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Waterhemp Management in Illinois Agronomic Crops

If a pigweed growing in your soybean field has a red root, does this characteristic always identify the plant as redroot pigweed? Unfortunately, most members of the pigweed family, including waterhemp, usually have reddish colored roots. There exists much variation in root, stem, and leaf color among the pigweeds commonly encountered in Illinois corn and soybean fields.

Correct identification of the members of the pigweed family can indeed be very challenging. What makes matters worse is that accurate identification of *small* pigweeds, the stage at which postemergence herbicides provide the most effective control, is most difficult. As plants near maturity and develop reproductive structures, correct identification becomes easier. At this stage, however, the weeds have won and crop yields have suffered the adverse consequences.

Where did this type of pigweed called waterhemp come from, and why has it become one of the most prevalent pigweeds in Illinois corn and soybean fields? Was it fairly recently introduced into the area, or is it simply a species that has always been present and only recently gained widespread attention? To answer these questions, we first need to explore the pigweed family as a whole and then examine some changes in agricultural production that have undoubtedly assisted in waterhemp's rise to fame.

The pigweeds commonly found throughout Illinois all belong to the botanical Amaranth family. The Latin, or scientific, name of each pigweed found growing in Illinois contains the genus name *Amaranthus;* the species name differentiates among the genus members. How many members of the Amaranth family are commonly found growing in Illinois corn and soybean fields? The simple answer is nine, but these species vary widely in their geographical distribution within the state. For example, the waterhemps are more common in the southern part, while Powell amaranth is most often encountered in the northern reaches of the state. Others, such as smooth pigweed, can be found in almost any area of the state. The nine pigweed species found in Illinois are redroot pigweed *(Amaranthus retroflexus),* smooth pigweed *(A. hybridus),* Powell amaranth *(A. powellii),* spiny amaranth *(A. spinosus),* tumble pigweed *(A. albus),* prostrate pigweed *(A. blitoides),* common waterhemp *(A. rudis),* tall waterhemp *(A. tuberculatus),* and Palmer amaranth *(A. palmeri).* Although it is not the intention in this chapter to provide detailed descriptions of each Amaranth, some basic identification characteristics are provided in Table 1. For further information on pigweed identification, consult an excellent guide developed jointly by Kansas State University and the University of Illinois: *Pigweed Identification: A Pictorial Guide to the Common Pigweeds of the Great Plains* is available from the Kansas State University Cooperative Extension Service Production Services/Distribution, 28 Umberger Hall, Kansas State University, Manhattan, KS 66506–3406.

Waterhemp Biology

Common and tall waterhemp are pigweed species native to Illinois. Historically, their distribution has been most prevalent in the southern part of Illinois (south

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Label registrations can change at any time. Thus the recommendations in this chapter may become invalid. The user must read carefully the entire, most recent label and follow all directions and restrictions. Purchase only enough pesticide for the current growing season.

of Interstate 70). They have also been commonly found extending north along the western border with Missouri and Iowa. An increased presence of waterhemp has been observed in central and eastern Illinois during the past several growing seasons. It has also become easy to identify waterhemp growing as far north as Interstate 80. As its name implies, waterhemp thrives best in wet areas of fields, especially during seasons with ample precipitation.

Waterhemp plants are either male or female; botanists classify this type of biology as dioecious (two). By contrast, monoecious (one) species have both male and female reproductive structures on the same plant. Thus, male waterhemp plants produce only pollen, and female plants produce only seed. This type of biology can lead to cross-pollination or fertilization of female plants with pollen from more than one male plant. Cross-pollination can greatly increase the genetic diversity of a population, and with genetic diversity comes a great range in physical appearance.

The waterhemps, similar to other Amaranths, are annuals that produce very small seed. These small seeds are ideally suited for shallow germination (< ¼"); increasing the depth seeds are buried likely would reduce seed survival and emergence. Waterhemps are very prolific seed producers; one female plant can produce in excess of 100,000 seeds in a growing season. High seed production and small seeds make waterhemp well suited for reduced-tillage production systems, where the soil is not disturbed and the seeds remain close to the soil surface.

