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General Principles of Weed Management [1]

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In any discussion of weed control, there must first be a definition of a weed. Many definitions have been used; however, for the purposes of this guide a weed is defined as: any plant that is a hazard, nuisance, or causes injury to man, his animals or his desired crops. It should be obvious from this definition that almost any plant can be a weed under certain circumstances. For example, corn and soybeans are both crops and neither is generally considered a weed; however, if you are producing soybeans, and corn is present in your field it could then be defined as a weed. Likewise, a small mixture of Bragg soybeans in a field of Cobb soybeans is of little consequence if the beans are to be sold for oil; however, if you are attempting to produce certified Cobb soybeans, then the Bragg variety is a serious weed problem. Also, sugarcane would normally never be considered a weed; however sugarcane growing in the drainage ditches of a sod farm would have to be managed as an aquatic weed.

Whether you live on the farm or in the city, weeds either directly or indirectly influence your everyday life. Weeds reduce yields, quality, and interfere with efficient harvest. These reductions are eventually passed to the consumer, either in increased prices or in poor quality products. Weeds interfere with recreational activities in aquatic areas or in parks and playground areas. Weeds, such as poison-ivy and poison-oak, cause misery to many people and others, such as ragweed, result in hay fever, thus causing discomfort and increased medical expenses.

It is estimated that the current total losses to Florida agriculture due to weeds are approximately 400 million dollars per year. In the United States, it is projected that the current use of herbicides comprises more than 60% of the total pesticide sales. With this magnitude of agricultural losses and herbicide usage, this aquatic weed control guide has been prepared to aid in more efficient and effective weed control. Since weed control consists of more than using herbicides, this guide refers to other methods of weed control in addition to herbicides.

Classification of Weeds

Weeds may be classified as grasses, sedges, and broadleaf weeds. In addition, for the purposes of this guide, algae will be considered weeds. Weeds may be further classified by the length of their life cycle. The three basic life cycles of weed plants are annuals, biennials, and perennials. The classification of weeds based on the length of their life cycle may not be obvious on visual inspection, but may have a great

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impact on the selection and success of control procedures.

Grass Weeds

True grasses have hollow, rounded stems and nodes (joints) that are closed and hard. The leaf blades are alternate on each side of the stem, have parallel veins, and are much longer than they are wide. Some examples are crabgrass, goosegrass, crowfootgrass, sandbur, annual bluegrass, torpedograss, and vaseygrass.

Broadleaf Weeds

Broadleaf weeds are a highly variable group of plants, but most have showy flowers and net-like veins in their leaves. They are easy to separate from grasses due to their generally different leaf structure and habits of growth. Some examples of broadleaf weeds are cudweed, creeping charlie, henbit, spurges, burning nettle, pennywort, creeping beggarweed, cocklebur, sicklepod, and Florida beggarweed.

Sedges

Sedges are an important group of "grass-like" weeds; however, they are not true grasses and are characterized by a solid, triangular-shaped stem with leaves extending in three directions. There are annual sedges (some are often called water grass), and the predominant and difficult to control perennial sedges. Of the latter group, yellow nutsedge is yellow-green in color and reproduces by seed, rhizomes (underground stems), and tubers. The rhizomes radiate from the plant, with a single bulb or tuber at the end, which may produce a new plant. Purple nutsedge is usually smaller in growth habit than yellow nutsedge, has reddish purple seed heads and produces a series of bulbs on radiating rhizomes called "tuber chains".

Algae

The algae are a diverse group of plants that occur in a wide range of environmental habitats. They are photosynthetic plants that contain chlorophyll, have simple reproductive structures, and their tissues are not differentiated into true roots, stems, or leaves. They range from unicellular, or single cells, to fairly complex multicellular organisms. Some algae have such a complex growth form that they are mistaken for vascular plants - Chara would be one such example. The size of individual algal plants range from microscopic, unicellular species, which are approximately 0.000039 in. (0.0010 mm) in diameter to large filamentous marine algae that obtain lengths of over 100 ft.(30 m).

Annual Weeds

Annual weeds, as the names implies, complete their life cycle within one year. They germinate from seed, grow, mature, produce seed and die in 12 months or less. They may be annual grasses, sedges, or broadleaf weeds. In addition, their life cycle may begin at different seasons of the year. Thus, summer annuals emerge in the spring, mature, produce seed, and die before winter of each year. Weeds such as crabgrass and cocklebur are typical of summer annuals. Similarly, winter annual weeds sprout from seed in the fall, and complete their life cycle before summer of the next calendar year. Sowthistle, henbit, annual bluegrass, and chickweed are examples of winter annual weeds.

