Weed Management

The previous chapter "Integrated Insect, Mite and Disease Management on Vegetable Crops" developed the idea that pests should be controlled through an "integrated crop health program," in which as many methods as possible are used to minimize pest problems and promote a healthy crop. Weeds too are best controlled by using an integrated approach that attempts to optimize growing conditions for the crop, strives to reduce weed seeds in the soil, prevents introduction of new weeds, and utilizes a variety of control methods.

Weeds reduce yield and quality of vegetables by competing with the crop for light, nutrients and water. Vegetable crops are most sensitive to weed growth during the first several weeks after planting and this is the period during which it is essential to have good weed control. A pre-planned approach to weed control that is tailor-made for each field is required. This pre-planned approach is called a weed control program, and takes into consideration the identity and biology of weed species found in the field, the relative importance of each species, soil characteristics, susceptibility of the field to soil erosion, available weed control tools (i.e., herbicides, cultivators, labor, etc.) and future crops.

Weed Biology

Many methods are used to control weeds. Regardless of the method, a knowledge of weed biology is necessary to use controls effectively. First learn to identify weeds in both mature and seedling stages. Weed control tools, especially herbicides, are very effective on some weed species but will be ineffective on others. Using herbicides requires accurate identification in order to match the most effective product to the dominant weeds found in the field. Postemergence herbicides require that weeds be identified in the seedling stage. Use a field guide such as *Weeds of the NorthEast* or refer to an Internet site such as The Ohio State University Weed Identification Guide (**http://www.oardc.ohio-state.edu/weedguide**). Selecting the wrong herbicide can be a recipe for disaster!

Secondly, it is important to understand the life cycle of weeds found in the field. Most weeds that are problems in vegetable fields are either summer annuals or creeping perennials and these classes of weeds require very different approaches to control.

Creeping Perennials include some of the worst weed problems found in Ohio, such as Canada thistle, yellow nutsedge, johnsongrass and quackgrass. While they do produce seed, most of their spread is through underground rhizomes, roots or nutlets. Creeping perennials tolerate cultivation, and are difficult to control with herbicides once the crop is planted. The underground parts have to be destroyed for effective control and this is best accomplished through pre-plant site preparation (see next section).

Summer Annuals include many common weeds, for example, lambsquarters, barnyardgrass, eastern black nightshade and common purslane. They germinate with the crop and may begin to compete almost immediately. Summer annuals grow faster than most vegetables and will quickly smother the crop unless controls are applied early. In most crops, control can be achieved with a combination of selective herbicides, cultivation and some hand-weeding. However, preventing seed production is the best long-term strategy for dealing with these weeds.

The Critical Weed-Free Period is the length of time, usually measured from planting, that weeds must be controlled to achieve maximum yield. After the critical period, weeds that grow do not affect yield. For a vegetable grower faced with no available herbicide for a crop or a herbicide that will not control all weeds in the field, using the critical weed-free period will minimize the need for cultivation and hand weeding. Research conducted in areas with conditions similar to Ohio indicates a critical period of 4 to 6 weeks for most crops. To be safe, plan on using at least a 6 week weed-free period unless otherwise indicated. Known exceptions include onions which should be kept weed-free for the entire season, and bell peppers which must be kept weed-free until at least fruit set. Drawbacks to using the critical weed-free period are significant and need to be remembered. Weeds that grow after the critical period will produce seed, which will result in infestations in future crops. Weeds growing in the crop at harvest time may reduce harvesting efficiency and may reduce the quality of the crop.

Controlling Perennial Weeds with Pre-Plant Site Preparation

Perennials such as quackgrass, johnsongrass, yellow nutsedge, Canada thistle and field bindweed spread and reproduce mainly by underground root stocks or rhizomes and are difficult to control with tillage alone. A plowed and disked field may appear to be free of these weeds; however, unless steps were taken prior to tillage to control the underground portions, re-infestation will occur. Once a crop has been planted perennials are difficult and costly to control. Glyphosate (many formulations and brands available) applied directly to perennial weed foliage before plowing and planting is the

most effective means of control. Glyphosate can be used prior to planting any crop. Application must be timed correctly and the right rate used for the weeds you are trying to control. Spot sprays or wiper applications of glyphosate can be used to control small patches of perennials in most vegetable crops after emergence or transplanting. However, the risk of localized crop injury is very high, thus treatments should be applied only by skilled operators.

Most perennial weeds are best controlled with fall-applied glyphosate. Grasses should be at least 8 inches tall when treated. An extended period of drought just before spraying may adversely affect control. Spring applications are effective on grasses but do not provide as good control of perennial broadleaf weeds as fall applications.

In the following recommendations for controlling specific perennials, application rates are provided for one of the most common formulations of glyphosate. The use of this brand name does not imply an endorsement over other glyposate products, nor a criticism of those products that are not named.

Quackgrass: For long-term control use Roundup UltraMAX at 1.0-2.5 quarts per acre. Use the 1 quart per acre rate of Roundup UltraMAX in 3 to 10 gallons of water per acre on land that has been in row crops. Use 1.75 quarts per acre of Roundup UltraMax if water volumes exceed 10 gallons/acre. The 2.5 quart per acre rate of Roundup UltraMAX will provide longer lasting control when spraying sod. Spray when quackgrass is about 8 inches high and wait at least three full days (72 hours) before plowing. Generally, do not delay plowing more than seven days or some recovery of quackgrass may occur. Quackgrass can be effectively controlled after fall frosts provided at least 60% of the foliage is still green when you spray. For spring applications of glyphosate do not fall plow, simply wait until quackgrass reaches the right growth stage (four to five new leaves in this scenario) and spray.

Johnsongrass: Apply Roundup Ultra at 1.0-2.5 quarts per acre in a spray volume of 3 to 10 gallons per acre, when johnsongrass is in the boot to heading stage. Use 1.75 quarts/acre if water volume exceeds 10 gallons/acre. In the fall, application can be made anytime prior to frost. 1.75 to 2.5 quarts/acre will provide better control when spraying sod. Addition of ammonium sulfate (17 pounds/100 gallons of spray) may improve johnsongrass control.

Yellow nutsedge: Yellow nutsedge requires special consideration because it is very difficult to control. Nutsedge persists from year to year by producing nutlets which grow at the end of rhizomes. Nutlets begin to break dormancy in spring and emergence follows in late spring and early summer. Emergence of new shoots will continue summer-long as more nutlets break dormancy and shoots emerge from expanding rhizomes. New nutlets, each capable of producing several shoots, begin to form soon after shoot emergence. Control with herbicides is rarely or never complete because translocation into nutlets is inadequate, and because dormant nutlets will germinate later in the season after herbicides have been applied. Reducing nutsedge populations requires an integrated approach. Use all available methods; preplant glyphosate on small nutsedge plants (control with Roundup UltraMAX is best when nutsedge is 6 to 12 inches high; earlier applications will provide some suppression—*Monsanto Research*) and/or tillage before planting, competitive crops, and close spacings. Plant and harvest early season crops before nutsedge emerges. Plant crops with selective herbicides later, around the anticipated time of nutsedge emergence. Selective herbicides can be used for seasonal control in sweet corn, dry and snap beans, potatoes and green peas (see table on page 77). Finally make use of post harvest tillage and summer fallow. Yellow nutsedge is sensitive to dense shade, thus close spacing of crops such as pumpkins will minimize growth and nutlet formation.