Prolific seed production also helps spread waterhemp to new fields via farm equipment. Harvest and tillage equipment can spread seed into fields where the species may not have been found in past years. Infestations of waterhemp into previously "clean" fields can sometimes be observed beginning along field edges where tillage and harvest equipment enters.

Seed germination and plant emergence of waterhemp often extend further into the growing season than for most other annual weed species (including other pigweed species) encountered in agricultural production systems. Waterhemp germination may be enhanced by higher soil temperatures. This trait contrasts with species such as common lambsquarters, which emerge earlier in the season. The extended germination and emergence presents the potential for several flushes of waterhemp during the course of a growing season. Soil-applied herbicides can provide effective control of earlier-season flushes but may not persist long enough to control later-emerging waterhemp. Conversely, postemergence herbicides are most effective when waterhemp are small, but few provide sufficient residual activity to prevent future emergence.

Research from Kansas State indicates that waterhemp grows taller and produces more biomass than does redroot pigweed. In practical terms, this means that waterhemp is capable of exceeding the growth stages specified on postemergence herbicide labels faster than redroot pigweed.

Waterhemp Identification

Without question, identification of the various pigweeds is indeed challenging. Experience is often a good teacher, but even persons experienced in identifying pigweeds can sometimes be fooled when attempting to identify plants in the seedling stage.

The waterhemps can and do vary greatly in their physical appearance. Remember, waterhemps are dioecious; pollen from many sources contributes to the variation in appearance. The most consistent characteristics for identifying waterhemp are related to features of the reproductive structures. There are, however, some characteristics that can be useful in distinguishing waterhemp from other pigweeds while they are in an early vegetative stage.

Is It Redroot Pigweed, Smooth Pigweed, or Waterhemp?

Waterhemp plants typically have no hairs on stems or leaves, giving the plant a smooth texture. In contrast, on both stems and leaves, smooth and redroot pigweed have small, fine hairs that feel rough to the touch. This is not to say, however, that hairs are never found on a waterhemp plant. With cross-pollination contributing to genetic diversity, some waterhemp plants have been identified with *sparse* hairs on the stems. In most cases, however, no hairs are found on waterhemp plants.

The leaves of waterhemp are typically glossy and often more elongated, or lanceolate, compared to redroot or smooth pigweed. Waterhemp leaves feel smooth, while redroot and smooth pigweed leaves feel rough and hairy. Stem color of waterhemp can vary from light green to dark red; several shades of red and green even may be present on the same plant. Plants with red stems and green petioles or green stems with red petioles are not uncommon. No strong relationship between stem color and sex of the plant appears to exist. Female plants may be completely red, green, or some combination of red and green. Male plants exhibit a similar color pattern.

With two species of waterhemp commonly found in Illinois, is there a need to differentiate between them? The simple and practical answer is "no." Little, if any, evidence suggests these two similar, yet distinct, species vary in response either to soil-applied or postemergence herbicides. From a practical standpoint, the only consistent way to differentiate between common and tall waterhemp is to examine how the capsule (utricle) surrounding the seed fractures when abraded.

Waterhemp: Why the Increased Prevalence?

There likely is no one single reason for the observed increased prevalence of waterhemp across much of Illinois. Rather, several factors likely have contributed to the increase. Many persons may question if widespread use of specific herbicides, in particular those that inhibit the ALS (acetolactate synthase) enzyme, has caused waterhemp to become so prevalent. There is little question that increased use of these herbicides has contributed to the spread of waterhemp, but other factors have also been involved.

