints)
- Grass selective:
  - clethodim (6–16 ounces)
  - sethoxydim (8–40 ounces)
- Broadleaf selective
  - butyrac (11–15 ounces)

Notes: Butyrac may damage soybeans if applied outside of flowering period. Glyphosate, dicamba, and glufosinate-tolerant soybean varieties are available.

On pages 10–20, seeding rates are listed per acre. Herbicide rates are listed per acre and are based on the product trade name followed by an asterisk in the Common Food Plot Herbicides section.

Cowpea (*Vigna unguiculata*)

Seeding rate: 50 pounds

Seeding depth: 0.75 inches

Preemergence herbicides

- Broad-spectrum selective:
  - imazethapyr (3–4 ounces)
  - S-metolachlor (1–2 pints)
  - pendimethalin (2–3.5 pints)
  - trifluralin (1–2 pints)

Postemergence herbicides:

- Broad-spectrum selective:
  - imazethapyr (3–4 ounces)
  - bentazon (1–2 pints)
- Grass selective:
  - clethodim (6–8 ounces)
  - sethoxydim (8–40 ounces)
- Broadleaf selective: none

Notes: Butyrac severely damages cowpea.

Lablab (*Lablab purpureus*)

Seeding rate: 35 pounds

Seeding depth: 0.75 inches

Preemergence herbicides

- Broad-spectrum selective:
  - S-metolachlor (1–2 pints)*
  - pendimethalin (2–3.5 pints)*

Postemergence herbicides

- Broad-spectrum selective: none
- Grass selective:
  - clethodim (6–8 ounces)*
  - sethoxydim (8–40 ounces)*
- Broadleaf selective: none

*Herbicide tolerance has not been evaluated by MSU.

American jointvetch (*Aeschynomene americana*)

Seeding rate: 20 pounds

Seeding depth: 0.25 inches

Preemergence herbicides

- Broad-spectrum selective:
  - imazethapyr (4 ounces)*
  - S-metolachlor (1–2 pints)*
  - pendimethalin (2–3 pints)*

Postemergence herbicides

- Broad-spectrum selective:
  - imazethapyr (4 ounces)*
  - imazamox (6 ounces)*
  - bentazon (1–2 pints)*
- Grass selective:
  - clethodim (6–16 ounces)*
  - sethoxydim (8–40 ounces)*
- Broadleaf selective:
  - butyrac (1–3 quarts)*

*Herbicide tolerance has not been evaluated by MSU.

Alyceclover (*Alysicarpus ovalifolius*)

Seeding rate: 20 pounds

Seeding depth: 0.25 inches

Preemergence herbicides

- Broad-spectrum selective:
  - imazethapyr (4 ounces)*
  - S-metolachlor (1–2 pints)*
  - pendimethalin (2–3 pints)*

Postemergence herbicides

- Broad-spectrum selective:
  - imazethapyr (4 ounces)*
  - imazamox (6 ounces)*
  - bentazon (1–2 pints)*
- Grass selective:
  - clethodim (6–16 ounces)*
  - sethoxydim (8–40 ounces)*
- Broadleaf selective: none

*Herbicide tolerance has not been evaluated by MSU.

Note: Alyceclover is not a true clover. Herbicides labeled for clover may not be safe on alyceclover. Butyrac severely damages alyceclover.

Sunflower (*Helianthus annuus*)

Seeding rate: 25 pounds

Seeding depth: 1 inch

Preemergence herbicides

- Broad-spectrum selective:
  - S-metolachlor (1–2 pints)
  - pendimethalin (2.5–3.5 pints)
  - trifluralin (1–2 pints)

Postemergence herbicides

- Broad-spectrum selective:
  - imazamox (4 ounces) only if planting *Clearfield or Clearfield Plus* sunflowers
- Grass selective:
  - clethodim (6–16 ounces)
  - sethoxydim (8–40 ounces)
- Broadleaf selective: none

Buckwheat (*Fagopyrum esculentum*)

Seeding rate: 60 pounds

Seeding depth: 0.75 inches

Preemergence herbicides

- None

Postemergence herbicides

- Broad-spectrum selective: none
- Grass selective:
  - clethodim (6–16 ounces)*
  - sethoxydim (8–40 ounces)
- Broadleaf selective: none

*Herbicide tolerance has not been evaluated by MSU.

