Model Certification Training Manual for Right-of-Way Pesticide Applicators

CHAPTER 3. PLANT BIOLOGY FOR RIGHT-OF-WAY VEGETATION MANAGERS

Important Terms

annual biennial broadleaf bulb bulbous perennial cambium chlorophyll conifer cotyledon creeping perennial dicotyledon evaporation evergreen fern fibrous root	heartwood inner bark leaf axil life cycle mature monocotyledon nutrients outer bark perennial phloem photosynthesis reproductive respiration rhizome rosette sapwood sedge	seeds simple perennial spores stolon summer annual taproot translocation transpiration tuber vascular bundle vegetative veins vine winter annual woody plant xylem

Although weeds are only one of several types of pests, they are the most important problem on rights-of-way. Therefore, it is important to have a basic understanding of plant biology, and how it influences weed management practices.

A plant is considered a weed when it is growing where it is not wanted. Some plants are considered to be weeds in rights-of-way because they interfere with the reliability of the right-of-way in a variety of ways, such as to obscure vision of signals, signs, crossroads, and other cars; prevent inspections; create a fire hazard; cause communication and power interruptions, provide cover for rodents; and restrict drainage in ballast, ditches, and channels. Some plants cause skin irritation and some can be poisonous to humans or animals. Most states have regulations that identify certain plants as noxious weeds.

There are many methods of classifying plants. Most place the plants into larger groups, for example annual vs. perennial, grass vs. broadleaf. In other instances, plants are identified by their appearance based on taxonomic keys. Being able to classify plants is important for the right-of-way applicator. For instance, some herbicides will kill broadleaf plants but have no effect on grasses. Controlling plant just before they were going to die anyway is a questionable application. A product may be effective on trees, but not all trees.

GROWTH STAGES

Nearly all plants have four stages of development (Figure ____):

-seedling
-vegetative
-reproductive
-mature

IPlants in the seedling stage are most easily controlled with herbicides. Compared to a more mature plant, the leaf surface is easily penetrated, less waxy coating of leaves, surface hairs are fewer and smaller, and the roots are near the soil surface. The small size of the plants requires less herbicide for control and there are no unsightly patches of dead weeds. As plants become larger, the leaves are more difficult to penetrate, and their roots are deeper and have more stored food. Product labels identify the best time of application when plants are at the optimum stage of growth for herbicide control.

PLANT LIFE CYCLES

Plants can be grouped by their life cycles:

- Annuals (summer and winter),
- Biennials
- Perennials

Annuals

Annual plants have a one-year life cycle. They grow from seed, produce seed for the next generation, and mature in one year or less.

Summer Annuals

Summer annuals are plants that germinate from seeds in the spring. The seeds were in the ground over the winter. They grow, produce seed, mature and die before winter. Examples include annual morningglory, barnyardgrass, crabgrass, foxtails (green, yellow and giant), kochia, lambsquarter, marijuana, partridge pea, pigweed, ragweed (common and giant), Russian thistle, and sweet clover.

Winter Annuals

Winter annuals grow from seeds that germinate in the fall, overwinter as young plants, set seed, mature, and die in the spring or summer. Examples include annual bluegrass, bedstraw, Carolina geranium, chickweed, downy brome, groundsel, henbit, little barley, ripgut brome, wild mustard, wild oats, wild radish, wild rye, and yellow rocket.

In milder climates the differentiation between winter and summer annual can become less distinct. Because the root systems of annual plants do not persist from year to year, defoliating these plants usually controls them. Treating annual plants after seed set is usually not recommended. Knowing the growth habits of annuals is important in planning how and when to control them.

Biennials

Biennials complete their life cycle within two years. In the first year they germinate from seed, develop a root system, and a compact cluster of leaves (**rosette**) on the soil surface. In the second year, they mature, flower, produce seed, and die. There are no grasses with a biennial life cycle. However, biennial broadleaves include bull thistle, burdock, common mullein, evening primrose, musk thistle, teasel, wild carrot, wild parsnip, and yarrow.

Control should be directed at the first year plants. After the seedhead has been produced, which is often the most visible part of the plant, the plant begins to senesce and die. Controlling annual and biennial plants with herbicides after flowering and seed production may be of questionable benefit. Mechanical cutting to reduce the height of the flower stalk may be more practical.

Perennials

Perennial plants live more than two years. Some live for many years. Most will reproduce each year and then repeat the vegetative, seed production, and mature stages for several following years. Others may grow for several years before they produce seeds. Some perennial plants, such as dandelions, die back each winter. Others, such as trees, may lose their leaves, but do not die back to the ground. In milder climates, some perennials can remain green year round. Most perennials grow from seed, but many also produce vegetative reproductive structures. These are a very diverse group of plants.

Simple Perennials

Simple perennials will spread by seed and root segments. These plants have persistent root systems that do not tend to spread by roots segments unless broken into parts by mechanical methods. They include bahiagrass, bluestem (big and little), broomsedge, plantain (buckhorn and broadleaf), chicory, curly dock, dandelion, goldenrod, spiderwort, Vasey grass, white heath aster, and most trees and shrubs.

Bulbous or Tuberous Perennials

Some perennials reproduce vegetatively from underground **bulbs** or **tubers**, as well as by seed (Figure _____). Bulbs are swollen underground leaf bases. Some examples include wild garlic and wild onions. Tubers are swollen tips of rhizomes. They contain buds that are capable of resprouting. Examples of plants with tubers include Jerusalem artichoke, and yellow and purple nutsedge. Bulbs and tubers can be spread by soil disturbance, and can resprout when the parent plant has been controlled.

Creeping Perennials

Creeping perennials spread vegetatively with **stolons** (horizontal stems running on the soil surface usually rooting at the joints) (Figure ____), by **rhizomes** (underground horizontal stems modified for food storage and asexual reproduction) (Figure ____), or by seed. Creeping perennials usually occur as a patch that continues to enlarge each year. Roots of creeping perennials can be located off the right-of-way while the spreading vines continue to reinvade the treated area. This makes the herbicide treatment appear to be ineffective. Repeated treatments may be necessary. Examples include Bermudagrass, blackberries, Canada thistle, common milkweed, dalmatian toadflax, hemp dogbane, horsenettle, horsetail, Japanese knotweed, Johnsongrass, leafy spurge, multiflora rose, Phragmites (common reed), prairie cordgrass, purple loosestrife, quackgrass, red sorrel, scouringrush, St. Johnswort, yellow toadflax, field bindweed, hedge bindweed, Japanese honeysuckle, kudzu, poison ivy, trumpetcreeper, Virginia creeper, and wild grape.