If you do not already have nutsedge in a field, prevent its introduction. It is most important to wash all soil from used equipment you acquire before allowing it on your farm. If you have some infested fields and others that are not, or if your equipment is used on fields of other farmers, be sure to wash all soil off the equipment before using it on land that is nutsedge-free. Nutsedge has also been introduced in transplants, nursery stock and seed potatoes. Make sure all transplant materials were produced under nutsedge-free conditions.

Canada thistle: Canada thistle can be treated in the flower bud to flowering stage in early summer or during the rosette to flower bud stage, during late summer and fall. In fallow fields, stop tillage in late July and allow thistles to regrow for at least 5 weeks. Apply glyphosate before a killing frost and when Canada thistle regrowth reaches the flower bud stage or is at least 10 to 12 inches high. Apply Roundup UltraMAX at 1.75-2.5 quarts per acre in 5 to 10 gallons of water. Spot sprays of a 2% solution will also be effective. Apply glyphosate at any time in fall, as long as thistle foliage is still green.

Field bindweed: Field bindweed must be treated when it is actively growing and at or beyond bloom. Fall treatment is best, but apply herbicides before a killing frost. Apply Roundup UltraMAX at 2.5-3.25 quarts per acre. Spot spray with a 2% solution.

Water volumes and adjuvants with glyphosate. Generally, low water volumes of 3 to 10 gallons per acre provide best weed control. If higher water volumes must be used, use the maximum rate of glyphosate for the weed to be controlled. At high water volumes adding a non-ionic surfactant at 0.5% (1 pint in 25 gallons) or ammonium sulphate (2 to 4 pounds per acre) to the spray mix will improve control. Always add ammonium sulfate to the water before adding glyphosate.

Hard water antagonizes glyphosate activity. Hard water with more than 500 parts per million of calcium or magnesium will usually reduce glyphosate activity. If hard water must be used, keep the water volume low (5 gallons per acre) or increase the rate of herbicide. Use clean water. Silt, clay, and organic debris in water will also reduce glyphosate activity.

Cultural Controls and Alternatives to Herbicide Use

A well-planned weed control program will utilize as many practices as possible to minimize weed populations. Prevention, eradication and cultivation, along with any other practice that makes the crop more competitive with weeds should be considered. Proper seedbed preparation, planting date, fertilization, crop rotation, row spacing, seeding rate and variety selection can give vegetables a head start over weeds in the race for water, nutrients and light. Collectively, the following practices are referred to as cultural controls. Cultural controls can supplement the control provided by herbicides or may serve as alternatives to herbicides when none are available, or when the grower decides against their use.

Prevention—Use only plants, seed, greenhouse media and soil amendments that are certified to be free of weeds or weed seed. Do not allow weeds to grow on compost or manure piles. Use screens on irrigation intake lines to ensure that weed seeds do not enter the system. Carefully wash all soil from new machinery or machinery that has been used on another farm before you allow it onto your field. Watch for invasive weeds along roadsides, ditches and field edges. If possible, control them with a selective herbicide that will allow grass to continue to grow in the treated area, forming a barrier to emergence of more invasive weeds.

Eradication—Be on the lookout for weeds that are new to your farm and destroy them, making sure they do not go to seed. Weeds that are close to flowering should be incinerated. Watch the area of original infestation carefully for more weeds, and destroy any that occur. Try to determine how the new weed got on your farm and take measures to prevent further infestation.

Crop rotation—Plant fields that are heavily infested with weeds to a field crop or to a vegetable crop in which good, season-long weed control is attainable such as potatoes or sweet corn. For creeping perennials, plant a winter cereal crop and attack perennial weeds with glyphosate either just before harvest or soon after harvest (in the latter case, harvest high so that as much weed foliage is left as possible). Rotating vegetables with glyphosate-tolerant corn or soybeans provides an opportunity to greatly reduce perennial and annual weed populations in future vegetable crops.

Crop competition—Competitive vegetables that can be cultivated early and that rapidly shade the soil surface include potatoes, beans, squash, pumpkins, cucumbers, melons and sweet corn.

Cultivation—The key to using cultivation is earliness. Cultivate when weeds are small, preferably at or just prior to emergence. Hoeing will be easier and more effective when weeds are small, and will be less likely to damage the crop.

Stale seedbed is a method that can be used to reduce weed seeds in the soil and reduce emergence of weeds once planting occurs. It is especially useful in crops, for which effective herbicides are not available. A stale seedbed involves preparing the seedbed in a normal manner but earlier, delaying planting from several days to 2 weeks, spraying with a herbicide to kill emerged weeds, and planting without reworking the seedbed. In soils that tend to bake or crust severely, the stale seedbed method may not be feasible. However, on soils of good tilth, modern seeders work satisfactorily even if rain occurs after the seedbed is prepared and before seeding. Gramoxone Extra may be used before planting direct-seeded asparagus, lettuce and melons. Glyphosate can be applied before planting virtually all crops.

Mulches—Mulches are often used to control weeds in vegetable production. For a complete discussion of synthetic (plastic) mulches refer to the section on Plastic Mulches and Trickle Irrigation on page 26. Mulching with crop residues has been successfully used to control weeds by a few vegetable farmers. Others who have tried this found that problems associated with crop residue mulches outweighed the advantages. Try this method on a small area initially. The practice is amenable to both conventional and organic production techniques. One approach used in Ohio calls for planting a winter annual crop such as fall rye and hairy vetch during September. Sufficient nutrients to grow the mulch crop and the vegetable crop must be applied before seeding. The mulch crop must be killed and mowed in the spring so that it will not compete with vegetables. Vegetable planting should be done with minimum tillage. Irrigation and fertilizer injection are usually required to make this system work. For a complete discussion of mulching vegetables with crop residues visit the USDA ARS-Beltsville internet site (**http://www.ars.usda.gov/is/np/tomatoes.html**) and download the pdf version of *Sustainable Production of Fresh Market Tomatoes and Other Summer Vegetables with Organic Mulches*.

Herbicides

Herbicides can be used to control weeds in most vegetable crops. Because they are selective, there will always be some "escapes," i.e., species that are not controlled. If these uncontrolled species go to seed and the same herbicide is used year after year, eventually they will become a major problem. To prevent this, do not depend exclusively on herbicides. Cultivate, hoe and pull "escapes." Rotate crops and be sure to use herbicides with differing modes of action in rotational

crops. Using herbicides with different modes of action (see Herbicides Used for Weed Control in Vegetables on page 73) and preventing escapes from producing seed, will prevent any one or few species from becoming dominant.

Herbicides recommended in this guide are referred to by their brand name, and application rates are provided in the actual amount of product per acre. If several brands of an active ingredient are available, the generic name is also provided along with as many brands and their respective application rates as we are aware of. This guide provides a minimum of information that will be useful in choosing a herbicide for a particular crop and weed situation. For complete information, it will be necessary to consult the label.

Read the Label!—The ten minutes taken to read the label will be the most valuable time spent in planning the weed control program. Labels contain explicit directions on using herbicides correctly. Labels identify all weeds that are controlled, registered crops and cautions regarding hazards, such as the potential for injury to rotational crops from carry-over in the soil (see Crop Injury From Herbicides and Soil Residue Carry-Over Problems, page 72). Full text labels and Material Safety Data Sheets (MSDS) should be provided by your dealer. They can also be obtained for most herbicides over the internet from company web sites or from compilers such as C & P Press Inc. *GREENBOOK* (**http://www.greenbook.net**) or CDMS, Inc. (**http://www.cdms.net/manuf/manuf.asp**).

