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Weed Control for Commercial Vegetable Crops

Weed management requires a multifaceted approach, built upon an understanding of weeds and the crop. Weed management may involve nonchemical methods, chemical methods (herbicides), or a combination of the two. Deciding which methods to use depends on environmental concerns, marketing opportunities, desired management intensity, labor availability, weed pressure, and the crop.

The first step in weed management is to identify the weeds and understand their life cycles. For assistance, consult identification guides, such as *Weeds of the North Central States* [Bulletin 772, University of Illinois Agricultural Experiment Station; available from ACES/ITCS Marketing and Distribution, 1917 S. Wright St., Champaign, IL 61820; (800)345-6087]. Weeds may be categorized by life cycles, and management strategies can be developed accordingly. Annual weeds complete their life cycles in 1 year and reproduce solely by seed. Annuals are divided into summer and winter groups depending on when they grow. Primary tillage operations often control winter annuals before a crop is planted in the spring. The most common weeds in vegetable crops are summer annuals (such as barnyardgrass, giant foxtail, common purslane, redroot pigweed, and common lambsquarters). Mechanical and cultural weed management methods help in suppressing summer annuals. Perennial weeds live for more than 2 years and reproduce by seed or vegetative structures (stolons, rhizomes, corms, bulbs, tubers, or roots). Because perennial weeds are extremely difficult to manage in vegetable crops, it is usually better not to use a field with severe perennial weed problems.

There are three sections in this chapter: nonchemical weed management strategies, chemical weed management strategies, and environmental and health hazards of herbicides. Many nonchemical weed management methods are common-sense farming practices. These practices are of increasing importance due to consumer concerns about pesticide residues, potential environmental contamination from pesticides, and unavailability of many older herbicides.

Nonchemical Weed Management Strategies

Weed management should start with nonchemical strategies that reduce problems caused by weeds. The aim should be to manage the weed population so it is below a level that reduces your economic return (the economic threshold). In some instances, the cost of controlling weeds may be more than the economic return obtained from any yield increase. This situation occurs when a few weeds are present or the weeds germinate late in the season. In those instances, the best strategy may be to do nothing. In other situations, weed populations and other considerations may require combining herbicides with nonchemical approaches.

Cultural Practices

You should aim to establish a vigorous crop that competes effectively with weeds. This approach starts with your *land selection.* A general rule is not to plant vegetables on land with a history of heavy weed infestation, especially of perennial weeds.

Crop selection can reduce the effects of weed competition. One criterion in selecting a crop should be the weed problems of the field. Plant the most competitive crops in the most weed-infested fields and the

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The information in this chapter is provided for educational purposes only. Product trade names have been used for clarity, but reference to trade names does not imply endorsement by the University of Illinois; discrimination is not intended against any product. The reader is urged to exercise caution in making purchases or evaluating product information.

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

least competitive crops in the cleanest ones. Consider planting heavily infested fields as long-term set-aside acres or as nonrow crops such as alfalfa. Permanent cover should help prevent buildup of annual weeds.

Crop rotation is another practice that can reduce weed problems. The characteristics of the crop, the methods used to grow it, and the herbicides used allow certain weeds to escape control inadvertently. Rotation also affects the weed-management tools at your disposal. Rotating between crops improves growth and the crops' competitiveness. Related vegetables should not be grown in the same location in successive years. Table 1 lists related vegetable crops.

Wild proso millet is an example of a problem weed for which rotation is an important management tactic. Rotating from sweet corn to small grains, early planted peas, or alfalfa almost completely eliminates wild proso millet. Alfalfa, early planted peas, and small grains are established before the soil is warm enough for wild proso millet to germinate. Rotating from sweet corn to broadleaf crops allows use of postemergence grass herbicides to manage wild proso millet.

Once a crop is selected, use *adaptive, vigorous varieties* resistant to diseases. Disease-infested plants cannot effectively compete with weeds.

Narrower row spacings and proper plant densities assure that the crop rapidly closes canopy. A closed canopy shades out later-emerging weeds and prevents germination of weed seeds requiring light. Weeds seldom are a problem once canopy closure occurs. Proper row spacing and plant density also allow row cultivation.

Another cultural method to improve crop competitiveness is to use the *correct planting time.* Crops may be divided into warm- and cool-season plants, depending on the optimal temperature for their growth. The planting date affects the time to emergence and early seedling vigor of the crop, which are important in determining crop competitiveness. Cool-season crops germinate at cooler soil temperatures and thus compete better against early emerging weeds than do warm-season crops. Table 2 lists crops according to their adaptation to field temperatures. Time plantings so that temperatures are favorable for crop growth.

Adequate fertilization and appropriate insect and disease management are important in assuring a competitive crop. Adequate fertility assures rapid, uniform germination and good crop growth, which enhance the crop's competitive ability. For information on fertility, consult *Fertilizer Guide for Commercial Vegetable Growers* (Circular 1185, University of Illinois Extension; available from ACES/ITCS Marketing and Distribution). Disease-management information is contained in Chapter 11 ("Plant Disease Management for Commercial Vegetable Crops") of this handbook and insect management information in Chapter 9 ("Insect Pest Management for Commercial Vegetable Crops"). While poor insect and disease control reduce a crop's competitiveness, inadequate weed control can also cause insect and disease problems.

Mulching can be useful in managing weeds. Mulches may be classified as either natural (straw, leaves, paper, and compost) or synthetic (plastic). Because natural mulches are difficult to apply over large areas, they are best for small, specialized areas. Natural mulches should be spread evenly at least 1½ inches thick over the soil to prevent light penetration. Natural mulch materials must be free of weed seeds and other pest organisms and be heavy enough that

Table 1. Botanically related vegetables

Corn	**Cucurbits**	**Onions**
Dent corn	Muskmelon	Garlic
Popcorn	Pumpkin	Onion
Sweet corn	Summer squash	
	Watermelon	**Solanaceous**
Crucifers	Winter squash	Pepper
Brussels sprout		Potato
	Legumes	Tomato
Cabbage	Dry bean	
Cauliflower	Lima bean	**Spinach**
Horseradish	Pea	Beets
Kale	Snap bean	Chard
Radish	Soybean	Spinach
Rutabaga		

Table 2. Classification of vegetable crops according to their adaptive field temperatures

Cool-season		Warm-season	
Hardy*	Semihardy	Tender	Very tender
Asparagus	Carrot	Pepper	Cucumber
Broccoli	Cauliflower	Snap bean	Eggplant
Cabbage	Chinese cabbage	Sweet corn	Lima bean
Horseradish	Lettuce		Muskmelon
Onion	Potato		Okra
Pea			Pumpkin
Spinach			Squash
			Watermelon

*Hardy crops are most tolerant of cool temperatures and frost, while very tender crops are most susceptible to frost and cool temperatures.

they are not easily displaced by wind or water. A major advantage of natural mulches is that they add organic matter to the soil.

Synthetic mulches control weeds within the row, conserve moisture, increase soil temperature, and are easy to apply. Black plastic mulches are the most common and are particularly effective in improving early season growth of warm-season crops such as tomatoes, muskmelons, watermelons, and peppers. Better early season growth of these crops improves their competitive ability against weeds. Plastic mulches used in combination with trickle irrigation also improve water-use efficiency.

The biggest disadvantage of plastic mulch is disposal, as many landfills do not accept it. Photodegradable plastic mulches have been developed, but their season-long persistence has been a problem. Also, photodegradable mulches just degrade into smaller pieces of plastic that still contaminate the environment. Biodegradable plastic mulches are not yet widely available.

Mechanical Practices

Mechanical weed management relies on primary and secondary tillage implements such as the rotary hoe and the row cultivator. Mechanical weed management starts with seedbed preparation. Few reduced-till systems have been developed for vegetable crops. Reduced-till suggestions are included in the section on chemical weed-management strategies in this chapter.

Moldboard plowing is usually the first step in mechanically managing weeds. It is particularly useful in controlling emerged annual weeds. An important second step is often *rotary hoeing* for mechanically managing weeds in large-seeded vegetable crops (sweet corn, snap beans, lima beans, and peas). Rotary hoeing needs to be done after the weeds germinate but before they emerge. It does not control large-seeded weeds, such as velvetleaf and shattercane.

Once the crop has emerged or transplants are established, a *row cultivator* may be used to manage emerged weeds. Adjust the cultivator sweeps or teeth to dislodge or cover as many weed seedlings as possible. Seedling weeds can be killed by cultivating 1 to 2 inches deep. The best weed control is obtained with a row cultivator in relatively dry soils by throwing soil into the crop row to cover small weed seedlings. Avoid crop injury from poor cultivation, which reduces crop yields.

In some vegetable crops, such as asparagus, *mowing* can be an effective weed-management tool. Mowing can prevent the production of weed seeds and kill upright weeds, reducing competition. Mowing must be carefully timed to prevent the growth of biennial weeds when reducing competition from upright plants. Timely, repeated mowing also helps deplete the food reserves of perennial weeds.

Mechanical control has many limitations that must be considered when designing weed-management systems. Because mechanical management relies on relatively dry weather, a rainy period may eliminate mechanical management options and lead to severe weed competition. Relying entirely on mechanical practices to manage weeds is difficult on large acreages. Also, several weeds are extremely difficult to manage unless herbicides are combined with nonchemical approaches. The problem weeds include wild proso millet in sweet corn, as well as Canada thistle, hemp dogbane, field bindweed, quackgrass, and johnsongrass. Newly introduced problem weeds often show up in scattered patches along headlands and field borders. These probably are best controlled or eradicated with herbicides before large areas are infested.