Grain sorghum (aka milo; *Sorghum bicolor*)

Seeding rate: 15 pounds

Seeding depth: 1 inch

Preemergence herbicides

- Broad-spectrum selective:
  - atrazine (3–4 pints)
  - S-metolachlor (1.33–1.67 pints) only with *Concep III* seed treatment

Postemergence herbicides

- Broad-spectrum selective:
  - atrazine (3–4 pints)
  - bentazon (1–2 pints)
- Grass selective: none
- Broadleaf selective:
  - dicamba (8 ounces)
  - 2,4-D (0.66–2 pints)
  - butyrac (11–15 ounces)*

*Herbicide tolerance has not been evaluated by MSU.

Japanese millet (*Echinochloa esculenta*)

Seeding rate: 25 pounds

Seeding depth: 0.5 inches

Preemergence herbicides

- None

Postemergence herbicides

- Broad-spectrum selective: none
- Grass selective: none
- Broadleaf selective:
  - 2,4-D (0.66–2 pints)*
  - butyrac (11–15 ounces)*

*Herbicide tolerance has not been evaluated by MSU.

White proso millet (*Panicum miliaceum*)

Seeding rate: 30 pounds

Seeding depth: 0.25 inches

Preemergence herbicides

- None

Postemergence herbicides

- Broad-spectrum selective: none
- Grass selective: none
- Broadleaf selective:
  - 2,4-D (0.66–2 pints)*
  - butyrac (11–15 ounces)*

*Herbicide tolerance has not been evaluated by MSU.

Corn (*Zea mays*)

Seeding rate: 15 pounds

Seeding depth: 1.5 inches

Preemergence herbicides

- Broad-spectrum selective:
  - S-metolachlor (1–2 pints)
  - pendimethalin (field corn only; 2–4 pints)
  - atrazine (3.5–4 pints)

Postemergence herbicides

- Broad-spectrum selective:
  - atrazine (3.5–4 pints)
  - bentazon (1–2 pints)
- Grass selective: none
- Broadleaf selective:
  - 2,4-D (0.5–1 pint)
  - butyrac (11–15 ounces)*
  - dicamba (8–16 ounces)

*Herbicide tolerance has not been evaluated by MSU.

Note: Some glyphosate- and glufosinate-tolerant corn varieties are available that allow broad-spectrum weed control.

Chufa (*Cyperus esculentus*)

Seeding rate: 40 pounds

Seeding depth: 1 inch

Preemergence herbicides

- None

Postemergence herbicides

- Broad-spectrum selective: none
- Grass selective:
    - clethodim (6–16 ounces)*
    - sethoxydim (8–40 ounces)
- Broadleaf selective:
    - 2,4-D (0.66–2 pints)*
    - butyrac (11–15 ounces)*
    - dicamba (8 ounces)*

*Herbicide tolerance has not been evaluated by MSU.

Cool-Season Species

Clovers

crimson (*Trifolium incarnatum*), balansa (*Trifolium michelianum*), berseem (*Trifolium alexandrinum*), arrowleaf (*Trifolium vesiculosum*), red (*Trifolium pratense*), ladino and durana (*Trifolium repens*)

Monoculture seeding rates (pounds): crimson (20), balansa (8), berseem (20), arrowleaf (10), red (12), ladino (6), durana (6)

Seeding depth: 0.25 inches

Preemergence herbicides

- None

Postemergence herbicides

- Broad-spectrum selective:
    - imazethapyr (3–6 ounces)
    - imazamox (4–6 ounces)
    - bentazon (1–2 pints)*
- Grass selective:
    - clethodim (6–16 ounces)
    - sethoxydim (8–40 ounces)
    - pinoxaden (8.2 ounces)*
- Broadleaf selective:
    - butyrac (1–3 quarts)*

*Herbicide tolerance has not been evaluated by MSU.

Note: Crimson clover may be damaged by imazethapyr but typically recovers within 14 days. Some clovers may be damaged by butyrac but typically recover within 14 days. Only apply imazethapyr to clover when it is in the second trifoliate stage or larger.