Herbicides and Weed Biology—Understanding weed biology is essential to using herbicides effectively. Each herbicide can be used only on certain crops and will control only certain weeds. The weed control program should attempt to schedule crops and herbicides to various fields according to the types of weeds known to exist in those fields. Often the weeds known to occur in a field cannot be controlled in the intended crop by the herbicides available. However, if a different crop can be grown in the field, another herbicide may control the weeds readily. For instance, herbicides registered for use on cole crops will not control ragweed; whereas, most of the herbicides used on sweet corn are effective. In addition to choosing the herbicide based upon the crop to be grown, the stage of weed development is also critical for product performance. Some herbicides are only effective when applied to the soil before weed seedlings have emerged (e.g., Prowl and Devrinol). Other herbicides (e.g., Basagran and Poast) may be effective only if applied after seedlings have emerged and are at a specified stage of growth. In a few instances, herbicides can be applied either before or after weed seedlings emerge.

Herbicides used to control weeds in vegetable crop plantings are applied (1) PREPLANT—preplant treatments applied before the crop is planted, (2) PRE—preemergence treatments, applied at the time of planting or some time before the emergence of the crops or (3) POST—postemergence treatments, applied after the crop plant has emerged.

Weed Maps—Using herbicides requires knowledge of the weeds found in each field. Each year it is a good idea to draw a weed map showing the identity, location and severity of each weed species found in the field. Wait until after weed control practices (herbicides, tillage, etc.) have had time to work so that the map focuses on the more difficult to control weeds. Make a rough sketch of the field, showing landmarks, roads, row directions, etc., and the date of map preparation. Note any areas of the field that have unique characteristics such as wet spots. Try to identify each weed. Use a field guide such as *Weeds of the NorthEast* or refer to an internet site such as The Ohio State University Weed Identification Guide (**http://www.oardc.ohio-state.edu/weedguide**). It is important to have any unknown weeds identified because you may be dealing with a species that is highly invasive or difficult to control. Record the distribution of each species as GENERAL = found throughout the field, LOCAL = found in a small portion of the field, or SPOTTY = found in just a few places. Also record the density of each species as either 1 = scattered, just a few weeds; 2 = SLIGHT, 1 weed per 6 feet of row; 3 = MODERATE, 1 weed per 3 feet of row; or SEVERE = more than 1 weed per 3 feet of row.

Managing Herbicide Resistance—Since the 1970s many weeds have developed resistance to herbicides, first to the triazines (atrazine, Bladex, and simazine), and more recently to Gramoxone Extra and to the sulfonyl urea (e.g., Permit) and imidazolinone herbicides used in corn and soybeans. Triazine resistant lambsquarters are fairly common in vegetable producing areas of Ohio and require special attention. Several new herbicides registered for use in vegetables, and others being considered for registration, all have the same mechanism of action. **Sandea/Permit, Matrix, and Accent** all kill sensitive plants by inhibiting the same plant enzyme system, acetolactate synthase (ALS). Other herbicides used in small grains, corn, and soybean affect the same target enzyme. Thus it is possible to practice an agriculturally sound crop rotation while never rotating herbicide mechanism of action. If resistance to these new herbicides develops their usefulness to vegetable farmers will be greatly **diminished**. Controlling resistant species can be difficult but the following suggestions may help:

1. Take measures to prevent spread from infested fields to non-infested. This may involve cleaning equipment and roguing of resistant plants if they occur in small numbers. Because resistant plants first occur in corn, which may be fed to livestock, be careful with manure. Spread uncomposted manure only on fields where triazine resistance is already known to occur.
2. Rotate crops. This alters cultural practices, weed control tactics, and crop competition. Be sure that herbicides with different mechanisms of action are used in each rotational crop (see Herbicides Used for Weed Control in Vegetables on page 73).

3. Plan on using a herbicide that will minimize triazine resistant weeds in sweet corn. For instance, Prowl provides excellent control of triazine resistant lambsquarters. Basagran is also very effective if applied at the correct stage of weed growth.

Herbicide mixtures for vegetable crops—Mixing two or more herbicides may improve control and the spectrum of weeds controlled, while minimizing required rates. However, do not mix herbicides unless the mixture is approved on at least one label of the products intended for use.

Record keeping—The 1990 Farm Bill requires that all applicators who apply restricted use pesticides keep and maintain records for two years. Records must include the brand name used, EPA registration number, total amount of product used, size of area treated, crop treated, location treated, date of application, and the name and certification number of the applicator. Keeping accurate records on soil moisture, environmental conditions, stage of crop or weed growth will help explain the success or failure of practices and will aid in planning the weed control program in subsequent seasons.

Crop injury from herbicides and soil residue carry-over problems—The most common causes of herbicide damage in vegetable crops are uneven application and soil-borne residues of herbicides used in previous years. Vegetable crops can be damaged from residues remaining in the soil from herbicides that were used on previous agronomic, vegetable or fruit crops. A few herbicides will damage vegetable crops 2 or more years after they were used. Soil-borne residues can be minimized by applying the lowest effective rate and ensuring even application. If you purchase or rent new land be sure to ask the owner or previous manager about herbicides used in previous years—the farther back, the better! Labels contain information on permissible rotational crops and the required time interval between use and rotational crops. Because more than one vegetable crop may be planted to a field per season, consideration must also be given to residues in the soil from herbicides applied earlier in the same year.

A **bioassay** is the simplest and most cost-effective method to check for herbicide carry-over problems. To do this, collect soil at random from all areas of the field in question. Sample the root zone, typically 6 inches deep. Each test requires about 1 gallon of soil. Ends of fields, knolls and low areas often have higher residues and may need to be tested separately. Collect a second sample from a nearby area of the same soil that was not treated with herbicide and use this for a control (for comparison) soil. If untreated soil is not available, add 1 teaspoon of activated charcoal per quart of dry soil and mix thoroughly. Activated charcoal can be purchased at most drug stores. Three or four pots of the test- and control-soils should be made and seeded out to several seeds of intended crop and the test species indicated in the table below. Place the pots in a warm, sunny location and monitor seedling growth for the symptoms described in the table. If any injury is noted, a crop known to be tolerant to the herbicide in question should be grown.

If a toxic herbicide residue is known to persist in the soil, activated carbon and vermiculite can be placed in the planting furrow to protect vegetable crops. Here's how to use this method. Thoroughly mix 1 lb of activated carbon with each cubic foot (cu ft) of No. 2 or No. 3 horticultural-grade vermiculite. Apply 1 cu ft of this mixture per 600 ft of seeded row (15 cu ft/A) by filling the seed furrow with the mixture. Use a positive-feed applicator to deliver the activated carbon plus vermiculite mixture to the seed furrow directly ahead of the planter press wheel. Apply immediately after seeding and before transplants.