Increased adoption of no-till production systems. Does adoption of no-till production systems result in an increase in waterhemp populations? Not necessarily, but lack of tillage does appear to create an environment ideal for species such as waterhemp. Why is waterhemp adapted to no-till systems? Remember, the seeds of waterhemp (as well as those of other pigweeds) are very small. Small seeds typically germinate from very shallow depths in the soil. Larger seeds, such as those of velvetleaf, can also germinate from shallow depths; but, with their additional stored seed reserves, large-seeded species are capable of germinating and emerging from deeper depths. With no disturbance of the soil, seeds produced from existing waterhemp plants are distributed primarily near the soil surface. This zone often remains moist, and the relative humidity under existing crop residue is higher than that encountered on a bare soil surface. Basically, this environment is ideal for waterhemp germination and emergence.

Adoption of no-till has, in many cases, altered the application timing of soil-applied herbicides. Applications frequently are made several weeks before planting, in an attempt to have the herbicide incorporated into the soil by precipitation. In many cases, the need for a burndown herbicide immediately before planting is eliminated. A severe limitation to this practice is the accurate prediction of when soil conditions will be conducive for planting. Herbicides applied when planting is expected within, for example, 14 days may actually be on the ground for several additional weeks if soil conditions are not conducive for planting as planned. Herbicides applied this far in advance of planting often do not provide adequate residual control of late-emerging weed species such as waterhemp.

Strict adherence to no-till practices eliminates an effective weed control option: mechanical cultivation. Years ago, before the adoption of no-till, tillage before planting killed the initial flushes of waterhemp, preemergence soil-applied herbicides provided several weeks of control, and one or more cultivations generally supplemented the weed control provided by the soil-applied herbicides. Without the option to cultivate, you may find that waterhemp escapees remain not controlled or additional postemergence herbicides are needed.

One additional factor of no-till systems that can contribute to waterhemp invasion is failure to control the weed by applying a burndown herbicide before planting. Soil conditions encountered early in the 1996 growing season caused delays in soybean planting well into June and July. By that time, waterhemp had emerged and made a fair amount of growth. Burndown herbicides applied at reduced rates and those without 2,4-D often missed some waterhemp. These plants were quite large by the time postemergence herbicides were applied. Many of these larger plants survived and produced seed for the following season.

Reduced use of effective, soil-applied herbicides; more postemergence applications. Following hand-in-hand with the increase in no-till production has been the decreased use of soil-applied herbicides for weed control. Many older, soil-applied herbicides possess substantial activity on small-seeded broadleaf weed species such as common lambsquarters and pigweeds. When broadcast applications of combinations of soil-applied herbicides were widely used, and usually followed by one or more cultivations, pigweeds of any species only occasionally escaped control and developed into substantial problems. However, with the reduced use of soil-applied and incorporated herbicides that control grasses and small-seeded broadleaves, pigweeds escaped control more frequently in recent years.

The increased use of postemergence herbicides has, without question, assisted the widespread adoption of no-till production practices. Postemergence herbicides offer many advantages over soil-applied programs, but there are also disadvantages. Many of today's postemergence herbicides control a wide spectrum of weeds, but few have adequate residual activity to control weeds, such as waterhemp, that may emerge several days or weeks following application. Several postemergence broadleaf herbicides used in soybean possess an identical mode of action, which can contribute to selection pressure for herbicide-resistant weed biotypes.

Variable response to herbicides. Several years ago, certain pigweed biotypes developed resistance to triazine herbicides; and, although this development is not widespread throughout the Midwest, certain areas have substantial acreage of triazine-resistant pigweeds. More recently, biotypes of waterhemp have been identified that are resistant to ALS-inhibiting herbicides. These herbicides comprise a large portion of the currently available soybean herbicides, as well as an increasingly large percent of corn herbicides, making ALS resistance an important issue. A few isolated locations exist with biotypes of waterhemp that are resistant to triazine herbicides, but these are not common.

So is all waterhemp encountered within Illinois resistant to some herbicide? Although there are confirmed instances of collecting waterhemp biotypes in Illinois that are resistant to ALS herbicides, by no stretch of the imagination is every waterhemp plant resistant. Waterhemps vary widely in morphology and also appear to be quite variable in their response to herbicides. This variation in response can range from highly susceptible to very resistant. Are ALS herbicides responsible for the increase in waterhemp? This class of herbicides may be partially responsible, but so are other herbicide classes, as well as a number of other factors.