Biological Practices

Currently, no system using insects or diseases to control weeds common to vegetable crops exists in the Midwest. Most biological management systems using diseases or insects to control problem weeds have centered on western rangeland areas. One biological system that has potential in the Midwest is the use of cover crops to suppress the development of weeds. These systems are still experimental, and problems have been encountered, including the duration of weed control from cover crops and the spectrum of weeds controlled. Herbicides are often required to kill the cover crop and to manage any emerged weeds. Overall, cover-crop systems tend to control small-seeded annual broadleaf weeds the best. The most promising cover-crop system is winter rye. Winter rye is planted in the late summer or early fall; the rye is killed in the spring with Roundup Ultra, and the crop is no-till planted. The system is experimental and should be evaluated in small areas before being used extensively.

Table 3 summarizes some of the nonchemical weed-management practices. An integrated approach should be used that combines many different practices to manage weeds. This approach must be adaptive, aiming to prevent weed problems or cope with any that occur.

Chemical Weed-Management Strategies

Several herbicides are often labeled for a crop. Scouting your area to determine which weeds are present can allow you to select the herbicide that can give you

Table 3. Nonchemical weed-management practices

Practice	Comments
Cultural	
1. Land selection	Avoid fields with a history of weed problems.
2. Crop selection	Grow the most competitive crops in fields with a history of weed problems.
3. Crop rotation	Rotate between vegetables and nonrow crops such as alfalfa. Rotate between vegetables in different botanical categories.
4. Adapted crop varieties	Select crop varieties adapted for your area.
5. Proper row spacings and plant densities	Use row spacings and plant densities that assure rapid crop-canopy closure.
6. Correct planting times	Plant crops when soil temperatures favor rapid germination and emergence.
7. Appropriate fertility, disease, and insect management	Vigorous, healthy crops are more competitive against weeds.
8. Mulch	Natural mulches are difficult to use over large acreages. Synthetic (plastic) mulches are useful to manage weeds within the row in warm-season crops. Consider disposal problems when using plastic mulches.
Mechanical	
1. Moldboard plowing	Can eliminate emerged annual weeds.
2. Rotary hoeing	Useful to manage small-seeded weeds in large-seeded crops such as sweet corn, snap beans, lima beans, and peas.
3. Row cultivating	Dislodge or cover as many weed seedlings as possible. Avoid damaging crop root systems.
4. Mowing	Mow weeds as soon as flowers appear so no viable weed seed is produced.
Biological	
1. Cover crops	Still experimental. Winter rye system is the most promising and most effective against small-seeded broadleaf weeds.
2. Insect or disease pests of weeds	No current system uses insects or diseases to manage weeds common to vegetables.

the best control. Potential environmental hazards must be considered when selecting a herbicide. Herbicide labels contain information on these hazards. The last section of this chapter discusses potential environmental hazards.

All the herbicides labeled for a crop are not necessarily listed in Table 4. If you are unfamiliar with a herbicide, conduct a small test under your environmental conditions and cultural practices before using the herbicide extensively.

Always Read and Understand the Herbicide Label Before Use

Reading the herbicide label is a very profitable use of your time. Label information directs you to correct uses, application methods, rates, and potential environmental hazards. Follow label directions for the best possible control with minimal crop injury and environmental contamination. The label contains restrictions on use and discusses environmental and soil conditions that can affect crop injury, influence the effectiveness of weed control, and cause nontarget site effects.

Use a Herbicide That Is Labeled for Your Particular Use and Crop

Using a nonregistered pesticide can cause harmful residues in the vegetable crop, which can result in crop seizure and consumer injury. The label also states whether the herbicide is a restricted-use or general-use pesticide. Labels for restricted-use pesticides contain a statement that the products are restricted and that only licensed applicators may buy them and supervise their application.

The information in this chapter is current as of the date of publication. Watch for notices of changes in the U.S. Environmental Protection Agency (US EPA) registration of herbicides in the *Pest Management and Crop Development Bulletin (*available from University of Illinois Extension Newsletter Service, 528 Bevier Hall, 905 S. Goodwin Avenue, Urbana, IL 61801). Or look for notices in the *Illinois Fruit and Vegetable News* (available from Rick Weinzierl, Department of Crop Sciences, AW-101 Turner Hall, 1102 South Goodwin Avenue, Urbana, IL 61801).

Reduced-Tillage Systems

Reduced-tillage systems are a method to combat soil erosion. Roundup Ultra, Gramoxone Extra, or Touchdown may be applied outside the normal growing season to control emerged weeds in reduced-tillage systems. Weeds should be growing actively, and the application must be made before the crop has emerged. If you are applying Roundup Ultra to control perennial weeds, it is recommended that it be applied before disturbing the soil. After Roundup Ultra is applied, it must be allowed to translocate throughout the perennial weed for several days, or incomplete control may result. Follow Roundup Ultra label directions carefully for the rates and timing of application. If perennial weeds are not a major problem, you can eliminate early flushes of weeds by applying Roundup Ultra or Gramoxone Extra to all weeds that emerge. Plant the crop with minimal working of the soil. Never apply Roundup Ultra or Gramoxone Extra to an emerged crop because severe crop injury or death will occur.

Roundup Ultra and Gramoxone Extra control most annual broadleaf and grass weeds. Neither herbicide has any soil-residual activity, so other weed-control measures are necessary during the growing season. Gramoxone Extra also suppresses perennials by killing their shoots but should not be expected to control regrowth of perennial weeds from rhizomes or other underground storage organs. Roundup Ultra is better for controlling perennials because it kills shoots and translocates to destroy underground parts. Roundup Ultra only suppresses some particularly hard-to-control perennials, such as bindweed, hemp dogbane, and milkweed. To obtain control of these perennials, applications of high rates, repeat applications of Roundup Ultra (within label guidelines), or mechanical removal may be necessary.

How to Use Herbicide Tables

Use Table 4 to determine the herbicides that are labeled for use in your crop. Once you have determined the herbicides available for your crop, use Table 5 to determine which of the labeled herbicides provides control of the weeds you have present. If you are uncertain of the herbicide name, you can find both common and trade names of all herbicides in this chapter in Table 6. These tables are not intended to replace careful reading of a current herbicide label. **Always read the label before applying any pesticide.**

Herbicide Rates and Guidelines for Use in Vegetable Crops

All herbicide rates given in Table 4 are in rate of product per broadcast acre. Adjust amounts accordingly for banded applications. Make preemergence applications before weeds emerge or after removing any weeds present. Make postemergence applications after weeds have emerged. Make stale seedbed treatments only if weeds have emerged but no crop plants are present.

Table 4. Herbicide rates and guidelines for use in vegetable crops

Herbicide	Rate of product per broadcast acre	Remarks
ASPARAGUS		
Preemergence		
Devrinol (napropamide)	4 to 8 lb of 50DF	Rainfall or irrigation is necessary for activity. Established beds only.
Karmex, others (diuron)	2 to 4 lb of 80DF	Do not apply to young plants during the first year. Two applications per year may be made. See label restrictions.
Sencor (metribuzin)	1 to 2 qt of 4L or 4F	Established beds only.
Sinbar (terbacil)	1.5 to 3 lb of 80WP	With direct-seeded asparagus, spray activated carbon over rows. High-organic soils inactivate Sinbar. Do not use on soils with less than 1% organic matter.
Solicam (norflurazon)	2.5 to 5 lb of 80DF	Apply in the fall after chopping ferns or in the spring before emergence. One application per year.
Treflan, others (trifluralin)	1 to 4 pt of HFP	See label for incorporation instructions. Established beds only.
Postemergence		
2,4-D amine	See label.	Apply to actively growing weeds.
Fusilade DX (fluazifop-butyl)	2 to 3 pt	Use oil concentrate or nonionic surfactant. Apply to nonbearing asparagus only.
Poast (sethoxydim)	1 to 1.5 pt of 1.5EC	Use a crop-oil concentrate.
Stringer (clopyralid)	⅓ to ⅔ pt of 3EC	Do not use on harvested spears.
Stale seedbed		
Gramoxone Extra (paraquat)	2 to 3 pt	See discussion of reduced-tillage systems.
Roundup Ultra (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems. Apply at least 1 week before spears emerge or delay until after harvest.
CARROTS		
Preemergence		
Treflan, others (trifluralin)	1 to 2 pt of HFP	Must be incorporated.
Postemergence		
Fusilade DX (fluazifop-butyl)	2 to 3 pt	Use crop-oil concentrate or nonionic surfactant. Two applications per year may be made.

Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)

Herbicide	Rate of product per broadcast acre	Remarks
CARROTS (CONT.)		
Linex or Lorox (linuron)	1.5 to 3 lb of 50DF	Carrots must be at least 3 in. tall. Apply before grasses are 2 in. tall.
Poast (sethoxydim)	1 to 1.5 pt of 1.5EC	Use crop-oil concentrate.
Sencor (metribuzin)	0.33 lb of 75DF or 0.5 pt of 4L	See label warnings. Carrots must have at least 5 or 6 leaves. Weeds must be small.
Stale seedbed		
Gramoxone Extra (paraquat)	2 to 3 pt	See discussion of reduced-tillage systems.
Roundup Ultra (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems.
COLE CROPS (BROCCOLI, BRUSSELS SPROUT, CABBAGE, CAULIFLOWER, AND TURNIP)		
Preemergence		
Devrinol (napropamide)	2 to 4 lb of 50DF	May apply to transplants or direct-seeded plants. Should incorporate shallowly.
Goal (oxyfluorfen)	1.25 to 2.5 pt of 1.6EC	Apply to soil after final tillage but before transplanting. May cause foliar injury. Do not apply to Brussels sprout.
Prefar (bensulide)	5 to 6 qt of 4EC	Incorporate shallowly.
Treflan, others (trifluralin)	1 to 1.5 pt (direct-seeded) or 1 to 2 pt (transplanted) of HFP	Direct-seeded cole crops exhibit marginal tolerance to Treflan. Stunting can occur under stress. Must be incorporated.
Postemergence		
Poast (sethoxydim)	1 to 1.5 pt of 1.5EC	Use crop-oil concentrate, 2 pt per acre. Maximum of 3 pt Poast per acre per season. 30-day preharvest interval.
Stale seedbed		
Gramoxone Extra (paraquat)	2 to 3 pt	See discussion of reduced-tillage systems.
Roundup Ultra (glyphosate)	2 to 3 qt	See discussion of reduced-tillage systems.
CORN (POP)		
Preemergence		
AAtrex, others (atrazine)	3.2 to 4 pt of 4L or 1.8 to 2.2 lb of Nine-O	Restricted-use pesticide. Weed resistance to atrazine is a problem. Atrazine can contaminate surface and groundwater. Atrazine carryover can injure follow crops.

Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)

Herbicide	Rate of product per broadcast acre	Remarks
CORN (POP) (CONT.)		
Preemergence		
Bladex (cyanazine)	1.3 to 4.0 qt of 4L or 1.3 to 4.0 lb of 90DF	Restricted-use pesticide. Cyanazine rates will be reduced each year until it is phased out in 2002.
Dual, others (metolachlor)	1.5 to 3 pt of 8EC	
Eradicane (EPTC + safener)	4.75 to 7.33 pt of 6.7EC	Must be incorporated. Can help with perennial grass control; see label.
Frontier (dimethenamid)	16 to 32 fl oz of 6EC	Use higher rates on fine-textured soils with 3% or more organic matter.
Harness, DoublePlay, TopNotch (acetolachlor)	1.25 to 2.75 pt of Harness 7EC, or 4.5 to 7 pt of DoublePlay, or 4 to 6 pt of TopNotch	
Lasso, others (alachlor)	2 to 4 qt of 4EC	
Sutan+ (butylate + safener)	2.5 to 3.5 qt of 6.7EC	Especially useful on sandy soils. Must be incorporated.
Postemergence		
2,4-D amine (numerous trade names)	See label.	Apply to actively growing broadleaf weeds, preferably before corn is 8 inches tall or use drop nozzles. Do not treat corn in the tassel to dough stage. May cause stalk to become brittle.
AAtrex, others (atrazine)	1 to 1.5 pt of 4L or 1. 6 lb of Nine-O	Applied with crop oils. See label precautions. Do not use after June 10.
Accent (nicosulfuron)	0.66 oz of 75DF	Avoid using with some soil insecticides such as Counter. Check with popcorn company to determine variety tolerance. Do not apply to popcorn taller than 20 inches (6 or fewer collars).
Banvel and Clarity (dicamba)	0.5 to 1 pt of Banvel or 16 fl oz of Clarity	**Can injure sensitive crops.** Verify that popcorn variety is tolerant before using. Apply to popcorn between emergence and 8 inches tall (5-leaf stage).
Basagran (bentazon)	1.5 to 2 pt of 4S	Apply when weeds are small and actively growing. Use crop-oil concentrate.
Beacon (primisulfuron)	0.76 oz of 74WD	Only make semidirected or directed applications with drop nozzles when popcorn is between 10 and 48 inches tall and before tassel emergence. Test varieties for sensitivity to Beacon before using.

Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)

Herbicide	Rate of product per broadcast acre	Remarks
CORN (POP) (CONT.)		
Postemergence		
Buctril (bromoxynil)	1 to 1.5 pt of 2EC	Primarily a contact herbicide, so thorough coverage is essential for control. Can cause temporary leaf burn of popcorn.
Tough (pyridate)	1 to 2 pt of 3.75EC	Can be applied up to 68 days before harvest. Apply to actively growing broadleaf weeds.
Stale seedbed		
Gramoxone Extra (paraquat)	2 to 3 pt	Restricted-use pesticide. See discussion of reduced-tillage systems.
Roundup Ultra (glyphosate)	1.5 to 2 pt	See discussion of reduced-tillage systems.
Touchdown (sulfonium)	0.5 to 5.33 pt of 6EC	Apply to actively growing annual weeds before 6 inches in height. Control may be improved by adding ammonium sulfate.
CORN (SWEET)		
Preemergence		
AAtrex, others (atrazine)	3.2 to 4 pt of 4L or 1.8 to 2.2 lb of Nine-O	Restricted-use pesticide. Can contaminate surface and groundwater. Weed resistance is a problem. Can injure follow crops.
Bladex (cyanazine)	1.5 to 6.0 lb of 80WP, or 1.3 to 5.3 lb of 90DF, or 1.25 to 4.75 qt of 4L	Restricted-use pesticide. Cyanazine rates will be reduced each year until it is phased out in 2002.
Dual (metolachlor)	1.5 to 3 pt of 8EC	May be incorporated or applied before emergence.
Eradicane Extra (EPTC + safener + extender)	4 to 8 pt of 6.7EC	Suppresses wild proso millet. Must be incorporated. Contains an extender that may lengthen the period of control.
Frontier (dimethenamid)	13 to 25 fl oz of 6EC	
Lasso, others (alachlor)	2 to 4 qt of 4EC	Restricted-use pesticide.
Prowl (pendimethalin)	1.2 to 3.6 pt of 3.3EC	Do not incorporate. For use on processing varieties. Do not apply prior to planting.
Sutan+ (butylate + safener)	2.5 to 3.5 qt of 6.7EC	Especially useful on sandy soils. Must be incorporated.
Postemergence		
2,4-D amine	See label.	Apply to actively growing weeds, preferably before corn is 6 inches tall. See label restrictions. Sweet corn injury may occur.

Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)

Herbicide	Rate of product per broadcast acre	Remarks
CORN (SWEET) (CONT.)		
Postemergence (cont.)		
AAtrex, others (atrazine)	1 to 1.5 pt of 4L, or 1.8 lb of 80WP, or 1.6 lb of Nine-O	May be applied with crop oils. See label precautions. Do not use after June 10.
Accent (nicosulfuron)	⅔ oz of 75SP	Processing corn only. Use only on tolerant varieties listed on label.
Basagran 4S (bentazon)	1.5 to 2 pt	Apply when weeds are small and actively growing. Consult label for specific directions.
Stale seedbed		
Roundup Ultra (glyphosate)	1.5 to 2 pt	See discussion of reduced-tillage systems.
CUCURBITS (CUCUMBER, MUSKMELON, AND WATERMELON)		
Preemergence		
Alanap (naptalam)	6 to 8 qt of 2L	A second application may be made before vining. Usually tank-mixed with Prefar.
Curbit (ethalfluralin)	3 to 4.5 pt of 3EC	Read label carefully before using. Avoid using on cool, wet soils. Requires signing a waiver of liability before using.
Prefar (bensulide)	5 to 6 qt of 4EC	Incorporate or irrigate in. May be tank-mixed with Alanap. Do not plant other than label-specified crops for 18 months after application.
Treflan (trifluralin)	1 to 2 pt of HFP	Apply after establishment to melons that have 3 to 4 true leaves. Direct between rows and incorporate.
Postemergence		
Poast (sethoxydim)	1.0 to 1.5 pt of 1.5EC	Use crop-oil concentrate, 2 pt per acre. Maximum of 3 pt Poast per acre per season. 14-day preharvest interval.
Stale seedbed		
Gramoxone Extra (paraquat)	2 to 3 pt	See discussion of reduced-tillage systems.
DRY BEANS (WHITE, NAVY, KIDNEY, PINTO, LIMA, AND ADZUKI)		
Preemergence		
Dual (metolachlor)	1.5 to 3 pt of 8EC	
Eptam (EPTC)	2.5 to 3.5 pt of 7EC	Do not use on adzuki beans, cowpeas, lima beans, or other flat-pod beans. Incorporate immediately.
Frontier (dimethenamid)	1 to 2 qt of 4EC	Incorporate.
Prowl (pendimethalin)	1.2 to 3.6 pt of 3.3EC	Must be incorporated.

Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)

Herbicide	Rate of product per broadcast acre	Remarks
DRY BEANS (WHITE, NAVY, KIDNEY, PINTO, LIMA, AND ADZUKI) (CONT.)		
Preemergence (cont.)		
Pursuit (imazethapyr)	3 fl oz of 2EC	Use on lima and red kidney beans only.
Treflan, others (trifluralin)	1 to 2 pt of HFP	Must be incorporated.
Postemergence		
Assure II (quizalofop)	6 to 10 fl oz of 0.88EC	Use crop-oil concentrate, 1 qt per acre. Good on quackgrass. 30-day preharvest interval.
Basagran (bentazon)	1 to 2 pt of 4S	Apply when weeds are small. Beans are tolerant after the first trifoliate leaf has expanded. Avoid applying when day temperatures are below 75°F.
Poast 1.5E (sethoxydim)	1 to 2 pt	Use crop-oil concentrate, 2 pt per acre. Maximum of 4 pt Poast per acre per season. 30-day preharvest interval.
Stale seedbed		
Roundup Ultra (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems.
EGGPLANT		
Preemergence		
Devrinol (napropamide)	2 to 4 lb of 50DF	Transplants only.
Prefar (bensulide)	5 to 6 qt	Apply before planting and incorporate 1 to 2 inches.
Treflan (trifluralin)	1 to 1.5 pt of HFP	Transplants only. Requires signing a liability waiver before using.
Postemergence		
Poast (sethoxydim)	1 to 1.5 pt of 1.5EC	Use crop-oil concentrate, 2 pt per acre.
Stale seedbed		
Gramoxone Extra (paraquat)	2 to 3 pt	See discussion of reduced-tillage systems.
Roundup Ultra (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems.
GREENS (CHICORY, COLLARD, KALE, MUSTARD, SPINACH, TURNIP)		
Preemergence		
Prefar (bensulide)	5 to 6 qt of 4EC	Lightly incorporate.
Treflan, others (trifluralin)	1 to 1.5 pt of HFP	Must be incorporated.
Postemergence		
Poast (sethoxydim)	1 to 1.5 pt of 1.5EC	Use crop-oil concentrate, 2 pt per acre. 30-day preharvest interval for all except spinach, which requires a 15-day preharvest interval.

Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)

Herbicide	Rate of product per broadcast acre	Remarks
GREENS (CHICORY, COLLARD, KALE, MUSTARD, SPINACH, TURNIP) (CONT.)		
Stale seedbed		
Gramoxone Extra (paraquat)	2 to 3 pt	Collards only. See discussion of reduced-tillage systems.
Roundup Ultra (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems.
HORSERADISH		
Preemergence		
Goal (oxyfluorfen)	2.5 pt of 1.6EC	Apply after planting and before emergence. Some crop injury may occur.
Postemergence		
Poast (sethoxydim)	1 to 1.5 pt of 1.5EC	Use crop-oil concentrate, 2 pt per acre.
Stale seedbed		
Roundup Ultra (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems.
LETTUCE		
Preemergence		
Balan (benefin)	2 to 2.5 lb of 60DF	Direct-seeded lettuce only. Must be incorporated.
Kerb (pronamide)	2 to 4 lb of 50WP	Moisture is necessary to activate. Label rates vary depending on variety.
Prefar (bensulide)	5 to 6 qt of 4EC	May be applied to head and leaf lettuce. Must be incorporated.
Postemergence		
Poast (sethoxydim)	1 to 1.5 pt of 1.5EC	Use crop-oil concentrate, 2 pt per acre. Preharvest intervals are 15 days for leaf and 30 days for head lettuce.
Stale seedbed		
Gramoxone Extra (paraquat)	2 to 3 pt	See discussion of reduced-tillage systems.
Roundup Ultra (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems.
OKRA		
Preemergence		
Treflan (trifluralin)	1 to 2 pt of HFP	Must be incorporated immediately after application.
Stale seedbed		
Roundup Ultra (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems.

Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)

Herbicide	Rate of product per broadcast acre	Remarks
ONION		
Preemergence		
Prefar (bensulide)	5 to 6 qt of 4EC	Dry bulb onions only. Incorporate or irrigate in.
Prowl (pendimethalin)	0.6 to 2.4 qt of 3.3EC	Apply when direct-seeded onions have 2 to 9 leaves or after transplanting.
Postemergence		
Buctril (bromoxynil)	1 to 1.5 pt of 2EC	Apply 2 to 3 days before onions emerge or when they have 2 to 5 true leaves. Sensitivity of onions is affected by variety and environment.
Fusilade DX (fluazifop-P-butyl)	1.25 to 1.5 pt of 1EC	Use nonionic surfactant, 1 pt per acre. 45-day preharvest interval. Use only on dry bulb onions.
Goal (oxyfluorfen)	5 to 10 fl oz of 1.6EC	Do not apply until onions have 2 true leaves. Best control is achieved when weeds are in the 2- to 4-leaf stage. Do not apply more than 2.5 pt per broadcast acre in one season. Use only on dry bulb onions.
Poast (sethoxydim)	1 to 1.5 pt	Add 2 pt crop-oil concentrate per acre. 30-day preharvest interval. May be used on dry bulb onions, green bunching onions, garlic, and leeks.
Stale seedbed		
Gramoxone Extra (paraquat)	2 to 3 pt	See discussion of reduced-tillage systems.
Roundup Ultra (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems.
PEAS		
Preemergence		
Dual (metolachlor)	1.5 to 3 pt of 8EC	Apply preemergence. See label for restrictions.
Command (clomazone)	1 pt of 3ME	
Pursuit (imazethapyr)	3 fl oz of 2EC	Do not use if applying Treflan to peas.
Treflan, others (trifluralin)	1 to 1.5 pt of HFP	Must be incorporated.
Postemergence		
Assure II (quizalofop)	6 to 12 fl oz of 0.88EC	Use crop-oil concentrate, 2 pt per acre. Good on quackgrass. 30-day preharvest interval.
Basagran (bentazon)	1.5 to 2 pt of 4S	Apply when weeds are small. Pea injury can occur. See label precautions. Do not add crop oil.
Poast (sethoxydim)	1 to 1.5 pt of 1.5EC	Use crop-oil concentrate, 2 pt per acre.

Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)

Herbicide	Rate of product per broadcast acre	Remarks
PEAS (CONT.)		
Postemergence (cont.)		
Pursuit (imazethapyr)	3 fl oz of 2EC	Add nonionic surfactant. Crops must have at least 1 true leaf, or crop injury may result. Do not apply if Treflan is used.
Thistrol (MCPB)	2 to 4 pt of 2EC	Apply when peas have developed 6 to 12 nodes and weeds are less than 3 inches tall. Use for Canada thistle control.
Stale seedbed		
Gramoxone Extra (paraquat)	2 to 3 pt	See discussion of reduced-tillage systems.
Roundup Ultra (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems.
PEPPER		
Preemergence		
Command (clomazone)	0.5 to 2 pt of 3ME	Use lower rates on light soil textures. Varieties differ in tolerance. Do not use on banana peppers.
Devrinol (napropamide)	2 to 4 lb of 50DF	May be applied to direct-seeded plants or transplants. Incorporate.
Prefar (bensulide)	5 to 6 qt of 4EC	Lightly incorporate.
Treflan, others (trifluralin)	1 to 2 pt of HFP	Incorporate. Apply to transplants only.
Postemergence		
Poast (sethoxydim)	1 to 1.5 pt of 1.5EC	Use crop-oil concentrate, 2 pt per acre. Maximum of 4.5 pt Poast per acre per season. 20-day preharvest interval.
Stale seedbed		
Gramoxone Extra (paraquat)	2 to 3 pt	See discussion of reduced-tillage systems.
Roundup Ultra (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems.
POTATO		
Preemergence		
Dual (metolachlor)	1.5 to 3 pt of 8EC	Apply preemerge, incorporated, or at lay-by. Do not use on muck soils.
Eptam (EPTC)	3.5 to 7 pt of 7EC	Incorporate immediately after applying. The variety Superior is sensitive.

Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)

Herbicide	Rate of product per broadcast acre	Remarks
POTATO (CONT.)		
Preemergence (cont.)		
Lexone or Sencor (metribuzin)	0.6 to 1.33 lb of 75DF	Make a single application before emergence.
Linex or Lorox (linuron)	1.5 to 2.5 pt of 4L, or 1 to 4 lb of 50WP or 50DF	Apply after planting but before potato emergence. Plant "seed" 2 inches deep.
Matrix (rimsulfuron)	1 to 1.5 oz of 25DF	Apply after hilling or drag-off, and before potatoes and weeds emerge.
Prowl (pendimethalin)	1.2 to 3.6 pt of 3.3EC	Incorporate lightly. Do not use on muck soils.
Treflan, others (trifluralin)	1 to 2 pt of HFP	Apply after planting and incorporate uniformly.
Postemergence		
Lexone or Sencor (metribuzin)	0.5 to 1 pt of 4L, or 0.3 to 0.67 lb of 75DF	Do not use on smooth-skinned white or red-skinned potatoes. Apply only after 3 successive days of sunny weather. Apply before weeds are 1 inch tall.
Matrix (rimsulfuron)	1 to 1.5 oz of 25DF	Apply before potatoes are 14 in. tall. Spray only after 3 days of sunny weather. May injure potatoes.
Poast (sethoxydim)	1 to 2.5 pt of 1.5EC	Use crop-oil concentrate, 2 pt per acre. Maximum of 5 pt Poast per acre per season. 30-day preharvest interval.
Stale seedbed		
Gramoxone Extra (paraquat)	2 to 3 pt	See discussion of reduced-tillage systems.
Roundup Ultra (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems.
PUMPKIN AND SQUASH		
Preemergence		
Command (clomazone)	1.5 to 2 pt of 3ME	Processing pumpkins only.
Curbit (ethalfluralin)	3 to 4.5 pt of 3EC	Apply after seeding squash or pumpkins and before weed or crop emergence. Carefully read label before using. Requires signing a liability waiver.
Prefar (bensulide)	5 to 6 qt of 4EC	Incorporate or irrigate in. See label restrictions.
Postemergence		
Poast (sethoxydim)	1 to 1.5 pt of 1.5EC	Use crop-oil concentrate, 2 pt per acre. Maximum of 3 pt Poast per acre per season. 14-day preharvest interval.

Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)

Herbicide	Rate of product per broadcast acre	Remarks
PUMPKIN AND SQUASH (CONT.)		
Stale seedbed		
Gramoxone Extra (paraquat)	2 to 3 pt	See discussion of reduced-tillage systems.
Roundup Ultra (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems.
SNAP BEANS OR GREEN BEANS		
Preemergence		
Dual (metolachlor)	1.5 to 3 pt of 8EC	
Eptam (EPTC)	3.5 pt of 7EC	Do not use on flat-pod beans. Must be incorporated.
Prowl (pendimethalin)	1.2 to 3.6 pt of 3.3EC	Apply before planting and incorporate.
Treflan, others (trifluralin)	1 to 1.5 pt of HFP	Must be incorporated.
Postemergence		
Assure II (quizalofop)	6 to 10 oz of 0.88 EC	Use crop-oil concentrate, 2 pt per acre. Good on quackgrass. 30-day preharvest interval.
Basagran (bentazon)	1.5 to 2 pt of 4S	Apply when weeds are small. Beans are tolerant after the first trifoliate leaf has fully expanded. Some injury to beans may occur.
Poast (sethoxydim)	1 to 2.5 pt of 1.5EC	Use crop-oil concentrate, 2 pt per acre. Maximum of 4 pt Poast per acre per season. 15-day preharvest interval.
Stale seedbed		
Gramoxone Extra (paraquat)	2 to 3 pt	See discussion of reduced-tillage systems.
Roundup Ultra (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems.
TABLE BEETS		
Preemergence		
Pyramin (pyrazon)	2.75 to 3.25 qt of 4.5SC, or 4.6 to 5.4 lb of 68DF	Rainfall or irrigation is needed for activation.
Ro-Neet (cycloate)	2 to 3 qt of 6EC	Must be incorporated. Use on mineral soils only.
Pyramin (pyrazon)	3.5 qt of 4.2FL	Timing is very important. Treat when beets have 2 expanded leaves and weeds have 2 to 4 leaves.
Spin-aid (phenmediphon)	3 to 6 pt of 1.3EC	Apply after beets have 4 leaves.

Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)

Herbicide	Rate of product per broadcast acre	Remarks
TABLE BEETS (CONT.)		
Stale seedbed		
Roundup Ultra (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems.
TOMATO		
Preemergence		
Devrinol (napropamide)	2 to 4 lb of 50DF	Must be incorporated.
Lexone or Sencor (metribuzin)	0.5 to 1 pt of 4L, or 0.33 to 0.66 lb of 75DF	Apply to transplanted tomatoes only. May be incorporated.
Prefar (bensulide)	4 to 5 qt of 4EC	Incorporate or irrigate in. Do not plant other than specified crops for 18 months after treatment.
Tillam (pebulate)	2.7 to 4 qt of 6EC	Do not use Tillam with row covers.
Treflan, others (trifluralin)	1 to 2 pt of HFP	Must be incorporated. For direct-seeded plants, apply at blocking or thinning as a directed spray between rows.
Postemergence		
Lexone or Sencor (metribuzin)	0.5 to 0.75 pt of 4L, or 0.33 to 0.67 lb of 75DF	Plants must be established; see label. Apply only after 3 successive days of sunny weather.
Poast (sethoxydim)	1.0 to 1.5 pt of 1.5EC	Use crop-oil concentrate, 2 pt per acre. Maximum of 4.5 pt Poast per acre per season. 20-day preharvest interval.
Stale seedbed		
Gramoxone Extra (paraquat)	2 to 3 pt	See discussion of reduced-tillage systems.
Roundup Ultra (glyphosate)		

Table 5. Weed susceptibility to herbicides labeled for use in vegetable crops

	Weeds controlled	
Herbicide	Grasses	Broadleaves
2,4-D amine		carpetweed, dandelion, dock, galinsoga, jimsonweed, lambsquarters, morningglory, pigweed, plantain, ragweed, smartweed, thistle, wild mustard
Accent (nicosulfuron)	barnyardgrass, fall panicum, foxtail, johnsongrass, quackgrass, sandbur, shattercane, sorghum almum, wild proso millet	burcucumber, jimsonweed, morningglory, pigweed, smartweed
Alanap (naptalam)		carpetweed, chickweed, cocklebur, hairy galinsoga, lambsquarters, purslane, ragweed
Assure (quizalofop)	shattercane, wild proso millet, foxtail, fall panicum, sandbar, volunteer grains, witchgrass, quackgrass, johnsongrass	
Balan (benefin)	annual bluegrass, barnyardgrass, crabgrass, fall panicum, foxtail, goosegrass, seedling johnsongrass	carpetweed, chickweed, knotweed, lambsquarters, pigweed, purslane
Basagran (bentazon)		Canada thistle, cocklebur, galinsoga, jimsonweed, lambsquarters, purslane, ragweed, smartweed, velvetleaf, wild mustard
Banvel (dicamba)		cocklebur, dandelion, dock, fleabane, jimsonweed, ladysthumb, lambsquarters, milkweed, morningglory, mustard, nightshade, pigweed, prickly lettuce, ragweed, smartweed, velvetleaf
Beacon (primisulfuron)	fall panicum, foxtail, johnsongrass, quackgrass, sandbur, shattercane	burcucumber, cocklebur, horsenettle, horseweed, jimsonweed, kochia, lambsquarters, morningglory, nightshade, pigweed, puncturevine, ragweed, prickly sida, smartweed, sunflower
Bladex (cyanazine)	annual bluegrass, barnyardgrass, crabgrass, fall panicum, foxtail, goosegrass, witchgrass	carpetweed, chickweed, cocklebur, jimsonweed, lambsquarters, morningglory, nightshade, pigweed, purslane, ragweed, velvetleaf, wild mustard
Buctril (bromoxynil)		annual morningglory, cocklebur, jimsonweed, lambsquarters, mustard, nightshade, pennycress, pigweed, smartweed
Command (clomazone)	barnyardgrass, crabgrass, fall panicum, foxtail, goosegrass, seedling johnsongrass	jimsonweed, lambsquarters, purslane, ragweed, smartweed, velvetleaf

Table 5. Weed susceptibility to herbicides labeled for use in vegetable crops (cont.)

	Weeds controlled	
Herbicide	Grasses	Broadleaves
Curbit (ethalfluralin)	annual bluegrass, barnyardgrass, crabgrass, fall panicum, foxtail, goosegrass, seedling johnsongrass, shattercane, witchgrass	carpetweed, chickweed, lambsquarters, nightshade, pigweed, purslane, wild buckwheat
Devrinol (napropamide)	barnyardgrass, crabgrass, foxtail, goosegrass, seedling johnsongrass, weedy brome	chickweed, common groundsel, lambsquarters, pigweed, prickly lettuce, prostrate knotweed, purslane
Dual (metolachlor)	barnyardgrass, crabgrass, fall panicum, foxtail, goosegrass, witchgrass, yellow nutsedge	carpetweed, galinsoga, nightshade, pigweed
Eptam (EPTC)	annual bluegrass, barnyardgrass, crabgrass, foxtail, goosegrass, shattercane, witchgrass	annual morningglory, carpetweed, chickweed, lambsquarters, nightshade, purslane
Eradicane Extra (EPTC + safener + extender)	annual bluegrass, barnyardgrass, crabgrass, foxtail, goosegrass, seedling johnsongrass, volunteer small grains	annual morningglory, carpetweed, lambsquarters, nightshade, pigweed, purslane, velvetleaf
Frontier (dimethenamid)	barnyardgrass, crabgrass, foxtail, goosegrass, witchgrass	carpetweed, pigweed, purslane, spurge
Fusilade DX (fluazifop-butyl)	barnyardgrass, bermudagrass, crabgrass, fall panicum, foxtail, goosegrass, johnsongrass, volunteer cereals, wild proso millet, witchgrass	
Goal (oxyfluorfen)		black nightshade, common groundsel, evening primrose, pigweed, purslane, shepherd's-purse
Gramoxone Extra (paraquat)	most annual grasses and broadleaves	See discussion of reduced-tillage systems.
Harness, others (acetolachlor)	barnyardgrass, crabgrass, cupgrass, foxtail, goosegrass, panicum, sandbur	carpetweed, galinsoga, henbit, lambsquarters, nightshade, pigweed, ragweed
Karmex, others (diuron)	annual bluegrass, barnyardgrass, crabgrass, foxtail	chickweed, mustard, pennycress, pigweed, purslane, ragweed, velvetleaf
Kerb (pronamide)	annual bluegrass, barnyardgrass, brome, foxtail, goosegrass, panicum, volunteer small grains	carpetweed, chickweed, henbit, knotweed, lambsquarters, morningglory, nightshade, purslane

Table 5. Weed susceptibility to herbicides labeled for use in vegetable crops (cont.)

