Chapter 6

Weed Management

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Weed and Soybean Interactions

Implementation of effective weed control strategies is an important component of soybean production. Control efforts become economically justified because of the potential for soybean yield reduction, crop quality loss, harvesting difficulties, or other problems associated with the presence of weeds. In some situations, low weed populations may not interfere with crop yield, harvestability, or crop quality. Thus, producers could allow low populations of certain weeds to remain in the field throughout the growing season without affecting the crop. However, weed species such as smooth pigweed (*Amaranthus hybridus*), Palmer amaranth (*Amaranthus palmeri*), and common lambsquarters (*Chenopodium album*) are capable of producing thousands of seeds from single plants, thus weed seed added to the soil bank from even relatively low populations can be substantial. It is advisable to control populations of most weeds, particularly newly introduced species, before they reach maturity. Furthermore, vining weeds such as

Figure 6-1. Hophornbeam copperleaf (*Acalypha ostryifolia*), also known as three-seeded mercury, is a summer annual that emerges from June through September and can grow from 1 to 3 feet tall. The characteristic leaves are heart-shaped with finely serrated margins attached alternately on the stem. In the young seedling stage this plant can be confused with prickly sida, which has more linear leaves and more coarsely serrated margins.

Table 6-1. Estimated impact of select weed species on soybean with a 50 bu/ac yield potential.[1]

Relative weed pressure	Yield Loss potential	Foxtail spp.	Johnson-grass	Morning-glory spp.	Smooth Pigweed	Common Cocklebur	Giant Ragweed	Estimated yield loss by a single species
	-- Weed Density (plants per 100 sq ft) --							(bu/ac)
Slight	(0-5%)	5	2	1	1	<1	<1	1
Low	(5-10%)	10	5	2	2	1	1	2
Moderate	(10-20%)	20	10	5	5	4	4	6
Severe	(20-30%)	40	20	15	10	8	8	12
Very Severe	(>30%)	60	30	20	15	10	10	20

[1] These specific plant density values are based on general observations, and estimates show relative differences among weed species. Estimated values can vary greatly depending on the environment and when the weeds emerge relative to the time of crop emergence. Adapted from University of Missouri-Columbia Extension bulletin "Integrated Pest Management--Practical Weed Science for the Field Scout Corn and Soybean," Nov 2009.

burcucumber (*Sicyos angulatus*), morningglory (*Ipomeoa* spp.) and trumpetcreeper (*Campsis radicans*) can interfere with soybean harvest and reduce yield. The potential yield loss from various weed populations is illustrated in Table 6-1.

Most studies evaluating weed-soybean competition indicate weeds that emerge and grow with soybean during the first three weeks but are then removed do not reduce soybean yield under normal environmental conditions. Weeds that remain in the crop from three to eight weeks after soybean emergence have the greatest potential to reduce soybean yields. Weeds that emerge six to eight weeks after soybean emergence in fields, which have been kept weed-free up to that point, are not likely to reduce yield or have a negative economic impact relative to the cost of in-season treatment. However, these later emerging weeds may cause harvest problems, reduce crop quality, or produce more weed seeds.

Double-Cropping

Double-cropping in Kentucky typically involves planting soybean after winter wheat harvest. In this system, double-crop soybean tends to have fewer weeds compared with full-season soybean due to the delay in planting date and vegetative cover provided by the wheat residue. Nevertheless, the impact of weeds on yield can still be significant because of limited moisture typically observed with later planting dates. Fields may appear to be weed-free after wheat harvest, but a close examination could indicate otherwise. It is important to use a burndown herbicide treatment to control emerged weeds prior to planting double-crop soybean and to utilize a soil-residual herbicide to extend control of critical weeds. Examples of weeds that emerge in wheat and transition over to double-crop soybean include johnsongrass (*Sorghum halepense*), marestail. also known as horseweed (*Conyza canadensis*), common ragweed (*Ambrosia artemisiifolia*), giant ragweed (*Ambrosia trifida*), and smartweed (*Polygonum* spp). Planting soybean in narrow rows (< 15-inch-wide rows) is important for weed control in double-crop soybean.