Waterhemp Control—A Few Basic Principles

Does waterhemp spell the end of farming as we know it? Of course not, but control of waterhemp may prove somewhat more challenging than control of other annual weed species. Where, then, do we start?

The first step in managing waterhemp, among all the other species a producer may encounter, is proper scouting and accurate identification of the weed species present in a particular field. As previously presented, correct identification of waterhemp can be difficult. The pigweed identification guide available through Kansas State University can help remove some of the guesswork.

Late summer and early fall are ideal times to identify accurately all pigweeds encountered in your fields. Although obviously too late to prevent crop-yield loss caused by competition, observations at this time of the year provide an opportunity to assess the kind and severity of the pigweed infestation. If seed production has been successful, it becomes very likely that the same pigweed species will be present the following growing season. It may prove beneficial to construct field maps indicating where waterhemp and other pigweed species are encountered within the field—so adjustments may be made in control programs.

Once you ascertain that waterhemp is indeed present in your fields, what's the next step? Do you need to overhaul your weed control programs dramatically, or can you make some minor modifications with promising results? What are some considerations for both soil-applied and postemergence herbicide programs?

Considerations with Soil-Applied Herbicides

Numerous soil-applied herbicides possess substantial activity on small-seeded broadleaf species, including waterhemp. Can these herbicides be applied several weeks before planting and good control still be expected? Would incorporation improve herbicide performance? Do the soil-applied "grass" herbicides have any activity on waterhemp? Would a postemergence herbicide program be a more reliable plan of attack? These questions are ones that we frequently encounter from producers who have only recently encountered waterhemp. Let's examine these questions in more detail.

Time of application can have a substantial impact on waterhemp control with soil-applied herbicides. A common practice in no-till systems is to apply the herbicide or herbicide combination several weeks before planting, in hopes of receiving adequate precipitation to incorporate the herbicide. However, the only foolproof method to determine when X number of days or weeks before planting occurs is to plant and *then* count backwards! Delays of one sort or another often lengthen the time between herbicide application and planting.

What exactly are we getting at? As soils warm, and if moisture is adequate, dissipation of soil-applied herbicides begins. When the concentration of herbicide in the soil is reduced, weed emergence occurs. Generally, the earlier a herbicide is applied, the earlier within the growing season that the level of weed control decreases. Waterhemp appears to have little difficulty germinating later in the growing season, long after soil-applied herbicides have dissipated. Often, producers question if a soil-applied herbicide did much for them in terms of controlling waterhemp, especially when treated fields appear infested with waterhemp. The soil-applied herbicide more than likely did its job but did not persist long enough to control later flushes of this weed.

What can be done to prolong the control provided by soil-applied herbicides? Three possible options are to

1. Increase the rate of the herbicide, if allowed by the label.
2. Apply the herbicide in a split application (generally, two-thirds early, with the remaining one-third at planting).
3. Apply the herbicide closer to planting time.

By applying the herbicide closer to planting time, control can be extended longer after the crop has emerged. Most producers who have dealt with waterhemp would agree that having a clean field is more desirable in June than in April.

Would it be beneficial to incorporate the herbicide? This answer obviously varies according to the herbicide applied; some herbicides (such as trifluralin) require mechanical incorporation to reduce herbicide loss, while others may be surface-applied without incorporation. When incorporation is not included, the herbicide is dependent upon precipitation to move into the soil solution. A soil-applied herbicide must be in either the soil solution or a vapor phase to be absorbed by a germinating seedling. Incorporation reduces the absolute dependence on precipitation and may also be beneficial in burying some waterhemp seed too deeply to emerge. Care must be taken, however, not to incorporate too deeply and dilute the herbicide.

The soil-applied "grass" herbicides (Dual II, Surpass, Treflan, etc.) all possess some activity on small-seeded broadleaf weeds. They are primarily grass-control herbicides, however, and probably should be selected primarily for this purpose. Is there enough difference among these herbicides with respect to controlling waterhemp to warrant changing programs? Research at the University of Illinois suggests that differences are slight, generally not enough to warrant changes in current programs.

