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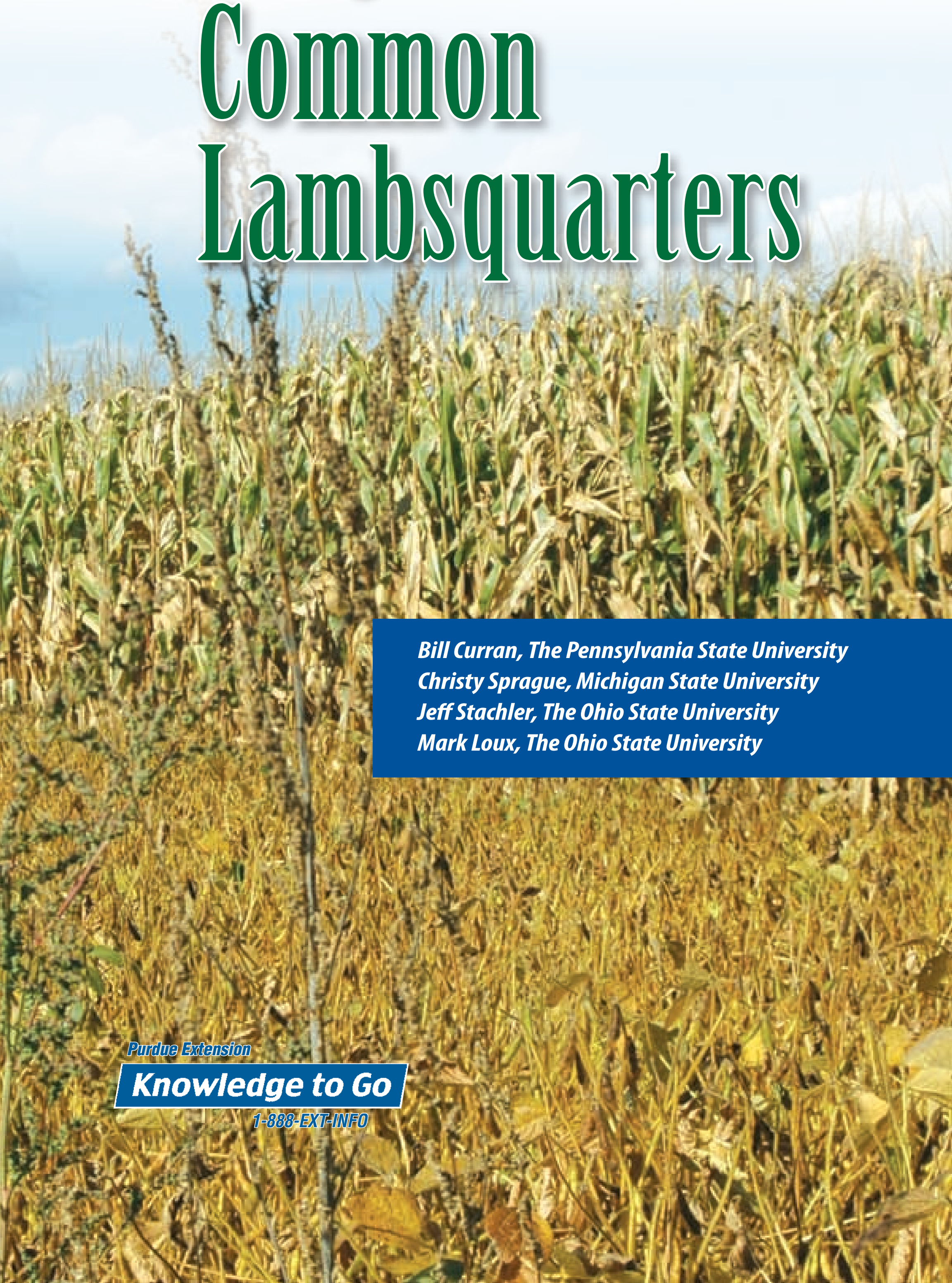
Biology and Management of Common Lambsquarters



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Biology and Management of Common Lambsquarters

Common lambsquarters (*Chenopodium album L.*) is a weed found in many agricultural systems. Its resistance to photosystem II inhibitors (triazines), ALS-inhibitors, and now suspected resistance to glyphosate makes this weed a serious threat to agricultural production systems across North America. Regardless of the type of resistance, resistant weed problems are often caused by producer practices, such as not rotating herbicides and including too few nonchemical management tactics.

