



INDUSTRIAL WEED CONTROL



Category 7C

KANSAS STATE UNIVERSITY
COOPERATIVE
EXTENSION
SERVICE

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INTRODUCTION

Federal regulations establish general and specific standards that you must meet before you can use or supervise the use of certain pesticides. You have been supplied with other material which you may study to help you meet the *general standards*.

This guide contains basic information to help you meet the *specific standards* for applicators who are engaged in industrial weed control.

Industrial areas concern installations, storage areas and land for industry. A list would include:

- industrial sites
- utility transmission stations

- warehouses and buildings
- petroleum tank farms
- pumping installations
- storage and work areas
- airports
- lumberyards
- along fence lines

Plant growth in industrial areas must be controlled to make sure that the industrial area is safe, usable, attractive, as inexpensive as possible to maintain, and not harmful to the environment of the surrounding area.

VEGETATION MANAGEMENT

Weeds on industrial sites are not only a nuisance but also cause fire hazards, contribute to losses for stored equipment and materials, and reduce the efficiency of men and machines working in the area. Usually, the objective of a weed control program in industrial areas is to totally eliminate vegetation.

Total vegetation control can be accomplished by both mechanical and chemical methods. Mechanical methods include hand-pulling, hoeing, blading, grubbing, mowing and tillage operations. Brush and trees can be removed by mechanical methods but this method is considerably more expensive. Herbicide treatments may include repeated use of contact herbicides, periodic use of sys-

temic herbicides, or use of residual (short-or long-term) soil-applied herbicides.

Consider the effectiveness and effects on the environment of mechanical and/or chemical treatments for weed control. If chemical control is considered, select herbicides registered for use to control the herbaceous weeds and/or woody plants at the industrial site. Evaluate alternative herbicides on relevant factors, such as efficacy for herbaceous weeds and/or woody plants; length of persistence of residual herbicides; environmental hazards including possible effect to nearby desirable vegetation; possible movement by run-off or leaching of soil applied herbicides; and cost.

WEEDS AND WOODY PLANTS

Classification

Methods needed for control are determined by the weeds' life cycle, season of growth, and methods of reproduction. There are three principal groups: annuals, biennials, and perennials.

Annuals are plants that complete their life cycles in less than one year. They grow from seed, mature, and produce seed for the next generation in one year or less. Examples of annual broadleaf weeds are pigweed and lambsquarters. An annual grass is crabgrass.

Summer annuals are plants that result from seeds which sprout in the spring. They grow, mature, produce seed, and die before winter. Examples: pigweed, foxtail, and sandbur.

Winter annuals are plants that grow from seeds which sprout in the fall. They grow, mature, produce seed, and die before summer. Henbit is a winter annual.

Biennials are plants with a two-year life cycle. They grow from seed and develop a heavy root and compact cluster of leaves (rosette) the first year. In the second year they mature, produce seed, and die. Examples: common mullein and bull thistle.

Perennials are plants which live more than two years and may live indefinitely. During the winter many lose their foliage and the stems of others die back to the ground. Some grow from seed. Others produce tubers, bulbs, or rhizomes (below ground, modified stems). Examples: dandelion, curly dock, and johnsongrass.

Creeping perennials may reproduce by rhizomes or by other methods. They may also reproduce by seed. Examples: field bindweed, and johnsongrass.

Woody plants include shrubs and trees. Shrubs are regarded as woody plants that have several stems and are less than 10 feet tall. Trees usually have a single stem (trunk) and are over 10 feet tall. The term "brush" is often used to refer to undesirable woody vegetation and relates to both shrubs and trees (usually less than 10 feet tall).

Identification

Target weeds and woody plants must be properly identified so that appropriate control practices can be selected to control them. The following publications provide information on many herbaceous weeds and woody plants that infest industrial sites:

1. Stephens, H. A. 1969. *Trees, Shrubs, and Woody Vines in Kansas*. The University Press of Kansas, Lawrence. 250 pp.
2. *Weeds of the North Central States*. 1981. NCR-281. 303 pp. (for sale, \$3) Available from County Extension Offices in Kansas or from the Distribution Center, Umberger Hall, Kansas State University, Manhattan, Kansas 66506.

Vegetation in Industrial Areas

Troublesome herbaceous and woody plants that may infest industrial areas are as follows:

1. Annuals

Annual grasses include barnyard grass, cheat, crabgrass, downy brome, fall panicum, foxtail, goosegrass, sandbur, stinkgrass, and witchgrass.

Annual broadleaf weeds include bedstraw, black nightshade, buffalobur, carpetweed, chickweed, cocklebur, common mallow, common ragweed, field pennycress, henbit, knotweed, jimsonweed, kochia, lambsquarter, marestalk, morningglory, pigweed, prickly lettuce, puncturevine, purslane, Russian thistle, shepherdspurse, smartweed, annual sowthistle, spurge, sunflower, tansymustard, velvetleaf, venice mallow, and wild buckwheat.

2. Biennials

Biennial weeds include bull thistle, burdock, common mullein, musk thistle, and wild carrot.

3. Perennials

Perennials include aster, buckhorn plantain, Canada thistle, cattail, common yarrow, curly dock, dandelion, field bindweed, goldenrod, hemp dogbane, horsetail, ironweed, johnsongrass, milkweed, nutsedge, swamp smartweed, and water hemlock.

4. Woody Plants

Brush and woody plants include ash, blackberry, black locust, cedar, cottonwood, dogwood, elm, honeylocust, mulberry, multiflora rose, oak, poison ivy, poison oak, Russian olive, sand plum, sumac, trumpet-creeper, and willow.

HERBICIDES FOR INDUSTRIAL WEED CONTROL AND ENVIRONMENTAL HAZARDS

CLASSIFICATION OF HERBICIDES

Herbicides can be classified by how they affect plants. Most herbicides will have several different types of effects which determine when and how they can be used. The application should be in a uniform pattern at rates recommended on the label.

Selective Herbicides

Selective herbicides are chemicals that are more toxic to some plant species than to others. Plants must be correctly identified and the proper chemical applied at the right rate and time. Examples are atrazine, chlorsulfuron, 2,4-D, dicamba, picloram, and triclopyr.

Nonselective Herbicides

Nonselective herbicides are chemicals that are generally toxic to plants without regard to species. Toxicity may be a function of rate, method of application, and other factors. They may be used to provide bare ground areas to reduce fire or safety hazards, improve line-of-sight, protect structures from damage, eliminate breeding area for rodents and insects, and improve security. Examples are bromacil, diuron, and paraquat.

Wind, water, and soil erosion can cause herbicides to move sideways after application and before the chemical is fixed in the soil. Be careful to prevent surface movement which could cause damage to desirable plants in adjacent areas. Herbicides seldom move off target when applied to ballast and pavement cracks.

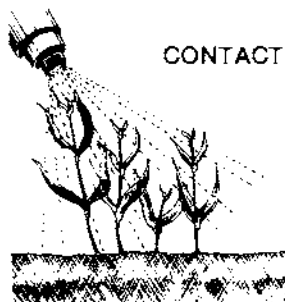
Nonselective herbicides or herbicides applied at nonselective rates usually should not be applied to slopes greater than 6:1, horizontal to vertical, without protecting the ground from erosion. Examples are amitrole, atrazine, cacodylic acid, diuron, glyphosate, imazapyr, prometon, sulfometuron, and tebuthiuron.

Contact Herbicides

Contact herbicides are chemicals that cause localized injury to plant tissues where contact occurs. They must be applied when the plants are leaved out and growing. Good coverage with the spray solution is necessary since only those areas covered are controlled. Most contact herbicides are nonselective. Examples are cacodylic acid, diquat, and paraquat.

Translocated Herbicides

Translocated herbicides are chemicals that are moved within the plant. Most are selective. Some are effective when applied to the plant foliage, while others are effective through root uptake from soil application. Length of control is determined by chemical used, rate applied, rainfall, and soil type. Examples are atrazine, bromacil, chlorsulfuron, 2,4-D, dicamba, glyphosate, picloram, and tebuthiuron.



CONTACT HERBICIDES

Spraying of visible plant foliage starts the action of a contact herbicide. A sprayer is usually used to apply herbicide after growth has started.



Herbicide is taken into the plant leaves where it interferes with growth. The plant begins to curl, wither, and then turn brown.