No-Tillage

The majority of soybean in Kentucky and surrounding states are produced using no-tillage practices. No-tillage practices provide numerous benefits for weed control. Undisturbed soil, with time, reduces the germination of weed seed that are buried deep in the soil-seed bank. No-tillage limits the amount of soil disturbance and scarification (that is, physical abrasion) of weed seeds and may explain why weeds such as common cocklebur (*Xanthium strumarium*), burcucumber, and sicklepod (*Senna obtusifolia*) are observed to a lesser extent in no-tillage compared with intensive tillage situations. Furthermore, leaving the soil undisturbed for several years may lead to rotting and/or predation of weed seeds on the soil surface.

The lack of soil disturbance may, however, promote the development of populations of certain weed species. Common pokeweed (*Phytolacca americana*) and curly dock (*Rumex crispus*) are examples of perennials with large fleshy tap-roots that grow well in a no-till environment. Also, some small-seeded annual weed species such as marestail, annual fleabane (*Erigeron annuus*), and daisy fleabane (*Erigeron philadelphicus*) are noticed more frequently under no-tillage conditions. These weed species can emerge during the late fall or early winter months and maintain active growth throughout the soybean growing season. The seed-like achenes with tufts of hair contribute to the spread of these weeds by wind. Thus, they can easily invade new fields and thrive if primary tillage is not used to destroy emergence of new plants. Emergence of other small-seeded weeds, such as common lambsquarters and pigweed species, as well as annual grasses, may also be favored in no-till fields. This is likely due to their ability to emerge from shallow depths in the soil.

No-tillage leaves much of the previous crop residue on the soil surface where it can partially intercept herbicide applications. Less crop residue is present if the previous crop was soybean as compared to corn or wheat. Rainfall occurring soon after application generally moves the herbicide off the crop residue and into contact with the soil. This reflects the importance of rainfall instead of mechanical incorporation as the means by which a major portion of the soil-residual herbicide is moved within close proximity to germinating weed seeds in a no-tillage system. Some herbicides intercepted by crop residue may be subjected to loss by photodecomposition or by volatilization. In general, research data have not indicated that performance of soil-active herbicides is greatly reduced as a result of crop residue left on the soil surface. The thick surface mulch often associated with long-term no-tillage production may

Figure 6-2. Prickly sida (*Sida spinosa*), also called teaweed, is a summer annual that emerges from June through August and grows 1 to 2 feet tall. The leaves are oblong and are generally 2 inches long, have short petioles and coarsely serrated margins. The leaves covered in fine hairs are arranged alternately on the stem. In the young seedling stage this plant can be confused with hophornbeam copperleaf.

Figure 6-3. Marestail (*Conyza canadensis*), also called horseweed, is an annual that can grow 1 to 6 feet tall when it matures in late summer. Seedlings emerge as rosettes in fall, late winter, or early spring and bolt (develop elongated stems) in late spring to early summer. Stems are covered with fine hairs. Leaves are also hairy with entire or slightly toothed margins. Seed, which develop in late summer, are small achenes that are attached to a pappus (group of hairs) that can become wind borne.

however be one factor that contributes to inconsistent control of broadleaf signalgrass (*Urochloa platyphylla*) with the chloroacetamide herbicides. The mulch may also slow the warming of soil and delay emergence of weeds such as johnsongrass.

Cultural Practices

Many cultural practices contribute to weed management in soybean, and to cropping systems in general. It is important to note that use of these practices alone is not likely to result in a satisfactory level of weed control. These cultural practices represent just some of the tools that should be utilized in a program of integrated weed management.

A key objective is to prevent weed seed dispersal into fields. Most crop seed utilized today is certified and weed-free. Efforts should also be made to only plant weed-free cover crop seed, avoiding bin-run seed. As much as is feasible, all equipment should be cleaned before moving from infested fields, particularly during periods of weed seed production. Combines are major contributors for spreading resistant weed seed throughout Kentucky. Fence rows, ditchbanks, and other non-crop areas that harbor agricultural weeds that may contribute to the spread of seed to nearby production fields should be managed through mowing or herbicide applications. In some cases, hand rogueing may be necessary especially when herbicide resistant weed species are first observed; removing these before they set seed can limit their spread. A vigorous and intensive scouting program can often detect these isolated individuals at low density.