Considerations with Postemergence Herbicides

Several postemergence herbicides available for use on corn and soybeans are very effective on waterhemp and other pigweeds. The factors governing the effectiveness of postemergence herbicides almost take on additional importance when you attempt to control waterhemp. Herbicide rate and application timing are critically important for success.

Because waterhemp can germinate and emerge for an extended period during the growing season, typically a broad range of waterhemp sizes exists by the time the postemergence herbicide is applied. What are the implications, adverse or otherwise, of this extended emergence on efficacy of postemergence herbicides? Plants that emerged early in the season would, obviously, be larger than those that emerged later. Spray interception by smaller plants may be reduced if these plants are growing under the protective canopy of the larger, more mature plants. Under this scenario, poor waterhemp control is most likely due to poor spray coverage. Another obvious implication of the extended period of waterhemp emergence is that larger plants are simply harder to control than smaller plants. This fact is no different than for other annual weed species, but few other species commonly encountered in corn and soybean production systems are so varied in size when postemergence herbicides are applied. Often, producers like to wait as long after planting as possible to apply postemergence herbicides, especially those herbicides that lack residual activity, in order to have as many weeds emerged as possible. The variable growth patterns and extended emergence of waterhemp can make delaying postemergence herbicide applications costly.

What about spray volume and pressure? As the trend to postemergence applications has grown, the amount of carrier (gallons per acre, gpa) has been reduced in exchange for higher spray pressures (pounds per square inch, psi). The less water applied per acre, the more acres that can be treated per load or per day. Waterhemp, as previously discussed, can form a variable canopy architecture that may limit the amount of herbicide intercepted by smaller plants. One possible strategy to improve coverage of the smaller plants is to increase the amount of carrier. Applications made at 20 gpa may provide more consistent control of waterhemp than those made at 7 to 10 gpa, especially when applying "contact" herbicides. As for spray pressure, it doesn't seem likely that using 90 (or even more than 100) psi accomplishes much more than forming spray droplets so small that they are easily carried out of the target area. Spray pressures between 40 and 60 psi, with carrier volumes of 20 gpa, provide very good coverage of the target vegetation.

Waterhemp regrowth from the lower nodes on the stem often has been noted following application of postemergence "contact" herbicides. This may raise some concern; but it has been our observation, particularly in soybean, that this regrowth is *generally* not sufficient to allow the waterhemp to overtop the soybean canopy. Additional applications of postemergence herbicides, diphenyl ether herbicides in particular, may provide some control of waterhemp regrowth but may also "reopen" the soybean canopy. With light striking the soil surface, adequate soil moisture, and the prolonged emergence pattern of waterhemp, these supplemental postemergence herbicide applications actually may allow additional waterhemp to emerge.

Control Programs for Field Corn

The most consistent control programs in field corn are those combining a soil-applied herbicide with either a postemergence herbicide or one or more cultivations.

Soil-applied

Triazines. Both atrazine and metribuzin (Table 2) have good activity on waterhemp, but application of these triazines or premixes containing these herbicides should not be made more than 2 to 3 weeks before planting. Simazine has a longer soil residual than many other triazines and also has activity on waterhemp. Cyanazine, by contrast, has little activity on pigweeds.

Chloroacetamides. The chloroacetamide herbicides are used primarily for control of grass weed species, but all these herbicides possess some activity on waterhemp. Often these products are premixed or tank-mixed with atrazine to enhance activity on broadleaf species, including waterhemp. However, research has indicated that these products generally do not possess enough residual activity to provide extended control of waterhemp. As discussed previously, these herbicides are primarily for grass control and probably should be selected mainly for this purpose.