The purpose of this publication is two-fold. First it describes the importance, biology, and some characteristics of common lambsquarters that make it a particular problem for agronomic cropping systems. Second, it provides management strategies using current technologies that could slow the development and spread of herbicide-resistant populations of common lambsquarters.

History and Importance

Originally from Europe and Asia, common lambsquarters is now known worldwide as one of the most important weeds in agriculture. One study ranked it as one of the five most widely distributed weeds in the world (Holm et al., 1977). Common lambsquarters is competitive with more than 40 crop species worldwide and is considered a principal weed for corn and soybean producers in the United States (Holm et al., 1977). In fact, common lambsquarters is one of the most prevalent weed species found in U.S. Corn Belt seedbanks (Forcella et al., 1992).

Herbicide resistance in common lambsquarters was identified as early as the 1970s with the discovery of a population in Ontario, Canada with triazine resistance (Bandeen and McLaren, 1979). More recently, common lambsquarters populations resistant to ALS-inhibitors have been identified in Michigan, Ohio, and Ontario (Heap, 2005). With its history of herbicide resistance and recent concerns about potential glyphosate-resistant weeds, attention has been focused on common lambsquarters and several other weed species.

Biology and Identification

Common lambsquarters is a member of the goosefoot family (*Chenopodiaceae*), which also includes spinach and beets. Common lambs-quarters is a summer annual that can emerge throughout the summer, with peak emergence in mid- to late spring.

As a seedling, common lambsquarters has two long, linear-shaped cotyledons, with the first ovate-shaped true leaves appearing opposite in arrangement (Figure 1). True leaves eventually become more distinctly alternate and may be purplish on the underside with both surfaces covered with white granules or a mealy substance (Figure 2). This granular substance is responsible for part of its scientific name — *album* is Latin for white. More mature plants have broadly triangle-shaped leaves with irregular, shallow-toothed margins.

The stems can be green or reddish, are grooved, and can be smooth or hairless. Mature plants generally reach a height of 2 to 6 feet. At flowering, very small, green or gray-green flowers are tightly clustered at the tips of stems and branches (Figure 3). These flowers turn into seeds with a thin, papery covering. An average

Figure 1. *The first ovate-shaped true leaves of common lambsquarters appear opposite in arrangement.*

Figure 2. *Eventually, common lambsquarters leaves become more distinctly alternate and may be purplish. Note the characteristicly white, granular substance on the leaves of this plant.*

Figure 3. *Common lambsquarter flowers are green and tightly clustered at the tips of stems and branches.*

common lambsquarters plant can produce more than 70,000 seeds, ensuring that the weed will be back the following spring (Stevens, 1932).

Removing the papery covering reveals smooth, shiny seeds (Figure 4). About 3% of the seeds are brown; the remainder are black (Williams and Harper, 1965). Brown seeds germinate readily, while black seeds are more dormant. Many of the seeds remain on the plant until early winter and these small, smooth seeds have no other apparent adaptation for dispersal other than their high density and ability to spread from site to site by various means, including equipment transfer. The seeds also can survive well in the digestive tracts of cows, sheep, and horses, so manure is considered a possible source for introducing seed.

Bill Curran, The Pennsylvania State University

Figure 4. *Common lambsquarter seeds are smooth and shiny. About 3% are brown, which germinate readily. The remainder are black, which are more dormant.*

Seed dormancy in common lambsquarters contributes to its success as a weed. Under certain conditions it can remain viable in the soil for several decades. In fact, viable seeds have been recovered from medieval ruins in Europe (Mohler and DiTommaso). Most seeds require some time before they are ready to germinate. Light, strong day and night temperature fluctuations, and the presence of nitrate in the soil increase common lambsquarters seed germination (Mohler and DiTommaso, 2006). Some research suggests that only 10 to 30% of the current season's seed will germinate under favorable conditions the following season (Forcella et al., 1997).