Alfalfa (*Medicago sativa*)

Seeding rate: 20 pounds

Seeding depth: 0.25 inches

Preemergence herbicides

- Broad-spectrum selective:
    - pendimethalin (1–4 pints)
    - trifluralin (established alfalfa only; 1–2 pints)
    - bentazon (1–pints)*

Postemergence herbicides

- Broad-spectrum selective:
    - imazethapyr (3–6 ounces)
    - imazamox (4–6 ounces)
- Grass selective:
    - clethodim (6–16 ounces)
    - sethoxydim (8–40 ounces)
- Broadleaf selective:
    - butyrac (1–3 quarts)

*Herbicide tolerance has not been evaluated by MSU.

Note: Only apply trifluralin preemergence when 0.5 inches of rain is expected within 3 days of spraying. Rainfall is required for trifluralin incorporation after preemergence applications. Pendimethalin applications (*Prowl H2O* only) prior to alfalfa germination may result in some crop reduction and stunting, but reduced weed competition will allow establishment of a quality stand. Only apply imazethapyr to alfalfa when it is in the second trifoliate stage or larger.

Austrian winter pea (*Pisum sativum*)

Seeding rate: 40 pounds

Seeding depth: 1 inch

Preemergence herbicides

- Broad-spectrum selective:
    - pendimethalin (1.5–3 pints)*

Postemergence herbicides

- Broad-spectrum selective:
    - imazethapyr (3–6 ounces)
- Grass selective:
    - clethodim (6–16 ounces)*
    - sethoxydim (8–40 ounces)
- Broadleaf selective: none

*Herbicide tolerance has not been evaluated by MSU.

Chicory (*Cichorium intybus*)

Seeding rate: 10 pounds

Seeding depth: 0.25 inches

Preemergence herbicides

- trifluralin (1–2 pints)

Postemergence herbicides

- Broad-spectrum selective:
  - imazamox (4–6 ounces)
  - imazethapyr (3–6 ounces)
- Grass selective:
  - clethodim (6–16 ounces)
  - sethoxydim (8–40 ounces)
- Broadleaf selective: none

Brassicas

radish (*Raphanus sativus)*, turnip (*Brassica rapa)*, rape (*Brassica napus*)

Monoculture seeding rates (pounds): radish (12), turnip (5), rape (8)

Seeding depths (inches): radish and rape (0.5), turnip (0.25)

Preemergence herbicides

- Broad-spectrum selective:
  - trifluralin (1–2 pints)

Postemergence herbicides

- Broad-spectrum selective: none
- Grass selective:
  - clethodim (6–16 ounces)
  - sethoxydim (8–40 ounces)
- Broadleaf selective: none

Wheat (*Triticum aestivum*)

Seeding rate: 120 pounds

Seeding depth: 1 inch

Preemergence herbicides

- trifluralin (1–2 pints)

Postemergence herbicides

- Broad-spectrum selective:
  - imazethapyr (4 ounces)*
- Grass selective:
  - pinoxaden (8.2 ounces)
- Broadleaf selective:
  - 2,4-D (0.66–2 pints)
  - butyrac (1–3 quarts)*
  - thifensulfuron-methyl and tribenuron-methyl (0.45–0.9 ounces)

*Herbicide tolerance has not been evaluated by MSU.

Note: Pinoxaden may be used for postemergence annual ryegrass control in wheat.

Oats (*Avena sativa*)

Seeding rate: 120 pounds

Seeding depth: 1 inch

Preemergence herbicides

- None

Postemergence herbicides

- Broad-spectrum selective: none
- Grass selective: none
- Broadleaf selective:
  - 2,4-D (0.5–1.5 pints)
  - butyrac (11–15 ounces)*
  - dicamba (2–4 ounces)
  - thifensulfuron-methyl and tribenuron-methyl (0.45–0.9 ounces)

*Herbicide tolerance has not been evaluated by MSU.

Note: Oats are more susceptible to 2,4-D than most other grasses. Do not spray 2,4-D over oats during or immediately following cold weather.