Weed growth above ground is eliminated. Some weeds will not come back. However, some weeds may regrow from roots. New weeds may grow from seeds in the soil.

TRANSLOCATED HERBICIDES



Apply to soil and young plants in early spring.



Rain washes herbicide into the soil. It dissolves and is absorbed by the plant.



Herbicide is translocated to growing points. Plant yellows and gradually dies.



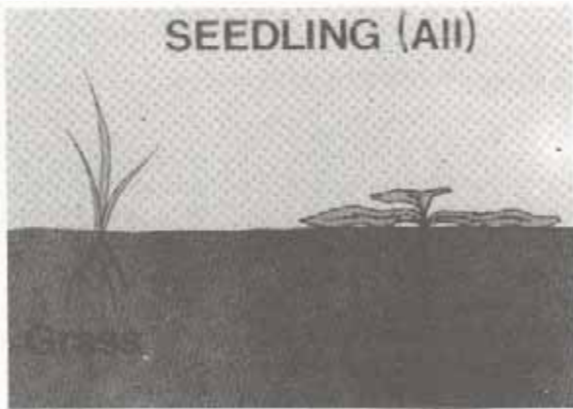
Plants die and ground may remain bare for a year or more.

FACTORS AFFECTING CONTROL

Grasses and broadleaf weeds go through four stages of growth: (1) seedling, (2) vegetative, (3) bud and flowering, and (4) maturity. Degree of control at any stage will vary according to the species of weed and the herbicide used.

Seedling

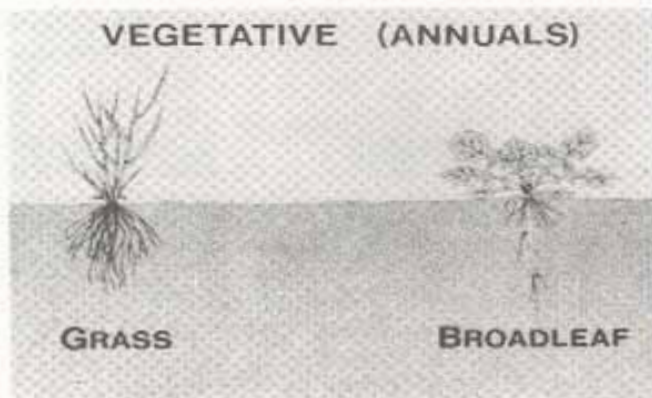
The seedling stage of growth is the same for annual, biennial, and perennial weeds. All start from seed. The weeds are small and tender, so less energy is required for control at this stage of growth than at any other stage. This is true whether mechanical or chemical control is used. Herbicides with foliar and/or soil activity are commonly used and usually effective at this stage.



ANNUALS AND BIENNIALS

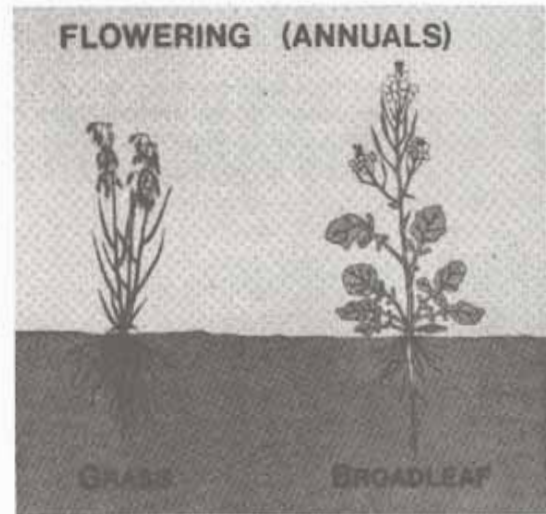
Vegetative

During the vegetative stage of growth, energy produced by the plant goes into the production of stems, leaves, and roots. Control at this stage is still possible but sometimes more difficult than at the seedling stage of growth. Cultivation, mowing, and postemergence herbicides are effective controls.



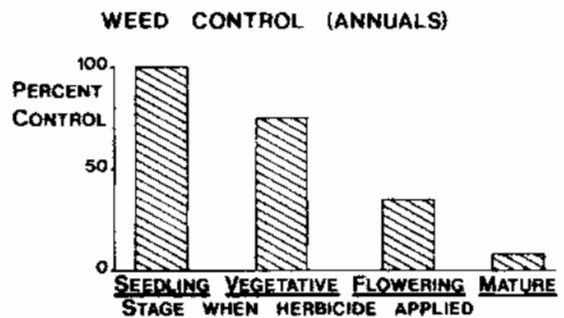
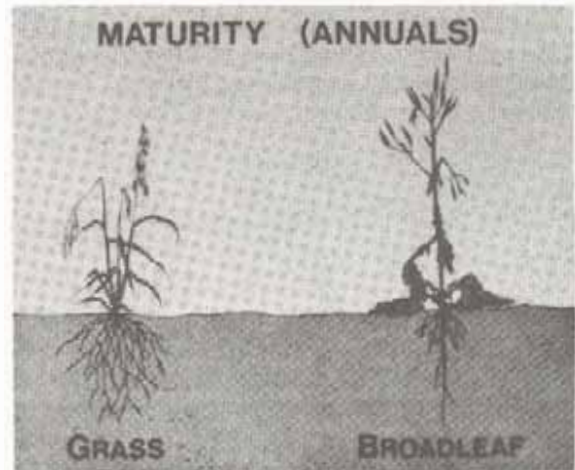
Bud and Flowering

When a plant changes from the vegetative to the flowering stage of growth, most of its energy goes into the production of seed. As plants reach this more mature stage, they are usually much harder to control by either mechanical or chemical methods.



Maturity

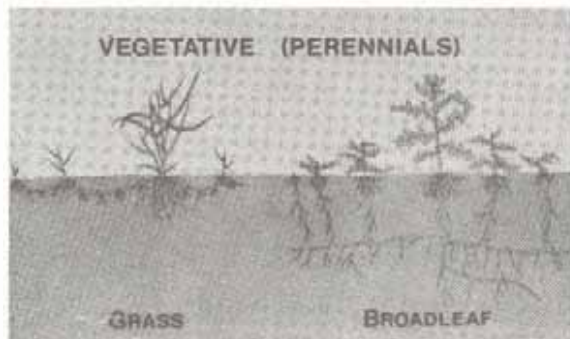
Maturity and seed set of annuals completes the life cycle. Since seed production has been accomplished, the population of the weed for subsequent years has been assured; chemical control at this point is of little value since the vegetative plants will soon die. Chemical control is usually not effective at this stage since there is little or no movement of materials in the plant. Once the seeds are mature, neither mechanical nor chemical controls can harm them.



PERENNIALS

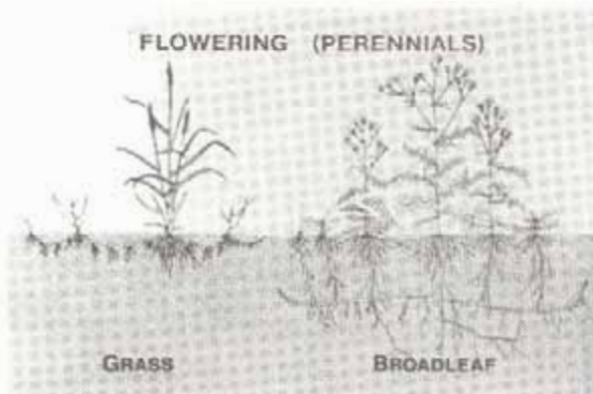
Vegetative

When the plant is small, part of the energy used to produce stems and leaves comes from energy stored in the underground roots and stems. As the plant grows, more energy is produced in the plant leaves. Some of this is moved to the underground parts for growth and storage. Because of the high translocation rate, herbicides provide good control at this stage.



