Weed Management

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The most economically important pests that reduce corn yield each year are unwanted plants that interfere with corn growth, development, or harvest. These plants, called weeds, compete with corn for water, light, and soil nutrients to reduce crop yield. Some weeds are capable of naturally releasing substances into the soil that are allelopathic, or toxic, to the crop. Weeds can serve as hosts for corn diseases, such as the maize dwarf mosaic and maize chlorotic dwarf virus complex (MDM/MCD) on johnsongrass rhizomes, which can be vectored and transported by insects to corn plants, thus reducing crop yield. Weeds also provide shelter and serve as a food source for insects and diseases that overwinter or provide habitat for wildlife species such as prairie voles that reduce corn stands.

A number of decisions must be considered in developing a successful weed control program. To assist in weed management decisions, a corn producer must be able to properly identify the specific weed problems in each field along with other aspects and factors that might influence weed emergence and growth. It is also important to understand the life cycle of weedy plants, their growth habit, and their potential competitiveness or impact on the crop.

Life Cycles of Weeds

Weeds can be grouped into three major categories. Annuals complete their life cycle in one growing season and reproduce only by seed. Summer or warm-season annuals, such as large crabgrass (*Digitaria sanguinalis*) and common cocklebur (*Xanthium strumarium*), germinate in the spring and set seed in late summer or fall. These plants are more likely to directly compete with the corn. Winter or cool-season annuals typically germinate in the fall and complete their reproductive cycle in the spring or early summer. Therefore, cool-season annual plants, such as common chickweed (*Stellaria media*) and Italian ryegrass (*Lolium multiflorum*) are generally more of a concern at the time of planting and during the early stages of corn growth in no-till corn production.

Biennials are capable of completing their life cycle during two growing seasons. The first year normally consists of vegetative growth, whereas the second year involves both vegetative and flower development. Biennials, such as musk thistle (*Carduus nutans*), reproduce only by seed. Sometimes these plants may complete their life cycle within one year.

Perennial plants are capable of existing for more than two years. Reproduction can be by seed and by vegetative structures such as rhizomes, stolons, tubers, taproots, or creeping roots. For example, johnsongrass (*Sorghum halepense*) plants frequently encountered in corn fields emerge from seed; however, johnsongrass plants are capable of emerging from rhizomes. Warm-season perennial weeds have become of increasing concern as no-tillage practices have increased in Kentucky's crop production systems. Ten of the most common and troublesome weeds found in Kentucky corn fields are listed in Table 1.

Weed Scouting

Proper weed identification is an essential component of any successful weed management program. It is even more critical in no-tillage systems because herbicides are the primary method of weed control.

Table 1. Common and troublesome weeds and their life cycle in Kentucky corn fields.

Weed species	Life cycle	Primary reproduction	Native/ Introduced
10 Most Commonly Occurring Weeds			
smooth pigweed	SA	seed	N
giant foxtail	SA	seed	I
large crabgrass	SA	seed	I
johnsongrass	P	seed, rhizome	I
morningglory (ivyleaf & pitted)	SA	seed	I
honeyvine milkweed	P	seed, creeping root	N
fall panicum	SA	seed	N
common cocklebur	SA	seed	N
giant ragweed (horseweed)	SA	seed	I
yellow nutsedge	P	tuber, rhizome, seed	N
10 Most Troublesome Weeds to Control			
honeyvine milkweed	P	seed, creeping root	N
broadleaf signalgrass	SA	seed	N
burcucumber	SA	seed	N
trumpetcreeper	P	creeping root, seed	N
giant ragweed (horseweed)	SA	seed	I
johnsongrass	P	seed, rhizome	I
common pokeweed	P	seed, taproot	N
ivyleaf morningglory	SA	seed	I
fall panicum	SA	seed	N
Italian ryegrass	WA	seed	I

Life cycle: SA = summer or warm-season annual; WA = winter or cool-season annual; P = warm-season perennial.
Origin: I = introduced plant; N = native plant.

Training and a skilled eye are often needed to properly identify weeds during early vegetative growth stages. In fact, an effective postemergence control strategy for weeds often depends on proper identification when weeds are less than 4 inches tall. Thus, field scouting should begin within 2 weeks of corn planting and continue at weekly intervals for 8 to 10 weeks into the growing season. Scouting methods recommended for weeds in corn can be found in *Kentucky Integrated Crop Management Manual for Field Crops—Corn* (IPM-2) available at your county Extension office.