Growth regulators. Dicamba may be used as a soil-applied treatment for control of broadleaf species and does have some activity on waterhemp. Dicamba is a relatively water-soluble herbicide, which indicates that it moves through the soil profile easily, given sufficient precipitation. In many cases, dicamba may move too deeply into the soil profile to provide sufficient residual control of waterhemp. Dicamba, alone or premixed with atrazine, generally provides better control of waterhemp when used as a postemergence treatment.

ALS and ALS premixes. Several ALS or ALS-premixed herbicide options are available for use in corn. Their performance on waterhemp has been fairly erratic, sometimes providing good control but often failing to provide adequate control. Utilizing these herbicides as premixes or tank-mixing with a herbicide having another mode of action and good activity on waterhemp usually improves control. Because these herbicides generally control a broad spectrum of other broadleaf and grass species, they still have a place in the market, even in fields with a substantial level of waterhemp.

Postemergence

Growth regulators. Dicamba and 2,4-D both possess substantial activity on waterhemp. These herbicides may be the best line of defense when attempting to control waterhemp postemergence. Dicamba generally has performed somewhat better than 2,4-D and provides slightly more residual activity. Both products may be tank-mixed with other herbicides to broaden the weed control spectrum. Many ALS-herbicide labels recommend tank-mixing reduced rates of dicamba to enhance performance on certain species such as waterhemp. If applications such as these are made to fields with ALS-resistant biotypes, the dicamba component likely is the only herbicide in the mix providing control of the resistant waterhemp. Thus, the rate of dicamba used in a tank mix should be as high as that which is sufficient, if applied alone, to provide good control of waterhemp.

If no layby cultivation is made, producers may wish to consider applying a growth-regulator herbicide with drop nozzles to control late-emerging waterhemp and reduce the amount of seed produced. Consult the respective herbicide label to determine if this type of application is permitted and what precautions to observe.

Triazines. Atrazine plus crop oil concentrate has performed well on waterhemp. Sencor also may be applied postemergence, but only when tank-mixed with another herbicide. Additive selection with Sencor tank mixes varies with the tank-mix partner. Both atrazine and Sencor are contact herbicides and provide better control of waterhemp when plants are small (less than 4 inches in height).

ALS and ALS premixes. There are more ALS or ALS-premixed herbicides available for postemergence applications than for soil applications. Postemergence applications of ALS herbicides have been extremely variable in their level of waterhemp control. In some fields with waterhemp, ALS herbicides alone control waterhemp very well. However, with ALS-resistant biotypes of waterhemp confirmed in several parts of the state, it may be best to use ALS herbicides only as premixed or tank-mixed applications. Tank-mixing or using premixes of ALS herbicides is a better strategy to delay further development of resistant biotypes than is applying these herbicides alone. Dicamba or 2,4-D is usually the tank-mix partner of choice.

Control Programs for Soybean

Similar to waterhemp control programs in field corn, the most consistent programs in soybean combine a soil-applied herbicide with either a postemergence herbicide or one or more cultivations.

Soil-applied

Dinitroanilines. The DNA herbicides once dominated the soil-applied market in soybean. With the trend to reduced tillage and the introduction of postemergence grass herbicides, the DNAs are used less today than 10 years ago. These herbicides, however, have good activity on many small-seeded broadleaf species, including waterhemp. Trifluralin requires mechanical incorporation to reduce losses by photodegradation and volatility, while Prowl may be surface-applied without incorporation. With application followed by no incorporation, precipitation is required to move the herbicide into the soil solution, where it becomes available for uptake by small weeds. Surface applications of Prowl with no accompanying plan to incorporate mechanically probably should occur 2 weeks before planting to have a greater likelihood of receiving the required precipitation. If no precipitation is received between application and planting, incorporation still can be performed and may provide the added benefit of burying some waterhemp seed too deeply to emerge.

Chloroacetamides. As with their use in corn, the chloroacetamides Dual II, Lasso, and Frontier can provide some control of waterhemp. However, the rates used in soybean are usually lower than those used in corn. Turbo is a premix of a chloroacetamide (Dual) and triazine (Sencor) that has performed fairly well on waterhemp. Similar to most other soil-applied herbicides, the chloroacetamides rarely provide enough residual control of waterhemp, and postemergence-herbicide applications are usually needed to provide adequate control.