Cereal rye (*Secale cereale*)

Seeding rate: 120 pounds

Seeding depth: 1 inch

Preemergence herbicides

- None

Postemergence herbicides

- Broad-spectrum selective: none
- Grass selective: none
- Broadleaf selective:
  - 2,4-D (0.5–1.5 pints)
  - butyrac (11–15 ounces)*

*Herbicide tolerance has not been evaluated by MSU.

Common Food Plot Herbicides

Trade names followed by an asterisk indicate the label that bulleted information is referenced from. Other trade names will have similar characteristics, but percent active ingredient and other important factors may vary, which will influence applications. Always reference the label before purchase and application. Rates are listed on a per-acre basis. This list represents some of the most common herbicides and plantings, but many others exist.

> An herbicide's rainfast interval indicates the amount of time required between application and precipitation. If the rainfast interval is not met, the plant will not completely absorb the herbicide, runoff will occur, and efficacy will be reduced. Some herbicides require only 30 minutes to be rainfast, while others require 6+ hours.

Broad-spectrum non-selective herbicides

Glyphosate

Common trade names: Buccaneer Plus*, Roundup, Rodeo, Eraser, Gly Star, Cornerstone

Broadcast rate: 1–3 quarts

Spot-spray rate: 2–5% solution (2.6 ounces herbicide per 1 gallon is a 2% solution)

Application method: postemergence

Required adjuvants: most glyphosate formulations do not require surfactants

Rainfast time: 0.5–4 hours depending on formulation

Residual activity: none

For use in: burndown applications before planting food plots, postemergence applications in glyphosate-tolerant crops, or spot-spray applications

Note: Various pigweed species, common lambsquarter, common ragweed, horseweed, annual ryegrass, and others have developed resistance in some areas. Glyphosate tends to be less effective on forbs and more effective on grasses than glufosinate. Some glyphosate-tolerant species are available, such as soybean, corn, and alfalfa.

Glufosinate

Common trade names: Liberty 280 SL*, Finale, Ignite, Interline

Broadcast rate: 22–82 ounces

Spot-spray rate: 1.3–3% solution (1.7 ounces herbicide per 1 gallon is a 1.3% solution)

Application method: postemergence

Required adjuvants: none

Rainfast time: 4 hours

Residual activity: none

For use in: burndown applications before planting food plots or postemergence applications in glufosinate-tolerant crops

Note: Glufosinate tends to be less effective on grasses and more effective on forbs than glyphosate. Glufosinate requires sunlight for activity. For best results, apply between sunrise and 2 hours before sunset. Some glufosinate-tolerant species are available, such as soybean and corn.

Broad-spectrum selective herbicides

Imazethapyr

Common trade names: Pursuit*, Thunder, Passport

Broadcast rate: 2–4 ounces

Spot-spray rate: not labeled

Application method: preemergence, preplant incorporated, postemergence

Required adjuvants: MSO is recommended when weeds are under moisture or temperature stress at 1% volume/volume solution or NIS at 0.25% volume/volume solution. Surfactants only required when applying postemergence.

Rainfast time: 1 hour

Residual activity: 4 months (alfalfa, wheat, clover, and cereal rye); 8.5 months (corn); 18 months (oats, sorghum, and sunflower); 40 months (brassicas)

For use in: pre- and postemergence in soybean and cowpea. Postemergence only for Austrian winter pea, clovers, and alfalfa.

Note: In addition to the labeled species above, imazethapyr has little to no activity on wheat (postemergence only), American jointvetch, and alyceclover. Adequate soil moisture to a depth of at least 2 inches is necessary for preemergence and preplant incorporated applications. Only apply imazethapyr to alfalfa or clovers in the second trifoliate stage or larger. Postemergence applications may damage some clovers and alfalfa, but plants typically recover within 2 weeks.