Herbicide Bioassays for Residue

Mode of Action	Herbicide Examples	Test Species	Injury Symptoms
Photosynthesis Inhibitor	Atrazine, Princep, Lorox, Karmex, Sinbar	Small grains, radish, cabbage	Creamy-white or yellow chlorosis
Growth Regulator	Stinger	Field peas, lentils	Growth deformities
	Banvel	Beans, corn	Growth deformities (shoot and root)
Seedling Growth Inhibitor	Treflan, Curbit, Dual, Lasso, Harness, Frontier, Devrinol	Small grains	Stunted foliar growth; inhibition and bottle-brush appearance of root system, swollen root tips
Amino Acid Synthesis Inhibitor	Accent, Classic, Firstrate, Peak, Pursuit	Sugarbeet, radish, cabbage	Stunted foliar growth, chlorosis, deformities
Pigment Inhibitor	Command	Wheat, oats	White (initially may be yellow) chlorosis, stunted growth
	Balance	Sugarbeet, snapbean, pepper	

Herbicide Application

Vegetable crops can be easily injured if too much herbicide is applied. To prevent this, calibrate the sprayer frequently and adjust nozzle tips to the proper height above soil level. Herbicides should be applied with a boom sprayer. Backpack and airblast sprayers should not be used because they will not give uniform application. Calibration of boom sprayers and mixing of pesticides is described in the chapter "Handling Pesticides" on page 46 of this guide. An excellent fact sheet which provides detailed information on this subject is Publication AEX-520 *Boom Sprayer Calibration* by H. E. Ozkan, Agricultural Engineering Department, The Ohio State University. This can be downloaded from the Internet at (**http://ohioline.osu.edu/aex-fact/0520.html**) and can also be obtained from most county Extension offices.

Sufficient agitation must be maintained in the spray tank so that the first gallon of spray discharged has the same concentration of herbicide as every other gallon, down to the last gallon sprayed. Without good agitation, many herbicides will settle to the bottom of the tank. If this occurs, some of the land area sprayed can receive such a low rate of herbicide per acre that none of the weeds are controlled and some of the treated area may receive such a high rate per acre of herbicide that the crop is injured. A high concentration of herbicide in the soil may damage following crops for 2-3 years, depending on the herbicide used. The forward speed of the tractor and spray equipment must also be constant. Increasing the forward speed, which might be experienced going down hill will result in a lighter application. Decreasing the speed, which occurs when climbing hills, will increase the application rate, and may result in crop damage. For example, if a tractor-sprayer speed of 4 miles per hour (mph) must be maintained, but the speed is reduced to 2 mph (which might easily occur at the end of the rows), twice the rate per acre of herbicide will be applied. Watch out for windy conditions! Winds greater than 5 mph can cause spray-drift. Also, crosswinds can concentrate nozzle output into a too-narrow band, thereby increasing the application rate on the sprayed area.

Nozzle tips wear out. Output should not vary more than 10% from the manufacturer's specifications. In general, it is a good idea to replace all nozzle tips at the start of each season. Checks should be made during the season to determine if an earlier change is necessary.

Band v. Overall Application—Banding the herbicide over the row area will reduce the cost per acre of the herbicide and will minimize possible adverse environmental effects. It probably is not worthwhile to use band applications where row spacings are less than 30-36 inches. With band applications, the actual area of the acre treated determines the amount of herbicide to be used per acre. The amount of herbicide required per acre for a banded application will be much less than the amount required for a broadcast application. For example, if planning to apply an 18-inch band over a row, with 36-inch spacing between rows, apply one-half the amount recommended per acre that was required for a broadcast application. Herbicide rates recommended in this guide are broadcast rates, i.e., the entire acre is sprayed.

Soil incorporation of herbicides (Adapted from: Cornell Vegetable Recommendations)—Herbicides such as trifluralin and Eptam should be incorporated for best results. Eptam is incorporated to reduce losses from volatility or evaporation. Trifluralin, on the other hand, is incorporated to ensure its presence in moist soil in the vicinity of sprouting weed seeds. It will fail in dry soil, because its solubility is exceptionally low. In contrast, Eptam's volatility is reduced by dry soil, and its performance is improved. Granular formulations of Eptam are somewhat less volatile and sometimes more effective than liquid sprays. Trifluralin is much more stable than Eptam and need not be incorporated for several hours. Chemicals to be incorporated should not be applied to rough, cloddy soil, because the herbicide will be distributed unevenly as the clods break up. One of the best implements for soil incorporation is the springtooth harrow. S-tine harrows are also highly effective. Lightweight combination disks can be used effectively but avoid large, heavy-weight disks. These throw too much soil to the outer edges and leave too little in the center, thus weed control is reduced in the center areas.

Herbicides Used for Weed Control in Vegetables

AATREX (atrazine—several brands and formulations are available). *Chemical Family*: s-triazine. *Crops*: Sweet corn. *Sensitive Weeds*: Mainly annual broadleaf weeds. Populations of resistant lambsquarters and pigweed which are not controlled occur in Ohio. *Timing*: PREPLANT, PRE, and POST. *Residual Control*: Depends on rate. Should control germinating weeds for several weeks. *Carryover Potential*: High. Use low rates and plant only labelled rotational crops. Dry weather during the year of treatment may increase the chance of injury to beans, onions, peas, tomatoes and turnips.

ACCENT (75% nicosulfuron). *Chemical Family:* sulfonyl urea. *Crops:* Sweet corn. The user assumes all responsibility for crop injury. Not all varieties of sweet corn have been tested for tolerance—check with DuPont Crop Protection before use. *Sensitive Weeds:* annual and perennial grasses, certain broadleaf weeds. *Timing:* POST broadcast or POST Directed (drop nozzles) up to the 5-collar stage on corn. Crop oil concentrate plus ammonium nitrogen fertilizer, or non-ionic surfactant plus ammonium nitrogen fertilizer is required. *Residual Control:* Non-residual. *Carryover Potential:* Low at the rates recommended for sweet corn.

AIM (40% carfentrazone-ethyl W/W). *Chemical Family*: Aryl triazinone. *Crops*: Sweet corn. The user assumes all responsibility for crop injury. Not all varieties of sweet corn have been tested for tolerance—check with your seed company or Extension specialist before use. Do not tank-mix with EC formulations of other herbicides. *Sensitive Weeds*: eastern black nightshade, velvetleaf, redroot pigweed, annual morningglories and lambsquarters. *Timing*: POST up to the 8-collar stage on corn and when weeds are 1-4 inches tall (velvetleaf is controlled up to 36 inches tall). Always include a non-ionic surfactant as prescribed on the label. *Residual Control*: Non-residual. *Carryover Potential*: Low; sweet corn can be planted any time after application of AIM, all other crops 30 days after.

ALANAP (23.7% naptalam—2 lb a.i./gal). *Chemical Family*: amide. *Crops*: Cucumbers, melons, squash and pumpkins. *Sensitive Weeds*: Seedlings of bindweed, chickweed, ragweed, velvetleaf, crabgrass and foxtail. Usually combined with Prefar for broader spectrum weed control. *Timing*: PRE. *Residual Control*: Little. Completely decomposes in 6 to 8 weeks. *Carryover Potential*: Low.

BASAGRAN (44% bentazon—4 lb a.i./gal). *Chemical Family*: benzothiadiazine. *Crops*: Sweet corn, peas, beans. A 1.5 pt/A rate marks up large seeded lima bean plants but apparently does not affect yield. It is best to have directed postemergence applications. Beans must be 6-8 inches tall for directed spray. This is later in the growth of the plant than indicated on the product label. Basagran can cause injury when applied to stressed or soft, succulent plants. Some varieties of snap beans are more susceptible to injury than other varieties. *Sensitive Weeds*: Controls a wide range of emerged broadleaf weed seedlings. Weed sensitivity depends on stage of growth, thus timing is important. *Timing*: POST. *Residual Control*: None. *Carryover Potential*: None.