Triazines. Sencor or Lexone is available for preemergence applications in soybean. In fields with a heavy population of waterhemp, these herbicides should not be applied several weeks before planting. Cost and soybean response are two factors that have contributed to a decline in the number of acres treated with these products. Applications made close to planting can provide good residual control of waterhemp, but follow-up postemergence herbicide applications are often required to remove later flushes of waterhemp.

Phenylureas. Lorox may be applied as a preemergence treatment for waterhemp control. The activity of Lorox is greatly affected by soil organic matter; the higher the organic matter content, the more herbicide remains bound to organic particles and unavailable for weed control. The half-life of Lorox in the soil is relatively short, thus applications should not be made several weeks before planting.

ALS and ALS premixes. Many ALS or ALS-premixed herbicide options are available for use in soybean. Similar to the performance of ALS herbicides in corn, performance of these products on waterhemp has been erratic in soybean fields. In fields with waterhemp, ALS herbicides likely should be combined (premixed or tank-mixed) with herbicides having another mode of action and good activity on waterhemp. ALS-resistant waterhemp usually is not controlled by soil-applied ALS herbicides, but performance on other weed species still may be sufficient.

Other soil-applied herbicides. Authority or premixes containing sulfentrazone offer growers an effective new herbicide for control of waterhemp. As with the efficacy of many other soil-applied herbicides, that of Authority is influenced by soil texture and organic matter content. The amount of sulfentrazone contained in field use rates of Canopy XL provides good residual control on soils with less than 3 percent organic matter but may not perform as well on soils with a higher organic matter content. Application timing of these products likely should be no more than 2 weeks before planting. Some soybean injury has been observed with higher rates of Authority, but this may be attributed to adverse growing conditions, as well as possible varietal differences.

Postemergence

Diphenyl ethers. Herbicides in this family have provided consistent waterhemp control. The best control is achieved when these herbicides are applied before waterhemp exceeds 3 to 4 inches in height. These herbicides are often applied at reduced rates with other postemergence broadleaf herbicides but tend to reduce grass control when applied with postemergence grass herbicides. Grass control from postemergence applications also can be antagonized when Pursuit or Raptor is applied with a diphenyl ether herbicide. When applied at labeled rates, Blazer/Status, Reflex/Flexstar, and Cobra all provide similar control of waterhemp. When rates are reduced and one of these herbicides is applied either alone or with another herbicide, Cobra has tended to perform slightly better than the other diphenyl ethers. With all these herbicides, crop injury should be expected and is generally greater when applications are made under conditions of high temperature and relative humidity and when crop oils or 28% UAN solution is included.

Roundup Ultra. Roundup Ready soybeans allow producers to apply Roundup Ultra for control of waterhemp. Rate and timing of application, as with all postemergence herbicides, ultimately determine success of the Roundup Ready system. Rates of Roundup Ultra should generally be no lower than 1.5 pints per acre and should be increased when larger waterhemp are encountered. Roundup Ready soybean varieties have shown good tolerance to applications of Roundup Ultra, with only occasional chlorosis noted. One potential benefit of using Roundup Ready soybeans for control of waterhemp is a lesser degree of soybean response following Roundup Ultra application, compared to other postemergence herbicides. In particular, soybean leaves are not "burned" or dropped from the plant following application, thereby allowing the soybean canopy to close sooner than is possible if the leaves had been severely injured. A closed soybean canopy is helpful in suppressing waterhemp that may emerge following herbicide application.

ALS and ALS premixes. Do all ALS herbicides fail to control waterhemp? Some people may think this is the case, but we actually have been able to control waterhemp in greenhouse and field research with several different ALS herbicides. The response, however, can range from complete control to complete failure. What about ALS-resistant biotypes? With no way to determine efficacy, other than applying the herbicide and observing the results, it's probably safe to assume that whatever ALS herbicide is applied, control will not be adequate. These herbicides should be applied as a premix or tank-mix with a herbicide having another mode of action and good activity on waterhemp.