Perennial plants are also best controlled while seedlings. **Mature perennials are difficult to control because of their persistent roots enables the plant to resprout from the root system.** Defoliating perennial plants provides only temporary growth suppression by killing the above ground plant. Herbicides that move through the plant (translocate) are most effective if applied after rapid vegetative growth has stopped and the plant has begun to store food reserves in its roots. Getting the herbicide to the roots the key to controlling perennial plants.

WEED CLASSIFICATION

Right-of-way pest plants can be grouped into broad categories:

- grasses,
- sedges,
- broadleaves (forbs),
- vines,
- brush and trees, and
- ferns and their allies.

Grasses

Grasses are monocotyledons with only one cotyledon that remains inconspicuous in the seed. Grass leaves are generally narrow and upright with parallel veins. All annual grasses have fibrous root systems and many perennial grasses have rhizomes or stolons with fibrous roots attached. The growing point on seedling grass is located below the soil surface (Figure ____). Some grass species are annuals, including barnyardgrass, crabgrass, downy brome, foxtail, ripgut brome, and wild oats. Others are perennials such as bahiagrass, bentgrass, Bermudagrass, bluegrass, bluestem, broomsedge, dallisgrass, fescue, Indian grass, Johnsongrass, quackgrass, reed canarygrass, switchgrass, Vasey grass, and wheatgrass.

Sedges

Sedges look like grasses. Most have triangular stems and three rows of leaves, but others can have round stems. Most sedges are found in wet places, but others can occur in fertile, welldrained soils. Some of the most problematic sedges, including yellow and purple nutsedge, are perennial weeds that produce rhizomes and tubers.

Broadleaves (Forbs)

Broadleaf seedlings have two conspicuous leaf-like structures as they emerge from the soil (dicotyledon). The leaves of these plants are generally broad with net-like veins. Broadleaves usually have a taproot and a relatively course root system. All actively growing broadleaf plants have exposed growing points on root tips, at the end of each stem, and in each leaf axil (Figure ____). Perennial broadleaf plants may also have growing points on stolons or other vegetative reproductive structures as well as above ground stems.. Herbaceous plants do not develop persistent woody tissue above ground. Broadleaves contain species with annual, biennial, and perennial life cycles. Examples of annuals include kochia, pigweed, ragweeds, Russian thistle, sweetclover, wild sunflower, yellow starthistle; biennials include bull thistle, common mullein, musk thistle, nodding thistle, rush skeletonweed, wild carrot, wild parsnip; and perennials include Canada thistle, many clovers, curly dock, dandelion, field bindweed, hemp dogbane, ironweed, knapweeds, leafy spurge, perennial pepperweed, plantains, purple loosestrife, tansy ragwort, and yellow toadflax.

Vines

Woody and herbaceous vines are also broadleaves with many similar characteristics. However, vines often have persistent woody stems. They invade treated weed-free areas from the surrounding untreated area; climb poles, signs, signals, guy wires, fence posts and other vegetation (Figure ______). Although some vines are annuals, including annual morningglory and wild buckwheat, most are perennials that vigorously sprout from underground vegetative reproductive structures. Examples of viney perennials include blackberry, field bindweed, greenbrier, hedge bindweed, Japanese honeysuckle, kudzu, poison ivy, trumpetcreeper, and wild grape.

Woody Plants

Woody plants are those that form secondary tissues on the vascular cambium (wood) (Figure ___). These include brush, shrubs, and trees. Brush and shrubs are woody plants that have several stems and are typically less than 10 feet tall. Trees are woody plants that usually have a single stem (trunk) and are over 10 feet tall. These perennial plants may reproduce by seed or from sprouting roots. Trees consist of two broad groups: hardwoods and conifers. With few exceptions, hardwoods shed their leaves in the fall. Examples include ash, black cherry, black locust, boxelder, cottonwood, dogwoods, elms, hickories, maples, mesquite, mulberries, oaks, red alder, redbud, salt cedar, sassafras, sumac, sweetgum, tree-of-heaven, tulip poplar, wild cherry, and willows. Most conifers keep their needles year round (evergreens). The needles are actually shed after 2 to 3 years, depending on species, but there is always newer green foliage present. Examples include black spruce, Douglas-fir, eastern redcedar, hemlocks, junipers, loblolly pine, Ponderosa pine, shortleaf pine, white fir, white pine, and Virginia pine. Larch and bald cypress are also conifers, but shed their needles each fall.

Ferns and Their Allies

These perennial plants do not produce seed but reproduce by spores and creeping rhizomes. They prefer moist soils. Some examples include bracken fern, common horsetail or jointgrass, scouringrush, and swordfern.

CONDUCTING TISSUES

Two groups of tissues, the xylem and phloem, are important for the movement of herbicides, water, nutrients, sugars, and naturally occurring growth regulators in plants. **Xylem** tissue moves water and nutrients from the roots to the leaves. Typically soil-applied herbicides move upward in this tissue. **Phloem** transports manufactured plant food (sugars) from the leaves to points of active growth, including root tips, reproductive tissues and storage organs. In grasses and broadleaf forbs, these two tissue types are grouped together into **vascular bundles**, which are evident as veins (Figure ____).

In woody plants, the outer bark and inner bark is composed of dead phloem tissue. The wood, sapwood and heartwood, is xylem tissue. They are separated by the cambium (Figure ______), the living tissue responsible for tree growth. This is the part of the tree that should be treated during a fresh cut stump application. Girdling a tree by removing a ring of bark from around the trunk prevents plant food from reaching the roots. Remember that the living tissues are on the outer edge of the wood and on the inner edge of the bark. The rest of the wood is providing structural support and the rest of the bark protects the tree from injury.

Some herbicides move only in the xylem tissue and others are translocated in both the xylem and phloem. Most soil-applied herbicides primarily move in the xylem. In contrast, most foliar-applied herbicides move primarily in the phloem. The product label will indicate where, when, and how the herbicide is to be applied to place the material in the best location for plant uptake and maximum control.

FACTORS INFLUENCING PLANT GROWTH

Water

Water carries dissolved nutrients up to the leaves and sugar (sap) to the roots. Nutrients in the soil and soil-applied herbicides must be dissolved in water and taken up by the roots of the plant. Water is also a necessary part of photosynthesis — the manufacturing of sugar from water and carbon dioxide in the presence of green chlorophyll with sunlight as the energy source. The effects of herbicides are reduced under drought conditions as is photosynthesis.