	Weeds controlled	
Herbicide	Grasses	Broadleaves
Lasso, others (alachlor)	barnyardgrass, crabgrass, fall panicum, foxtail, goosegrass, witchgrass	carpetweed, galinsoga, nightshade, pigweed, purslane
Lexone or Sencor (metribuzin)	crabgrass, downy brome, foxtail, seedling johnsongrass	chickweed, jimsonweed, lambsquarters, pepperweed, pigweed, prickly sida, purslane, ragweed, shepherd's-purse, smartweed
Linex or Lorox (linuron)	barnyardgrass, crabgrass, fall panicum, goosegrass	annual morningglory, carpetweed, cocklebur, groundsel, lambsquarters, mustard, pigweed, prickly sida, purslane, smartweed, velvetleaf
Matrix (rimsulfuron)	barnyardgrass, foxtail, goosegrass	chickweed, cocklebur, galinsoga, ladysthumb, mustard, pigweed, smartweed, velvetleaf
Poast (sethoxydim)	barnyardgrass, bermudagrass, crabgrass, fall panicum, foxtail, goosegrass, johnsongrass, quackgrass, volunteer cereals, wild proso millet, witchgrass	
Prefar (bensulide)	crabgrass, fall panicum, foxtail, goosegrass	
Prowl (pendimethalin)	barnyardgrass, crabgrass, fall panicum, foxtail	carpetweed, lambsquarters, pigweed, purslane
Pursuit (imazethapyr)		kochia, nightshade, pigweed, wild mustard
Pyramin (pyrazon)		henbit, lambsquarters, mustard, nightshade, pigweed, purslane, ragweed, shepherd's-purse, smartweed
Ro-Neet (cycloate)	annual bluegrass, barnyardgrass, crabgrass, foxtail, volunteer barley	henbit, lambsquarters, nightshade, purslane, redroot pigweed, shepherd's-purse
Roundup Ultra (glyphosate)	most annual and perennial grasses and broadleaves	See discussion of reduced-tillage systems.
Sinbar (terbacil)	annual bluegrass, barnyardgrass, crabgrass, foxtail, seedling johnsongrass	chickweed, dandelion, henbit, jimsonweed, knotweed, lambsquarters, pepperweed, pigweed, plantain, purslane, ragweed, shepherd's-purse, wild mustard
Spin-aid (phenmedipham)		chickweed, groundcherry, lambsquarters, purslane, ragweed, shepherd's-purse, wild mustard

Table 5. Weed susceptibility to herbicides labeled for use in vegetable crops (cont.)

	Weeds controlled	
Herbicide	Grasses	Broadleaves
Stringer (clopyralid)		Canada thistle, cocklebur, dandelion, dock, horseweed, jimsonweed, ladysthumb, nightshade, prickly lettuce, ragweed, sorrel, sowthistle, wild buckwheat
Sutan+ (butylate + safener)	barnyardgrass, crabgrass, fall panicum, foxtail, goosegrass, shattercane, seedling johnsongrass	
Thistrol (MCPB)		annual morningglory, Canada thistle, lambsquarters, pigweed, smartweed, sowthistle
Tillam (pebulate)	barnyardgrass, crabgrass, foxtail, goosegrass	lambsquarters, pigweed, purslane, shepherd's-purse
Touchdown (sulfonium)	many annual and perennial grasses and broadleaves	See discussion of reduced-tillage systems.
Tough (pyridate)		carpetweed, chickweed, cocklebur, galinsoga, henbit, jimsonweed, lambsquarters, nightshade, pigweed, velvetleaf
Treflan (trifluralin)	annual bluegrass, barnyardgrass, crabgrass, foxtail, goosegrass, seedling johnsongrass	carpetweed, chickweed, knotweed, lambsquarters, pigweed, purslane

Table 6. Common names of herbicides and corresponding trade names

Common name	Trade name	Common name	Trade name
2,4-D amine	several names	imazethapyr	Pursuit
acetolachlor	Harness, others	linuron	Linex, Lorox
alachlor	Lasso, others	MCPB	Thistrol
atrazine	AAtrex, others	metolachlor	Dual
benefin	Balan	metribuzin	Lexone, Sencor
bensulide	Prefar	napropamide	Devrinol
bentazon	Basagran	naptalam	Alanap
bromoxynil	Buctril	nicosulfuron	Accent
butylate + safener	Sutan+	oxyfluorfen	Goal
clomazone	Command	paraquat	Gramoxone Extra
clopyralid	Stringer	pebulate	Tillam
cyanazine	Bladex	pendimethalin	Prowl
cycloate	Ro-Neet	phenmedipham	Spin-aid
dicamba	Banvel, Clarity	primisulfuron	Beacon
dimethenamid	Frontier	pronamide	Kerb
diuron	Karmex, others	pyrazon	Pyramin
EPTC	Eptam	pyridate	Tough
EPTC + safener + extender	Eradicane Extra	quizalofop	Assure II
		rimsulfuron	Matrix
ethalfluralin	Curbit	sethoxydim	Poast
fluazifop-butyl	Fusilade DX	sulfonium	Touchdown
glyphosate	Roundup Ultra	terbacil	Sinbar
		trifluralin	Treflan, others

Environmental and Health Hazards of Herbicides

Nontargeted effects can occur from the use of herbicides. With the increased attention directed toward such nontargeted effects, it is very important to educate yourself and consider nontargeted effects when designing weed-management systems. This overview discusses some of the potential environmental and health hazards of herbicides. More detailed information is contained in herbicide labels, other chapters of this handbook, and trade publications.

Environmental Hazards

Adverse environmental effects from herbicides can have long-term consequences that are difficult to correct and must be avoided. Some environmental hazards, such as herbicide drift and carryover, affect mainly your operation, while others, such as water contamination, affect all the residents of Illinois. The following section discusses some of the potential hazards and methods to avoid them.

Herbicide Carryover. Herbicide carryover from persistent herbicides is a particular problem to growers of vegetable crops. Some vegetable-crop herbicides and many common soybean, corn, and wheat herbicides can persist and injure following crops. Persistent herbicides can kill vegetable plants, reduce growth, affect fruiting, or injure root systems. Root-system injury may not show up until the plants are under stress and the plants suddenly die.

Generally, the biggest problems are ALS-inhibiting herbicides (sulfonylureas and imidazolinones). ALS-inhibiting herbicides can be used on corn, soybeans, and wheat. Examples of sulfonylurea herbicides are Classic, Canopy, and Accent, while some imidazolinones are Pursuit, Scepter, and Raptor. These herbicides inhibit branch-chain amino acid synthesis. Injury from ALS-inhibiting herbicides appears as chlorosis of the growing points and new growth along with root-growth inhibition. Another herbicide that can persist and injure vegetable crops is atrazine. It inhibits photosynthesis in plants, causing the older leaves to turn yellow. Atrazine is a very common corn (including sweet corn and popcorn) herbicide that is contained in a wide variety of products.

Some ALS-inhibiting herbicides have a very long persistence. Generally, rotation restrictions provide an indication of how long after its application a herbicide persists. For example, Passport, Pursuit, and others require that you wait 40 months after they are applied

Table 7. Rotation restrictions for common vegetable crops

Herbicide		Rotation restriction (months)[c]													
Trade name	Active ingredient	Site of action[a]	Crop use[b]	Sweet corn	Pop-corn	Dry beans	Snap beans	Peas	Potato	Tomato	Pepper	Cu-cum-bers	Pump-kins	Water-melon	Cole crops
Aatrex, others	atrazine	PSI	c	AT	AT	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY
Accent	nicosulfuron	ALSI	c	10[d]	10	10	10	10	10/18[e]	10/18	10/18	10/18	10/18	10/18	10/18
Assert	toluic acid	ALSI	w	15	15	15	15	15	15	15	15	15	15	15	15
Basis	rimsulfuron + thifensulfuron	ALSI	c	10	10	8	8	8	4	18	18	18	18	18	18
Beacon	primisulfuron	ALSI	c	8	8	8	18	8	18	18	18	18	18	18	18
Bicep	atrazine + metolachlor	PSI + CHA	c	AT	AT	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY
Broadstrike + Dual	flumetsulam + metolachlor	ALSI CHA	c,s	18	9	4	26FB	4	12	26FB	26FB	26FB	26FB	26FB	26FB
Broadstrike + Treflan	flumetsulam + trifluralin	ALSI DNA	c	18	9	4	26FB	4	12	26FB	26FB	26FB	26FB	26FB	26FB
Canopy	chlorimuron + metribuzin	ALSI PSI	s	18	NY	12	12	12	30	10[f]	30	18	18	18	30
Canopy XL	chlorimuron + sulfentrazone	ALSI CBI	s	18	NY	12	30	30	30	12[f]	30	18	30	18	18/30[g]
Classic	chlorimuron	ALSI	s	18	NY	9	9	9	30	9[f]	30	18	18	18	18/30[g]
Command	clomazone	PBI	s	9	9	9	9	AT[h]	12	9[f]	AT	9	AY	9	12
Commence	clomazone + trifluralin	PBI DNA	s	9	9	9	NNY	9	9	9[f]	9	9	9	9	NNY
Concert SP	thifensulfuron + chlorimuron	ALSI	s	9FB	9FB	9	9FB	9FB	9FB	9[f]	9FB	9FB	9FB	9FB	9FB
Contour	imazethapyr	ALSI	c	18	18	9	40FB	9	26	40FB	40FB	40FB	40FB	40FB	40FB
Cover, others	sulfentrazone	CBI	s	18	NY	12	30	30	30	30	30	18	18	18	18/30
Detail	imazaquin + dimethenamid	ALSI CHA	s	18	18	11	18	18	18/26[i]	18/26	18	18	18	18	18/26
DoublePlay	EPTC + acetochlor	THC	c	NNY	AT	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY

Table 7. Rotation restrictions for common vegetable crops (cont.)