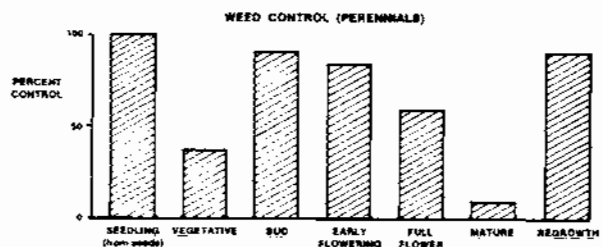
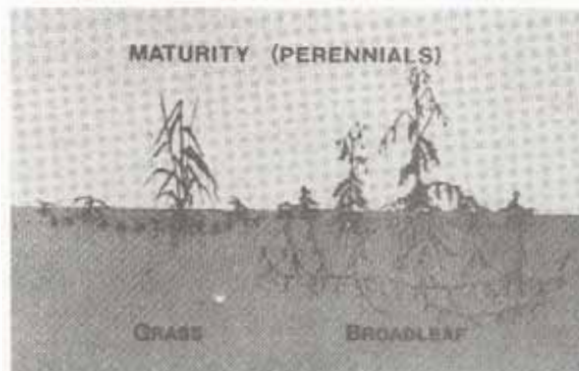
Bud and Flowering

At this stage the plant's energy goes into the production of flowers and seeds. Food storage in the roots begins during these stages and continues through maturity. Chemical control is more effective at the bud stage than at the flowering stage.



Maturity

Only the above-ground portions of these plants die each year. The underground roots and stems remain alive through the winter and send up new plant growth the next spring. Chemical control is usually ineffective at this stage.



WOODY PLANTS

Woody plants go through the same four growth stages as other perennial plants. They do not die back to the ground during the winter, but deciduous trees lose their foliage. Woody plants can be controlled with herbicides at any time, however control is best when the plants are small. Foliar treatments can be used at any time when the woody plants have actively growing leaves. They usually work best as the leaves reach full size.

STUDY QUESTIONS
**VEGETATION MANAGEMENT, WEEDS AND
WOODY PLANTS, HERBICIDES, ENVIRONMENTAL HAZARDS**

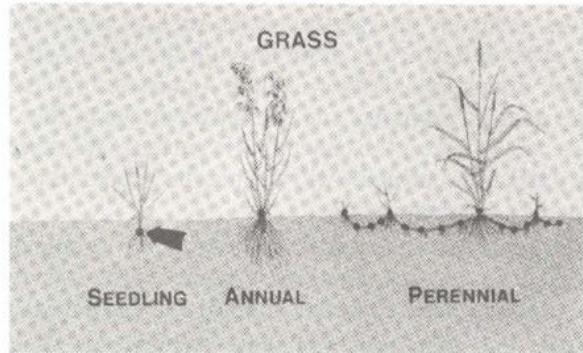
These study questions are to aid you in learning
the material on pages 1 through 5.

1. (1) Weeds are controlled on industrial sites because:
 - a. they are a nuisance
 - b. they cause fire hazards
 - c. they reduce efficiency of men and machines working in the area
 - d. all the above
2. (1) Factors to consider when selecting a herbicide include:
 - a. is the chemical registered on the weed or woody plant?
 - b. is the chemical registered on the site?
 - c. is the length of persistence acceptable when using a residual herbicide?
 - d. all the above
3. (2) An example of a winter annual weed is:
 - a. pigweed
 - b. henbit
 - c. sandbur
 - d. foxtail
4. (2) Shrubs are woody plants with several stems which are less than _____ feet tall.
 - a. 10
 - b. 15
 - c. 20
 - d. 25
5. (2) Bull thistle, burdock and wild carrot are all examples of _____ plants.
 - a. annual
 - b. biennial
 - c. triennial
 - d. perennial
6. (3) Picloram, dicamba and 2,4-D are examples of _____ herbicides.
 - a. selective
 - b. nonselective
 - c. contact
 - d. none of the above
7. (3) Diuron, imazapyr and prometon are examples of _____ herbicides.
 - a. selective
 - b. nonselective
 - c. contact
 - d. translocated
8. (4) The most susceptible growth stage for controlling weeds is the _____ stage.
 - a. seedling
 - b. vegetative
 - c. bud and flower
 - d. maturity
9. (4) Control of weeds in the vegetative growth stage can be controlled by:
 - a. cultivation
 - b. mowing
 - c. postemergence herbicides
 - d. all the above
10. (4) Chemical control of annual plants in the maturity stage is:
 - a. always very effective
 - b. of little value
 - c. the best stage to prevent seed production
 - d. always the least costly time
11. (5) Herbicides provide good control of perennial plants in the vegetative growth stage because:
 - a. there are lots of leaves
 - b. of the high translocation rate
 - c. of their bright green color
 - d. the plant stems are easily penetrated by the spray
12. (5) Chemical control of perennial plants in the maturity growth stage is usually:
 - a. aided by the natural die back
 - b. ineffective in this stage
 - c. best when it rains two hours after application
 - d. none of the above

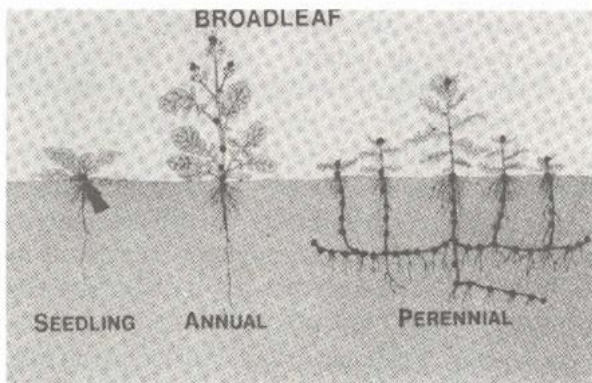
FACTORS AFFECTING FOLIAGE-APPLIED HERBICIDES

Location of Growth Points

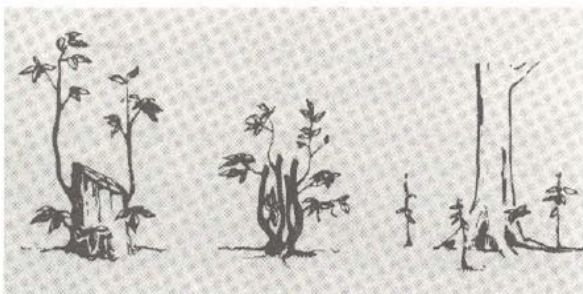
The growing point of a **seedling grass** is protected below the soil surface until seed stalks are produced. The plant will grow back if the herbicide or cultivation does not reach the growing point. Creeping perennial grasses have buds below the soil surface.



Seedling broadleaf weeds have an exposed growing point at the top of the young plant. They also have growing points in the leaf axils. Herbicides and cultivation can reach these points easily. The established perennial broadleaf plant is hard to control because of the many buds on the roots, stems, and crown.



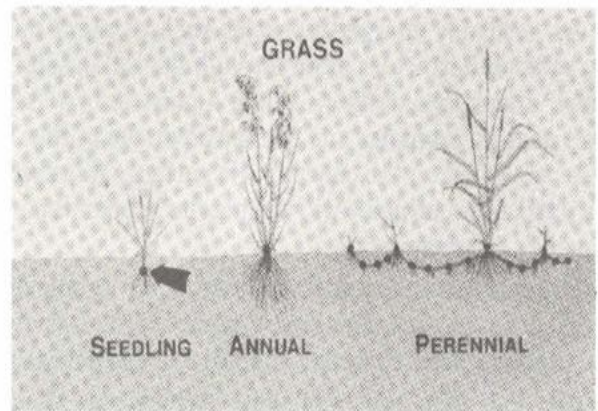
Many **woody plants**, either cut or uncut, will sprout from any point where buds are found. These include roots, collar (base of trunk), trunk or stem, and limbs.



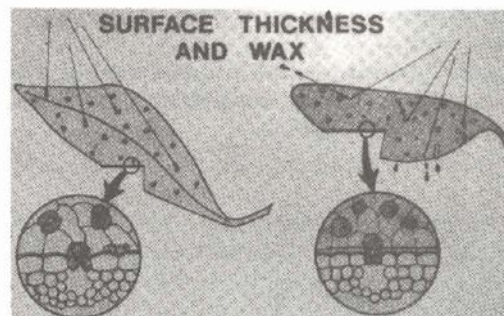
Physical Characteristics

Physical and species characteristics greatly affect the ability of herbicides to gain entrance in the weed. By considering each one, more effective control will be achieved.