Rainfall must be sufficient to reach the root zone. Light rain in hot, dry weather will have little effect on soil moisture because the water quickly evaporates without reaching the plant roots. Short, heavy rains may also have little effect on soil moisture because of excessive and rapid run-off.

During drought periods, plants undergo growth stress conditions and produce thick waxy layers on the leaves. They may close their stomates and reduce their metabolic rate to protect against excessive moisture loss. Because photosynthesis and, consequently sugar production, are slowed, translocation of nutrients and herbicides will also be greatly reduced. Under these conditions, it is difficult for herbicides to penetrate the leaf surfaces so control may be reduced and their use questionable. Plants growing in dry (arid) environments adapt to these conditions; for example, they may have small, thick leathery leaves; a thick waxy layer on the leaf surface; or the ability to grow and flower rapidly when rain occurs.

Temperature

Temperature influences all plant activities—absorption of water, transpiration (the evaporation of water from plants), respiration (plant food is used to produce energy), germination, growth, and reproduction. Temperature is one of the most important environmental factors affecting evaporation. Evaporation cools the leaf so its temperature is not as high as the surrounding air. Plant growth tends to increase when temperature rises, and it declines when temperature falls. Most plant growth occurs between 50-100^{o} F (10-38^{o} C). Temperature is also a factor in determining how far north and south a specific plant will grow. The duration of temperature extremes determines the length of the growing season or frost-free period.

Relative Humidity

At high relative humidity, plant leaves are more succulent, may have less of a waxy layer, and a thinner cuticle. In addition, the cuticle accumulates water. As relative humidity increases, transpiration decreases. High relative humidity and optimum temperatures usually enhance plant growth.

Liquid sprays more easily penetrate leaf surfaces as relative humidity increases. This increased penetration results in better control because spray droplets do not evaporate as fast on the leaf surface. This allows more time for the herbicide to enter the leaf.

Light

Light affects photosynthesis, plant growth, and flowering. Light is the energy source that drives photosynthesis. The rate of photosynthesis increases with increased light (up to about one-third of full sunlight). Plants growing in moderate shade tend to be taller and have larger leaves than the same species growing in full sunlight. Leaves in the sun usually are thicker, smaller, and more cuticle than plants in shade. Some plants require high light intensity. “Shade tolerant” plants have the capacity to survive and grow in the shade of other plants. Shade intolerant plants often establish first on disturbed sites.

SUMMARY

Although plants come in a variety of shapes and sizes, they can be grouped by a variety of similarities for vegetation management purposes. All plants, including grasses, broadleaves, or woody plants, go through similar growth stages and have very specific life cycles. In general, they respond similarly to environmental influences, although some plants may be more adapted to environmental extremes than others. Herbicides work best when plants are actively growing. Any conditions that make it difficult for plants to grow will reduce the effect of herbicides used to control them. Slow growth means the movement of water, nutrients, and herbicides, is greatly reduced. Understanding the biology of weeds can help in planning effective management programs, regardless of whether you are trying to prevent, suppress or release them.

CHAPTER 4. CHARACTERISTICS OF HERBICIDES USED FOR RIGHTS-OF-WAY VEGETATION MANAGEMENT

Important Terms

amino acid synthesis inhibitors auxin growth regulators bud development inhibitor cell membrane disruptors chlorosis contact epinasty	leaching nonpersistent nonselective persistent photosynthesis photosynthesis inhibitors postemergent	preemergent resistant root inhibitors selective systemic translocate

Herbicides are pesticides used to control unwanted vegetation (weeds). Weeds along rights-of-way include those that are a safety hazard, a nuisance, and are unsightly. Weeds also include those that impede the use and maintenance of rights-of-way, cause injury to workers, interrupt electric flow or communications, are declared a noxious weed under state laws, crowd out desired native plants, damage structures and ballast, or could reduce crop yield if allowed to spread to adjacent farm land.

Control methods applied to rights-of-way must fit into a sound weed management program and one that is sensitive to the environment. Herbicides are one of several options available to rights-of-way managers. This chapter discusses herbicides in general use for rights-of-way vegetation control. It is not expected to be all-inclusive.

HERBICIDE TERMINOLOGY

The effective use of a herbicide in weed management depends on characteristics of the active ingredient. In this manner, we can classify herbicides by: 1) foliage-absorbed (**postemergent**) vs. root-absorbed (**preemergent**), 2) contact vs. translocated (**systemic**), 3) selective vs. nonselective, and 4) persistent vs. nonpersistent, and 5) mode of action. These terms may sound very black and white, but recognize that in actuality there is lots of gray as we attempt to place herbicides in very specific categories. Effective weed control can be accomplished by combining the desired characteristics of selected herbicides (assuming no incompatibility or label restrictions) integrated with weed biology.

Foliage-Absorbed vs. Root-Absorbed

Foliage-absorbed herbicides primarily enter the plant through the leaves which means the weeds have already emerged above the soil; thus the term **postemergent**. **Root-absorbed** herbicides enter the plant through the roots. They are generally most effective when applied before the weeds emerge from the soil; thus the term **preemergent**. Some herbicides are absorbed by both foliage and roots (Table 1). Herbicide formulation, method of application, and adjuvants can influence which part of the plant absorbs the herbicide. Examples of foliage-absorbed herbicides include 2,4-D, diquat, fosamine (Krenite), glyphosate, and triclopyr (Garlon). Root-absorbed herbicides include bromacil (Hyvar), diuron, oryzalin (Surflan), and tebuthiuron (Spike). Herbicides that can be absorbed by either the leaves or roots include clopyralid (Transline), hexazinone (Velpar), imazapyr (Arenal), picloram (Tordon), and sulfometuron (Oust).

Selective or Nonselective

Selective herbicides control only certain types of plants. When applied to mixed vegetation some plant types or species will not be affected or will show minimal signs of injury. **Nonselective** herbicides generally control most plants and are used where complete control is desired. Selectivity may occur because of true physiological selectivity. For example, grasses are naturally tolerant to the herbicide 2,4-D whereas dandelions and ragweeds are susceptible. However, rate, timing, method of application, and plant characteristics also can determine selectivity (Table 2). Nonselective herbicides include bromacil (Hyvar), glyphosate, sulfosate (Touchdown) and tebuthiuron (Spike). Some herbicides such as diuron, hexazinone (Velpar), imazapyr (Arsenal), and sulfometuron (Oust) have selective uses in other situations such as crop production and forestry, but are considered to be nonselective herbicides as they are used for rights-of-way vegetation management (Table 1).

Table 2. Selectivity of herbicides commonly used on rights-of-way.