	Herbicide			Rotation restriction (months)[c]											
Trade name	Active ingredient	Site of action[a]	Crop use[b]	Sweet corn	Pop-corn	Dry beans	Snap beans	Peas	Potato	Tomato	Pepper	Cu-cum-bers	Pump-kins	Water-melon	Cole crops
Express	tribenuron	ALSI	w	2	2	2	2	2	2	2	2	2	2	2	2
Finesse	chlorsulfuron + metsulfuron	ALSI	w	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB
FirstRate	cloransulam	ALSI	s	30	9	9	30	9	30	30	30	30	30	30	30
FlexStar	fomesafen	CBI	s	10	10	10	10	10	18	18	18	18	18	18	18
Frontier	dimethenamid	CHA	c,s	AT	AT	AT	NY	NY	NY	NY	NY	NY	NY	NY	NY
Harmony Extra	thifensulfuron + tribenuron	ALSI	w	2	2	2	2	2	2	2	2	2	2	2	2
Harness	acetochlor	CHA	c	NY	AT	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY
Hornet	flumetsulam	ALSI	c	18	10.5	10.5	26FB	18	18	26FB	26FB	26FB	26FB	26FB	26FB
Lariat, Bullet	atrazine + alachlor	PSI CHA	c	AT	AT	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY
Liberty	glufosinolate	AASI	c,s	3	3	3	3	3	3	3	3	3	3	3	3
Lightning	imazethapyr + imazapyr	ALSI	c	18	18	9.5	40FB	9.5	26	40FB	40FB	40FB	40FB	40FB	40FB
Marksman	atrazine + dicamba	PSI GR	c	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY
Passport	imazethapyr trifluralin	ALSI DNA	s	18	18	AT	AT	AT	26	26	26	18	18	18	26
Permit	halosulfuron	ALSI	c	3	3	9	9	9	9	6[f]	10	9	9	36	11/18
Pinnacle	thifensulfuron	ALSI	s	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Pursuit	imazethapyr	ALSI	c,s	18[j]	18[j]	4	4	40FB	40FB	40FB	40FB	40FB	40FB	40FB	40FB
Pursuit Plus	imazethapyr pendimethalin	ALSI DNA	c,s	18	18	4	4	40FB	26	40FB	40FB	40FB	40FB	40FB	40FB
Python	flumetsulam	ALSI	c,s	18	9	4	26FB	4	12	26FB	26FB	26FB	26FB	26FB	26FB
Raptor	imazamox	ALSI	s	9	9	9	9	9	9	9	9	9	9	9	9/26FB[k]
Reflex	fomesafen	CBI	s	10	10	10	10	10	18	18	18	18	18	18	18
Reliance STS	thifensulfuron	ALSI	s	9/18[l]	9	9	9	9	30	9[f]	30	9	9	9	18/30[g]
Resolve	imazethapyr dicamba	ALSI GR	c	9/18	18	9.5	9.5	9.5	26	40FB	40FB	40FB	40FB	40FB	40FB
Scepter	imazaquin	ALSI	s	18	18	11	11	11	18/26[i]	18/26	18	18	18	18	18/26
Scorpion II	flumetsulam + clopyralid	ALSI GR	c	10.5	10.5	10.5	26FB	18	18	26FB	26FB	26FB	26FB	26FB	26FB

Table 7. Rotation restrictions for common vegetable crops (cont.)

	Herbicide			Rotation restriction (months)[c]											
Trade name	Active ingredient	Site of action[a]	Crop use[b]	Sweet corn	Pop-corn	Dry beans	Snap beans	Peas	Potato	Tomato	Pepper	Cu-cum-bers	Pump-kins	Water-melon	Cole crops
Shotgun	atrazine + 2,4D	PSI GR	c	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY
Squadron	imazaquin + pendimethalin	ALSI DNA	s	18	18	11	11	11	18/26i	18/26	18	18	18	18	18/26
Steel	imazaquin, imazethapyr, pendimethalin	ALSI ALSI DNA	s	18/26[i]	18/26	11	11	11	26	40FB	40FB	40FB	40FB	40FB	40FB
Stringer	clopyralid	GR	c,w	10.5	10.5	10.5	18	18	18	18	18	18	18	18	10.5
Surpass 100	acetolachlor + atrazine	CHA	c	NNY	AT	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY
Synchrony STS	chlorimuron	ALSI	s	18	9	9	9	9	30	9[f]	30	18	18	18	18/30[g]
TopNotch	acetolachlor	CHA	c	NNY	AT	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY
Touchdown	sulfonium	ALSI	c,s	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Tri-Scept	imazaquin + trifluralin	ALSI DNA	s	18	18	11	11	11	18/26[i]	18/26	18	18	18	18	18/26
Turbo	metolachlor + metribuzin	CHA	s	8	8	12	12	8	8	12	12	12	12	12	12

[a]Sites of action include: PSI = photosynthetic inhibitor; ALSI = ALS-inhibiting; CHA = chloroacetamide; THC = thiocarbamate; DNA = dinitroaniline; CBI = chlorophyll-biosynthesis inhibitor; PBI = pigment-biosynthesis inhibitor; AASI = amino acid–synthesis inhibitor; GR = growth regulator.
[b]Crops include: c = corn; s = soybean; w = wheat.
[c]Rotation restrictions include: AT = anytime; NNY = not next year; FB = field bioassay (the first number is the months that must pass before the bioassay); NY = next year.
[d]Except Merit, Carvinal, Sweet Success sweet corn cultivars, where the restriction is 15 months.
[e]The rotation restriction is 10 months at pH ≤ 6.5 and 18 months at pH > 6.5.
[f]Transplanted tomatoes only.
[g]Cabbage/other cole crops.
[h]If more than 1.33 pt/acre, then 9 months.
[i]Rotation restriction for southern or northern Illinois, respectively.
[j]Some sweet corn and popcorn varieties may be planted the year following an application of Pursuit.
[k]Cabbage and broccoli may be planted 9 months after Raptor applications. Other cole crops have a 26-month rotation restriction and require a field bioassay.
[l]9 months for processing sweet corn or 18 months for sweet corn.

(Table 7) and then successfully conduct a field bioassay before planting vegetable crops. Atrazine generally requires that you plant no other crops the year following an application.

Herbicide persistence is dependent on soil and environmental factors. Breakdown of herbicides in the soil occurs either by microbial degradation or chemical hydrolysis. Both factors require that the soil be moist and temperatures warm. Thus, cool temperatures and dry conditions slow herbicide degradation. Soil pH and organic matter are also important for herbicide degradation. For example, at pHs above 6.5, degradation of Accent is slowed considerably. Because these soil and environmental influences affect herbicide degradation and persistence, rotation restrictions should be used as minimum guidelines.

What is a field bioassay? A field bioassay is the planting of a test strip of the sensitive vegetable crop across the treated field and letting it grow to maturity. It is a way of determining if sufficient herbicide residual remains to injure a sensitive follow crop. Field bioassays should be conducted after you have waited the number of months prescribed by the herbicide label.

How do you conduct a bioassay? Generally, strips of a test crop are planted across a field. Several rows of the test crop should be planted in each strip, and several strips should be planted in the field. The test strips should be planted perpendicular to the direction the herbicide was originally applied. Test strips should include field margins and ends, low areas, knolls, and sections of the field varying in soil characteristics such as type, organic matter, and pH.

Avoid carryover because correcting carryover problems once they occur is virtually impossible. The best solution for avoiding herbicide carryover injury is selecting fields that have not had persistent herbicides. Fields that previously were in pasture, CRP land, or vegetables (besides sweet corn) are unlikely to have persistent herbicides. Many wheat herbicides have short persistence and do not injure following crops. If you must use fields that had corn or soybeans, choose those having Roundup Ready crops. Roundup tightly binds to the soil and does not injure rotational crops.

Herbicide Drift. Another frequent hazard to vegetable growers is crop injury from herbicide drift. The term *drift* refers to movement of herbicides off the site where they were applied. Drift can occur either during herbicide application (spray drift) or because the herbicide volatilizes after being applied to plants (vapor drift). Both types of drift can injure your vegetable crops. Vegetables are extremely sensitive to some herbicides, such as growth regulators. This extreme sensitivity means that very low concentrations of growth-regulator herbicides can drift and injure your crop.

What are growth-regulator herbicides? They are herbicides that mimic auxins. Auxins are natural chemicals that govern growth in plants. They regulate shoot and root response to gravity, shoot branching, leaf growth, and fruit development. Tolerant crops are able to degrade growth regulators into nonactive compounds, while most vegetables cannot metabolize these herbicides. Growth-regulator herbicides are inexpensive and widely applied to corn, soybeans, wheat, turf, and rights-of-way. In agricultural settings, growth-regulator herbicides are used before planting for burndown in no-till corn and soybeans, at planting in corn, and postemergence in both corn and wheat. Growth-regulator herbicides used in turf or by railroads, utilities, and townships on rights-of-way can also drift to injure vegetables. Growth-regulator herbicides can drift up to a mile and cause serious damage to grapes, tomatoes, peppers, other vegetables, fruit crops, and ornamental plants. Table 8 lists the trade names of some growth-regulator herbicides.

The most common growth-regulator herbicides are 2,4-D and dicamba. The ability of 2,4-D and dicamba to drift or volatilize depends on the formulation. The ester formulations of 2,4-D (that is, Barrage, Estron, and Salvo) are more likely to volatilize and drift than are amine formulations (that is, Formula 40, Amine 4, and Savage). Ester formulations of 2,4-D are widely used because they have cheaper cost, greater penetration, and better activity against weeds than other formulations. Dicamba formulations also differ in their volatility. The older Banvel formulation appears to volatilize more than the newer Clarity formulation of dicamba.