Healthy, competitive soybean plants are also key to outcompeting weeds. Select good quality seed, plant at recommended seeding rates, and use appropriate planting practices to ensure a good stand of soybean. Adjust soil pH and soil fertility according to recommendations. Plant or drill in narrow rows (< 15 inches) to ensure quick canopy closure. See *Chapter 4: Cultural Practices* and *Chapter 5: Nutrition Management* for additional details.

Rotating with other crops also contributes to weed management. The main advantage in a corn/soybean rotation or a corn/wheat/double-crop soybean rotation is the opportunity to rotate herbicide sites of action and reduce the buildup of weeds that can occur in a monoculture cropping system. The use of cover crops can also contribute to weed management in a subsequent soybean crop. Actively growing cover crops help suppress emergence of winter annuals that germinate in the fall and summer annuals that germinate early in the spring by outcompeting them. Depending on when the cover crop is killed, cover crop residues can also suppress weeds in the subsequent crop by limiting germination and emergence. The more cover crop biomass that accumulates and the thicker the mulch layer prior to soybean planting, the more weed suppression occurs and the longer this effect lasts. Cover crops should be terminated at the proper time to balance weed management goals with soybean establishment. Growers are cautioned that soybean planting issues can result from large amounts of cover crop residue, so special care must be taken when planting to avoid stand establishment problems.

Mechanical Control

Mechanical control is not practiced as much today due to no-till production practices, a variety of effective herbicide options, the use of narrow row spacing, and the adoption of herbicide-resistant varieties. However, mechanical control may still be used in an integrated weed management program. In some situations, tillage prior to planting can help with control of troublesome weeds such as marestail and perennial weeds with taproots such as common pokeweed and curly dock. Tillage is best utilized on fields with less potential for soil erosion.

Early season cultivation can take advantage of size differences between weeds and crops—especially early in the season when smaller weeds are more vulnerable to physical disruption than the larger crop plants. Operating a rotary hoe or a spring-tine harrow at high speeds is effective when weeds are in the white-thread stage–when the small stems are thin and have the appearance of a white thread. Once fully emerged soybean are generally tolerant of rotary hoeing until they reach 3 to 4 inches tall (about V2 growth stage), but they can be significantly injured by rotary hoeing as the hypocotyl forms a crook while emerging from the soil.

When soybean plants are taller, cultivation equipment that specifically works the area between the crop rows is needed but may be less practical with narrow rows (≤ 15 inches). If cultivation is feasible it should be done as shallowly as possible to minimize soil disturbance and to avoid damaging the soybean plant roots. Weeds should be targeted when they are small. Effective cultivation needs good soil conditions or soil will not flow around the tools and weeds can re-root after being removed from the soil.

Herbicide Use and Timing

Herbicides are the primary method used by producers for control of weeds in soybean. They are particularly important for combating weed problems in no-till or conservation tillage production systems. Herbicides are generally considered to be either soil-active or foliar-active. Soil-active herbicides are generally applied to the soil surface since they are most effective as weed seeds germinate, whereas foliar-active herbicides control weeds after they have emerged from the soil.

Soil-active herbicides are often applied to the soil surface (i.e. preemergence [PRE]) before the crop and weeds emerge. Herbicides applied to the soil surface are either dependent on rainfall to move the herbicide into the weed seed zone or are mechanically incorporated (i.e. preplant incorporated [PPI]). Some weeds such as Eastern black nightshade (*Solanum ptychanthum*) and yellow nutsedge (*Cyperus esculentus*) are more susceptible to herbicides when they are mechanically incorporated into the soil. However, mechanical soil incorporation is not feasible in no-till soybean production systems. Herbicide products that contain acetochlor (e.g. Warrant), S-metolachlor (e.g. Dual II Magnum) and pyroxasulfone (e.g. Zidua) are examples of soil-active herbicides generally applied at time of planting, but they can also be applied after soybean emergence. To be effective, however, they must be applied before seeds of target weeds germinate.