Antonio DiTommaso, Cornell University

Figure 5. *Oakleaf goosefoot is often confused with common lambsquarters, but mature oakleaf goosefoot leaves are generally oval and have wavy-toothed margins, often with a prominent yellowish green line down the center of the upper leaves.*

Across the Corn Belt, there are at least 16 *Chenopodium* species. Several members of this goosefoot family are frequently confused with common lambsquarters, including oakleaf goosefoot (*C. glaucum L.*, Figure 5), late flowering goosefoot (C. strictum), and narrow-leaved goosefoot (*C. pratericola*). A related genus, *Atriplex*, contains at least 3 species found in the north central and northeast United States that can be confused with common lambsquarters, including spreading orach (*Atriplex patula L.*, Figure 6). Common lambsquarters

Figure 6. *(Top photo) Spreading orach (left) is similar in appearance to common lambsquarters (right), but* Atriplex *species have 2 to 6 pairs of opposite leaves and branches. (Bottom photo) Spreading orach (top) and other* Atriplex *species also have a diamond-shaped bract surrounding each flower (circled), unlike common lambsquarters (bottom).*

is by far the most abundant weedy member of the goosefoot family. A number of *C. album* subspecies, varieties, and forms have been recognized over the years, but most are believed to be minor variants of the species (Abrams, 1944). Information on the herbicide susceptibility of goosefoot members other than common lambsquarters is lacking.

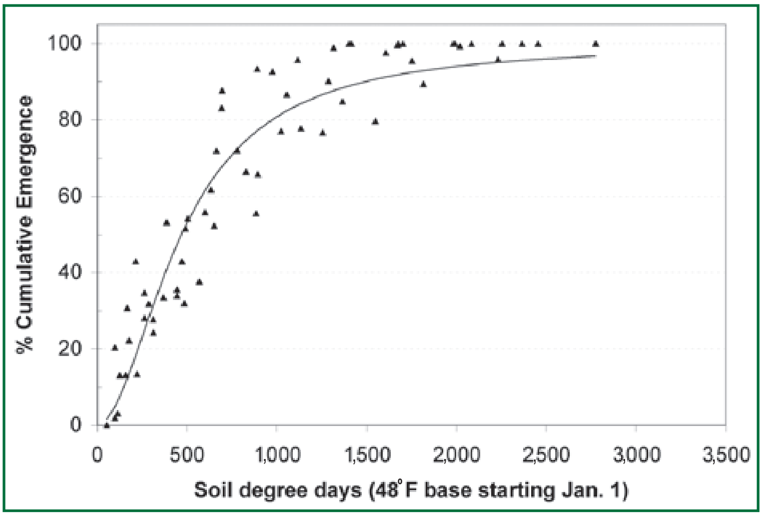

Figure 7. *This graph shows the percent cumulative emergence for common lambsquarters in seven locations. The line represents predicted values and the triangles represent actual values. Predicted values were determined using soil degree days with a base temperature of 48°F starting from January 1.*

Distribution and Emergence

Except for extreme deserts, common lambsquarters is found throughout most of the United States. Within the Corn Belt, it is generally a greater problem in the north.

Common lambsquarters prefers well-drained soils and, as a summer annual, can begin emergence prior to spring corn planting. In Iowa, common lambsquarters begins emergence before 150 degree days (GDD, base temperature 50°F) or several weeks prior to corn planting (Buhler et al., 1997). In the Mid-Atlantic states, common lambsquarters is one of the earliest emerging weed species with about 25% seedling emergence occurring before spring tillage or burndown applications for corn (Myers et al., 2005). The most rapid emergence period in these states occurs during the first 600 GDD (base temperature 48°F), with about 60% seedling emergence (Figure 7).

Some research suggests that tillage promotes germination and that peak emergence frequently occurs within 2 to 3 weeks of turning the soil, provided soil moisture and temperatures are sufficient (Mohler and DiTommaso, 2006). A Wisconsin study found disturbing soil with tillage increased common lambsquarters emergence sixfold one year, but decreased emergence the following year (Mulugeta and Stoltenberg, 1997). However, in the Mid-Atlantic states, spring soil disturbance had little effect on the timing of common lambsquarters emergence (Myers et al., 2005). The optimum seed depth for emergence is about 0.1 inch, and very few seedlings emerge from deeper than 1 inch (Mohler and DiTommaso, 2006).