A history of previously known weed problems in a field greatly aids in preparing an overall weed control strategy at the beginning of the growing season. Knowing the previous field history can also provide insight on their identity when weeds emerge. A good method for developing a field history of weed problems is by mapping weeds from previous and current field scouting reports and from observations made at harvest. A detailed weed map for each field will provide information on the location of weed infestations and help monitor changes in these infestations from year to year.

Weed and Corn Interactions

An economic threshold exists when a weed population reaches a level whereby it becomes economically justified to control because of the potential for corn yield reduction, crop quality loss, harvesting difficulties, or other problems caused by the weeds. Low weed populations do not interfere with crop yield, harvestability, or crop quality. Thus, producers may allow low populations of weeds to remain in the field throughout the growing season without affecting the crop. On the other hand, viny weeds such as burcucumber (*Sicyos angulatus*) can reduce yield and interfere with corn harvest at low plant populations. Other weed species such as smooth pigweed (*Amaranthus hybridus*) and common lambsquarters (*Chenopodium album*) are capable of producing thousands of seeds from a single plant. Therefore, it can be a good strategy to control low populations of such annual weeds. The overall impact that replenishing the soil seed bank may have, when some weeds are allowed to grow through maturity, is not fully understood. It is also desirable to control light infestations of perennial weeds and newly introduced annuals before they become a serious problem. The anticipated yield loss from various weed populations is illustrated in Table 2.

Most weed-corn competition studies indicate weeds that emerge and grow with corn during the first 2 to 4 weeks under normal environmental conditions, and then removed, do not reduce corn yield. In addition, if weeds are kept out of the field for up to 4 to 6 weeks after corn emergence, weeds that emerge later are not likely to reduce yield relative to the cost of treatment. However, late emerging weeds may cause harvest problems or reduce crop quality depending on the weed species.

Impact of Tillage

Management practices used in Kentucky and surrounding states emphasize reducing tillage in a rotation of corn, wheat, and double-cropped soybeans during a two-year period. This tillage and rotation system offers both benefits and drawbacks with regard to weed management.

No-tillage practices provide numerous benefits for weed control, and often a shift in the dominant weeds will be noticed. Undisturbed soil, with time, reduces the germination of weed seed that are deep in the soil seed bank. The fact that no-tillage limits the amount of soil disturbance and scarification of weed seeds may explain why such weeds as common cocklebur, burcucumber, and sicklepod (*Cassia obtusifolia*) are observed to a lesser extent in no-tillage compared to more intensive tillage situations. Furthermore, leaving the soil undisturbed for several years may lead to rotting and/or predation of seeds on the soil surface.

The lack of soil disturbance may promote the development of populations of certain weed species. The in-

Table 2. Estimated impact on corn yield with different weed species at various populations in corn with a 100 bu/ac yield potential.[1]

Weed pressure category (yield loss potential)	Foxtail spp.	Johnsongrass	Pigweed spp.	Morningglory spp.	Common Cocklebur	Giant Ragweed (Horseweed)	Estimated yield loss by a single species	Estimated yield loss by all species
	-- Weed density per 100 sq ft --						(bu/ac)	(bu/ac)
Slight (0-5%)	10	8	5	5	4	2	<2	<10
Low (5-10%)	20	15	10	10	8	4	5	20
Moderate (10-20%)	50	30	25	30	10	8	10	30
Severe (20-35%)	100	75	50	60	30	20	20	40
Very Severe (>35%)	200	125	75	100	50	40	35	50

[1] These specific plant density values are based on general observations, and estimates show relative differences among individual 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 Soybeans," February 2001.

cidence and severity of weeds such as common pokeweed (*Phytolacca americana*) and curly dock (*Rumex crispus*) are examples of perennials with large fleshy tap-roots that grow well in a no-tillage environment. Also, an occurrence of some annual weed species such as marestail (i.e., horseweed) (*Conyza canadensis*) and prickly lettuce (*Lactuca serriola*) are noticed more frequently under no-tillage conditions. These two weed species can emerge during the late fall or early winter months and maintain active growth throughout the corn growing season. Perhaps one reason marestail and prickly lettuce become established is that their seedlike achenes with tufts of hair are spread easily by wind. Thus, they can easily invade fields where primary tillage is not used to destroy emergence of new plants.