CALLISTO (mesotrione 4 lbs/gal). *Chemical Family*: 4 HPPD Callistemone. *Crops*: Sweet corn. *Sensitive Weeds*: annual broadleaf weeds, some broadleaf perennials and crabgrass—for best results combine with low-rates of atrazine. *Timing*: PRE and POST. *Residual Control*: Significant. *Carryover Potential*: May affect certain agronomic and vegetable crops 12 months after application.

CAMIX (36.8% s-metolachlor + 3.68% mesotrione). *Chemical Family:* Acetanalide + callistemone. *Crops:* Sweet corn. *Sensitive Weeds:* Annual grasses and broadleaf weeds. *Timing:* PRE. *Residual Control:* Significant. *Carryover Potential:* May affect certain rotational crops 12 months after application.

CAPAROL (44.4% prometryne 4 lb a.i./gal). *Chemical Family*: s-triazine. *Crops*: Celery. *Sensitive Weeds*: Germinating seedlings of annual broadleaf weeds, and grasses. Populations of resistant lambsquarters and pigweed which are not controlled occur in Ohio. *Timing*: PRE and POST to weeds. POST to transplanted celery. *Residual Control*: Seasonal. *Carryover Potential*: Soil residue may be a problem to certain rotation crops planted the same growing season. Onions and red beets may not be planted within 8 months of use.

CLARITY (dicamba) *Chemical Family*: Synthetic Auxin. *Crops*: Asparagus. *Sensitive Weeds*: Annual and perennial broadleaf weeds. *Timing*: Post. *Residual Control*: Minimal. *Carryover Potential*: Rotational crops may be planted 120 days or more following application of 1.5 pt/A.

COMMAND 4EC/COMMAND 3ME (clomozone – 3 and 4 lb a.i./gal, respectivley). *Chemical Family*: None generally accepted. *Crops*: Command 4EC is registered on pumpkins, peas and peppers, and there is a Section 24C registration for squash, cucumbers and cabbage. Command 3ME has a Section 24C registration on squash, cucumbers, cabbage and peppers. *Sensitive Weeds*: Annual grasses and some broadleaf weeds. *Timing*: Command 4EC—PREPLANT Incorporated. Command 3ME—PRE. Command is a highly volatile herbicide and can severely damage nearby sensitive plants. Do not apply Command during or prior to periods of warm humid weather or during an inversion. Do not apply Command if sensitive crops or ornamentals (see the label) are nearby. *Residual Control*: Rate dependent—May persist for more than one season. *Carryover Potential*: Potential for damage to rotational crops in the season of use is high. At 2.67 pt/A wait at least 12 months before planting sweet corn.

CURBIT (31.5% ethalfluralin—3 lb a.i./gal). *Chemical Family*: dinitroaniline. *Crops*: Cucumbers, squash, melons and pumpkins. *Sensitive Weeds*: Germinating seedlings of annual grasses and some broadleafs. *Timing*: PRE—apply no later than 2 days after seeding. *Residual Control*: Seasonal. *Carryover Potential*: Low.

DACTHAL (75% DCPA). *Chemical Family*: pthalate. *Crops*: Cole crops, green onions, eggplant, peppers, melons. *Sensitive Weeds*: Germinating annual grasses and some broadleaf weeds. *Timing*: PREPLANT incorporated. PRE applications must be activated by rainfall or irrigation. Can be applied POST to most crops. With most transplants—such as tomatoes or muskmelons—the plants should be well-established (3-4 weeks) before application. Brittle stem with resultant breakage can result if the herbicide is applied too soon. *Residual Control*: Seasonal. *Carryover Potential*: Low.

DESICATE II (53% endothall). *Chemical Family*: None generally accepted. *Crops*: Vine killing in potatoes. *Sensitive Weeds*: NA. *Timing*: Use at least 10 days before harvest. *Residual Control*: Nil. *Carryover Potential*: Nil.

DEVRINOL (50% napropamide). *Chemical Family*: amide. *Crops*: Peppers, tomatoes, cole crops, asparagus. *Sensitive Weeds*: Germinating annual grasses and some broadleaf weeds. *Timing*: PREPLANT incorporated. PRE applications must be activated by rainfall or irrigation. *Residual Control*: Seasonal. *Carryover Potential*: May affect fall seeded cereal and cover crops. May affect non-labelled rotational crops up to 12 months after application.

DUAL MAGNUM/DUAL II MAGNUM (s-metolachlor—7.62 and 7.64 lb a.i./gal, respectively). *Chemical Family*: acetanilide. *Crops*: Snap beans. Sweet corn—Dual II Magnum contains the safener benoxacor which will minimize the chance of crop injury under adverse weather conditions. Peppers, onions and cabbage are covered under a Section 24C label for Dual Magnum. Tomatoes are covered under a Section 18 label for Dual Magnum. *Sensitive Weeds*: Germinating annual grasses, yellow nutsedge and some broadleaf weeds including eastern black nightshade and hairy galinsoga. *Timing*: PREPLANT incorporated or PRE. *Residual Control*: Seasonal. *Carryover Potential*: May affect fall seeded cereal and cover crops if planted sooner than 4 to 5 months after application.

ERADICANE EXTRA/EPTAM/GENEP (EPTC—various concentrations). *Chemical Family*: thiocarbamate. *Crops*: Sweet corn, use Eradicane Extra which contains a safener and an extender. Beans and potatoes, use Eptam or Genep. *Sensitive Weeds*: Germinating annual grasses, yellow nutsedge, quackgrass, and some broadleaf weeds including common purslane and pigweed. *Timing*: PREPLANT incorporated. Apply to dry soil and incorporate immediately 2-3 inches deep. Can be used as a layby treatment in potatoes. *Residual Control*: Seasonal. *Carryover Potential*: Should not affect rotational crops the year after application.

FORMULA 40 (2,4-D amine salt). *Chemical Family*: phenoxy. *Crops*: Asparagus and sweet corn (moderately to severe damage has occasionally been observed on sweet corn). *Sensitive Weeds*: Emerged annual and perennial broadleaf weeds. *Timing*: POST. 2,4-D drift or vapor may severely damage sensitive crops. Tomatoes are especially sensitive. Do not spray other crops with equipment that previously had been used for the application of 2,4-D. *Residual Control*: Essentially none. *Carryover Potential*: Nil.

OUTLOOK/FRONTIER (dimethenamid). *Chemical Family*: chloracetamide. *Crops*: Sweet corn. *Sensitive Weeds*: Germinating annual grasses, yellow nutsedge and some broadleaf weeds including pigweed and eastern black nightshade. *Timing*: PREPLANT incorporated, PRE or early POST according to the label specifications. *Residual Control*: Seasonal. *Carryover Potential*: Low.

FUSILADE DX (24.5% fluazifop-P—2 lb a.i./gal). *Chemical Family*: aryloxyphenoxypropionate. *Crops*: Onions, carrots and asparagus. *Sensitive Weeds*: Emerged annual and perennial grasses. *Timing*: POST. Activity on grasses is dependent upon stage of growth and rate. Always include a crop oil concentrate or non-ionic surfactant according to label specifications. *Residual Control*: Essentially none. *Carryover Potential*: Nil.