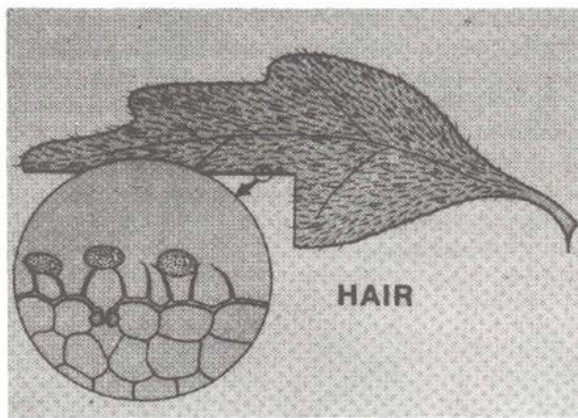
Leaf shape affects the amount of herbicide to be used. Herbicide sprays tend to bounce or run off plants with narrow vertical leaves. Broadleaf plants tend to hold the spray. If recommended on the label, add an adjuvant to increase spray retention.



Wax and cuticle formation affects the absorption of the chemical by the weed. To be effective, the herbicide must penetrate the leaf surface. A leaf with a thin cuticle allows the spray solution good contact with the leaf surface. On a leaf with a thick, waxy surface, the spray solution tends to stand in droplets. The wax and cuticle are thinner on young weeds. This is another reason for applying herbicides at the early growth stage.



Hairs on the leaf surface tend to keep the spray solution from entering. The droplets stand up on the hair and do not contact the leaf surface. Seedling weeds usually have fewer and shorter hairs, which is another reason for early control.



Environmental Factors

Temperature. Temperature determines the rate at which plants grow and are able to take up and translocate herbicides. At low temperatures, plants may not be active and will not take up the herbicides or they may be so inactive that the herbicide works very slowly. At very high temperatures, the herbicide may evaporate (volatilize).

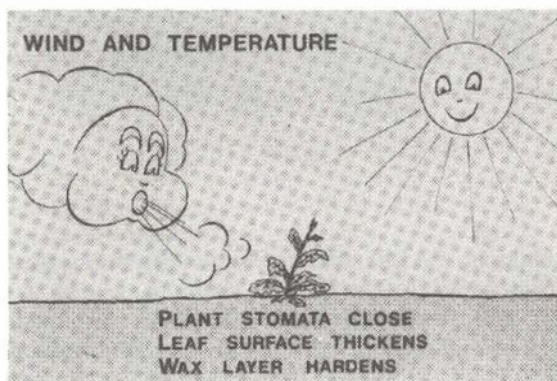
Humidity. A foliar-applied herbicide will enter the leaf more easily and rapidly at high humidity than at low humidity. At high humidity, the leaf is more tender and has a thinner layer of wax and cuticle.

Precipitation. If rainfall occurs soon after a foliar-applied herbicide treatment, it may decrease effectiveness. Rain increases soil moisture so soil-applied herbicides can be more readily absorbed by the weeds. But too much rain may move the herbicide too deep, past the zone where the weeds are. A hard rain may move surface-applied herbicides out of the target area. This is especially true if the soil surface is packed or sloping.

Wind and temperature. Wind and temperature can also affect the weed. A hot, dry wind will cause:

- the openings on the plant surface to close,
- the leaf surface to become thicker, and
- the wax layer to harden.

These factors make it harder for herbicides to penetrate the leaves and help explain why herbicides are often ineffective during hot dry periods.



FACTORS AFFECTING SOIL-APPLIED HERBICIDES

Soil Properties

Texture. Soil texture refers to the relative amounts of sand, silt, and clay particles in a particular soil. Soil particles have exchange sites which are negatively charged. Clay, the smallest particles, has the most exchange sites. Silt and sand have fewer exchange sites and are generally not considered as a factor.

As positively charged particles such as plant nutrients, salts, or herbicides move through the soil in solution (water), attractions develop. When a particle in solution passes near an exchange site, it may be drawn to that site and be adsorbed on the clay particle surface. Whether or not a particular herbicide will be adsorbed depends on the herbicide's characteristics.

Organic Matter. As with clay particles, organic matter has exchange sites. However, organic matter has many more exchange sites than the smallest clay particles have.

pH. The effectiveness of some herbicides is affected by pH. Certain pH ranges or extremes may reduce or enhance the effectiveness. When labels have cautions involving soil pH, observe them.

Soil moisture. To be taken up by plant roots soil-applied herbicides must be in moist soil. This requires water in the form of precipitation or irrigation.

Herbicide Characteristics

Soil particle adsorption. Herbicides are chemicals and have positive or neutral charges. Positive-charged particles can be attracted to negative-charged sites on soil particles. Whether or not they will be adsorbed on soil particles is determined by the size of the charge on both particles, the distance between the particles (amount of water in the soil), concentration of herbicide and other salts in the soil solution, and rate of movement of water through the soil. The unexchanged particles are moved down through the soil by a process known as leaching.

Persistence. Persistence of a herbicide in the soil depends on herbicide characteristics, rate of application, soil texture, organic matter, precipitation, temperature, and surface flow. Herbicides can:

- remain concentrated at the soil surface,
- partially leach (diluting effect), or
- move through the soil in a front, out of reach of plant roots above.

Herbicides for Weed Control in Various Situations

Rates of application for weed control are often given in minimum and maximum amounts, depending on the situation. The reason for the range in application rates is that control is influenced by differences in response to weed species, stage of growth when treatment is made, the period of residual toxicity desired, the amount and distri-

bution of rainfall, soil texture and organic matter, and other environmental conditions. Refer to Table 1, "Situations where Minimum and Maximum Rates of Herbicides Are Needed" for suggestions in selecting the proper rate for a specific situation.

Table 1. Situations where minimum and maximum rates of herbicides are needed

Minimum rates	Maximum rates
Herbaceous Plants	
Susceptible species	Tolerant species
Annuals	Perennials
Seedlings	Annuals and Biennials in flower
Perennials in bud	Established perennials —flower to maturity
Shallow-rooted	Deep-rooted
Residual Toxicity	
Short period	Several years
Arid regions	Humid regions
Soil Type	
Low in organic-matter content	High in organic-matter content
Low in clay content	High in clay content
Well drained	Poorly drained
Root-Absorbed Chemical	
Bare soil	Heavy plant residue

Table 2. Properties of important industrial herbicides regarding absorption, translocation, selectivity, and soil persistence.

Common name (Trade name)	Absorption		Translocation Characteristics		Selectivity		Soil persistence at recommended rates
	Foliage	Roots	Contact	Systemic	Selective	Nonselective	
Amitrole (several)	X			X		X	About 2 to 4 wks
Atrazine (several)	X	X		X	X	high rates	About 1 yr or more
Bromacil (Hyvar XL)	some	X		X		X	Usually for more than 1 season
Bromoxynil (Buctril)	X		X		X		No soil residue
Cacodylic Acid (several)	X		X			X	Nonpersistent
Chlorsulfuron (Telar)	X	X		X	X		Half life, 4 to 6 weeks
2, 4-D (numerous)	X	X		X	X		1 to 4 weeks
Dicamba (Banvel)	X	X		X	X		May persist more than 1 year at higher rates

Table 2 continued

Common name (Trade name)	Absorption		Translocation Characteristics		Selectivity		Soil persistence at recommended rates
	Foliage	Roots	Contact	Systemic	Selective	Nonselective	
Dichlobenil (Casoron, Norosac)		X		X	X		2 months to 1 year
Diquat (Diquat)	X		X		X		Persistent but biologically unavailable
Diuron (several)	some	X		X		X	May persist more than 1 year at higher rates
DSMA (several)	X			X	X		Inactivated in soil
Fosamine (Krenite)	X			X	X		Broken down quickly by soil
Glyphosate (Roundup, Rodeo)	X			X		X	Relatively nonpersistent
Hexazinone (Velpar)	X	X		X		X	Half life, 1 to 6 months
Imazapyr (Arsenal)	X	X		X		X	3 months to 1 year
Metsulfuron methyl (Escort)	X	X		X	X		2 to 4 weeks
MSMA (several)	X			X	X		Inactivated in soil
Paraquat (Gramoxone Super)	X		X			X	Persistent but biologically unavailable
Picloram (Tordon)	X	X		X	X		Persistent, but varies with rate, soils, and climate
Prometon (Pramitol)	X	X		X		X	May persist for several years
Simazine (several)		X		X		X	May persist for more than 1 year at higher rates
Sulfometuron (Oust)	X	X		X		X	Half-life, about 4 weeks
Tebuthiuron (Spike)	some	X		X		X	Half-life, more than 12 to 15 months
Triclopyr (Garlon)	X	X		X	X		Half-life, about 46 days

Table 3. Names, toxicities, and persistence of herbicides in or on soils.