Poor control of perennial weeds is a major complaint about no-tillage corn production. Common pokeweed with its perennial tap-root system grows well and is difficult to control in a no-tillage system. Honeyvine milkweed (*Ampelamus albidus*) and trumpetcreeper (*Campsis radicans*) are warm-season perennial vines with creeping roots, whereas Italian ryegrass is a cool-season annual grass that often escapes control from traditional burndown herbicides but is easily controlled with spring tillage.

Since less tillage leaves previous crop residue on the soil surface, that residue intercepts some of the herbicide spray when it is applied. Less residue is present if the previous crop was soybean compared with corn stubble or when the previous crop was wheat. A rainfall event occurring soon after application generally moves the herbicide off the crop residue and in contact with the soil. This reflects the importance of rainfall, instead of mechanical incorporation, as the avenue by which a major portion of the herbicide is moved within close proximity to germinating weed seeds. Some herbicides intercepted by crop residue may be subjected to loss by processes such as 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. However, the thick surface mulch often associated with long-term no-tillage production may be one factor that contributes to inconsistent control of broadleaf signalgrass (*Brachiaria platypylla*) with the chloroacetamide herbicides. The mulch may also slow the warming of soil and delay emergence of such weeds as johnsongrass. Delaying the emergence of johnsongrass may limit the opportunities to apply postemergence herbicides for optimum control with minimum risk to corn.

One noted effect of more residue on the surface is the change in soil characteristics at the soil surface. Generally, under continuous no-till corn production an increase in soil organic matter occurs from decaying crop residue, and often the soil surface pH becomes more acidic because of annual additions of nitrogen fertilizers. These two factors can change the effectiveness and the persistence of some herbicides. For example, the triazine herbicides, such as atrazine and simazine (Princep, etc.), tend to persist less and may provide less weed control in a no-tillage system compared to conventional tillage. This can be explained by a faster degradation rate of triazine herbicides under acidic conditions (pH 5.0). Timely applications of lime will overcome this pH effect. On the other hand, overapplication of lime may result in high soil pH levels (pH 7.0) that can cause herbicide carryover concerns to other rotational crops.

Cultural Practices and Mechanical Controls

In addition to a scouting program and field mapping of weed problems, a good program of integrated weed management should employ a variety of crop management tools to deal with weed problems. These include preventing the introduction of new weeds and cultural practices such as seeding rates and planting dates that maximize the competitiveness of the crop. This allows the corn to compete better with weeds by reducing weed seed emergence and growth. Mechanical methods, such as minimum tillage cultivators capable of functioning in high crop residue, will provide weed control between the rows.

Crop rotation can also be an effective tool for managing some problem weeds. It helps limit the increase in the population of some perennial or difficult-to-control weeds in continuous crop production systems. For example, johnsongrass can be difficult to control in corn but easier to control in soybean because a wider variety of herbicide options are available. Rotation to densely planted crops (i.e., forages or small grains) can smother some weeds, such as crabgrass, that compete in row crops. Rotation of crops also allows for more opportunities to rotate herbicides, which in turn helps prevent the development of herbicide resistance in some weed species.

Herbicide Use and Timing

Herbicides are the primary method of weed control in corn production. 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 shortly after weed seed germination, whereas foliar-active herbicides control weeds after they have emerged from the soil; thus, they are applied postemergence (POST) to the weeds.

Soil-active herbicides are usually applied to the soil surface (i.e., preemergence [PRE]) before the crop and weeds emerge. Herbicide products that contain atrazine, pendimethalin (e.g., Prowl), or other soil-active ingredients can also be applied after corn emergence but before weeds emerge. Some soil-active herbicides can also be incorporated into the soil before crop planting and weed emergence (i.e., preplant incorporated [PPI]). Preplant-incorporated herbicide applications are possible with crop management systems that leave some surface residue but not in no-till corn production. This narrows the list of potential herbicides available for use. Herbicides applied to the soil surface are more dependent on rainfall to move the herbicide into the weed seed zone compared to herbicides mechanically incorporated. Weeds, such as broadleaf signalgrass, Eastern black nightshade (*Solanum ptychanthum*), and yellow nutsedge (*Cyperus esculentus*) that are more susceptible to herbicides applied preplant incorporated, are less effectively controlled with herbicides applied to the soil surface.