In no-tillage systems herbicides are usually needed to control weedy vegetation prior to or at time of crop planting (i.e. preplant foliar [PPF]). For example, paraquat (Gramoxone, etc), glyphosate (Roundup, etc.), glufosinate (Liberty, etc), and 2,4-D can be used to "burndown" the existing vegetation. With full-season soybean, the green vegetation present usually consists of cool-season annual weeds, occasionally some perennials, and/or cover crop plants. In double-crop soybean, which are planted later in the season, the existing vegetation can also consist of emerging summer annual weeds and certain warm-season perennials.

In recent years there has been greater reliance on foliar-active herbicides that are applied postemergence (POST) to the weeds and the crop. Postemergence applications became more popular with the introduction of herbicide-

Figure 6-4. Johnsongrass (*Sorghum halepense*) is a perennial warm-season grass that can emerge from rhizomes or seed and grows 2 to 8 feet tall. The stem and leaves have no hairs with a relatively large, membranous ligule with jagged edges. The wide leaves contain a prominent whitish midrib.

Figure 6-5. Common lambsquarters (*Chenopodium album*) is a summer annual that can grow up to 5 feet tall. Leaves are lanceolate to triangular shaped (2 to 2.5 inches long) with a dull to pale grayish green color covered with a white powdery coating particularly on younger leaves. Older stems are vertically grooved with red, purple or light green stripes.

Figure 6-6. Giant ragweed (*Ambrosia trifida*), also called horseweed, is a summer annual that can grow 3 to 8 feet tall or more. First true leaves are unlobed; subsequent leaves often have three prominent, deeply segmented lobes, although occasionally may have five to seven palmate lobes. Leaves are hairy, with an opposite arrangement on upright stems.

resistant soybean varieties (i.e. Roundup Ready soybean, LibertyLink soybean). Postemergence herbicide applications must be made at the proper stage of soybean and weed growth to be effective. Since most foliar-active treatments work best on small weeds, timing is extremely important. Treating weeds at the proper weed size is also important to minimize potential crop yield losses. Furthermore, actively growing weeds are more susceptible to herbicides than when weeds are under stressful environmental conditions. Since the desirable stage of weed growth to achieve the most effective control can vary by weed species and the herbicide used, read the product label for proper application timing.

Certain weeds are best controlled with foliar-active treatments, especially perennials. However, the best overall approach is to implement herbicide programs that utilize soil-active (preemergence) herbicide applications followed by postemergence herbicide treatments. Weed control programs should also include multiple modes of herbicide activity and vary herbicide programs from year to year.

Herbicide mode of action can be defined as the way that a herbicide interferes with normal plant metabolism, inhibits plant growth, or otherwise contributes to plant death. Some herbicides interfere with photosynthesis, some cause unregulated growth, and some interfere with amino acid synthesis. Refer to University of Kentucky Extension publication *Weed Control Recommendations for Kentucky Grain Crops* (AGR-6) for a more detailed discussion of herbicide modes of action and for specific herbicide products available for use on soybean.

Figure 6-7. Pitted morningglory (*Ipomoea lacunosa*) is a summer annual vine that can grow to lengths of 6 feet. Cotyledons are deeply indented helping to distinguish this morningglory from other species; true leaves are heart-shaped tapering to a point arranged alternately on the stem. The leaves are smooth or may be slightly hairy, and often have purplish margins.

Figure 6-8. Ivyleaf morningglory (*Ipomoea hederacea*) is a summer annual vine that can grow up to 6 feet or more in length. Cotyledons are butterfly-shaped and often narrow at the base. True leaves are three-lobed and ivy-shaped and arranged alternately on the stem. The leaves contain erect hairs on both surfaces.