Common name	Trade name	Acute oral toxicity LD ₅₀ mg/kg ¹	Dermal toxicity ¹	Persistence in or on soils ²
Amitrole	Several	24,600	Mildly irritating	2 to 4 weeks
Atrazine	AAtrex, Atrazine, Atratol	5,100	Mildly irritating	About 1 year or more
Boron compounds	Numerous	2,000–5,560	Moderately irritating	1 or more years
Bromacil	Hyvar, Krovar	5,200	Irritating	More than 1 season
Cacodylic acid	Phytar	830	Mildly irritating	Nonpersistent
Chlorsulfuron	Telar	5,545	LD ₅₀ more than 3,400 mg/kg	Half life, 4 to 6 weeks
Dicamba	Banvel	2,900	Mildly irritating	3 to 12 weeks
Dichlobenil	Casoran, Norosac	3,160	LD ₅₀ 1,350 mg/kg	2 months to 1 year
Diquat	Diquat	230	LD ₅₀ more than 40mg/kg	Persistent but biologically unavailable
Diuron	Karmex, Krovar	3,400	Mildly irritating	About 1 season or more
DSMA	Several	3,630	Mildly irritating	Nonpersistent
Fosamine	Krenite	24,400	Nonirritating	Nonpersistent
Glyphosate	Roundup, Rodeo	5,600	Nonirritating	Nonpersistent
Hexazinone	Velpar	1,690	LD ₅₀ more than 5,278 mg/kg	Half life, 1 to 6 months
Imazapyr	Arsenal	Above 5,000	LD ₅₀ more than 2,148 mg/kg	3 to 12 months
Metsulfuron methyl	Escort	Above 5,000	LD ₅₀ more than 5,000 mg/kg	2 to 4 weeks
MSMA	Several	Above 1,585	Mildly irritating	Nonpersistent
Paraquat	Gramoxone Super	120	LD ₅₀ more than 480 mg/kg	Persistent but biologically unavailable
Picloram	Tordon	8,200	Mildly irritating	Persistent, but varies with rate, soils, climate
Prometon	Pramitol	2,276	LD ₅₀ 2,000–2,500 mg/kg	Several years
Simazine	Princep	Above 5,000	Mildly irritating	About 1 year or more
Sodium chlorate		5,000	Irritating	
Sulfometuron	Oust	Above 5,000	Milding irritating	Half life, about 4 to 6 weeks
Tebuthiuron	Spike	644	Nonirritating	Half life, more than 12 to 15 months
Triclopyr	Garlon	2,140	Nonirritating	Half life, 46 days
2,4-D	—	300–1,000	Irritating	1 to 4 weeks

¹LD₅₀ is a statistical estimate of the dosage necessary to kill 50 percent of a large population of laboratory animals under stated conditions. The lower the LD₅₀, the more toxic the chemical. The acute oral toxicities for several substances to rats (approximate LD₅₀, mg/kg of body weight) are caffeine, 200; aspirin, 1,000; and table salt, 3,000. Dermal toxicity refers to poison absorbed through the skin to produce toxic symptoms. The following are classifications of relative toxicity.

Degree of toxicity	Acute oral LD ₅₀ ,mg/kg	Probably lethal dose for 150-pound person	Signal word on container
Extremely toxic	50 and below	Few drops to 1 teaspoon	Danger, poison
Very toxic	50 to 500	1 teaspoon to 1 ounce	Warning
Moderately toxic	500 to 5,000	1 ounce to 1 pint or 1 pound	Caution
Slightly toxic	above 5,000	Over 1 pint or 1 pound	Caution

²Average persistence at recommended rates.

STUDY QUESTIONS
**FACTORS AFFECTING FOLIAGE—
APPLIED AND SOIL-APPLIED HERBICIDES**

These study questions are to aid you in learning
the material on pages 7 through 11.

1. (7) In the case of seedling broadleaf weeds, growing points are located:
 - a. at the top of the plants
 - b. in the leaf axials
 - c. a and b
 - d. none of the above
2. (7) Plant physical characteristics important in herbicide application include:
 - a. leaf shape
 - b. wax and cuticle thickness
 - c. hairs on the leaf surface
 - d. all the above
3. (8) Environmental factors which are important in herbicide application include:
 - a. temperature and humidity
 - b. humidity and precipitation
 - c. temperature and precipitation
 - d. all the above
4. (8) Soil properties important to herbicide applications to the soil include:
 - a. texture and organic matter
 - b. pH and moisture
 - c. a and b above
 - d. none of the above
5. (8) Persistence of a herbicide in the soil depends on:
 - a. rate of application and soil texture
 - b. organic matter and precipitation
 - c. temperature and surface flow
 - d. all the above
6. (8) A reason for giving a max./min. range for a herbicide application rate is that control is influenced by:
 - a. weed species and growth stage
 - b. amount and distribution of rain fall
 - c. soil texture and organic matter
 - d. all the above

HERBICIDES FOR INDUSTRIAL WEED CONTROL

Amitrole

■ **Products and Manufacturers:** Restricted Use Pesticides, Amitrol-T and Amizol—Rhone Poulenc.

■ **Herbicide Use Information:** For control of annual grasses, annual and perennial broadleaf weeds, suppression of certain perennial grasses, and control of certain woody vines. Apply to herbaceous weeds when they are actively growing but before they reach size limits listed on label. Apply to foliage of woody plants from time foliage is fully developed until plants begin to go dormant. Amitrole inhibits chlorophyll formation and bud regrowth.

Do not allow spray drift on desirable plants. Do not apply directly to water or wetlands. Do not contaminate water.

Atrazine

■ **Products and Manufacturers:** AAtrex and Atrazol 90—Ciba-Geigy, and Atrazine—Drexel and DuPont.

■ **Herbicide Use Information:** For long-term weed control of annual and perennial broadleaf and grass weeds on industrial sites and in noncrop areas. Apply before or soon after weeds begin growth. Make postemergence applications when weeds are young and growing actively. Atrazine inhibits chlorophyll formation.

Do not apply to sand and loamy sand where water table is close to the surface. Do not apply directly to water or wetlands. Do not contaminate water.

Bromacil

■ **Product and Manufacturer:** Hyvar X, Hyvar X-L, Krovar I DF—DuPont.

■ **Hyvar X-L Use Information:** For control of brush, and many annual and perennial weeds on noncropland such as industrial plant sites. Apply before or during the period of active growth of plants to be controlled when rainfall can be expected for soil activation. For brush control, apply as a broadcast or basal (soil) treatment. Bromacil inhibits photosynthesis.

Do not apply on or near desirable trees or other plants or on areas where their roots may extend. Do not contaminate domestic waters.

Bromoxynil

■ **Product and Manufacturer:** Bucril—Rhone Poulenc.

■ **Bucril Use Information:** For control of susceptible broadleaf weeds on industrial sites and in noncrop areas. Apply when weeds are small and actively growing but before weeds reach size limits listed on label. Bucril is a contact herbicide, therefore thorough coverage of weeds is important for optimum control. Bromoxynil inhibits photosynthesis.

This pesticide is toxic to wildlife and fish. Do not apply directly to water. Do not contaminate water.

Cacodylic Acid

■ **Product and Manufacturer:** Phytar 560—InterAg.

■ **Phytar Use Information:** For general weed control around buildings and on other noncrop areas. Apply to unwanted vegetation to just short of run-off. If regrowth occurs, re-apply as required. Phytar 560 produces top-kill only, therefore, repeat applications are required for season-long weed control of perennials.

Do not apply directly to water. Do not contaminate water. Do not apply when weather conditions favor drift.

Chlorosulfuron

■ **Product and Manufacturer:** Telar—DuPont.

■ **Telar Use Information:** For selective or non-selective control of many annual and perennial broadleaf weeds in plant sites, storage areas, and other noncropland areas. Apply preemergence or postemergence to weeds, but for best results, apply postemergence to young, actively growing weeds at any time of the year except when ground is frozen. Chlorosulfuron rapidly inhibits growth in tips of both roots and shoots of susceptible plants. Do not apply on or near desirable trees or other plants, or on areas where their roots may extend.