In no-tillage systems herbicides are usually needed for vegetation control prior to crop emergence (i.e., preplant foliar [PPF]). Paraquat (Gramoxone), glyphosate (Roundup, Touchdown, etc.), dicamba (Banvel, Clarity, etc.), and 2,4-D are often used to "burndown" the existing vegetation (Table 3). In many cases, the green vegetation present among the previous crop residue consists of cool-season annuals and perennials, along with some emerging summer annual weeds. When planting corn into a perennial grass or grass/legume sod, treatment combinations of atrazine plus paraquat or glyphosate provide the best control. Glyphosate applied in the fall is generally more effective for killing sod crops, especially in fields containing orchardgrass, fescue, alfalfa, and/or other forage legumes. To control alfalfa in the spring prior to planting corn, dicamba (Banvel, Clarity, etc.) should be used.

Where previous crop residue exists, an alternative to "burndown" applications at planting is to apply herbicides several days prior to planting (i.e., early preplant [EPP]). In corn, soil-active herbicides can be applied as a sequential treatment with the first application made 15 to 30 days before planting and the second at planting. Single applications can be successful as much as 15 days ahead of planting. When an early preplant herbicide program is used in corn, a nonselective "burndown" herbicide may not be needed.

Table 3. Relative response of cover crops and weeds to burndown herbicides.

	Cover crops									Weeds														
Herbicide[1]	Alfalfa	Clover, Red	Clover, White	Fescue, Tall	Orchardgrass	Rye	Ryegrass, Annual	Vetch, Hairy	Wheat	Brome spp.	Chickweed, Common	Dandelion	Dock, Curly	Fleabane, Annual	Foxtails	Henbit / Deadnettle	Lettuce, Prickly	Marestail	Mustard spp.	Thistle, Musk	Johnsongrass (seedling)	Johnsongrass (rhizome)	Pokeweed	Ragweed, Giant
Atrazine	3	5	4	6	3	6	5	6	6	7	9	4	4	-	6	8	9	9	8	4	0	0	2	9
Dicamba	8	9	8	0	0	0	0	8	0	0	7	8	7	8	0	6	9	7	7	8	0	0	6	9
2,4-D Ester	6	8	5	0	0	0	0	8	0	0	5	8	4	6	0	4	8	8	8	7	0	0	5	8
Paraquat	3	7	5	5	3	7	6	7	7	7	9	4	2	6	9	8	5	4	6	3	7	3	4	7
Paraquat + Atrazine	4	-	-	8	7	7	7	8	9	8	9	7	5	-	9	9	9	9	9	5	7	3	4	9
Glyphosate	6	6	5	7	6	8	7	6	9	9	9	6	4	8	9	8	8	9	8	6	9	8	6	9

Good = 8-9 Fair = 6-7 Poor = 5 or less - Insufficient Data

[1] Herbicide products that contain these active ingredients include atrazine (AAtrex, etc.); dicamba (Banvel, Clarity, etc.); paraquat (Gramoxone); and glyphosate (Roundup, Touchdown, Glyphomax, etc.).

Herbicide formulations are changing to fit the needs of crop production. Package mixtures of herbicides with more than one active ingredient have become prevalent due to the need for a broad spectrum of weed control activity. Water dispersible granules and dry flowable herbicide formulations with low use rates have also increased. Some specialized herbicide formulations can reduce the "binding" of the herbicide with the plant residue left on the soil surface (i.e., micro-encapsulated). Other formulation changes that may evolve in the future include the development of formulations that reduce volatilization loss of surface-applied herbicides.

In recent years there has been greater reliance on postemergence herbicides. Certain weeds, especially warm-season perennials, may not be readily controlled by preemergence treatments. In addition, weed escapes (due to resistance or environmental conditions not conducive to weed control) must be treated with postemergence herbicides. Postemergence herbicides also provide the benefit of allowing the use of a more integrated weed management approach since herbicides are applied only when needed.

Herbicide Persistence and Carryover

Paraquat and glyphosate are tightly bound to soil and offer no soil-residual activity, whereas atrazine (AAtrex or Atrazine) and simazine (Princep) can remain active in soil for a period of time. While persistence of herbicides in soil is beneficial in regard to weed control, it is a concern when associated with carryover to rotational crops or other environmental impacts.