GOAL 2XL (22% oxyfluorfen 2 lb a.i./A). *Chemical Family*: diphenyl ether. *Crops*: Onions. Cabbage—apply prior to transplanting as a surface application before weeds emerge. Transplanting should be done with as little soil disturbance as possible. *Sensitive Weeds*: Germinating and small emerged broadleaf weed seedlings. Good coverage is essential. *Timing*: PRE or POST. *Residual Control*: Up to 1 month, depending on rate. *Carryover Potential*: Nil.

GRAMOXONE EXTRA (37% paraquat – 2.5 lb a.i./A). *Chemical Family*: bipyridylium. *Crops*: Gramoxone is often referred to as a chemical mower and can be used in production of most crops. It can be used prior to planting in a stale seedbed system to control most emerged weeds, as a directed spray to control weeds between rows of plastic mulch and for spot spraying. In asparagus it can be used to control emerged weeds before the crop emerges and after the last harvest. *Sensitive Weeds*: Kills essentially all green plant material, however, good coverage is requred. *Timing*: POST. *Residual Control*: Nil. *Carryover Potential*: Nil.

IMPACT (29.7% topramezone 2.8 lb/gal). *Chemical Family*: benzoylpyrazole. *Crops*: Sweet corn. Impact has not been tested on all sweet corn varieties and tolerance may vary. *Sensitive Weeds*: annual broadleaf weeds and suppression of annual grasses—for best results tank-mix with low-rates of atrazine. *Timing*: POST. *Residual Control*: *Carryover Potential*: Signficant.

KARMEX (80% diuron). *Chemical Family*: urea. *Crops*: Asparagus. *Sensitive Weeds*: Annual broadleaf weeds and grasses. *Timing*: PRE. *Residual Control*: Persistent. *Carryover Potential*: Up to 2 years following the last application, depending upon the rotational crop.

KERB (50% pronamide). *Chemical Family*: amide. *Crops*: Lettuce, endive and escarole. *Sensitive Weeds*: Annual broadleaf weeds and grasses. *Timing*: PRE to weeds and seeded lettuce or POST to lettuce after transplanting. Activation with at least 1 inch of water as soon as possible after application is required. *Residual Control*: Persistent. *Carryover Potential*: Up to 2 years following the last application, depending upon the rotational crop.

LASSO/PARTNER/MICROTEC (alachlor—concentration varies). *Chemical Family*: acetanilide. *Crops*: Sweet corn. *Sensitive Weeds*: Germinating annual grasses and some broadleaf weeds, some suppression of yellow nutsedge. *Timing*: PRE. *Residual Control*: Seasonal. *Carryover Potential*: Nil.

LENTAGRAN 45WP (45% pyridate). *Chemical Family*: phenyl pyridazine. *Crops*: Cabbage. *Sensitive Weeds*: Seedling broadleaf weeds including triazine resistant biotypes, and some annual grasses. *Timing*: POST—controls only very small weeds. *Residual Control*: Nil. *Carryover Potential*: Nil.

LEXAR (20% atrazine + 19% s-metolachlor + 2.44% mesotrione). *Chemical Family:* Triazine + acetanalide + callistemone. *Crops:* Sweet corn. *Sensitive Weeds:* Annual grasses and broadleaf weeds. *Timing:* PRE. *Residual Control:* Significant. *Carryover Potential:* May affect certain rotational crops 12 months after application.

LOROX DF (50% linuron). *Chemical Family*: urea. *Crops*: Carrots, celery, potatoes. *Sensitive Weeds*: Germinating and small emerged annual broadleaf weeds and grasses. *Timing*: PRE to weeds and potatoes. May be applied POST in carrots. Controls many emerged annual broadleaf weeds up to 1-3 inches tall. *Residual Control*: Seasonal, depending on rate. *Carryover Potential*: Late applications of high rates may affect non-labeled rotational crops.

LUMAX (11% atrazine + 29.4% s-metolachlor + 2.94% mesotrione). *Chemical Family:* Triazine + acetanalide + callistemone. *Crops:* Sweet corn. *Sensitive Weeds:* Annual grasses and broadleaf weeds. *Timing:* PRE. *Residual Control:* Significant. *Carryover Potential:* May affect certain rotational crops 12 months after application.

MATRIX (25% rimsulfuron). *Chemical Family*: sulfonyl urea. *Crops*: Potatoes (Matrix only) and tomatoes. *Sensitive Weeds*: Annual grasses, certain annual broadleaf weeds including pigweeds, and top-growth of certain broadleaf perennials. *Timing*: PRE or POST (seedling should be less than 1 inch tall) to weeds. POST to both crops. Always include a non-ionic surfactant as prescribed on the label. *Residual Control*: Rainfall or irrigation (1/2 to 1 inch) from 4 hours to 5 days after application will provide suppression of late emerging sensitive annuals. *Carryover Potential*: Nil.

POAST (18% sethoxydim—1.5 lb a.i./gal). *Chemical Family*: cyclohexanedione. *Crops*: Virtually all vegetable crops are listed on the Poast label. *Sensitive Weeds*: Emerged annual and perennial grasses (mainly top-growth). *Timing*: POST to weeds and to the crop. Activity is dependent upon rate and spraying at the correct stage of growth. *Residual Control*: Nil. *Carryover Potential*: Nil.

PREFAR (46% bensulide—4 lb a.i./gal). *Chemical Family*: benzenesulfonamide. *Crops*: Cucurbits. *Sensitive Weeds*: Germinating annual grasses. Some control of redroot pigweed, lambsquarters and shepherd's purse. Usually combined with Alanap for broader spectrum weed control. *Timing*: PREPLANT incorporated. *Residual Control*: Season-long control of sensitive species. Degrades slowly. *Carryover Potential*: May injure non-labeled rotational crops, planted during the same growing season as Prefar application. Cucurbits, cole crops, carrots, lettuce, peppers or tomatoes can all be planted without restriction following Prefar.

PROWL (37.4% pendimethalin—3.3 lb a.i./gal). *Chemical Family*: dinitroaniline. *Crops*: Snap beans, lima beans, onions and sweet corn. *Sensitive Weeds*: Germinating annual grasses and many broadleaf weeds, including triazine resistant lambsquarters and pigweed. *Timing*: PRE to weeds. Onions—apply PRE or POST. Sweet corn—Apply POST at the spike leaf stage or later. Corn must be planted at least 1.5 inches deep. *Residual Control*: Generally, season-long. On muck soils, repeated applications are usually required to provide season-long control. *Carryover Potential*: May injure non-labeled rotational crops.

PURSUIT (22.87% imazethapyr 2 lbs/gal). *Chemical Family*: Imidazilinone. *Crops*: English and succulent peas and beans including garbanzo, kidney, lima and white beans. Maturity may be delayed. Peas, lima beans and lentils should be planted at least 0.5 inch deep. Do not use Pursuit if the crop is under environmental stress. *Sensitive Weeds*: Annual grasses and broadleaf weeds. *Timing*: POST—Use only non-ionic surfactants with Pursuit on vegetable crops. *Residual Control*: Significant. *Carryover Potential*: Significant.