Do not apply where run-off water may flow onto agricultural land as injury to crops may result. Do not contaminate any body of water.

2,4-D

■ **Products and Manufacturers:** Numerous—Farmland, PBI/Gordon, Rhone Poulenc, and Uniroyal.

■ **2,4-D Use Information:** For control of broad-leaved weeds and certain woody plants in industrial sites and similar noncrop areas. Best results are obtained when product is applied to young, succulent weeds that are actively growing. For perennial weeds and conditions such as the very dry area of the western states, where control is difficult, the higher recommended rates should be used. Some plants and weeds, especially woody varieties, are difficult to control and may require repeat applications. 2,4-D causes abnormal growth response, affects respirations, food reserves, and cell division.

Do not apply directly to water except as specified on some labels for aquatic weed control. Do not contaminate water. Do not apply when weather conditions indicate drift from target area.

Herbicides for Industrial Weed Control, continued

Dicamba

- **Product and Manufacturer:** Banvel—Sandoz, and Trooper—Monsanto.
- **Banvel Use Information:** For control of annual, biennial, and many woody brush and vine species in non-cropland areas. Banvel should be applied at the rate for weed stage and type as shown on the product label. Retreatments may be made as needed. Banvel may be applied as a cut surface, frill or girdle, stump, or Lo-Oil basal bark treatment for control of unwanted trees. Dicamba is readily absorbed through both roots and leaves and translocated in the xylem and phloem by most plants.

Keep out of lakes, streams, or ponds. Do not contaminate water. Banvel herbicide may cause injury to desirable trees and plants. Avoid making applications when spray particles may be carried by air currents to areas where sensitive crops and plants are growing. Do not apply Banvel in vicinity of sensitive plants when temperature is expected to exceed 85°F. Temperature above 85°F can cause Banvel to volatilize and may result in significant damage to off-target vegetation.

Dichlobenil

- **Products and Manufacturers:** Carson 10G—Uniroyal, and Norosac 10G—PBI/Gordon.
- **10G Use Information:** For nonselective control of annual and perennial broadleaf and grass weeds in industrial and noncrop areas. For annual weed control, application should be made prior to germination or when new plants are very small. For perennial weeds, make application during coldest weather when plants are fully dormant, or in the winter rosette stage. In areas of limited rainfall apply just prior to or during rainy season. Apply only to areas where complete plant control is desired. Dichlobenil acts primarily on growing points and root tips.

Do not apply to any body of water except as specified on the label. Do not contaminate water.

Diquat

- **Product and Manufacturer:** Diquat—Chevron.
- **Diquat Use Information:** For control of undesirable above-ground grass and broadleaf weed growth in industrial areas. Apply for full coverage and thorough weed contact. Apply to young weeds since control decreases as weeds mature. Re-treatment may be necessary to control grasses and established weeds.

Avoid spray contact with foliage of food crops or ornamental plants. Do not apply directly to water except as specified on the label.

Diuron

- **Products and Manufacturer:** Diuron—Drexel, and Karmex DF, Krovar I Df—DuPont.
- **Herbicide Use Information:** For control of many annual and perennial grasses and herbaceous weeds on industrial plant sites and other noncropland areas. The product may be used preemergence at any time of the year except when the ground is frozen, provided adequate moisture is available to activate the herbicide. Best results are obtained if application is made to the soil shortly before weed growth begins. If dense growth is present, remove tops and spray the ground. Retreatment may be necessary for longer control or when hard-to-kill, deep-rooted perennial weeds are present. Diuron inhibits photosynthesis in susceptible plants.

Do not apply on or near desirable trees or other plants, or on areas where their roots may extend. Do not apply directly to water. Do not contaminate any body of water.

DSMA

- **Products and Manufacturer:** DSMA—Drexel.
- **DSMA Use Information:** For selective post-emergence weed control, particularly for grassy weeds. Spray unwanted vegetation thoroughly to just short of run-off. If regrowth occurs, re-apply as required.

Do not apply directly to any body of water. Do not contaminate water. Do not apply when weather conditions favor drift from areas treated.

Fosamine

- **Product and Manufacturer:** Krenite S—DuPont.
- **Krenite Use Information:** For use as a foliar spray for control and/or growth suppression of many woody species on industrial plant sites and other noncropland areas. For woody plant control, make a single foliar application of the recommended rate of Krenite during the period from July to first fall coloration. When applied before fall coloration, fosamine inhibits bud development the following spring.

Do not contaminate water. Do not apply directly to water. Do not allow drift or spray mist to contact desirable trees, shrubs, or other plants, as injury may result.

Herbicides for Industrial Weed Control, continued

Glyphosate

- **Product and Manufacturer:** Roundup and Rodeo (for aquatic weeds)—Monsanto.
- **Herbicide Use Information:** For use as a foliar spray for control or destruction of most herbaceous plants in industrial plant sites and other noncrop areas. Unless otherwise indicated, delay application until vegetation has emerged and reached the stages described for control of such vegetation on the label. Use the higher rate of the product per acre within the recommended range when (1) weed growth is heavy or dense, or (2) weeds are growing in a noncultivated area. Best control of most perennial weeds is obtained when treatment is made at late-growth stages approaching maturity. Glyphosate inhibits growth and causes chlorosis and desiccation.

Do not contaminate water. Do not allow the herbicide solution to mist, drip, drift, or splash onto desirable vegetation since minute quantities of this herbicide can cause severe damage or destruction to the crop or desirable plants.

Hexazinone

- **Product and Manufacturer:** Velpar L—DuPont.
- **Velpor L Use Information:** For use as a foliar spray for nonselective weed and brush control on industrial plant sites and other non cropland areas. For broadcast treatments, apply as a spray just before or soon after weed emergence. Do not apply to frozen or snow-covered soil. For brush control, apply to soil between late winter and early summer. In areas where the soil normally remains frozen during the winter and spring rains are usually inadequate for soil activation, a fall or winter treatment may be applied before the soil freezes.

Keep out of any body of water. Do not apply where run-off is likely to occur. Do not contaminate water.

Imazapyr

- **Product and Manufacturer:** Arsenal—Cyanamid
- **Arsenal Use Information:** For use as a foliage spray for control of most annual and perennial grasses and broadleaf weeds on utility plant sites and other noncropland areas. For best results, uniformly cover the foliage of the vegetation to be controlled with the spray solution. Do not over-apply and cause run-off from the treated foliage. Imazapyr causes cessation of growth followed by death of meristemic regions.

Do not apply directly to any body of water. Do not contaminate water. To minimize drift, select proper nozzles to avoid spraying a fine mist and do not spray under windy or gusty conditions.

Metsulfuron methyl

- **Product and Manufacturer:** Escort—DuPont.
- **Escort Use Information:** For use as a foliar spray for control of unwanted woody plants and annual and perennial broadleaf weeds on plant sites and other noncrop areas. For general brush control, apply from the period after brush has reached the one-half leaf stage until the beginning of fall leaf coloration. Spray until run-off for thorough coverage. For nonselective control of the indicated broadleaf weeds and vines, apply Escort any time, except when the ground is frozen. Metsulfuron rapidly stops growth of susceptible species.

Keep out of any body of water. Do not contaminate water. Do not apply on or near desirable trees or other plants, or on areas where their roots may extend.

MSMA

- **Product and Manufacturer:** MSMA—Drexel and InterAg.
- **MSMA Use Information:** For selective postemergent weed control, particularly for grassy weeds in noncrop areas. Apply when weeds are small and conditions are favorable for good weed growth. Spray unwanted vegetation thoroughly. If regrowth occurs, re-apply as required.

Do not apply directly to water. Do not contaminate water. Do not apply when weather conditions favor drift from areas treated.

Paraquat

- **Product and Manufacturer:** Gramoxone Super—ICI.
- **Gramoxone Super Use Information:** Restricted Use Pesticide. For killing emerged annual broadleaf weeds and grasses and for top kill and suppression of perennials in noncrop areas. Apply for full coverage and thorough weed control. Best results are obtained when applications are made to young succulent weeds and grasses. Mature woody weeds are less susceptible. Repeat as needed.