Herbicide	**Plants Not Controlled**
2,4-D	grasses
chlorsulfuron (Telar)	perennial grasses
clopyralid (Transline)	grasses, many broadleaves
dicamba	grasses
diquat (Diquat)	perennials
fosamine (Krenite)	non-woody plants
glufosinate (Finale)	perennials
metsulfuron (Escort)	grasses
oryzalin (Surflan)	most broadleaves
pendimethalin (Pendulum)	many broadleaves
picloram (Tordon)	grasses
prodiamine (Endurance)	most broadleaves
simazine	perennial plants
triclopyr (Garlon)	grasses

Contact vs. Translocated (Systemic)

We generally think of a **contact** herbicide as one that kills only the green portion of the plant that it touches. The activity of these compounds is so rapid that the herbicide moves (**translocates**) very little in the plant. Consequently, good coverage is necessary. A contact herbicide is usually nonselective on annual species since they do not resprout. However, contact herbicides cause only temporary suppression of perennial weeds because they will resprout from the underground root system. Translocated (**systemic**) herbicides move throughout the plant, whether they are taken in by the foliage and translocated downward to the roots (**phloem mobile**) or by the roots and translocated upward to the leaves (**xylem mobile**) (Table 1). Foliage applied herbicides that translocate are useful for controlling perennial weeds because the herbicide will move to the growing points, including the roots and shoots. Nearly all herbicides used for rights-of-way vegetation control translocate within the plants, including 2,4-D, bromacil (Hyvar), dicamba, diuron, glyphosate, imazapyr (Arsenal), picloram (Tordon), sulfometuron (Oust), and triclopyr (Garlon). The very few contact herbicides include diquat (Diquat), glufosinate (Finale), and MSMA. The herbicides that inhibit root development are, in a sense, contact herbicides since they do not move through the plant. They are taken up by the roots and express their activity in the roots.

Persistent vs. Nonpersistent

Persistent herbicides remain active in the environment for an extended period of time (Table 1). The ability of the herbicide molecule to persist depends on its ability to resist microbial degradation in the soil. Herbicides vary greatly in their resistance to breakdown. **Nonpersistent** herbicides are short-lived in the environment. Soil organisms easily break them down, or they become so tightly bound to soil particles that they are not available for plant uptake.

Persistence is an important characteristic when long-term (residual) weed control is desired for total vegetation control around a guide rail, median barrier, substation, or rail yard. Persistence allows the control of shallow-rooted annual weeds among deep-rooted established perennial plantings. Persistence is undesirable when it hinders or delays desirable plant growth as in reseeding or plant release programs. Usually cold temperatures, dry soils, clay soils, compacted soil, and high use rates increase persistence. Conversely, warm temperatures, frequent rainfall, low use rates, sandy soils, high organic soils, reduce persistence. Herbicides generally considered to be persistent include bromacil (Hyvar), diuron, imazapyr (Arsenal), picloram (Tordon), sulfometuron (Oust), and tebuthiuron (Spike). Nonpersistent herbicides include 2,4-D, fosamine (Krenite), glufosinate (Finale), glyphosate, and triclopyr (Garlon).

HERBICIDE CHARACTERISTICS

Herbicides can be placed into broad groups, sorted by chemical families, based on plants' response to the herbicide (Table 3).

Table 3. Rights-of-way herbicides listed by general modes of action.

I. Herbicides causing injury to new growth and generally move from leaves to roots

Auxin Growth Regulators
- Phenoxy acid
  - 2,4-D
- Benzoic acid
  - dicamba
- Pyridine acid
  - clopyralid (Transline)
  - fluroxypyr (Vista)
  - picloram (Tordon, Pathway)
  - triclopyr (Garlon, Pathfinder)

Amino Acid Inhibitor, Nonpersistent
  - glyphosate
  - sulfosate (Touchdown)

Amino Acid Inhibitors, Persistent
- Sulfonylurea
  - chlorsulfuron (Telar)
  - metsulfuron (Escort)
  - sulfometuron (Oust)
- Imidazolinone
  - imazapyr (Arsenal)

II. Herbicides causing injury to established growth and generally move from the roots to the growing points (leaves)

Photosynthesis inhibitors
- Triazine
  - hexazinone (Velpar)
  - prometon (Pramitol)
  - simazine
- Substituted urea
  - diuron
  - tebuthiuron (Spike)
- Uracil
  - bromacil (Hyvar)

III. Herbicides causing localized injury with little or no movement within the plant

Cell membrane disruptors
- Bipyridiliums
  - diquat (Diquat)
- Other
  - glufosinate (Finale)

IV. Herbicides applied to the soil to inhibit root development of emerging seedlings

- Dinitroanaline
  - prodiamine (Endurance)
  - oryzalin (Surflan)
  - pendimethalin (Pendulum)

V. Inhibit bud development

  - fosamine (Krenite)

VI. Grass specific herbicides

Lipid biosynthesis inhibitors
  - fenoxaprop (Horizon)
  - fluazifop (Fusilade)
  - sethoxydim (Poast)

VII. Mode of action not clear

- Organic arsenical
  - MSMA

Auxin Growth Regulators

Auxin growth regulator herbicides [2,4-D, dicamba, clopyralid (Transline), fluroxypyr (Vista), picloram (Tordon, Pathway), and triclopyr (Garlon, Pathfinder)] act as natural plant-growth regulators. However, they are more active than natural growth regulators because they are applied at much higher rates. The plant dies, in part, because growth stops at the meristems and mature tissues undergo cell division that chokes the vascular tissues. One of the common symptoms of these herbicides is distorted growth, including twisting and curling (**epinasty**). This symptom is not considered to be involved in the death of the plant.

These herbicides translocate in the plant but are usually applied to the foliage. Because they translocate, it is not necessary to treat every part of the plant. Low-volume sprays can also provide effective control of many species.

These herbicides can cause distorted plant growth at low rates. Drift to susceptible crops such as cotton, grapes, soybeans, sugar beets, tobacco, and tomatoes is a concern.

They can move downward in the soil. Since picloram has persistent residual soil activity, some products containing picloram are classified as Restricted Use Pesticide.

These herbicides are available in liquid forms as water-soluble salts (amine and mineral salts) and emulsifiable concentrates (EC). The water-soluble formulations are usually applied to leaves and fresh cut stumps, or can be injected into woody stems. The EC formulations are best used to control woody plants, and they can be applied to young green stems or leaves of trees.

These herbicides are effective for controlling many broadleaf weeds and trees. Grasses are usually not controlled (**resistant**) at labeled rates.