Biennial Weeds

Compared to annual weeds, biennial weeds are few in number. These weeds have a 2-year life cycle. They germinate from seed in the fall, and develop large root systems and a compact cluster of leaves during the first year. The second year they mature, produce seed and die. Examples of biennial weeds are cudweed, Carolina falsedandelion, wild carrot, and bull thistle.

Perennial Weeds

Weeds that live more than two years are perennials. They reproduce by vegetative parts such as tubers, bulbs, rhizomes or stolons (above-ground stems). Some also produce seed in addition to vegetative reproduction. During the winter season most live-over in a dormant state and many lose their above-ground foliage and stems. With the beginning of spring they regenerate from food reserves in their root systems. Torpedograss, nutsedge and various vines are members of this group of weeds. Florida betony is a perennial weed that under a sub-tropical climate, initiates its growth in the fall, grows during the winter months and goes dormant during the heat of summer.

Perennial weeds may be further divided into groups based on the type of root system and their reproductive process:

- Simple perennials reproduce by seeds but root pieces disturbed by cultivation or other mechanical means will produce new plants. Florida betony, and certain trees and shrubs are characteristic of this group;

- Bulbous perennials reproduce by seed and above or below-ground bulbs. Yellow nutsedge and wild onions have their bulbs below ground while wild garlic has an above ground bulb.

- Creeping perennials which produce seed but also produce rhizomes or stolons. Bermudagrass, torpedograss and purple nutsedge produce these specialized stems (rhizomes and stolons) that act as food storage organs and can initiate growth at each node along the stem.

The perennial weeds are the most difficult to control because of their great reproductive potential and persistence.

In annual cultivated row crops, annual weeds, such as crabgrass, goosegrass, cocklebur and ragweed are the most prevalent. However, perennial weeds such as nutsedge, johnsongrass and common bermudagrass may also be severe problems. In pastures and rangeland, perennial weeds tend to dominate among the perennial forage crops. Weeds such as smutgrass, dogfennel, waxmyrtle and pricklypear are very competitive but would not survive in a cultivated, row crop situation. Similarly in fruit crops where the desirable plants are also perennial, weeds such as guineagrass, vaseygrass, and milkweed vine are perennial problems.

Methods of Weed Control

There are several methods of weed control, including mechanical crop competition, crop rotation, biological, fire, and chemical. Best weed control is usually achieved by a combination of two or more of these methods. Many times this combination of weed control methods is called an integrated weed control program.

Mechanical

One type of mechanical control is burial. This method is most effective on annual weeds in which all the growing points can be buried. Burial is usually less effective on perennial weeds which have underground stems and roots and are capable of regrowth from these underground storage organs. Another method of mechanical control is cultivation. The main objective in cultivation is to cut the root system of the weeds; deep cultivation should usually be avoided due to damage to the crop roots. Deep cultivation may also bring more weed seed to the surface where they will germinate. Most studies have shown that when weeds can be controlled without cultivation, there is no advantage to cultivating. In fact, there may be disadvantages such as drying out the soil surface, bringing weed seed to the surface, and disturbing the root system of the crop.

Mowing is another method of mechanical control. Mowing is usually most effective on tall growing annuals, and not as effective on short growing plants or perennials. The growth habit of the plant usually indicates how effective mowing will be. Since grasses grow from basal meristems, mowing is not usually an effective method of controlling these weeds. Perennial weeds which regrow from underground storage organs require frequent and usually long-term mowing for control. This is because the leaf area must be removed continually and not allowed to regenerate any carbohydrates for storage in order to starve the underground plant parts. Annual weeds are usually mowed to prevent seed production and to allow the crop a better competitive advantage.

Draglines or backhoes are frequently used for mechanical control of aquatic weeds in sites such as canals and ditches. Aquatic weed removal may be done when the canal or ditch is cleaned, removing silt and sediments to restore the original profile of the waterway, or as a separate operation using a special "weed bucket" on the equipment. A variety of floating, cutter and harvester machines are manufactured which can be used in many aquatic sites. The requirements needed for operating such equipment are an access area to launch the boat, sufficient space to operate in the body of water, and sufficient water depth to float the equipment in the area of the proposed operation.

Plant and Crop Competition

Crop competition is usually one of the most economical and best methods of weed control; however, it is often one of the most overlooked methods. Weeds compete with crops for space, light, moisture, nutrients, and carbon dioxide. Usually the plant which starts first and is growing under ideal conditions will have the competitive advantage. Factors such as planting date, row spacing, seeding rate, planting depth, soil moisture, soil fertility, and soil pH have an influence on the competitive advantage of the crop or weed.