This product is toxic to wildlife. Birds and other wildlife in treated areas may be killed. Do not apply directly to water or wetlands. Do not contaminate water. Gramoxone Super is a contact herbicide that kills all green plant tissue. Do not apply when weather conditions favor drift from areas treated.

Herbicides for Industrial Weed Control, continued

Picloram

■ **Product and Manufacturer:** Tordon K and Tordon 101—Dow.

■ **Tordon Use Information:** Restricted Use Pesticides. For use as a foliar spray for control of susceptible annual and perennial broadleaf weeds, woody plants on industrial sites and other noncrop areas. Apply after the foliage is well developed and in the manner to give thorough spray coverage. Products can be applied by several types of treatments, including high volume leaf-stem, spot treatment, broadcast ground, and woody plant control.

Do not apply directly to any body of water. Do not contaminate water. Do not permit Tordon sprays to contact crops or other desirable broadleaf plants. Avoid injurious spray drift. Very small quantities of spray may seriously injure susceptible plants.

Prometon

■ **Product and Manufacturer:** Pramitol 25E and Pramitol 5PS—Ciba-Geigy.

■ **Pramitol Use Information:** Nonselective herbicides for complete control of all vegetation in industrial sites and similar areas. For best results apply Pramitol 25E prior to weed emergence or when weeds are young and actively growing. Pramitol 5PS can be applied before or after plant growth begins. Since Pramitol enters the plants through the roots, its effectiveness is dependent on rainfall to move the chemical into the root zone. Prometon inhibits photosynthesis.

Do not apply directly to water or wetlands. Do not contaminate water. Users of Pramitol 5PS are advised not to apply the product where the water table is close to the surface and where soils are very permeable.

Simazine

■ **Product and Manufacturer:** Princep—Ciba-Geigy, and Simazine—Drexel.

■ **Herbicide Use Information:** For nonselective control of annual and perennial broadleaf and grass weeds. Simazine can provide long-term weed control on industrial sites and other noncrop areas. Best results are obtained when application is made before weeds emerge. Simazine inhibits photosynthesis.

Do not apply directly to water or wetlands. Do not contaminate water. Users of these products are advised not to apply Simazine where the water table is close to the surface and where the soils are very permeable.

Sulfometuron

■ **Product and Manufacturer:** Oust—DuPont.

■ **Oust Use Information:** For control of many annual and perennial grasses and broadleaf weeds on plant sites and other noncrop areas. Oust may be applied pre-emergence or postemergence to the weeds; best results are obtained if application is made before or during early stages of weed growth. If adequate moisture is available for herbicide activation, the product may be applied at any time of the year except when ground is frozen. Sulfometuron stops plant growth by arresting cell division in the growing tips of roots and plants.

Do not apply directly to wetlands or any body of water. Do not contaminate water. Do not apply on or near desirable trees or other plants, or on areas where their roots may extend. Prevent drift of spray to desirable plants.

Tebuthiuron

■ **Product and Manufacturer:** Spike—Elanco.

■ **Spike Use Information:** For total control of vegetation around industrial buildings and other noncropland areas. Apply Spike before or during the period of active growth of plants to be controlled. For woody plant control, apply the product to the soil where it is absorbed by the roots of plants. Effects are slow to appear and will not become apparent until sufficient moisture has carried Spike into the root zone. Spike can be applied anytime except when the ground is frozen or the soil is saturated with moisture. Tebuthiuron appears to inhibit photosynthesis.

Do not contaminate any body of water. Do not apply on any area into which the roots of field crops or other desirable vegetation may extend. Avoid nontarget drift or product movement.

Triclopyr

■ **Product and Manufacturer:** Garlon—Dow.

■ **Garlon Use Information:** For control of woody plants and broadleaf weeds on industrial sites and other noncrop areas. For best results foliar applications should be made when woody plants and weeds are actively growing. Use the higher dosage rates when brush approaches an average of 15 feet in height or when brush covers more than 60 percent of area to be treated. Garlon may be applied by several types of treatments, including high volume leaf-stem and broadcast applications with ground equipment.

Keep out of lakes, streams, or ponds. Do not contaminate water. Avoid injurious spray drift.

PROPER USE OF HERBICIDES

All herbicides used for industrial weed control should be applied in accordance with the directions on the manufacturer's label, as registered under the Federal Insecticide, Fungicide and Rodenticide Act. Most herbicides have low acute oral and dermal toxicities but a few industrial herbicides are toxic to human beings as shown in Table 3. Paraquat is toxic to wildlife. Birds and other wildlife in treated areas may be killed.

Proper use of herbicides will result in the most effective control of undesirable vegetation on industrial sites with little or no effect on non-target organisms. Follow these rules:

Selection. Select the appropriate herbicides to control identified target weeds and/or woody plants.

Label. Apply the herbicide(s) in accordance with all directions, warnings, and precautions on the label.

Registered Uses. Do not use a herbicide unless directions for applying it to the industrial site are given on the label.

Application Rates. Do not exceed the rate specified on the label. Use only the rate recommended for the soil type. Apply foliage herbicides only at the recommended stage of weed and/or woody plant growth.

Storage. Store excess pesticides under lock and key—out of reach of unauthorized personnel—and away from food or feed.

Disposal. Properly dispose of empty pesticide containers.

ENVIRONMENTAL HAZARDS

Hazards to the atmosphere, soil, or water in the environment from herbicides occur as a result of misapplication and misuse of these chemicals. Herbicides and other pesticides are constantly being re-evaluated regarding the benefits and risks from their use. Availability of needed herbicides in the future will be determined by how they are used or misused today.

Damage from herbicides as a result of misapplication is due either to (1) lack of understanding of how to safely and effectively apply herbicides, or (2) lack of concern or disregard for other private or public property.

To help avoid more restrictive regulations in the use of herbicides, apply and use each herbicide according to all directions, warnings, and precautions on the herbicide label; and encourage other users to do the same.

Controlling Drift and Volatility

Drift is the airborne movement of spray, granule or dust particles to places other than the target area. Carefully select the appropriate equipment, operation parameters, drift control additives (polymers) and gallonage rate to deliver the pesticide directly to the site of the pest being controlled, with a minimum of risk to non-target areas.

Gardens, desirable trees, other plants and crops are needlessly damaged each year as a result of drift and/or fumes from improper application of foliage-applied herbicides. Foliage-applied herbicides that have damaged desirable plants included dicamba (Banvel) and phenoxy herbicides such as 2,4-D. Other herbicides such as atrazine have also damaged desirable plants as a result of improper application.

To reduce drift and fumes from volatile herbicides:

- **Apply chemicals when wind is calm** or when a light breeze is blowing away from non-target plants. **Spray drift from 2,4-D can injure susceptible plants further than 6 or 7 miles away.**
- **Use low pressure** (20 to 30 pounds per square inch) or pressure as designated on the label.
- **Apply the herbicide in the amount of carrier as designated on the label.**
- **Apply herbicide spray as close to target plants as possible.**
- **Use drift control agents—if necessary—to avoid hazard of damage to nearby plants.**
- **Phenoxy Herbicides:** Use amine salt formulation if possible and if temperatures are expected to exceed 80° F. If ester formulations must be used, apply low-volatile ester formulations when air temperatures are expected to be below 85° F for several hours. High volatile ester formulations of 2,4-D release vapors or fumes rapidly at about 80° F; low volatile ester formulations at about 90° F.
- **Other herbicides: Do not allow spray mist to drift** since even minute quantities of spray of some herbicides such as Banvel (dicamba), Roundup (glyphosate), and Tordon (picloram) can cause severe damage or destruction to nearby desirable plants. Do not apply Banvel in vicinity of sensitive plants when the temperature is expected to exceed 85° F.

Herbicide Movement from Soils

Non-target soil areas are frequently contaminated as the result of improper use of herbicides. **Washing is a major hazard on slopes and on bare ground.** The herbicide may be carried by surface run-off or soil movement and cause severe damage or destroy desirable plants down-slope. To prevent damage to desirable non-target vegetation:

- *Do not apply a herbicide on sloping land that may injure or destroy non-target plants down slope.*
- Do not drain or flush equipment where run-off to desirable plants may occur.
- *Do not use a herbicide that may injure or destroy desirable plants by root absorption if roots of desirable plants extend under area to be treated.*
- Do not drain or flush equipment where leaching to roots of desirable plants may occur.