Amino Acid Inhibitors, Nonpersistent

The amino acid inhibiting, nonpersistent herbicides include glyphosate and sulfosate (Touchdown). These herbicides prevent the plant from making important amino acids. They are generally nonselective compounds that must be absorbed by the leaves. However, they can be used selectively in some situations when applied at low rates, with directed methods, and when desired plant species are not actively growing.

Glyphosate and sulfosate translocate throughout the plant. Symptoms in the plant are slow and may take a week or more for control. Rapid foliage discoloration (brown out) does not occur, even from concentrated sprays. There is essentially no soil activity at normal use rates because of soil adsorption.

Amino Acid Inhibitors, Persistent

Chlorsulfuron (Telar), metsulfuron (Escort), sulfometuron (Oust), and imazapyr (Arsenal, Stalker) prevent plants from making important branched-chain amino acids. Unlike glyphosate and sulfosate, all these herbicides have useful residual soil activity. They are taken in through the leaves and roots and translocated throughout the plant. Imazapyr and sulfometuron control many grasses and herbaceous weeds. Chlorsulfuron and metsulfuron are less effective on grasses. Although symptoms may take weeks to appear, plant growth stops soon after application. These herbicides are used at low rates (ounces or pints per acre).

Photosynthesis Inhibitors

These herbicides [hexazinone (Velpar), diuron, prometon (Pramitol), simazine, tebuthiuron (Spike), bromacil (Hyvar)] block **photosynthesis** (combining water and carbon dioxide to produce oxygen and sugar in the presence of sunlight) in susceptible plants. They have no direct effect on root growth although uptake by the roots is the best route for these herbicides to enter the plant. Both roots and leaves take up hexazinone. All photosynthetic inhibitors persist in the soil and provide residual weed control. The length of persistence varies with each herbicide, and depends on the amount applied, soil type, and climate.

Cell Membrane Disruptors

The herbicides diquat (Diquat) and glufosinate (Finale) disrupt cell membranes. They are nonselective, contact herbicides. Diquat injury may be visible a few hours after application. **Chlorosis** (yellowing resulting from the loss of green pigment) occurs within 2-5 days for glufosinate. Good coverage is required. Plants can recover from incomplete spray coverage.

Root Development Inhibitors

Herbicides that prevent seedling root development [oryzalin (Surflan), pendimethalin (Pendulum), prodiamine (Endurance)] stop the growth of roots and shoots of germinating seeds or small seedlings by disrupting cell division. Because they translocate to only a limited degree in plants, they seldom control established weeds. They are highly selective between species and usually do not leach in soils. Effective control usually depends on sufficient rainfall or soil incorporation.

Bud Development Inhibitor

Fosamine (Krenite) inhibits bud development when applied to woody plants late in the growing season, but before leaves start changing colors. Except for pines, there is little or no visible effect (brownout) until the following spring, when susceptible woody plants do not resume growth. Since fosamine moves only from the leaves to the buds, uniform coverage of the plant is necessary. Fosamine has no soil activity and does not injure grasses at normal use rates.

Grass Specific Herbicides

A common characteristic of grass specific herbicides [fenoxaprop-ethyl (Horizon), fluazifop-p-butyl (Fusilade), sethoxydim (Poast)] is that their activity is limited almost entirely to postemergent control of annual and perennial grasses. Nearly all non-grass species are resistant. These herbicides are absorbed by the leaves and have little soil activity. They are most effective when applied to unstressed, rapidly growing grasses. Death of susceptible species takes a week or more. Crop oil concentrates, nonionic surfactants, and nitrogen solutions increase their effectiveness. Antagonism has been observed when these products are tank mixed with auxin growth regulator herbicides, such as 2,4-D. Many grass weed species have been reported to develop resistance to this group of herbicides.

PLANT GROWTH REGULATOR CHARACTERISTICS

Plant growth regulators (PGR) do not cause plant death, but only a reduction in plant growth. The two most common uses are seedhead suppression of roadside grasses reduced mowing and to reduce sprout growth from line clearance trimming on electric rights-of-way.

Cell Division Inhibitor

The plant growth regulator mefluidide (Embark) inhibits cell division. It reduces growth and suppresses seedhead formation of various turf grass species. It does not readily translocate out of the applied leaf. Mefluidide does not persist in the soil and has been show to injure some desirable plant species.

Amino Acid Inhibitors

Characteristics of the herbicides glyphosate, imazapyr (Arsenal), chlorsulfuron (Telar), metsulfuron (Escort), and sulfometuron (Oust) have been previously discussed. Their use as plant growth regulators emphasizes the importance of application rate. At very low rates, some of these herbicides can be used to either suppress seedhead production of certain grasses or release desirable grasses not injured by low rates.

Gibberellin Synthesis Inhibitor

Paclobutrazol (Profile) is a tree growth regulator that inhibits the biosynthesis of gibberellins, plant growth substances that stimulate cell division and cell elongation. Inhibition of cell division and elongation limits tree growth, especially resprouting stimulated by pruning. Growth inhibition can usually last for several (2-4) years. Stem cambial growth of some tree species is also inhibited by paclobutrazol. It is injected into the soil or applied as a drench around the base of the tree.

FACTORS INFLUENCING HERBICIDE SELECTION AND USE

The previous section discussed many aspects of the chemical nature of herbicides. However, there are plant characteristics and environmental conditions that can influence, for better or worse, the effect of a herbicide.

Plant Characteristics

Location of Growing Points

Seedling grasses have their growing point below the soil surface. Control is difficult when growing points are protected in this manner and the herbicide does not move in the phloem. If a herbicide does not reach the growing point, the plant will continue to grow. Creeping perennial grasses have protected buds below the soil surface. Many seedling broadleaf weeds have an exposed growing point at the top of the young plant, and in the leaf axils. Many perennial broadleaf plants are difficult to control because of the protected buds on the creeping roots and stems. Translocated herbicides are necessary to reach these protected growing points.

Leaf Shape

The shape of the leaf can reduce or improve the effectiveness of a herbicide. Spray solution tends to bounce or run off when applied to a plant with narrow vertical leaves. In contrast, a vertical leaf can also direct the chemical downward into the growing point. A broadleaf plant with flat, wide leaves can more easily retain the spray solution. Retention of spray solution is critical to the effectiveness of contact herbicides, which must be absorbed through the foliage.

Hairs

Some weeds lack hairs; others have many and varied hairs. A dense layer of leaf hairs can hold the herbicide droplets away from the leaf surface, reducing chemical absorption into the plant. However, a thin layer of leaf hairs causes the chemical to stay on the leaf surface longer than normal, allowing more chemical to be absorbed into the plant. Surfactants will facilitate greater spreading and penetration of the herbicide solution through a dense layer of hairs. Generally, there are fewer and shorter hairs on seedling weeds compared with the older growth stages. For this and other reasons, seedlings are easier to control than mature plants.