Conclusions

Common and tall waterhemp are two members of the pigweed complex that have demonstrated extensive expansion into previously uninfested areas, as well as resistance to herbicides with certain other modes of action. The biology and ecology of waterhemp present additional challenges to producers and herbicide programs for adequate control. Late-season germination and emergence, as well as misidentification, are major factors that have enabled waterhemp to elude control for the past few seasons. Changes in agronomic practices and a reluctance to utilize effective soil-applied herbicides have also contributed to the rapid expansion of this "new" weed problem.

University research has demonstrated that many currently available corn and soybean herbicides provide adequate control of waterhemp, but it has shown also that few existing options provide acceptable control alone. Mechanical cultivation in combination with soil-applied and/or postemergence herbicide programs greatly increases waterhemp control. Sequential herbicide programs have consistently yielded better results than single applications, either soil-applied or postemergence.

Table 1. Pigweed Identification Characteristics

Species	Hairs	Leaves	Flowers	Seed head
Redroot	Small, fine	Rounded	Monoecious	Highly branched, compact
Smooth	Small, fine	Rounded	Monoecious	Highly branched, < compact
Waterhemp,				
Tall	None	Lanceolate	Dioecious	At top of plant and leaf tips
Common	None	Lanceolate	Dioecious	
Palmer Amaranth	Few to none	Poinsettia-like, "V" variegation	Dioecious	Nonbranching, 1 to 2 feet long
Powell Amaranth	Small, fine to none	Tapered and slightly pinched at end	Monoecious	Branched, < RR or smooth, 4 to 8 inches long
Spiny Amaranth	None	"V" variegation, spines at nodes	Monoecious	Male towards top, female towards bottom
Tumble		Egg-shaped, wavy edges; olive green	Monoecious	No distinct flowering structure, flowers at nodes
Prostrate		Spatulate, cotyledons longer than others	Monoecious	No distinct flowering structure, flowers at nodes

Redroot vs. Smooth: Differentiate only when seed head is present.
Redroot/Smooth vs. Waterhemp: Differentiate by hairs, leaf shape (sometimes), waxy leaves of waterhemp.
Tall vs. Common Waterhemp: Differentiate by fracture of seed capsule (utricle): Common = 2 sections, Tall = irregular.

Table 2. Herbicides for Waterhemp Control, Classified by Chemical Family

Corn herbicides

Triazines	**Chloroacetamides**	**Growth regulators**	**Dinitroanalines**
atrazine (AAtrex)	acetochlor (Harness, Surpass, TopNotch)	2,4-D (many)	pendimethalin (Pentagon, Prowl)
metribuzin (Sencor)	alachlor (Lasso, Micro-Tech)	dicamba (Banvel, Clarity)	
simazine (Princep)	dimethenamid (Frontier)		
	metolachlor (Dual II Magnum)		
	+ atrazine	**+ atrazine**	
	acetochlor (FulTime, Harness Xtra, Surpass 100)	2,4-D (Shotgun)	
	alachlor (Bullet)	dicamba (Marksman)	
	dimethenamid (Guardsman)		
	metolachlor (Bicep II Magnum, Bicep Lite II Magnum)		

Soybean herbicides

Triazines	**Chloroacetamides**	**Dinitroanilines**	**Diphenyl ethers**
metribuzin (Lexone, Sencor)	alachlor (Lasso, Micro-Tech)	pendimethalin (Pentagon, Prowl)	acifluorfen (Blazer, Status)
	dimethenamid (Frontier)	trifluralin (Treflan, others)	fomesafen (Flexstar, Reflex)
	metolachlor (Dual II Magnum)		lactofen (Cobra)
	+ metribuzin		
	metolachlor (Turbo)		
Phenylureas			
linuron (Lorox)			
Other			
glyphosate (Roundup Ultra)			
sulfentrazone (Authority)			

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