Growth and Development

Spring-emerging common lambsquarters plants generally flower and set seed in late summer and fall. Later emerging plants can reach the reproductive stage in as little as 6 weeks (Mohler and DiTomasso, 2005). Prolonged drought may trigger early maturation. Common lambsquarters is primarily self-pollinated, although wind can cause some cross-pollination. This plant only reproduces by seed, and once plants flower, they set seed over a relatively short period before they die.

Interference and Competition

Due to its early emergence and rapid growth rate, common lambsquarters is a successful competitor with corn and soybean in the Midwest. However, as with most weed species, the exact degree of common lambsquarters competition is determined by weed density, the relative time of crop and weed emergence, and, most importantly, the environment.

For example, a 2-year, 7-state study found that eight common lambsquarters plants per foot of row reduced corn yield anywhere from 0 to 100 percent (Fischer et al., 2004). Yield loss varied both by location and between years, showing that environment, temperature, and rainfall all affected weed competition.

In addition to competing for nutrients, moisture, and light, green common lambsquarters stems can hamper corn and soybean harvest by clogging up combines. Furthermore, common lambsquarters is a host for several crop diseases, including alfalfa mosaic virus, cucumber mosaic virus, bean yellow mosaic virus, clover yellow vein virus, potato virus, soybean mosaic virus, tobacco etch virus, turnip mosaic virus, and watermelon mosaic virus.

Increased Prevalence

Common lambsquarters has long been a frequent weed problem for producers across the Corn Belt. Historically, it has been successful across tillage systems and seems equally adept in plowed and no-till fields. Rotations away from summer annuals that include a winter grain or perennial forage can help break the life cycle of this and other summer annual weeds. Delaying summer annual crop planting until June in the Corn Belt can also reduce the presence of this early emerging species.

Herbicide Resistance

Triazine

Since the early 1970s, a number of states and several European countries documented the presence of common lambsquarters resistant to triazine and other photosystem II inhibitors. To date, 18 countries have reported the presence of common lambsquarters resistant to these herbicides.

In the United States, most triazine-resistant common lambsquarters has been reported east of the Mississippi River in the so-called, "Dairy Belt." In these areas, corn is often grown for several years in the same field, and triazine herbicides (such as atrazine and simazine) have been frequently used at high rates to control susceptible weeds. These herbicides can persist in the soil, increasing the selection for resistant biotypes.

Other factors have increased the prevalence of common lambsquarters. One is the growth of no-till or reduced-till farming practices where mechanical control is seldom used. Another is the unintended practice of spreading cattle manure containing viable seed in high livestock and production areas. In high livestock production states where corn and reduced tillage are common, triazine-resistant biotypes are often widespread. In a Pennsylvania livestock farm survey, 98% of the 60 farms sampled contained some triazine-resistant common lambsquarters and more than 80% of the common lambsquarters tested on these farms were atrazine-resistant (Bravo, 2002).

ALS Inhibitors

To date, ALS-resistant common lambsquarters has been identified in just Michigan, Ohio, and Ontario. The resistant biotypes were selected in soybean because of the frequent use of ALS-inhibitors. The resistant weeds survived applications of thifensulfuron (Harmony GT®) and/or imazamox (Raptor®), both used in soybean. In central Michigan, unacceptable common lambsquarters control was observed in a field following at least 14 annual consecutive applications of an ALS-inhibiting herbicide (Heap, 2005).

Glyphosate

For many years, producers in several states have reported problems controlling common lambsquarters with postemergence glyphosate applications. Common lambsquarters has become more prevalent in glyphosate-resistant soybean fields in the Midwest and anecdotal observations in several states suggest that common lambsquarters populations are not being effectively controlled with glyphosate in glyphosate-resistant (Roundup Ready®) crops (Owen and Zelaya, 2005).

Historically, common lambsquarters has been problematic for several post-emergence herbicides and environmental conditions before, during, and after foliar application can influence performance. Common lambsquarters size at application also affects common lambsquarters response to glyphosate.