The risk of injury from herbicide carryover is dependent on several factors including the susceptibility of rotational crops and the persistence of the herbicide. The typical cropping sequence used in Kentucky and portions of neighboring states include corn, wheat, and double-cropped soybean. In this cropping sequence crop injury from carryover seldom occurs from herbicides used in Kentucky. However, some soybean herbicides such as imazaquin (e.g., Backdraft, Scepter, Squadron, Steel), imazethapyr (e.g., Extreme, Pursuit), and chlorimuron (e.g., Canopy, Canopy XL, Classic, Synchrony) have potential to persist long enough to injure corn. Corn herbicides such as atrazine and simazine have label precautions for rotating to wheat or soybean.

Certain herbicide-tolerant crops can limit the risk of injury from herbicide carryover. Clearfield™ corn hybrids have a high degree of tolerance to imidazolinone herbicides; consequently, they have more flexibility than regular hybrids when rotating to corn where imazaquin was applied the previous season under dry soil conditions. Similarly, STS soybeans are tolerant to many sulfonylurea herbicides and are recommended where prosulfuron-containing products (e.g., Exceed, Spirit) were applied to corn during conditions that limited herbicide degradation processes.

Environmental conditions also affect herbicide persistence and rotational crop injury. 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 percent), and 4) soils with medium pH levels (usually pH 6.0 to 6.8).

Many of the soil-active herbicides used in corn have the potential to contaminate surface and groundwater. The labels of these products have groundwater advisory statements that recommend not applying where the water table is close to the surface and where the soils are very permeable. Atrazine-containing products have special label restrictions for use near ground or surface waters. Emphasis is placed on using low atrazine rates, buffer zones, and conservation tillage practices as strategies for minimizing the risk of contaminating water sources.

Herbicide Interactions

Mixing herbicides with other chemicals, 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 signs of compatibility of tank mixtures but will not indicate the potential for synergism (i.e., enhancement) or antagonism (i.e., less activity) as it relates to crop injury or weed control.

Nitrogen fertilizers such as 28 to 32 percent liquid nitrogen, 10-34-0, or ammonium sulfate are sometimes used as additives with postemergence herbicides. Although the benefit of these materials as additives is debatable for certain herbicides, there are situations where their use can enhance control or limit antagonism. It is well known that the use of nitrogen fertilizers as an additive enhances postemergence control of velvetleaf. Ammonium sulfate and liquid nitrogen may reduce activity of Accent Gold, whereas 10-34-0 is the preferred source of nitrogen as an additive with this product. The sequence in which nitrogen fertilizers are added in the spray mixtures may also impact the activity of certain herbicides. For example, it is recommended that ammonium sulfate be added first in the spray mixture to limit antagonism of certain tank mixtures with Roundup Ultra and other glyphosate products in hard water or with certain herbicides.

While herbicide interactions with insecticides are seldom a problem, there are situations where their use as tank mixtures or sequential sprays can result in problems. Corn injury can occur when tank mixing certain Acetolactate Synthase (ALS)-inhibiting herbicides with organophosphate insecticides. The use of insecticides and herbicides as separate applications in the same field, such as in-furrow treatments of certain organophosphate insecticides followed by postemergence sprays of ALS-inhibiting herbicides, may result in corn injury.

The risk of antagonism varies depending on specific products, methods of application, and environmental conditions. 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 four to 24 hours after mixing. Consulting the labels of all materials involved in a spray mixture will help avoid physical incompatibility issues with mixing, as well as potential problems with crop injury, or weed control.

Herbicide-Resistant Weeds

A major concern in weed management is the resistance of weeds to commonly used herbicides. Not all pigweed plants are created alike. Nor are all common lambsquarters or johnsongrass plants the same. There is genetic diversity among plants of the same species. Sometimes this diversity is expressed by small differences in the physical appearance of the plants. These differences can also be expressed as a differential response to herbicides. The basis for herbicide resistance is the fact that genetic diversity allows biotypes within a species to survive a herbicide treatment that is generally known to be lethal to that plant species.

Examples of herbicide-resistant weeds documented in Kentucky corn fields include smooth pigweed to triazine type herbicides (i.e., Atrazine and Princep) and to ALS-type herbicides (i.e., Accent, Beacon, Exceed, etc). The potential for weed resistance to develop increases with a continuous use of a herbicide or herbicide products that have the same mode of action on the same field for several seasons. Therefore, herbicide use should be monitored and production practices implemented to prevent and reduce the potential for weed resistance to occur.