Size

Seedling and small weeds are easier to control than large, more established weeds. Smaller plants, regardless of their stage of growth, are usually easier to control than larger plants. Lower use rates can be used on seedling weeds. For some herbicides, more chemical is needed as the plants become larger. Contact herbicides can be effective on seedling weeds before perennial root systems become established.

Environmental Influences

Precipitation

Soil moisture and rain affect herbicide efficacy. They also influence how long herbicides stay on the soil and plant surfaces. Herbicides work best with moderate soil moisture. Excessive soil moisture may keep the herbicide in solution and increase leaching through the soil. Some rain is beneficial after application of root-absorbed herbicides because it moves the herbicide into the soil and in the root zone. Rain during or soon after foliar applications may wash herbicides off the leaves and reduce effectiveness.

During drought periods plants are stressed and growth is slowed. This causes most translocated herbicides to perform poorly. Even contact herbicides do not perform well under drought conditions as plants produce heavy wax or corky layers of tissue on leaves or stems to protect against excessive transpiration losses. During dry periods herbicides remain on the soil surface until moisture is received to carry them to the root zone. Effectiveness may be reduced if herbicides remain on the soil surface for a long period of time (several weeks) before rainfall.

Temperature

Temperature generally does not affect weed control results. It may, however, affect the amount of time required for the herbicide to kill the weed. As temperature increases, the herbicide effects occur more quickly. In cold weather, the action of herbicides may be slowed. High temperatures can enhance herbicide volatility (change from a liquid to a gas or vapor). Warm temperatures increase soil temperature, which increases microbial activity. This can reduce the persistence, hence effectiveness, of residual, soil-active herbicides.

Light

Sunlight is essential for photosynthesis and growth. Light may break down some herbicides if they remain on the soil or plant surface for a long time. This process is called photodegradation. Soil incorporation is an effective way of eliminating photodegradation. Since soil incorporation is not possible for rights-of-way, herbicides used on rights-of-way are not light sensitive.

SUMMARY

Herbicides registered for use on rights-of-way present the opportunity to control almost all plant species or to selectively manage for broad groups of plants. Most programs will use only a small number of the products available. Other products are available that are mixtures of the active ingredients above. Premixed and tank mixed combinations offer convenience and utilize the desired characteristics of each component. Each product has its unique advantages that enable it to occupy a market niche, and some products may not be suited for a desired use. Before using any herbicide, read the label for the best source of information.

CHAPTER 9. APPLICATOR SAFETY IN HERBICIDE APPLICATIONS FOR RIGHTS-OF-WAY VEGETATION MANAGEMENT

Important Terms

acute	inhalation	NOEL
chronic	LC_{50}	oral
dermal	LD_{50}	signal words
hazard	MSDS	toxicity

Some classes of pesticides are hazardous to you because the life process they control in pest works the same way in people. For example, rodenticides and insecticides that interfere with the enzyme cholinesterase in pests can interfere with the same enzyme in you and cause uncontrolled twitching and loss of nerve control. In contrast, most herbicides are designed to disrupt processes in plants that are not present in humans, such as interfering with root or shoot growth. Most herbicides are not readily absorbed through the skin. Most are rapidly broken down and excreted in urine and feces. Properly trained applicators should always take precautions and follow label instructions to minimize exposure since, for most products, the level of toxicity determines the amount of safety equipment that must be worn.

TOXICOLOGY CONCEPTS

Exposure to herbicides occurs in two primary ways: acute and chronic exposure. However, several other toxicology tests are required before a herbicide can be registered. These include effects on reproduction and organ toxicity, as well as teratogenic, carcinogenic and mutagenic effects. A properly trained applicator should understand the long term hazards (if any) associated with the products they work with.

Acute

Acute exposure is a single exposure to a large amount of herbicide in your mouth, on your skin, or in your eyes during mixing. It can also include spilling or spraying the product onto your clothing, face, or body, as a result of broken or leaking equipment. Often symptoms of acute poisoning begin in the minutes and hours after exposure and are easily traced to a specific exposure. Acute exposure can also include irritation and burns.

Acute **oral exposure** refers to a single dose taken by mouth (ingestion). Acute **dermal exposure** refers to a single dose directly contacting the skin (skin absorption). Acute **inhalation exposure** refers to a single dose exposure through breathing or inhaling in an enclosed area. Few herbicides are highly toxic to humans, and few herbicides are readily absorbed through the skin. Since most right-of-way herbicide mixing usually occurs outside, inhalation is not generally a problem. However, you should always take precautions to avoid breathing herbicide vapors, mists, or dusts.

Chronic

Chronic exposure is the result of repeated contact with low levels of a pesticide over a long period of time. Chronic effects may appear after months or even years. Chronic exposure is often the result of inadequate or improper use of protective clothing or equipment. It can occur from wearing the same contaminated clothes without proper laundering or by not washing or bathing after working with a herbicide product. Examples of chronic exposure response include cancer, birth defects, and organ damage.

Toxicity and Hazard

The terms toxicity and hazard do not mean the same thing. **Toxicity** is a measure of the ability of a chemical to cause harm; injury, illness or death. **Hazard** is the possibility that injury can occur and includes two factors — toxicity of the product or mixture, and the degree of exposure. A herbicide diluted in water has the same toxicity as the concentrated form, but presents less of a hazard because the applicator must be exposed to a greater quantity of solution to receive the same amount of toxicant. Applicators should be particularly knowledgeable of the hazards when handling concentrated forms of herbicides before they are mixed for application.

LD_{50}/LC_{50}

The terms **LD_{50}** and **LC_{50}** are used to express the level of toxicity of herbicides. LD is an abbreviation for "lethal dose". The LD_{50} is a single dose of a chemical that, when fed to a group of test animals or applied dermally, will kill 50% of the animals. LC means "lethal concentration". LC_{50} is the concentration of the chemical in the air or water that will kill 50% of the test animals with a single exposure. In most cases, herbicide acute toxicity measurements are determined on both male and female rats. LD amounts are expressed in milligrams of product per kilogram of body weight (mg/kg). LC amounts are expressed in terms of milligrams of chemical mist, or dust, per liter of air (mg/l) or as milligrams of herbicide per liter volume of solution (mg/l), usually water. Milligrams per liter is equivalent to parts per million (ppm). The higher the LD_{50} or LC_{50} value the less toxic the herbicide. This may seem, at first glance, to be incorrect. The higher the LD_{50} means it takes more of the herbicide to kill half of the test animals; therefore, the product is considered less toxic than those herbicides which kill half the animals at lower doses. A herbicide with an acute oral LD_{50} of 5,000 mg/kg requires almost 0.1 ounce of the herbicide per pound of body weight to reach the LD_{50} value, assuming a similar level of sensitivity as the test animal. LD_{50} and LC_{50} values can be measured for both the active herbicidal compound or for the entire herbicide formulation, which can include the inert ingredients and adjuvants.