Although poor management decisions, unfavorable weather, or other factors have been the culprit for inconsistent common lambsquarters control with glyphosate, differences in glyphosate sensitivity have been documented in several states. In a Virginia study, a common lambsquarters population survived glyphosate applied at 1 lb. ae/A (1.25 quarts per acre of 3 pounds acid per gallon) and the resistant or more tolerant trait was passed on to the next generation (King et al., 2004). Weed scientists in Ohio and Indiana have identified a biotype of common lambsquarters in at least a dozen fields that appears to have low-level glyphosate resistance.

Expression of this resistance has been somewhat variable under greenhouse and field conditions, but for complete control the biotype can require a glyphosate rate of 2 to 4 times the labeled rate of 0.75 lb. ae/A. Assuming that plants were relatively small when glyphosate was first applied, a second glyphosate application will frequently improve control of the biotype and reduce the number of seeds that surviving plants produce.

In general, higher rates may still control smaller plants that exhibit low resistance levels, but may not effectively control larger plants. This type of resistance will have a greater impact on growers who routinely apply glyphosate to large weeds. Regardless of the level of resistance, most weed scientists agree that problems with controlling this weed will become more numerous — and the continuous use of glyphosate and Roundup Ready® crops will exacerbate the situation. Therefore, avoid using Roundup Ready® crops and glyphosate repeatedly in the same fields on an annual basis.

Cultural and Mechanical Control

Cultural practices that help control common lambsquarters include anything that makes the crop more competitive and reduces the success of the weed. Such practices include selecting crops with quick emergence, altering planting dates relative to weed emergence, planting to narrow rows and using higher seeding rates for greater crop competition, placing fertilizer with the crop (not the weed), and implementing crop rotations that discourage summer annual weed success.

Late seeding in particular can give some control because common lambsquarters tends to germinate early in the season and those seedlings are killed through soil preparation or with a burndown herbicide. Remember, delayed planting may not yield as well as earlier planting, especially for full-season corn. Once resistant weeds are identified, follow preventive practices that reduce the movement of weed seeds into uninfested fields.

Crop rotation interrupts pest life cycles and allows alternative tillage and herbicide options. When following corn or soybean with a fall- or spring-seeded small grain, common lambsquarters may never emerge, compete, or set seed the year of the cereal grain. In addition, because common lambsquarters seeds persist in the soil, removing escapes before seed set is useful for long-term management. Clean up tillage, mowing, or an effective herbicide application after cereal grain harvest can often prevent seed production. Alternatively, underseeding a legume cover or forage crop in the small grain, or after harvest, can compete effectively with common lambsquarters if the grain and cover crops are dense and vigorous.

Mechanical weed control operations, such as rotary hoeing and row cultivating, can help reduce herbicide dependence and effectively control seedling weeds. Because common lambsquarters seedlings are very small and fragile, and the seeds germinate in response to soil disturbance, stirring of the top 1 to 2 inches of soil is highly effective at controlling emerging seedlings during the first 4 to 6 weeks after planting. Row cultivators must be used when weeds are small. The potential to use in-crop cultivation depends on tillage system in corn, and on tillage system and row spacing in soybean.

Chemical Control

Preemergence (PRE) herbicides can effectively control common lambsquarters in corn and soybean, and there are a number of effective postemergence (POST) herbicides available in corn. POST control in soybean can be more difficult. PRE herbicides are often effective enough in both corn and soybean that POST herbicides are not required. However, some common lambsquarters populations can germinate later in the growing season or are triazine-resistant, so they require a combination of PRE and POST herbicides for effective control. Effective herbicides for control of common lambsquarters are provided in Tables 1 and 2.

Burndown in No-Till

Common lambsquarters can emerge early enough in the spring to be present at the time of no-till corn and soybean planting. Effective control of emerged plants at this time is essential for effective in-season management. Depending on plant size and environmental conditions, glyphosate provides variable control, as does paraquat (Gramoxone®). Adding 2,4-D ester to burndown treatments can help ensure effective control. In corn, adding atrazine, mesotrione (Camix®, Lumax®, Lexar®), or dicamba (Clarity®) can also improve control of emerged plants.