PYRAMIN RB (pyrazon). *Chemical Family*: pyridazinone. *Crops*: Table beets. *Sensitive Weeds*: Controls a wide range of germinating broadleaf weeds. *Timing*: PRE. *Residual Control*: Seasonal. *Carryover Potential*: Unlikely to injure rotational crops, except winter cereals following 4.8 pt/A or sugar beets, red beets and spinach before 12 months after Prowl application.

REFLEX (22.8% fomesafen 2 lbs/gal). *Chemical Family*: Diphenyl ether/ PPO inhibitor. *Crops*: Dry and snap beans. May cause temporary leaf burn. *Sensitive Weeds*: Annual broadleaf weeds, suppresses sedges, bindweeds and climbing milkweed. *Timing*: POST. *Residual Control*: Minimal. *Carryover Potential*: Significant for grass crops.

Herbicide Effectiveness for Vegetable Crops in Ohio

	Barnyardgrass	Crabgrass	Fall Panicum	Foxtails	Johnsongrass	Johnsongrass Seedlings	Quackgrass	Yellow Nutsedge	Common cocklebur	Galinsoga	Jimsonweed	Lambsquarters	Morningglory	Mustards	Pigweed	Purslane	Ragweed—common	Ragweed—giant	Smartweed	Velvetleaf	Nightshade	Burcucumber	Apple of Peru
Preplant Incorporated																							
Command	G	G	G	G	N	G	N	N	-	F	G	G	P	F	P	G	F	-	G	G	-	N	P
Devrinol	G	G	G	G	N	F	N	N	N	P	P	G	N	G	G	G	N	-	P	N	N	-	-
Eptam	G	G	G	G	G	G	G	G	P	N	N	G	P	-	G	G	N-P	-	-	F	F-G	-	-
Prefar	G	G	G	G	N	G	N	N	N	-	N	F-G	N	P-F	G	F-G	N	N	N	N	N	-	-
Ro-Neet	G	G	F	G	N	P	N	F	N	N	N	F	N	G	G	G	N	-	N	N	G	-	-
Tillam	G	G	G	G	-	-	-	G	N	G	N	P	-	-	G	F	N	-	-	-	-	-	-
Treflan	G	G	G	G	N	G	N	N	N	N	N	F-G	P	N	G	G	N	-	P-F	N	N	N	-
Sutan	G	G	G	G	-	G	G	G	-	N	N	P-F	P	-	G	-	P	-	P	F	N	-	-
Preemergence																							
Aatrex	F-G	P-F	P-F	G	N	P	F	P-F	F/G	G	G	G[1]	G	G	G[1]	G	G	G	G	F	G	F	G
Alanap	P	P-F	P	F	N	-	N	N	P	F	F	G	F	N	F-G	F	G	-	P	F	P	-	-
Bladex	F	G	G	G	N	G	N	-	-	N	G	G[1]	G	-	P[1]	G	G	-	F	P-F	G	-	-
Caparol	G	G	G	G	N	N	N	N	-	-	P	G[1]	F	-	G[1]	G	F	-	G	F	N	-	-
Curbit	F	G	G	-	N	-	N	N	N	N	N	P-F	P	-	F	F-G	N	-	P	P	P	-	-
Dacthal	F-G	G	F	G	N	-	N	N	N	N	N	G	N	P	G	G	N	-	N	N	G	-	-
Dual	G	G	G	G	N	P	N	F-G	N	F	P	P-F	N	-	G	G	N	-	P	P	G	N	F
Frontier/Outlook	G	G	G	G	N	-	N	G	-	N	N	P	-	-	G	-	N	N	-	-	G	N	F
Goal	P	P	P	P	N	P	N	P	P	G	F	G	F	G	G	G	F	N	G	G	F	-	-
Karmex	G	F-G	G	G	N	N	N	N	-	G	G	G	G	G	G	G	G	-	G	G	G	-	-
Kerb	G	G	G	G	N	N	N	N	N	P	P	G	G	G	G	G	N	-	G	N	G	-	-
Lasso	G	G	G	G	N	P	N	F-G	-	G	P	P-F	N	-	G	G	N	N	P	P	G	-	F
Lorox	F	F	-	F	N	-	N	N	P	G	F	G	F	-	G	G	G	P	G	-	G	-	P
Prowl	E	E	E	E	N	-	N	P	N	F	-	G	-	-	G	F	P	N	F	F	P	N	P
Sandea	N	N	N	N	N	N	N	F	G	G		G	NA	G	G	F	G	N	G	G	G	P	F
Sencor or Lexone	P	P	P	P	N	-	N	F-P	F	G	G	G[1]	G	F-G	G[1]	G	G	-	G	G	N	P	F-G
Sinbar	-	-	-	-	-	-	F-G	-	-	G	G	G	-	G	F	G	G	G	G	G	G	-	-
Strategy	G	G	G	F	N	F	N	N	N/F	F	N	G	P	P	F	G	F	-	F	F	P	-	P
Postemergence																							
Aim	0	0	0	0	0	0	0	0	P	-	-	F-G	G	-	G	-	P-F	P	P	G	G	P	N
Atrazine	F	P	P	G	N	N	F	F	F	G	G	G	G	G	G	G	G	G	G	G	G	G	G
Basagran	N	N	N	N	N	N	N	F	G	-	F-G	F	F	-	F	F-G	G	F	G	F-G	F	P	P
2,4-D	N	N	N	N	N	N	N	P	F/G	F-G	F	F-G	G	G	G	G	G	G	F	G	G	P	F
Fusilade	G	G	G	G	G	G	G	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Gramoxone Extra[2]	-	F-G	F	G	F-G	F-G	F-G	F-G	G	G	G	F-G	F-G	F-G	G	F-G	F-G	F-G	F-G	F-G	F-G	-	F-G
Lentagran	F	P	P	F	N	-	N	P	-	G	-	G	-	-	G	P	P	-	F	F	G-E	-	-
Matrix	G	F	G	G	F	F	F	F	F/G	-	-	F-G	F-G	G	G	G	F	-	F-G	F-G	P-F	-	P
Permit	N	N	N	N	N	N	N	G	-	G	P	N	F	G	G	N	G	G	G	G	N	P	P
Poast	G	G	G	G	G	G	G	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Roundup	Most weeds.																						
Sandea	N	N	N	N	N	N	N	G	G	G	P	N	F	G	G	N	G	G	G	G	N	P	F
Select	G	G	G	G	G	G	G	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Spin-Aid	P	P	P	P	-	-	P	P	P	G	-	G	-	G	P	G	G	-	G	P	F	P	-
Stinger	N	N	N	N	N	N	N	N	G	-	G	N	-	P	P	-	G	G	F	-	G	P	F

The performance of herbicides is affected by weather conditions. Therefore, these ratings indicate only the relative effectiveness. Actual effectiveness may be better or worse than indicated in this table.

Blank spaces indicate insufficient data.

N	None
P	Poor
F	Fair
G	Good

[1]Triazine-resistant biotypes occur in Ohio and will not be controlled.

[2]Variable control is mostly related to weed size. Smaller weeds are more readily controlled.

REGLONE (diquat). *Chemical Family*: bipyridylium. *Crops*: Potatoes—used as a vine-killer. *Sensitive Weeds*: Kills essentially all green tissue sprayed. *Timing*: POST to potatoes about 2 weeks prior to harvest. *Residual Control*: Nil. *Carryover Potential*: Nil.