Figure 6-9. Palmer amaranth (*Amaranthus palmeri*) is a summer annual that can grow 3 to 6 feet tall. Characteristics can resemble those of other pigweed species and can vary within the same population, therefore assess multiple plants within the field for proper identification. The stem and leaves are smooth with leaf petioles that are typically longer than the leaf blade. Often, but not always, there will be single hair in the leaf tip notch. Some Palmer amaranth plants have white chevron or V-shaped watermarks.

Figure 6-10. Waterhemp (*Amaranthus tuberculatus*) is a summer annual, which can grow 3 to 6 feet tall. Characteristics can also resemble those of other pigweed species and can vary within the same population, therefore assess multiple plants within the field for proper identification. The stem and leaves are smooth with long, lance-shaped leaves that are glossy or waxy in appearance. Waterhemp cotyledons are often more egg-shaped than the long, linear cotyledons of other pigweeds.

Herbicide Persistence and Carryover

While persistence of herbicides in soil is beneficial for maintaining season-long weed control, it can be a significant concern when it results in carryover to rotational crops. The potential risk of subsequent crop injury from herbicide carryover is dependent on several factors, including the susceptibility of the rotational crop and the persistence of the herbicide. Consult herbicide product labels for specific guidelines when planting subsequent crops.

A typical cropping sequence used in Kentucky and portions of neighboring states include corn, wheat, and double-crop soybean. In this cropping sequence crop injury from carryover seldom occurs from the most commonly used herbicides. The risk of carryover however, may be greater in double-crop soybean compared with full-season soybean due to less time for dissipation of herbicides and drier conditions at the time of application following wheat harvest. Some soybean herbicides that contain chlorimuron (e.g., Canopy, Classic, Synchrony, etc.), fomesafen (e.g. Flexstar, Prefix, etc.), imazaquin (e.g. Scepter), and imazethapyr (e.g., Extreme, Pursuit) have potential under some environmental conditions to persist long enough to injure corn. Corn herbicides that contain atrazine and simazine or wheat herbicides such as Finesse (chlorsulfuron plus metsulfuron) have precautions on their labels for rotating to soybean. Certain herbicide-tolerant crops can limit the risk of injury from herbicide carryover. For example, soybean varieties with BOLT™ technology and other STS (sulfonylurea-tolerant soybean) varieties are more tolerant to many sulfonylurea type herbicides and are recommended when certain ALS-inhibiting herbicides have been used previously.

Environmental conditions also affect herbicide persistence and rotational crop injury potential. Factors that help promote herbicide dissipation and limit carryover problems in Kentucky include: 1) an ample supply of moisture throughout the growing season, 2) mild winter temperatures, 3) relatively low levels of organic matter (usually 2 to 3 %), and 4) soils with medium soil pH levels (usually pH 6.0 to 6.8).

Herbicide Interactions

Herbicides marketed as package mixtures and premixes with more than one active ingredient have become prevalent due to the need for broad spectrum weed control activity and to introduce multiple herbicide modes of activity. Furthermore, mixing herbicides with other chemicals, including other pesticides and fertilizers, either as tank mixtures or sequential applications, is practiced widely. It is important to recognize the potential benefits as well as drawbacks for using such strategies. The "jar test" method that is described on many product labels helps determine physical compatibility of tank mixtures but will not indicate the potential for synergism (i.e., more activity) or antagonism (i.e. less activity) as it relates to weed control or crop injury.

Surfactants, crop oils, methylated seed oils, and nitrogen fertilizers, such as 28 to 32 percent liquid nitrogen, 10-34-0, or ammonium sulfate (AMS) are sometimes used as additives with foliar-active herbicides. Although the benefit of nitrogen fertilizers as additives is debatable for certain herbicides, there are situations where their use can enhance control or limit antagonism. For example, it is well known that the use of AMS as an additive enhances postemergence control of velvetleaf (*Abutilon theophrasti*). It also enhances the activity of glyphosate in hard water by preventing the reaction between the glyphosate salt and calcium ions. On the other hand, AMS should not be used with some dicamba herbicide formulations as it increases the potential for volatilization.