Shawn Askew, Virginia Tech

Figure 8. *Common lambsquarters can emerge so early that it may be present at planting. Control at this time is crucial.*

Table 1. Herbicides for Common Lambsquarters Control in Corn.

Active Ingredient	Example Trade Names	Herbicide Group*	Remarks
Soil applied			
acetochlor	Degree®, Harness®, Surpass®	15	For suppression only.
atrazine, simazine	Aatrex®, Princep®	5	Not effective on triazine-resistant biotypes.
flumetsulam	Python®, Hornet®	2	Not effective on ALS-resistant biotypes.
isoxaflutole	Balance®, Radius®	28	Not labeled in Michigan, Minnesota, or Wisconsin.
mesotrione	Callisto®, Camix®, Lexar®, Lumax®	28	
pendimethalin	Prowl®, Pendimax®	3	Will likely require subsequent POST application for complete control.
rimsulfuron	Basis®, Resolve®	2	Not effective on ALS-resistant biotypes.
POST			
2,4-D	2,4-D	4	Apply to common lambsquarters less than 4 inches tall.
atrazine	Aatrex®	5	Apply to common lambsquarters less than 6 inches tall. Not effective on triazine-resistant biotypes.
bromoxynil	Buctril®	6	Apply to common lambsquarters less than 10 inches tall.
dicamba	Banvel®, Clarity®	4	Apply to common lambsquarters less than 4 inches tall.
dicamba, diflufenzopyr	Distinct®, Status®	4, 19	Apply to common lambsquarters less than 4 inches tall.
dicamba, primisulfuron	NorthStar®	2,4	Apply to common lambsquarters less than 4 inches tall.
glufosinate	Liberty®, Ignite®	10	Even at highest labeled rate, apply to common lambsquarters less than 5 inches tall.
glyphosate	Roundup®, etc.	9	Apply to common lambsquarters less than 6 inches tall.
iodosulfuron, foramsulfuron	Equip®	2	Apply to common lambsquarters less than 4 inches tall. Not effective on ALS-resistant biotypes.
mesotrione	Callisto®	28	Apply to common lambsquarters less than 5 inches tall.
primisulfuron, prosulfuron	Spirit®	2	Apply to common lambsquarters less than 3 inches tall. Not effective on ALS-resistant biotypes.
thifensulfuron	Harmony GT®, Basis®, Stout®	2	Apply to common lambsquarters less than 3 inches tall. Not effective on ALS-resistant biotypes.
topramezone	Impact®	28	Apply to common lambsquarters less than 6 inches tall.

*Weed Science Society of America (WSSA) herbicide classification according to primary site of action.

Soil Applied and POST Control

Acetochlor provides fair to good early-season control of common lambsquarters, but needs to be tank-mixed with another effective PRE herbicide or followed with a POST herbicide application for the most effective control. Metolachlor (Dual®, etc.), dimethenamid (Outlook®, Propel®), and flufenacet (Define®) do not provide effective control.

Many POST corn herbicides are effective for common lambsquarters control, but the plants should be less than 6 inches tall at the time of application for best results.

In soybean, using PRE herbicides or combining a PRE herbicide followed by a POST herbicide provides the most consistent control (Figure 9). Avoid total POST herbicide programs for common lambsquarters control in soybean.