Are other herbicides besides growth regulators likely to injure vegetables? Generally, despite their reactions to growth regulators, vegetable crops are not extremely sensitive to other herbicides, compared to the reactions of other crops (Table 9).The other herbicides of concern are glyphosate and ALS inhibitors. Both groups of herbicides translocate to and kill growing points of plants. Glyphosate is the active ingredient in Roundup Ultra and similar products. Glyphosate inhibits synthesis of aromatic amino acids (that is, phenyl alanine and others). Roundup traditionally has been used as a nonselective herbicide for burndown prior to planting or after harvest. These application times were usually not a problem because most vegetables were not actively growing when glyphosate was applied. This situation has dramatically changed with the widespread use of Roundup-Ready corn and soybeans. Now, Roundup is often ap-

Table 8. Common and trade names of some herbicides that might injure vegetable crops (This list is not all inclusive. Other herbicides may also injure vegetables.)

Growth regulators			*Glyphosate*	*ALS inhibitors*	
2,4D	Dicamba	Others		Sulfonylurea	Imidazolinone
Amine 4	Banvel	Amitrole T	Accord	Accent	Assert
Barrage	Clarity	Rhomene	Bronco	Ally	Contour*
Brush-Rhap	Fallow Master*	Sword	Landmaster*	Basis	Lightning
Crossbow*	Marksman*	Telone C-17	Protocol	Basis Gold*	Pursuit
Esteron	OpTill*		Ranger	Beacon	Pursuit Plus
Formula 40	Resolve*		Rodeo	Canopy*	Raptor
Grazon*			Roundup Ultra	Classic	Resolve
Landmaster*				Concert*	Scepter
Phenoxy 088*				Escort	Squadron*
Salvo		*Pigment inhibitors*		Exceed	Steel*
Scorpion III*		Command		Express	Tri-Scept*
Shotgun*		Commence		Finesse*	
Tiller*				Glean	
Weedar				Harmony	
Weedmaster*				Matrix	
Weedone				Oust	
Weedone 638*				Permit	
2 Plus 2				Pinnacle	
				Synchrony*	

*A prepackaged mixture also containing other active ingredients.

plied when vege- tables are actively growing and fruiting. Vegetable crops are likely to be injured only by spray drift from nearby applications. The injury symptoms include chlorosis and death of growing points, misshapen growth, reduced survival, less fruiting, and lower fruit quality.

Herbicides containing clomazone (Command and Commence) can cause bleaching of nearby sensitive plants. This herbicide inhibits pigment synthesis in plants. Plants usually recover from the bleaching caused by clomazone. Often yields are not effected by the drift. Older formulations of Command were volatile and required incorporation soon after application. The current 3ME formulation of Command is less volatile and less likely to drift and injure susceptible plants.

Many vegetable crops are also sensitive to acetolactate synthase (ALS)–inhibiting herbicides. These herbicides are sulfonylureas (that is, Classic, Accent, and Permit) and imidazolinones (that is, Pursuit and Scepter). They inhibit the key enzyme (acetolactate synthase) that controls branch-chain amino acid synthesis. ALS inhibitors are widely used in corn, soybean, and wheat production. They are applied both before planting and postemergence at extremely low rates. The high biological activity of ALS-inhibiting herbicides increases the likelihood of drift. Injury symptoms from ALS-inhibiting herbicides are similar to those from glyphosate, except root injury is more likely. Generally, it is believed that vegetable-crop injury from ALS inhibitors is likely only from very nearby applications.

What can you do about herbicide drift? You must work to prevent drift because once vegetables are injured there is no cure. Do not cause a drift problem yourself. Work with your neighbors to minimize the potential for drift from nearby applications. Spray only on calm days, and use drift inhibitors when appropriate. Minimize drift by applying herbicides with nozzles that produce large droplets. Use less-volatile forms of herbicides, especially 2,4-D. Spray Command (clomazone), dicamba, and 2,4-D when the temperature is expected to be lower than 80°F for several days after treatment. Avoid applying Command or other volatile soil-applied herbicides to wet soils, and incorporate soon after application. Apply herbicides unlikely to injure your vegetables (Table 9). Use preemergent herbicides such as Lasso, Dual, Harness, Frontier, Treflan, and Prowl, which are effective only against emerging seedlings. Drift from photosynthetic inhibitors such as Attrex (atrazine), Lexone, and Lorox, along with contact herbicides such as Basagran, Blazer, Reflex, and Authority does not cause long-term damage to vegetables. These chemicals might cause leaf burn but will not translocate to growing points or fruit.

Table 9. Some herbicides that can be used on corn or soybeans and that are unlikely to drift and injure vegetables

Corn	Soybeans
Preemergence	
Atrazine	Broadstrike
Dual	Dual
Eradicane	Frontier
Frontier	Harness
Larness	Lasso
Lasso	Lexone/Sencor
	Prowl
	Treflan
Postemergence	
Atrazine	Basagran
Basagran	Blazer
Buctril	Poast
	Prism
	Reflex
	Select

Spray-Tank Residuals. Dicamba or 2,4-D residues in spray tanks also can injure susceptible vegetable crops. Carefully follow label directions for cleaning spray equipment after using dicamba or 2,4-D. If possible, do not use the same spray equipment to apply 2,4-D or dicamba that you use to apply other pesticides.

Herbicide Resistance. There are now more than 50 documented reports worldwide of weeds that have developed resistance to herbicides. Herbicide resistance tends to occur when a persistent herbicide is used year after year in the same field. Thus, continued use of the same herbicide on a perennial crop such as asparagus should be avoided. Many of the resistance problems have occurred with triazine herbicides, such as simazine and atrazine. The labels of those herbicides contain information about avoiding resistance problems.

Approaches to avoid herbicide resistance combine herbicides with mechanical (cultivation) and cultural (crop rotation) weed-management practices. Rotate between or use tank mixes of herbicides with different mechanisms of killing the plant. For example, in asparagus, rotate between Sencor and Treflan. Use tillage to control weeds that escape from herbicide applications. Especially important in minimizing any weed resistance that does occur is scouting your fields, paying special attention to any patches of a weed normally controlled by the herbicide.

Water Quality. Residues of some herbicides, such as atrazine, metolachlor, alachlor, cyanazine, and metribuzin, have been found in surface water or groundwater. The levels detected have normally been low, but contamination of water resources is a growing concern. For example, groundwater contamination from pesticides and nitrates is a particular concern in areas of the state with sandy soils and shallow groundwater.

Factors determining the potential for groundwater and surface-water contamination include herbicide solubility in water, rate of degradation, volatility, and tendency for the herbicide to attach to soil particles or organic matter. Herbicides that have high water solubility and long persistence are of particular concern.

Site characteristics (soil type, soil depth, water-table depth, slope, and weather) also can lead to contamination of water resources from herbicides. You should be aware of the potential problem of herbicide contamination and take all possible steps to avoid contaminating surface and subsurface water resources.

Disposing of Herbicides and Containers

Surplus Herbicides. If possible, use surplus herbicide mixtures by applying them to labeled crops that have the same weed problems. Never drain surplus pesticides in any location where they can contaminate groundwater or surface-water supplies. Avoid creating surplus tank mixes by accurately measuring the treatment area and mixing the correct amount of pesticide. If a large amount of surplus pesticide is generated, contact the Illinois EPA Division of Land Pollution Control for instructions about disposal.

Pesticide Containers. Rinse all empty containers, regardless of their type, three times before disposal. Dump rinse water into the tank. Puncture or break triple-rinsed containers to facilitate drainage and to prevent reuse for any purpose. Then dispose of containers according to label directions and local regulations, with regard for the protection of water resources.

Health Hazards

Health hazards from exposure to pesticides may be divided into acute and chronic effects, according to the duration and amount of exposure.

Acute Effects. Acute effects or poisoning occurs soon after exposure to large amounts of a pesticide.

Effects of this type are dangerous to you, your family, and your workers. The potential for human or animal poisoning from pesticides can be reduced by careful storage and handling. Keep pesticides in a separate area, room, or building used only for storage purposes. The storage area should be dry and ventilated. Keep all entrances to the area locked at all times to protect children, other people, and animals. **Caution**: Do not store herbicides together with insecticides or fungicides. Remove only the pesticide to be used in one day and, after use, return the pesticide to the storage area. Follow label directions when handling pesticides. Pay particular attention to sections on protective-clothing requirements and any field-reentry limitations.

Herbicide Residues in Vegetables

The issue of pesticide residues in vegetables is currently receiving intense public attention. Many of the herbicides used in vegetable crops are older products that were registered before current toxicological and environmental standards were established by the US EPA. Congress has required the US EPA to reregister these older products to bring the data up to current toxicological and environmental standards, causing some companies to remove products from the market.

Data exist that some herbicides (and other pesticides) potentially cause adverse health effects, such as cancer from chronic (long-term) exposure. There is controversy about the reliability and importance of these data. Groups that are particularly concerned about pesticide residues in vegetables include the National Resources Defense Council, National Coalition Against Misuse of Pesticides, and Americans for Safe Food. Because customers may question you, it is recommended that you stay up-to-date on this issue. The groups listed have information reflecting their views. Information reflecting food industry views is also available from groups such as the Alliance for Food and Fiber, the Food Marketing Institute, and the Center for Produce Quality.

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