The risk of antagonism between herbicides varies depending on specific products, method of application, and environmental conditions. For example, when tank mixing a postemergence herbicide for grass control (e.g. clethodim) with another herbicide to target broadleaf weeds (e.g. fomesafen) the control of weedy grasses could be reduced. Furthermore, some products are not stable in water over time and should be sprayed soon after mixing. This is especially true of many of the sulfonylurea herbicides, which may degrade within 4 to 24 hours after mixing. It is important to consult the product labels of all herbicides and other additives involved in a spray mixture to avoid physical incompatibility issues with mixing as well as potential problems with crop injury or weed control.

Application Stewardship

Applying herbicides correctly is just as important as choosing the right products and the success of a herbicide treatment can sometimes be dependent on the applicator. The applicator should be knowledgeable of the herbicide being used and the conditions whereby the application will be made. Some herbicide products should be applied at low spray volumes (10 GPA) to achieve the best results, while other products require higher spray volumes (15 GPA or even greater) for good weed coverage. A significant consideration when making herbicide applications is to minimize the potential for off-site movement of spray particles. Nearby sensitive vegetation can be severely damaged or killed when herbicides move off-target. Look around, be aware of your surroundings, and know what your neighbor is growing. Crops such as tobacco, grapes, and vegetables, or greenhouses, home gardens, and landscape trees could be nearby and can be sensitive to exposure to certain herbicide products. With any herbicide application be aware of wind speed and direction since direct physical drift of spray particles can injure off-target vegetation. For the desired spray volume, use the correct spray nozzles and spray pressure to produce coarser spray droplets. Herbicide products that contain 2,4-D and dicamba have an especially high potential for damage to nearby vegetation. Therefore, label guidelines for application of these herbicides should be closely followed. It is also important to to keep the spray boom close to the target vegetation while maintaining the correct spray pattern across the spray boom.

Proper sprayer cleanout following an application is another important consideration. This is especially true when using the same sprayer for pesticide applications on subsequent crops or when applying certain herbicides to the same crop that do not have the same genetic herbicide tolerances. This may require multiple rinses of the spray tank including the hoses on the spray boom, cleaning all the strainers and spray nozzles, and in some cases using special spray tank cleaners. Most herbicide products will detail the procedures for sprayer cleanout on the label.

Herbicide-Resistant Weeds

A major concern in soybean weed management is the development of weed biotypes that are resistant to commonly used herbicides. The basis for herbicide resistance is the genetic diversity that allows biotypes within a species to survive a herbicide that is generally known to be lethal to that plant species.

There are several weeds in Kentucky that have evolved resistance to certain herbicides. The ones of greatest concern include marestail, Palmer amaranth, and waterhemp (*Amaranthus tuberculatus*). Biotypes of all three species are now resistant to glyphosate. There is mounting evidence that populations of Palmer amaranth and waterhemp have multiple resistance involving glyphosate, ALS inhibitors, and PPO inhibitor type herbicides.

The potential for weeds to evolve resistance increases with repeated use of a herbicide or herbicide products that have the same site of action on the same field for several seasons. Therefore, herbicide history should be considered and production practices implemented to prevent or reduce the potential for weed resistance to occur.

The key to avoiding development of herbicide-resistant weed populations is prevention. Examples of management strategies to help prevent or limit herbicide-resistant weeds are:

- Scout fields regularly and respond quickly to shifts in weed populations.
- Utilize cultural practices to minimize weed seed production and restrict the spread of weeds.
- Select a herbicide based on weeds present and use a herbicide only when necessary.
- Utilize the labeled herbicide rates, and apply herbicides to the recommended weed sizes with the proper spray volume.
- Apply herbicides with different sites of action as a tank mixture or sequential application during the same season.
- Avoid sole use of herbicides with the same site of action (i.e. herbicides that inhibit the same process in target weeds) for two consecutive years.
- Utilize cultural practices, such as narrow row spacing, to maximize crop competitiveness.
- Utilize cover crops where appropriate to suppress weed emergence. Treating fewer weeds with herbicides can reduce the chances that one of those individuals has developed resistance.
- Rotate crops. Crop rotation helps disrupt weed cycles, and some weed problems are more easily managed in certain crops than others.
- Utilize physical (mechanical) management if appropriate.
- Clean tillage and harvest equipment to avoid moving weed problems from one field to the next.