RO-NEET (cycloate). *Chemical Family*: thiocarbamate. *Crops*: Table beets, spinach and swiss chard. *Sensitive Weeds*: Controls most germinating grasses, some broadleaf weeds, and yellow nutsedge. *Timing*: PREPLANT incorporated. *Residual Control*: Seasonal. *Carryover Potential*: Unlikely to injure rotational crops.

ROUNDUP ULTRAMAX (glyphosate/many other formulations and brands available). *Chemical Family*: amino acid. *Crops*: May be applied immediately prior to planting of most vegetables. Spot sprays and wiper applications permitted on certain crops. *Sensitive Weeds*: Essentially all emerged annual and perennial weeds. *Timing*: Glyphosate severely injures or kills all plants. Applications to bare soil will not affect emerging crop seedlings nor weeds. *Residual Control*: Nil. *Carryover Potential*: Nil.

SANDEA/PERMIT (75% halosulfuron). *Chemical Family*: sulfonyl urea. *Crops*: Sandea is registered on asparagus, cucumbers, pumpkins, winter squash, cantaloupes, honeydew melons, crenshaw melons, pepper and tomato. Permit is registered on sweet corn. Some sweet corn varieties may be sensitve—check with your seed company or Extension specialist prior to using. Do not use on the variety Jubilee. Do not use on sweet corn if a soil-applied organo-phosphate insecticide has been used prior to Permit. Do not apply organo-phosphate insecticides within 7 days before or 3 days after application of Permit to sweet corn. *Sensitive Weeds*: Yellow nutsedge and certain annual broadleaf weeds, including redroot pigweed and velvet leaf. *Timing*: PRE or POST to fruiting vegetables; POST to sweet corn. Always include a non-ionic surfactant with POST applications as prescribed on the label. *Residual Control*: Significant. *Carryover Potential*: Several agronomic and certain vegetables may be sensitive within 12 months of application.

SELECT (clethodim). *Chemical Family*: cyclohexanedione. *Crops*: Most vegetable crops. *Sensitive Weeds*: Emerged annual and perennial grasses. *Timing*: POST. Requires crop oil concentrate or surfactant for activity. *Residual Control*: Nil. *Carryover Potential*: Nil.

SENCOR (metribuzin—75% DF or 4 lb a.i./gal). *Chemical Family*: triazine. *Crops*: Carrots, potatoes, tomatoes. *Sensitive Weeds*: Annual broadleaf weeds and grasses. Biotypes of lambsquarters and pigweed occur in Ohio which are resistant to triazines and must be controlled with herbicides of a different chemical family. *Timing*: PRE to weeds. May be applied POST to tomatoes and certain potato varieties. *Residual Control*: Seasonal, depending on rate. *Carryover Potential*: Late applications of high rates may affect fall seeded cereals and cover crops.

SINBAR (terbacil). *Chemical Family*: uracil. *Crops*: Asparagus. *Sensitive Weeds*: Germinating and emerged broadleaf weeds and grasses. Species controlled dependent mainly on rate. Small seedlings are controlled with rates of less than 0.5 lb/A. *Timing*: PRE or POST. *Residual Control*: Seasonal or longer, depending upon rate. *Carryover Potential*: Soil residues of Sinbar will injure most rotational crops 1 or more years after the last application.

SOLICAM DF (norflurazon). *Chemical Family*: Pyridazinone. *Crops*: Asparagus. *Sensitive Weeds*: Grass and broadleaf weeds; suppression of many perennials. *Timing*: PRE. Apply to fields that have been established for at least one year. *Residual Control*: Essentially none. *Carryover Potential*: Rotational crops may be severely injured. Check label for Replant Rotational Crop Intevals.

SPARTAN (39.6% sulfentrazone 5 lbs/gal). *Chemical Family*: PPO Inhibitor. *Crops*: Transplanted processing cabbage. *Sensitive Weeds*: Annual broadleaf weeds and yellow nutsedge. *Timing*: PRE. *Residual Control*: Significant. *Carryover Potential*: Significant.

SPIN-AID (phenmedipham). *Chemical Family:* carbanilate. *Crops:* Spinach (processing) and Red Beets. *Sensitive Weeds:* Wild mustard, lambsquarters, shepherdspurse, groundcherry, common chickweed, common purslane, common ragweed, annual sowthistle. *Timing:* POST. Weeds should be at the 2-leaf stage. Apply after the crop reaches the 4-6 true-leaf stage. Earlier applications may cause severe crop injury. *Residual Control:* Seasonal. *Carryover Potential:* May injure cereal crops planted less than 120 days following application.

STINGER (clopyralid). *Chemical Family:* pyridine. *Crops:* Cole crops and red beets. *Sensitive Weeds:* Emerged broadleaf weeds of the legume, composite, knotweed and nightshade families. *Timing:* POST. *Residual Control:* Insufficient to provide weed control. *Carryover Potential:* There is some potential to injure rotational peas, beans, tomatoes and potatoes.

STRATEGY (18.2% ethalfluralin + 5.6% clomozone). *Chemical Family*: dinitroaniline + None generally accepted). *Crops*: Cucumbers, melons, pumpkins, squash, and watermelons. *Sensitive Weeds*: Controls annual grasses and certain broadleaf weeds. Control of pigweed, ragweed and smartweed may be inadequate late in the season. *Timing*: PRE applied

after seeding but before crop emergence. May be applied PRE to weeds in row middles of transplanted crops in plastic mulch. Do not apply Strategy under plastic or other mulches. *Residual Control*: Short-lived. *Carryover Potential*: Delay planting tomatoes and wheat for 12 months or longer after applying. See the label for further restrictions.

SUTAN + (butylate plus safener). *Chemical Family*: thiocarbamate. *Crops*: Sweet corn (do not use on early plantings of sweet corn). *Sensitive Weeds*: Germinating annual grasses, some broadleaf weeds, quackgrass, johnsongrass and yellow nutsedge. *Timing*: PREPLANT incorporated. *Residual Control*: Seasonal. *Carryover Potential*: Should not affect rotational crops the year after application.

TARGA/ASSURE (10.3% quizalafop 0.88 lbs/gal). *Chemical Family*: aryloxyphenoxy propionoate/ ACCase inhibitor. *Crops*: Dry beans, lentils, succulent peas and snapbeans. *Sensitive Weeds*: Annual and perennial grasses. *Timing*: POST always use crop oil concentrate or non-ionic surfactant. *Residual Control*: Minimal. *Carryover Potential*: May be significant for grass crops—see label.

TILLAM (pebulate). *Chemical Family*: thiocarbamate. *Crops*: Tomatoes. *Sensitive Weeds*: Germinating annual grasses, some broadleaf weeds and yellow nutsedge. *Timing*: PREPLANT incorporated. *Residual Control*: Seasonal. *Carryover Potential*: Should not affect rotational crops the year after application.

TREFLAN (trifluralin). *Chemical Family*: dinitroaniline. *Crops*: Cole crops, beans, peas, peppers and tomatoes. *Sensitive Weeds*: Germinating annual grasses and some broadleaf weeds. Cold, wet soils may contribute to crop injury and to poor weed control. *Timing*: PREPLANT incorporated. *Residual Control*: Seasonal. *Carryover Potential*: Fall seeded cereals, cover crops and rotational sweet corn the year after application may be injured.