A key to avoiding development of herbicide-resistant weed populations is prevention. Listed below are management strategies to consider in preventing and dealing with herbicide-resistant weeds.

- Scout fields regularly and identify weeds present. Respond quickly to shifts in weed populations to restrict spread of weeds.
- Select a herbicide based on weeds present and use a herbicide only when necessary.
- Rotate herbicides. Avoid using the same herbicide or another herbicide with the same mode of action (i.e., herbicides that inhibit the same process in target weeds) for two consecutive years in a field. It is possible for a herbicide used in one crop to have the same mode of action as a different herbicide used in another crop. For example, Accent, Basis, Beacon, Canopy, Classic, Exceed, FirstRate, Harmony Extra, Harmony GT, Lightning, Permit, Pursuit, Python, Scepter, Spirit, and Synchrony "STS" contain active ingredients with the same mode of activity in plants (i.e., these herbicides are ALS inhibitors).
- Apply herbicides with different modes of action as a tank mixture or sequential application during the same season.
- Rotate crops. Crop rotation helps disrupt weed cycles, and some weed problems are more easily managed in some crops than others.
- Combine mechanical weed control practices such as cultivation with herbicide treatments where soil erosion potential is less of a concern.
- Clean tillage and harvest equipment to avoid moving weed problems from one field to the next.

Herbicide-Tolerant Corn Hybrids

Crops traditionally susceptible to some herbicides have been developed and are now available that are tolerant to specific herbicides. Herbicide tolerance in crops results from two different procedures: 1) selection by traditional plant breeding methods and 2) biotechnology techniques. Examples of corn hybrids include Clearfield corn tolerant to imidazolinone-type herbicides (i.e., Lightning or Pursuit); Roundup Ready™ corn hybrids tolerant to glyphosate (Roundup, Touchdown, etc.); Liberty Link™ hybrids tolerant to glufosinate (Liberty); and Poast Protected corn hybrids (see Table 4).

Herbicide-tolerant crops provide additional options to control some weed problems. However, there are concerns associated with their use. These include a) misapplication to a normal or traditional crop hybrid, b) drift to nearby susceptible vegetation, c) greater selection for resistant weed species or shifts in weed populations, d) herbicide-tolerant crops becoming weedy and difficult to control, e) marketing issues, and f) negative public reaction to biotechnology-derived crops. Herbicide-tolerant crops do require greater management to prevent problems such as misapplication, spray drift, or further development of weed resistance.

Other Information

This publication explains general concepts of weed management in corn. More specific information on herbicides and their use in corn can be found in University of Kentucky Extension bulletin *Weed Control Recommendations for Kentucky Farm Crops* (AGR-6), revised annually. A computerized decision aid (WeedMAK II—Weed Management Applications for Kentucky), which is designed to rank treatment options for weed problems in corn and soybean, is another source of information for Kentucky corn producers and crop consultants. Information about these reference materials can be obtained through your local county Extension office or the University of Kentucky Agricultural Distribution Center.

This table should be used only as a guide. Information presented in this table is the relative burndown response of emerged plants to herbicides applied at normal rates for no-till corn. This information generally does not reflect soil residual effects of the herbicides. The relative response values are based on a numerical scale from 0 to 9 and compare effectiveness of herbicides to control a particular cover crop or weed species. A herbicide may perform better or worse than indicated in the table due to weed size or environmental conditions or when tank mixed with other herbicides. If farmers are achieving satisfactory results under individual conditions, they should not necessarily change products as a result of information in this table.

Table 4. Herbicide-tolerant corn hybrids and method of development.

Year released	Herbicide-tolerant corn	Herbicides	Method of development
1992	Imidazolinone Tolerant (IT) and Resistant (IR) (also known as Clearfield or IMI-hybrids)	Pursuit, Lightning	Plant breeding techniques
1995	Poast Protect hybrids	Poast, Poast Plus	Plant breeding techniques
1997	Liberty Link hybrids	Liberty, Liberty ATZ	Gene insertion
1998	Roundup Ready hybrids	Roundup Ultra, ReadyMaster ATZ, Touchdown, and several other glyphosate products.	Gene insertion