Imazamox

Common trade names: Raptor*, Beyond, Clearcast

Broadcast rate: 4–6 ounces

Spot-spray rate: not labeled

Application method: postemergence

Required adjuvants: use MSO or COC at 1–2% volume/volume solution or NIS at 0.25% volume/volume solution

> *On pages 21–24, herbicide rates are listed per acre and are based on the product trade name followed by an asterisk in the Common Food Plot Herbicides section.*

Rainfast time: 1 hour

Residual activity: 3 months (alfalfa and wheat); 4 months (cereal rye); 8.5 months (corn); 9 months (sorghum, millet, oats, and sunflower); 18 months (turnip)

For use in: alfalfa, soybean, clover, chicory, and *Clearfield* and *Clearfield Plus* sunflower

Note: In addition to the labeled species above, imazamox has little to no activity on American jointvetch and alyceclover.

S-metolachlor

Common trade names: Dual Magnum*, Pennant Magnum

Broadcast rate: 1–2 pints

Spot-spray rate: not applicable

Application method: preemergence or preplant incorporated

Required adjuvants: none

Rainfast time: N/A

Residual activity: 2 months (turnip, radish, chicory, chufa); 4 months (alfalfa); 4.5 months (oats, wheat, cereal rye); 9 months (clover); 12 months (buckwheat and sorghum)

For use in: soybean, corn, sunflower, cowpea, and grain sorghum if treated with *Concep III*

Note: In addition to the above labeled species, S-metolachlor has little to no activity on American jointvetch and alyceclover. Rainfall within 2 days is necessary to avoid degradation by sunlight after preemergence applications. Use preplant incorporated applications to minimize sunlight degradation.

Pendimethalin

Common trade names: Prowl H2o*, Pendulum, Stealth

Broadcast rate: 1–4 pints

Spot-spray rate: not applicable

Application method: preemergence or preplant incorporated

Required adjuvants: none

Rainfast time: N/A

Residual activity: 4 months (wheat); 12 months (white proso millet and sorghum)

For use in: field corn, alfalfa, cowpea, Austrian winter pea, soybean, and sunflower

Note: In addition to the above labeled species, pendimethalin has little to no activity on American jointvetch and alyceclover. Some alfalfa reduction and stunting may occur, but reduced weed competition will allow establishment of a successful stand. Only Prowl H2O is labeled for application prior to alfalfa germination. Other pendimethalin formulations can only be sprayed over established alfalfa.

Bentazon

Common trade names: Basagran T/O*

Broadcast rate: 1–2 pints

Spot-spray rate: not labeled

Application method: postemergence

Required adjuvants: COC or MSO at 1% volume/volume solution or NIS at 0.25–0.5% volume/volume solution

Rainfast time: 4 hours

Residual activity: none

For use in: soybean, cowpea, field corn, and sorghum

Note: In addition to the labeled species above, bentazon has little to no activity on American jointvetch, alyceclover, alfalfa, and clovers.

Trifluralin

Common trade names: Treflan 4L*

Broadcast rate: 1–2 pints

Spot-spray rate: not applicable

Application method: preemergence or preplant incorporated

Required adjuvants: none

Rainfast time: N/A

Residual activity: 14 months (white proso millet, corn, grain sorghum, and oats)

For use in: established alfalfa, chicory, turnip, radish, rape, cowpea, soybean, wheat, and sunflower

Note: Only use preemergence applications with incorporation via rainfall for established alfalfa. At least 0.5 inches of rain is required within 3 days of spraying to activate trifluralin after application.

Atrazine

Common trade names: Atrazine 4L* and AAtrex

Broadcast rate: 3–4 pints

Spot-spray rate: not labeled

Application method: preemergence, preplant incorporated, and postemergence

Required adjuvants: COC at 1 quart per acre for postemergence applications

Rainfast time: 2 hours

Residual activity: Do not rotate to any crop except corn or sorghum until the following year or injury may occur. If applied after June 10, do not rotate with crops other than corn or sorghum the next year. Injury may occur to soybeans planted the year following application on soils having a calcareous surface layer. Do not plant spring-seeded small grains or small-seeded legumes and grasses the year following application or injury may occur.