GROUNDWATER

Some pesticides can seep or leach through soil and enter groundwater which may be used for drinking water. Do not apply them where the water table (groundwater) is close to the surface and where soils are very permeable, i.e., well drained soil such as loamy sands.

Water contaminated with an industrial herbicide may be toxic to fish, may cause injury to irrigated crops, and, if consumed, may be a health hazard to people, livestock,

and wildlife. Some industrial herbicides, such as 2,4-D and dichlobenil (Casoron/Norosac), are registered for control of specific weeds for specific water use situations. Rodeo (glyphosate) and Krenite (fosamine) are registered for control of undesirable vegetation growing on land adjacent to and surrounding domestic water supply reservoirs, supply streams, lakes, and ponds. **Do not use a herbicide in or around water unless it is registered for use in or around water.**

STUDY QUESTIONS HERBICIDES FOR INDUSTRIAL WEED CONTROL, PROPER USE OF HERBICIDES, GROUNDWATER

These study questions are to aid you in learning the material on pages 13 through 18.

- (13) Amitrol:
 - inhibits chlorophyll formation
 - inhibits bud regrowth
 - a and b above
 - inhibits root formation
- (13) 2,4-D causes abnormal plant growth response and affects:
 - respiration
 - food reserves
 - cell division
 - all the above
- (14) Dichlobenil should be applied to perennial weeds:
 - when plants are fully dormant
 - are in the winter rosette stage
 - a and b above
 - in the seedling stage
- (14) Diuron can be applied preemergence:
 - only in the early spring
 - only in mid summer
 - anytime except when the ground is frozen
 - only under very dry soil conditions
- (15) Arsenal kills plants by:
 - inhibiting root tip elongation
 - inhibiting photosynthesis in the stems
 - inhibiting growth and death of meristemic regions
 - inhibiting chlorophyll formation
- (15) Paraquat gives best results when:
 - it is applied preemergence to the weeds
 - it is applied to young succulent weeds and grasses
 - it is applied to plants in the mature stage
 - it is applied as a seed treatment
- (16) Prometon enters the plants through the:
 - leaves
 - buds
 - stems
 - roots
- (16) The higher dosage rates of Garlon should be applied when:
 - the brush height approaches 15 feet high
 - brush covers more than 60% of the area to be treated
 - a and b above
 - none of the above
- (17) Considerations (rules) when using herbicides include:
 - select the appropriate herbicide
 - apply all herbicides according to the label
 - properly store excess herbicides
 - all the above
- (17) To reduce drift and fumes from volatile herbicides:
 - apply when winds are calm
 - use low pressure
 - apply spray as close to the target plants as possible
 - all the above
- (18) Groundwater and/or surface water contaminated with industrial herbicides can cause injury to:
 - fish, wildlife, livestock
 - irrigated crops
 - people
 - all the above

HERBICIDE TERMS AND DEFINITIONS

Acid equivalent (AE). The theoretical yield of parent acid from the active ingredient content of a formulation.

Active ingredient (AI). The agent in a product primarily responsible for the intended herbicidal effects and shown as the active ingredient on the herbicide label.

Adjuvant. Any substance in a herbicide spray mixture that enhances the effectiveness of the herbicide. (*See surfactant.*)

Antagonism. Opposing action of two or more chemicals such that the total effect is less than the sum of components used separately. (*See synergism.*)

Broadcast treatment. Application of a herbicide over an entire field area.

Carrier. A gas, liquid, or solid substance used to dilute or suspend a herbicide during its application.

Contact Herbicide. A herbicide that causes localized injury where it contacts plant tissue. Not translocated.

Crop oil. A mixture of nonphytotoxic, paraffin-based, petroleum oil with 1 to 2 percent surfactant (which serves as the emulsifying agent). Used as an adjuvant.

Crop oil concentrate. A mixture of 80 to 83 percent non-phytotoxic, paraffin based, petroleum oil, and 17 to 20 percent surfactant. Used as an adjuvant to increase foliar uptake.

Dry flowable (DF). A highly concentrated granule designed to break up and disperse in water in a manner similar to that of wettable powders. Requires agitation.

Dry soluble (DS). A dry formulation that forms a solution when added to water.

Emulsifiable concentrate (EC). A single-phase liquid system that forms an emulsion when mixed with water. Requires mild agitation to maintain the emulsion.

Emulsion. One liquid suspended as minute globules in another liquid (for example, oil dispersed in water).

Flowable Formulation. A two-phase concentrate that contains solid herbicide suspended in liquid and is capable of suspension in water. Requires only moderate agitation.

Foliar application. Application of a herbicide to the leaves of plants.

Granule (G). Low concentration (usually 5 to 15 percent active ingredient) designed to be spread dry.

LD₅₀. The dose (quantity) of a chemical(s) calculated to be lethal to 50 percent of the organisms in a specific test situation. It is expressed in weight of the chemical (mg) per unit of body weight (kg) and the toxicant may be fed (oral LD₅₀), applied to the skin (dermal LD₅₀), or administered in the form of vapors (inhalation LD₅₀).

Low-volatile ester (LVE). Any ester with a high molecular weight like butoxy-ethanol, iso-octyl, or propylene glycol butyl ester. Low-volatile esters do not include methyl, ethyl, propyl, isopropyl, butyl, amyl, and pentyl esters. Low-volatile esters are less likely than high-volatile esters to injure plants by vapor drift.

Persistent herbicide. See residual herbicide.

Pesticide. A chemical that destroys pests (plants or animals).

Phytotoxic. Injurious or lethal to plants or seedlings.

Postemergence (POST). Applied after the specified weed or planted crop emerges.

Preemergence (PRE). Applied before the specified weed or crop emerges.

Rate. The amount of active ingredient, acid equivalent, or product applied per unit area or other treatment unit.

Residue. That quantity of a herbicide remaining in or on the soil, plant parts, animal tissues, whole organisms, and surfaces.

Residual herbicide. Soil-applied herbicides that remain active over a period of time until they are broken down into compounds not toxic to seedlings or plants. Duration of activity (persistence) depends mainly on the chemistry of the herbicides, but also may be influenced by rainfall, soil pH, and temperatures. Herbicide persistence must be taken into account when planning rotation of crops.

Selective herbicide. A chemical that is more toxic to some plant species than others.

Soil application. Application of a herbicide primarily to the soil surface rather than to vegetation.

Spot treatment. Application of a herbicide over small areas of a whole unit; i.e., treating spots or patches of weeds in a larger field.

Spray drift. Movement of airborne spray from the intended area of application.

Surfactant. A material that favors or improves the emulsifying, dispersing, spreading, wetting, or other surface-modifying properties of liquids.

Susceptibility. Capacity to react to herbicide treatment.

Synergism. A complementary action of two or more chemicals such that the total effect is greater than the sum of the independent effects. (*See antagonism.*)

Tank-mix combination. Mixing of two or more pesticides or agricultural chemicals in a spray tank at application time.

Total vegetation control. Applying single or multiple herbicides at one time or in sequence to provide pre-emergent and/or postemergent control of all plants. The term usually refers to noncrop areas.

Toxicity. The degree to which a given substance injures plants or animals. Toxicity is classified as acute (immediate) or chronic (long term). Toxicity to animals varies with species, age, sex, nutritional state, method administered, and chemical formulation. (LD50.)

Translocated herbicide. A herbicide that moves within the plant. Translocated herbicides may be either phloem mobile or xylem mobile, but the term is frequently used in a more restrictive sense to refer to herbicides that are moved in the phloem, e.g., from the foliage to the growing points of roots and shoots.

Vapor drift. The movement of chemical vapors from the area of application. Some herbicides, when applied at normal rates and normal temperatures, have vapor pressures that change them into vapor form, which may seriously injure susceptible plants away from the

application site. Note: Injury from vapor drift and spray drift often are difficult to distinguish.

Volatility. The ability of a compound to evaporate or vaporize (change from a liquid to a gas) at ordinary temperatures when exposed to the air.

Water dispersed granule (WDG). See dry flowable.

Wettable powder (WP). A finely divided dry formulation that can be readily suspended in water. Requires agitation.

Wetting agent. Substance that reduces interfacial tensions and causes spray solutions or suspensions to make better contact with treated surfaces. (*See surfactant.*)

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