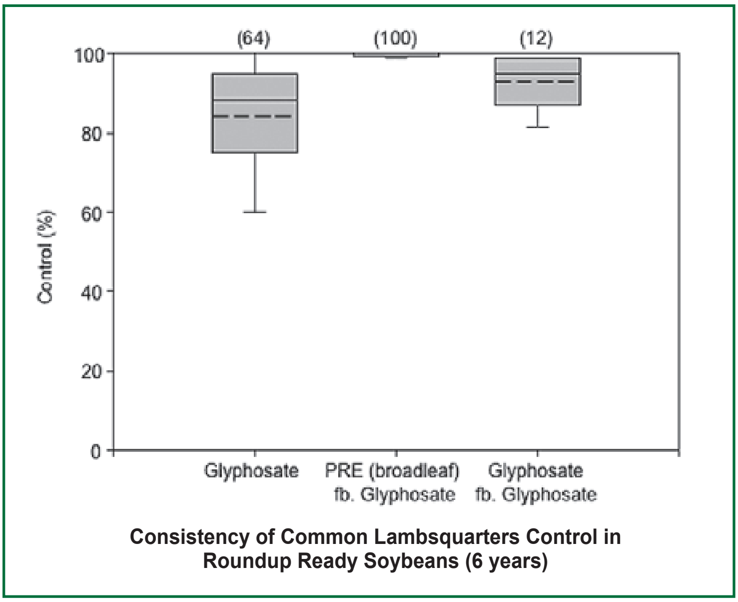

Figure 9. *A 2-pass program consisting of a soil-applied or preemergence (PRE) herbicide followed by glyphosate (POST) was more consistent in controlling common lambsquarters than either 1 or 2-postemergence glyphosate applications.*

The tails in this graph represent minimum and maximum values, while the boxes represent the 25th to 75th percentiles of those values. The dashed lines represent the mean (or average) value and the solid line represents the median (or most frequent) observation. The numbers in parentheses are the number of observations for each treatment. This data is a compilation of 6 years of research trials conducted at Michigan State University (C. Sprague, 2005).

Table 2. Herbicides for Common Lambsquarters Control in Soybean.

Active Ingredient	Example Trade Names	Herbicide Group*	Remarks
Soil Applied			
chlorimuron	Canopy EX®, Synchrony XP®	2	Not effective on ALS-resistant biotypes.
chlorimuron and metribuzin	Canopy®	2	Not effective on triazine- or ALS-resistant biotypes.
clomazone	Command®	13	
cloransulam	FirstRate®	2	Not effective on ALS-resistant biotypes.
cloransulam, flumioxazin	Gangster®	2, 14	
cloransulam, sulfentrazone	Authority First®, Sonic®	2, 14	
flumetsulam	Python®	2	Not effective on ALS-resistant biotypes.
flumioxazin	Valor®, Valor® XLT	14	
imazaquin	Scepter®	2	Not effective on ALS-resistant biotypes.
imazethapyr	Pursuit®	2	Not effective on ALS-resistant biotypes.
linuron	Lorox®, Linex®	7	Will likely require subsequent POST application for complete control.
metribuzin	Sencor®	5	Not effective on triazine-resistant biotypes.
pendimethalin	Prowl®, Pentagon®, Pendimax®	3	Will likely require subsequent POST application for complete control.
POST			
glyphosate	Roundup®, etc.	9	Apply to common lambsquarters less than 6 inches tall.
imazamox	Raptor®	2	Apply to common lambsquarters less than 5 inches tall. Not effective on ALS-resistant biotypes.
thifensulfuron	Harmony GT®, Synchrony XP®	2	Apply to common lambsquarters less than 4 inches tall. Not effective on ALS-resistant biotypes.

*Weed Science Society of America (WSSA) herbicide classification according to primary site of action.

POST Control in Soybean

Apply soybean herbicides with POST activity to small common lambsquarters plants less than about 4 weeks old. When plants are less than 6 inches tall, apply glyphosate at a rate of 0.75 to 1.5 lbs. ae/A. For plants approaching 6 inches, use a minimum of 1.1 lbs. ae/A; and for plants more than 6 inches tall, use 1.5 lbs. ae/A.

A second glyphosate application may control plants that survive an initial application and greatly reduce weed seed production, which may help slow the development of resistant populations. However, a second application is a "rescue" treatment only and should not be used to reduce selection for glyphosate-resistant weeds.

Conclusions

Although weed resistance to herbicide has been around for decades, resistance to glyphosate is unique and of particular concern for no-till agriculture. Being aware of resistance and reducing management practices that select for it are the first steps to dealing with the problem. As with other weed resistance issues, dealing with resistant common lambsquarters requires adjusting or altering management strategies. Knowing herbicide modes and mechanisms of action (WSSA Herbicide Group), rotating herbicide groups, using effective combinations of herbicides from different groups, and implementing nonchemical management strategies can control existing resistance problems and help minimize new ones.

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Biology and Management of Common Lambsquarters

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