For use in: corn and grain sorghum

Forb-selective herbicides

2,4-D

Common trade names: 2,4-D Amine*, Enlist One, Weedone

Broadcast rate: 0.66–2 pints

Spot-spray rate: 1% solution (1.3 ounces herbicide per 1 gallon solution)

Application method: postemergence

Required adjuvants: LI-700 surfactant is recommended, or COC or MSO at 1 % volume/volume solution, or NIS at 0.25–0.5% volume/volume solution

Rainfast time: 1 hour

Residual activity: 30 days

For use in: corn, sorghum, wheat, oats, and cereal rye

Note: In addition to the above labeled species, 2,4-D has little to no activity on chufa, Japanese millet, and white proso millet. Oats are more susceptible to 2,4-D than most other grasses. Do not spray over oats during or immediately following cold weather. 2,4-D volatilizes quickly, and volatility is greatest with high temperatures and low relative humidity.

2,4-DB

Common trade names: Butyrac 200*, Butyrac 175

Broadcast rate: 1–3 quarts

Spot-spray rate: 2.3% solution (2.9 ounces herbicide per 1 gallon solution)

Application method: postemergence

Required adjuvants: NIS at 0.25% volume/volume solution

Rainfast time: 6 hours

Residual activity: 14 days

For use in: soybeans and alfalfa

Note: In addition to the above labeled species, 2,4-DB has little to no activity on American jointvetch, clover species listed on page 16, chufa, corn, grain sorghum, Japanese millet, white proso millet, wheat, oats, and cereal rye. Butyrac will severely injure alyceclover and cowpea. 2,4-DB is weaker on forb species than 2,4-D but can be sprayed safely on some legume crops that 2,4-D kills.

Thifensulfuron-methyl and tribenuron-methyl

Common trade names: Harmony Extra SG*

Broadcast rate: 0.45–0.9 ounces

Spot-spray rate: not labeled

Application method: postemergence

Required adjuvants: NIS at 0.06–0.5 % volume/volume solution or COC or MSO at 1% volume/volume solution

Rainfast time: 4 hours

Residual activity: 14 days (soybean); 21 days (field corn and sorghum); 60 days (turnip, radish, and rape)

For use in: wheat and oats

Dicamba

Common trade names: Banvel*, Clarity, Diablo

Broadcast rate: 8–64 ounces

Spot-spray rate: 0.5% solution (0.6 ounces herbicide per 1 gallon solution)

Application method: postemergence

Required adjuvants: NIS at 0.25–0.5% volume/volume solution

Rainfast time: 4 hours

Residual activity: 20–45 days per pint of Banvel per acre for most species

For use in: corn, sorghum, wheat, and oats

Note: In addition to the above labeled species, dicamba has little to no activity on chufa. Soil moisture is essential for dicamba degradation. Residual activity is longer when rainfall is limited.

Grass-selective herbicides

Clethodim

Common trade names: Clethodim 2EC*, Select, Cleanse, Tapout, and many others

Broadcast rate: 4–16 ounces

Spot-spray rate: 0.5% solution (0.6 ounces herbicide per 1 gallon solution)

Application method: postemergence

Required adjuvants: COC at 1 % volume/volume solution or NIS at 0.25% volume/volume solution

Rainfast time: 1 hour

Residual activity: up to 30 days for some grass crops

For use in: soybean, cowpea, sunflower, clovers, alfalfa, chicory, turnip, radish, and rape

Note: In addition to the above labeled species, clethodim has little to no activity on lablab, American jointvetch, alyceclover, buckwheat, chufa, and Austrian winter pea.

Sethoxydim

Common trade names: Poast*, Vantage

Broadcast rate: 8–40 ounces

Spot-spray rate: 1.5% solution (1.9 ounces herbicide per 1 gallon solution)

Application method: postemergence

Required adjuvants: NIS at 0.25–0.5% volume/volume solution or COC or MSO at 1% volume/volume solution

Rainfast time: 1 hour

Residual activity: none

For use in: soybean, cowpea, lablab, American jointvetch, alyceclover, sunflower, buckwheat, chufa, clovers, alfalfa, Austrian winter pea, chicory, turnip, radish, and rape.

Pinoxaden

Common trade names: Axial*

Broadcast rate: 8.2 ounces

Spot-spray rate: not labeled

Application method: postemergence

Required adjuvants: NIS at 0.25–0.5% volume/volume solution or MSO at 0.5–1% volume/volume solution

Rainfast time: 30 mins

Residual activity: no residual activity on wheat; 1 month (brassicas); 3 months (other cereal grains)

For use in: wheat

Note: In addition to the above labeled species, pinoxaden has little to no activity on clovers. Pinoxaden is especially useful for Italian (annual) ryegrass control in wheat. Pinoxaden will control other cereal grains.