The LD50 and LC50 values are normally found on the Material Safety Data Sheets (MSDS) for each product. Pesticide labels will generally not provide the LD_{50} or LC_{50} values. Instead these numbers are provided to the applicator through a signal word found on each pesticide label. The signal words are CAUTION (high LD50 or LC50 values), WARNING (moderate LD50 or LC50 values), and DANGER (low LD50 or LC50 values). Generally speaking, DANGER/POISON labeled products require greater protective equipment than those products classified as WARNING or CAUTION. Likewise, a product with the signal word WARNING may require additional safety equipment than those herbicides with a CAUTION signal word. It is important to note that the signal words provide a quick overview of the product's acute toxicity.

NOEL

No Observable Effect Level (NOEL) is the highest exposure dose that gave no effect on the animal in a particular toxicological test. It is an important measure because LD_{50} and LC_{50} values do not indicate the toxicity of a compound over a range of herbicide concentrations. For example, two compounds may have the same LD_{50} value, but one is much more toxic at a lower dosage that the other. Not only are NOEL values useful in acute and chronic toxicology studies, but also are critical in determining maximum tolerated doses (MTD) base on results of reproductive, teratogenic, mutagenic and carcinogenic studies. From the NOEL, a safety factor of 100 to 1,000 is often built into MTDs to account for possible differential sensitivity between experimental test animals and other animals or humans.

Routes of Exposure

Most herbicides have low toxicity (high LD_{50}). Exposures that cause illness are rare. However, herbicides with low toxicity can irritate the nose, throat, eyes, and skin of sensitive applicators. Know how to protect yourself, your workers, and other people from the possible effects due to exposure of the herbicides being mixed or applied.

The manner by which the herbicide contacts the body plays a critical role in how the body responds to the herbicide. Herbicides can enter the body through the mouth (**oral**), through the skin and eyes (**dermal**), and through the lungs (**inhalation**).

Oral exposure can occur by not washing your hands before eating, drinking, smoking, or chewing, or by wiping your hand across your mouth.

Dermal exposure can occur by not washing your hands after handling herbicides or their containers, not wearing gloves while mixing and loading and handling containers, directly splashing the product on the skin, the spray mist contacting unprotected skin or eyes, wearing herbicide contaminated clothing (including hats, boots and gloves), wearing improperly cleaned protective clothing and safety equipment, and handling contaminated equipment during mixing or application, and not washing gloves and boots before removing them.

Inhalation exposure can occur by breathing vapor, dust or mist during mixing or application, and by not wearing appropriate protective equipment.

PERSONAL PROTECTIVE EQUIPMENT

The most important thing that any applicator could do to prevent exposure is to wear the personal protective equipment (PPE) required by the herbicide label. Follow all directions on the label regarding protective clothing. The lack of any statement or mention of only one piece of safety equipment does not rule out the use of additional protection. Understanding herbicide toxicity, route of entry, length of exposure, and mixing and application methods should help you assess the hazard and select the proper protective clothing. You must know and comply with all label requirements. The greatest potential for exposure occurs while handling concentrated products during mixing and loading. The product label or state regulations may specify additional protective clothing to be worn during loading that may not be required during application. Remember, the PPE required by the label is based on the LD_{50} or LC_{50} values and concerns about chronic exposure.

Hand Protection - Gloves

? Wear appropriate gloves when handling herbicide concentrates or when in contact with the spray solution, such as cleaning nozzles or adjusting the sprayer.

? Gloves should be long enough to protect the wrist.

? Liquid-proof, unlined, chemical-resistant (neoprene or nitrile) gloves are best for liquid formulations.

? Gloves should NOT be fabric-lined because the lining absorbs herbicides.

? Most labels require wearing long-sleeved shirts. <u>Shirtsleeves should be outside of the gloves</u> to keep the herbicide solution from running down the sleeves and into the gloves. However, when spraying or working with your hands and arms over your head, the shirtsleeves should be inside the gloves to prevent the herbicide from running from the gloves on to unprotected skin of the hands and arms.

- **?** Gloves should be washed with soap and water before you remove them to prevent being exposed to herbicides when you remove, store or re-use them.

- **?** Test your gloves for leaks by filling them with water and gently squeezing.

- **?** Replace gloves when the exterior shows signs of tearing, staining, or distress.

Eye Protection – Goggles/Face Shield

Since eyes can readily absorb most herbicides, wear some form of eye protection, such as safety glasses with brow and side protection, goggles, or a face shield. Liquid products can splash and dry materials can bounce or be blown into unprotected eyes.

- Be aware that goggles can fog up and present a different type of hazard.

- It's best to purchase safety glasses with ULV protection. This will help protect the eyes from the herbicide and blocks the sun's rays.

- Wash your eye protection equipment after each use so you do not become exposed to herbicide with the next use.

- When not in use, store safety glasses or goggles in any container to help protect them against scratches and breaks.

Head Protection – Hat

- o Wear some form of head covering to protect your head anytime you are handling or applying herbicides.

- o A wide-brimmed hat will help keep herbicides off your neck and face.

- o Hats should not have a cloth or leather sweatband as they absorb chemicals and are difficult to clean.

- o A sweatband should be easy to clean or be disposable.

- o Baseball-type caps provide limited head protection from chemical exposure, and should be washed regularly with other clothes you wear during application.

Foot Protection - Shoes and Boots

- o Sturdy shoes or boots are sufficient for most herbicide applications. Canvas or cloth boots can absorb herbicide and should be avoided.

- o Boots are worn with trouser legs outside the boots to prevent the herbicide from running down your legs and into the boots.

- o Neoprene or rubber boots are good precautionary gear when applying liquid herbicides in areas that must be walked through while making the application or when required by the product label.

- o Rinse your neoprene boots before removing them to prevent exposure to chemicals when handling them.