Herbicide-Tolerant Traits in Soybean

Much of the current weed control technology involves soybean varieties that have tolerance to specific herbicides (See Table 6-2). Herbicide-tolerant soybean varieties can be developed from two different procedures: 1) selection by traditional plant breeding methods and 2) biotechnology techniques resulting in a genetically modified organism (GMO).

Herbicide-tolerant varieties provide additional options to control some weed problems. However, there are concerns associated with their use. These include a)

Figure 6-11. Smooth pigweed (*Amaranthus hybridus*) is a summer annual that can grow 3 to 5 feet tall. Characteristics can resemble those of other pigweed species and can vary within the same population; therefore assess multiple plants within the field for proper identification. Smooth pigweed cotyledons are often long and narrow; true leaves are generally more egg-shaped. Fine hairs are generally present on the stem and leaves.

Figure 6-12. Velvetleaf (*Abutilon theophrasti*) is a summer annual with branched stems that can grow 2 to 7 feet tall. Leaves arranged alternately on the stem are often light green, orbicular to heart-shaped with dentate leaf margins. The stems and leaves are covered with very soft, velvety hairs.

Figure 6-13. Common pokeweed (*Phytolacca americana*) is a bushy perennial that can grow up to 8 feet tall. It can emerge from a large, fleshy taproot or from seed. The succulent red-purplish stems are smooth with alternately arranged large lance-shaped leaves. The fruit forms grape-like structures that produce dark purple berries in the fall.

misapplication of a herbicide to a traditional susceptible soybean variety, b) greater selection pressure for herbicide-resistant weed species or shifts in weed populations due to the repeated use of the same herbicide mode of action, c) herbicide-tolerant crops becoming weedy and difficult to control, d) marketing issues, and e) negative public reaction to biotechnology-derived crops. Herbicide-tolerant crops require a high level of management to prevent problems such as misapplication, spray drift, or further development of weed resistance.

Other Information

This publication describes general concepts of weed management in soybean. More specific information on herbicides and their use in soybean can be found in University of Kentucky Extension bulletin *Weed Control Recommendations for Kentucky Farm Crops* (AGR-6), revised annually. Additional information may be found on the University of Kentucky Weed Science website: http://weedscience.ca.uky.edu/graincrops.

Table 6-2. Crop technologies involving herbicide-tolerant traits

Commercial Launch Year	Trait	Herbicide	Method of Development
1993	Sulfonylurea Tolerant Soybean (STS)	ALS type herbicides • Synchrony STS • Permit Plus	Traditional plant breeding techniques
1996 ----- 2010	Roundup Ready Soybean (RR) • 1st Generation ----------- • Genuity Roundup Ready 2 Yield	glyphosate • Roundup PowerMax • several other products	Biotechnology techniques
2009	LibertyLink (LL)	glufosinate • Liberty, Ignite • other products	Biotechnology techniques
2015	BOLT soybean	ALS herbicides + glyphosate • LeadOff[1] / Basis Blend[1] • Finesse[2] • Synchrony STS	Traditional plant breeding and Biotechnology techniques
2016	Roundup Ready 2 Xtend soybean	dicamba + glyphosate • XtendiMax, FeXapan • Engenia	Biotechnology techniques
2018	Enlist soybean ---------- Enlist E3	2,4-D choline + glyphosate • Enlist Duo, Enlist One ------------ 2-4-D choline, glyphosate + glufosinate • Enlist Duo, Enlist One • glufosinate products	Biotechnology techniques

[1] BOLT soybean can be planted zero days following application of LeadOff or Basis Blend
[2] Reduced plantback to double-crop soybean following application of Finesse to wheat

The entire publication, ID249, A Comprehensive Guide to Soybean Management in Kentucky, can be view at http://www2.ca.uky.edu/agcomm/pubs/ID/ID249/ID249.pdf