Residual Activity

Many food plot species are not listed on herbicide labels, so plant-back intervals are not available. Any crop not listed may be injured or killed if planted following application of herbicides with soil activity. Refer to the herbicide's label for more information.

Chemical	Crop	Plant-back interval (months)
2,4-DB	some forbs	0.5
2,4-D	some forbs	1
atrazine	wheat, cereal rye	15
atrazine	soybean	18
atrazine	oats, alfalfa	21
trifluralin	white proso millet, corn, sorghum, oats	14
pendimethalin	wheat	4
pendimethalin	white proso millet, sorghum	12
S-metolachlor	turnip, radish, chicory, chufa	2
S-metolachlor	alfalfa	4
S-metolachlor	oats, wheat, cereal rye	4.5
S-metolachlor	clover	9
S-metolachlor	buckwheat, sorghum	12
imazamox	alfalfa, wheat	3
imazamox	cereal rye	4
imazamox	corn	8.8
imazamox	sorghum, Japanese millet, white proso millet, oats, sunflower	9
imazamox	turnip	18
imazethapyr	alfalfa, wheat, clover, cereal rye	4
imazethapyr	corn	8.5
imazethapyr	oats, sorghum, sunflower	18
imazethapyr	turnip, radish, rape	40
pinoxaden	turnip, radish, rape	1
pinoxaden	oats, cereal rye	4
clethodim	some grasses	1
dicamba	many forbs	6
thifensulfuron-methyl + tribenuron-methyl	soybean	0.5
thifensulfuron-methyl + tribenuron-methyl	field corn, sorghum	0.75
thifensulfuron-methyl + tribenuron-methyl	turnip, radish, rape	2

Sprayer Calibration

Sprayer calibration is one of the most important and frequently overlooked steps in safe and effective herbicide applications. It is impossible to ensure the proper rate of herbicide is applied without calibrating the sprayer. Without proper application rates, managers waste time and money, often damage or kill the planted crop, and fail to control weeds. The risk of weeds developing herbicide resistance increases when herbicide rate is insufficient. If too much herbicide is applied, time and money are wasted because more herbicide is used than necessary and risk of runoff and injury to non-target plants increases. Ground speed of the spray rig, sprayer pressure, nozzle type, nozzle spacing, nozzle height relative to vegetation canopy, and viscosity of the solution all influence sprayer calibration. Each of these factors will influence control of target weeds, accidental injury to non-target plants, and overall efficacy of herbicide application.

Mixing a solution of *x* percent herbicide is sufficient for spot applications where the applicator can ensure adequate spray coverage is achieved for each plant while avoiding excess coverage and herbicide runoff. However, mixing *x* percent herbicide is not sufficient for broadcast applications, which require a properly calibrated sprayer. Mixing herbicide based on percent solution for broadcast application ignores the importance of ground speed, sprayer pressure, and nozzle type, spacing, and height on herbicide coverage and control of target weeds. Any boom or boomless sprayer should be calibrated before applying herbicide.

Nozzle droplet size is critical for optimizing spray coverage on weeds with drift mitigation. Large droplets minimize risk of drift but decrease coverage on the plant. Small droplets increase the risk of drift and volatilization but improve coverage.

Herbicides are either classified as *contact* or *systemic*. Contact herbicides typically require better coverage than systemic herbicides.

Herbicide labels specify which nozzle to use. In general, a nozzle that produces medium droplets will balance drift control and coverage.

To calibrate a sprayer, first determine time to travel 100 yards (seconds):

If the sprayer doesn't have a speedometer but instead reports RPM, mark a 100-yard section on straight, level ground and record how many seconds it takes to travel 100 yards at a steady RPM. If the sprayer has a speedometer, use the following equation to convert MPH to seconds per 100 yards:

$$\frac{360{,}000}{(\text{MPH x } 1{,}760)}$$

For example, if the sprayer speed is 5 MPH (5–10 MPH is appropriate for most applications):

$$\frac{360{,}000}{(5 \times 1{,}760)} = 40.9 \text{ seconds to travel } 100 \text{ yards}$$

Next, determine the total sprayer output per minute (ounces):

Set your sprayer at 40 PSI (unless specified otherwise by the manufacturer) and collect water in a measuring cup out of each nozzle for 1 minute. Sum the output for all nozzles to determine total sprayer output per minute.