Lung Protection - Respirators

The respiratory tract, including the lungs and other parts of the breathing system, is the fastest route for herbicide exposure. You must wear an approved respirator if required on the label. **Very few herbicides require the use of a respirator, but follow label directions for those that do.**

Surgical/Dust Mask

Dust masks can trap dust particles and pollen, but, as a general rule, should **NOT** be considered respirators for handling pesticides..

Cartridge Respirator

A functional cartridge respirator absorbs herbicide vapors when the inhaled air is drawn through both a fiber filter pad and a cartridge. Cartridge respirators cover only the mouth and nose. For that reason, it is best to use one that is combined with goggles, or wear separate goggles that protect your eyes. Newer cartridge respirators are lightweight and disposable. Respirators are usually not required when using herbicides. Whether you are legally required to wear a NIOSH (National Institute of Safety and Health) approved respirator will depend on the herbicide label. If you do wear a respirator, wash it daily and check for proper fit before each use to prevent exposure to chemicals when wearing it again.

While it is beyond the scope of this manual, applicators should never wear a respirator unless they have completed an OSHA approved medical questionnaire, been examined by a physician if required, and been fitted by a trained professional to ensure the proper respirator is selected.

Hearing Protection

Ninety decibels is the maximum continuous volume limit for an 8-hour period allowed by OSHA (Occupational Safety and Health Act). Control noise at the source by keeping the engine exhaust system in good repair and by using good quality mufflers on every machine.

The two basic types of hearing protection are the insert and the muff. The insert is placed in the ear canal and is made of rubber, plastic, wax, or special cotton-like fibers such as "Swedish wool." The muff, or cup type, resembles earphones and covers the external ear to provide an acoustical barrier.

Rubber and plastic inserts must be properly fitted to assure a good seal, and should be reasonably comfortable. They tend to work loose with jaw movement. They must be kept clean. Wax and "Swedish wool" inserts are shaped by hand and are useful where loud noise is only occasional. They are inexpensive and can be discarded after one use.

Muff protectors can quickly be taken off and put on as needed. They are ideal where loud (more than 90 decibels) noise is continuous or for short durations. They provide more dependable protection than inserts.

If you experience headaches and/or temporary loss of hearing working in a noisy area, then hearing protection is a must.

Whole Body Protection – Coveralls, Safety Vests

If you are wearing only a shirt and trousers, you should consider wearing coveralls or a liquid-proof apron when handling concentrates. If you wear a cover-all type garment, it should be made of woven or laminated fabric that has been manufactured for this purpose. Fabric garments should be laundered regularly. Disposable protective clothing can also be used for herbicide applications. Disposable fabrics are usually lightweight and strong, and have the advantage of not requiring cleaning or decontamination after use.

Bright reflective vests are required on many operations where applicator visibility is critical, such as roadsides and railroads.

FIRST AID BASICS

While herbicide poisonings are rare to right-of-way applicators, it is never the less important to recognize signs and symptoms of herbicide poisoning. When in doubt, seek medical attention and be sure to bring the herbicide label and MSDS to the physician.

Herbicide Poisoning Recognition

Certain herbicides may cause an allergic reaction in a sensitive person. It is important to know the signs and symptoms most likely to be caused by the herbicides you use. Symptoms such as nausea or headache are noticeable only to the affected person. Signs, such as vomiting, sweating, sluggishness, staggering, or rash development can be seen by other people. Know what your own symptoms might mean and what signs of poisoning to look for in your coworkers.

Herbicides that are chemically similar to one another cause the same type of symptoms. They may be mild or severe, depending on the specific herbicide involved and the level of exposure. If you have been working with herbicides and some signs or symptoms begin to develop, let your coworkers know, and get medical attention quickly. The herbicide label or MSDS will have a telephone number to contact in case of a medical incident.

Procedures

Get medical attention quickly if you or any of your fellow workers experience unusual or unexplained symptoms that start during work hours or later the same day.

Do not allow yourself or anyone else to become extremely sick before calling a physician or going to a hospital.

Read the first aid instructions on the product label or the Material Safety Data Sheet (MSDS) for each product.

Follow the instructions, and avoid becoming exposed while trying to help another person.

Give the label and MSDS to the physician or emergency personnel. Most labels have a telephone number to contact in case of medical emergencies involving the product. You should provide this number to medical personnel.

Most of the following recommendations are for usual cases of pesticide exposure. Always read the label for specific instructions.

Herbicide on Skin

Wash the herbicide from skin with soap and water. This should be adequate in most instances of skin exposure. You should have a ready supply of soap and clean water on the spray equipment to wash your hands or protective equipment after working on the sprayer or coming in contact with the spray solution. Seek medical treatment when skin burns and irritation persists.

Herbicide in Eye

Eye exposure to herbicides can be serious. Always pour, measure, or mix herbicides with the containers held below eye level to avoid splashing the product into your eyes. Wettable powders and granules are abrasive and may damage your eyes. Always wear eye protection when mixing.

If herbicides contact your eye(s),

- Remove any protective equipment and wash the eyes quickly but gently.
- Hold the eyelid open and wash with a gentle stream of clean running water.
- Wash for 15 minutes or more.
- Do not use chemicals or eye wash solutions in the wash water because they may increase the extent of the injury.
- Seek medical attention when burning in the eyes persists.

Herbicide in the Lungs

Because herbicides are used outdoors, inhalation is not a common route of exposure. However, there are situations with potential inhalation exposure, including during mixing of wettable powders and handling herbicides in a storage room or rail car.

- Stand where the wind blows across your body so the wind will carry any herbicide dust away from you.

- Cutting the bags, rather than tearing them, avoids stirring up any dust from the product.

Herbicide in Mouth or Swallowed

Rinse the mouth with plenty of water. If swallowed carefully read and follow all instructions on the product label regarding treatment. Induce vomiting **only** if instructed to do so on the label. Get medical attention.

Supplies

A standard first aid kit is important for treating cuts and scrapes associated with working around equipment.

A supply of clean water for emergency eye flushing should be readily available at the storage facility, on the application equipment, and at the job site. This water should **NOT** be contaminated in any way. Special eye washing kits that contain water and eye cups can be purchased from safety supply stores.

Soap and water for routine hand washing should be kept with each piece of equipment, especially if crews eat on location.

Also consider a Tyvek suit that can be used in the event of an applicator’s clothing becoming contaminated.

SUMMARY

There are hazards associated with weed control whether by applying herbicides or using mechanical equipment such as week-eaters, mowers, and saws. There is no need to take short cuts when it comes to the safe handling of pesticides. Wearing the required personal protection equipment will reduce most hazards associated with the use of herbicides. A well trained applicator will avoid unnecessary exposure and follow the directions on the label. The label is always the best source of information.