Next, determine spray width (feet):

Turn on the sprayer and measure the total spray width at the working height of the sprayer (approximately 20 inches above the vegetation canopy). If the sprayer produces a weak pattern on the outer edges, exclude those from the measurement. For example, if a sprayer produces a 20-foot spray width but the outer 6 inches of the pattern on each side are receiving less spray than the rest of the area, use 19 feet as your spray width.

Finally, calculate gallons per acre (GPA) with the following formula:

$$\frac{100 \text{ yard time (seconds)} \times \text{Total nozzle output per minute (ounces)} \times 0.019}{\text{spray width (feet)}} = \text{GPA}$$

For example, if sprayer speed is 40.9 seconds per 100 yards (5 MPH), total nozzle output per minute is 365 ounces, and spray width is 19 feet:

$$\frac{40.9 \times 365 \times 0.019}{19} = 15.1 \text{ GPA}$$

Adjusting Gallons per Acre (GPA)

An herbicide's label will specify the GPA range required for application. 15 GPA is appropriate for most herbicide applications. If a sprayer is applying too few GPA, you can increase GPA by:

- decreasing ground speed
- choosing a nozzle with a higher GPM rating
- increasing sprayer pressure

If a sprayer is applying too many GPA, you can decrease GPA by:

- increasing ground speed
- choosing a nozzle with a lower GPM rating
- decreasing sprayer pressure

This method works for boom and boomless sprayers. Recalculate GPA after any adjustments.

> A nozzle's gallons per minute (GPM) rating specifies the nozzle output at a standard 40 PSI for 1 minute. A nozzle might be labeled 8003, for example, which means the nozzle produces an 80 degree pattern and 0.3 GPM at a standard 40 PSI, whereas an 8005 nozzle produces the same 80 degree pattern but 0.5 GPM. When all other variables are equal, greater GPM ratings produce greater GPA rates.

References

DeWerff, R. P., Conley, S. P., Colquhoun, J. B., & Davis, V. M. (2015). Weed control in soybean as influenced by residual herbicide use and glyphosate-application timing following different planting dates. *Weed Technology, 29*(1), 71–81.

Hamrick, W. W., & Strickland, B. K. (2019). *Supplemental wildlife food planting manual for the Southeast* (Publication 2111). Mississippi State University Extension Service.

Harper, C. A. (2019). *Wildlife food plots and early successional plants.* NOCSO Publishing.

Myers, M. W., Curran, W. S., & Vangessel, M. J. (2005). The effect of weed density and application timing on weed control and corn grain yield. *Weed Technology, 19*(1), 102–107.

Nath, C. P., Singh, R. G., Choudhary, V. K., Datta, D., Nandan, R., & Singh, S. S. (2024). Challenges and alternatives of herbicide-based weed management. *Agronomy, 14*(1), 126.

Oliveira, M. C., Feist, D., Eskelsen, S., Scott, J. E., & Knezevic, S. Z. (2017). Weed control in soybean with preemergence- and postemergence-applied herbicides. *Crop, Forage, & Turfgrass Management, 3*, 1–7.

Pavlović, D., Vrbničanin, S., Anđelković, A., Božić, D., Rajković, M., & Malidža, G. (2022). Non-chemical weed control for plant health and environment: Ecological Integrated Weed Management (EIWM). *Agronomy, 12*(5), 1091.

Resop, L., & Strickland, B. K. (2024). *Survey of food plot practitioner motivations and techniques* [Unpublished survey]. Mississippi State University.

Publication 4178 (POD-06-26)

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Produced by Agricultural Communications.

Extension Service of Mississippi State University, cooperating with U.S. Department of Agriculture. Published in furtherance of Acts of Congress, May 8 and June 30, 1914. ANGUS L. CATCHOT JR., Director