Most of our crop plants have been developed under conditions which were as near optimum as possible for that crop; therefore, everything that can be done to simulate these conditions for the crop plant should be in its favor. Since weeds have not been developed by plant breeders for specific conditions, they are often more tolerant of a wide range in conditions. Usually only one crop species is planted; however, there are many weed species available to compete with this crop. For example, as soil pH becomes higher or lower than its optimum for the crop there is usually a weed species which is tolerant of that pH. This is also true for factors such as fertility, soil moisture, and depth of emergence. Planting the crop at the optimum soil temperature, depth, soil moisture, soil fertility, and soil pH will allow it to emerge most rapidly, grow, and cover the row middles, thus reducing much of the weed competition by shading.

Plant competition is used successfully to control aquatic weeds in certain situations. For example, Chara has been planted and managed in South Florida canals to limit and suppress the regrowth of Hydrilla.

Crop Rotation

If the same crop is planted in the same field year after year there usually will be some weed or weeds which are tolerant and favored by the cultural practices and herbicides used on that crop. By rotating to other crops many of the cultural practices and herbicide programs are changed. This often will reduce the population of specific weeds which were tolerant in the previous crop.

Biological Control

Biological weed control as a practical tool has not been utilized to a great extent in controlling weeds. There have been certain instances of successful biological control programs; however, these have been infrequent. This is an area in which present and future research appears promising. Insects, disease, and nematodes do naturally suppress growth of certain plants, a continual process in the field. One area of weed science which should be recognized is how the use of fungicides, nematicides, and insecticides influence weed populations. If a plant, which is not a serious problem, is naturally suppressed by one of these organisms, will that plant become a weed if that organism is controlled?

There has been considerable work in the biological control of aquatic weeds. Three insects have been introduced into the United States, including Florida, for control of water-hyacinth. Additional insects have now been introduced to control other aquatic weeds in Florida. In addition, the Florida Game and Fresh Water Fish Commission has a permit system which enables the public to use grass carp for control of submersed, emergent, and other aquatic weeds. A permit must be obtained from the Florida Game and Fresh Water Fish Commission before anyone in Florida may purchase, possess, or use the grass carp for aquatic weed control purposes.

Fire

Fire is an old method of weed control, and in certain instances can be used to favor selectively certain species over others. Controlled burning can be useful to remove weeds from ditch banks, roadsides and other waste areas. Fire has been used for many years to favor the growth of pine seedlings over hardwoods. Special equipment for flaming is available. Fire is usually more effective on annual weeds than on perennial weeds and usually does not kill weed seed in the soil.

Chemical Control

Time of Application

The time of application is usually divided into three areas: preplant, preemergence, and postemergence.

Preplant

Preplant refers to applications made before the crop is planted. Currently, in most cases, these materials are incorporated into the soil and are called preplant incorporated treatments (ppi). The great advantage of these incorporated treatments is that the herbicide is placed in the zone where weed seed germinate and is not dependent on rainfall to move the herbicide into this zone. This type of treatment adds to the cost of incorporation and requires that the crop be tolerant of the herbicide, as the crop seed and the herbicide will be in contact. Examples of such herbicides are trifluralin, profluralin, benefin, and vernolate.

Preemergence

Preemergence treatments usually refer to applications made after the crop is planted but before it emerges. However, strictly speaking, preemergence may apply to other situations such as preemergence to the crop, preemergence to the weeds, or preemergence to both crop and weed. These preemergence applications are usually applied to the soil surface and require rainfall or irrigation to move the herbicide into the soil. If the herbicide is not moved into the soil where the weed seed are located it will not be effective. If left on the soil surface, these herbicides are often lost due to photodecomposition and vaporization.

Postemergence

Postemergence treatments are applied following emergence; however, as with preemergence it should be specified as to postemergence to the crop or weed. If the crop has emerged but no weeds are present then the application is postemergence to the crop but preemergence to the weeds and would be applied to the soil surface. If the crop has emerged and the weeds have emerged, then the application is postemergence to both weed and crop and would be applied to the foliage of the weeds.

Area of Application

The area to which chemicals are usually applied are described as band, broadcast, directed, and spot treatments, although some individuals may give more specific descriptions such as semi-directed, directed broadcast, and directed spray and recovery.

Broadcast Applications

As the name implies, broadcast applications cover the entire area. These treatments, while requiring the largest amount of chemical and highest cost per acre, usually result in the best weed control.

Band Applications

Band applications usually refer to treating a narrow strip directly over the row. This reduces the amount of chemical required and the cost per acre; however, with this type application the area between the rows is not treated and usually will require cultivation or chemical treatment later in the season.

Directed Applications

Directed applications are applied to a particular area or part of the plant. These applications are usually directed to the base of the crop plant and away from the leaves. The ability to use directed sprays usually depends on a height differential between the crop and the weed. If the crop is taller than the weeds then drop nozzles can be used to direct the spray treatment over the weeds but below the leaves of the crop.

Directed sprays are very useful in late season control of weeds and usually follow a preplant or preemergence application. In many cases preplant or preemergence applications do not persist long enough to control late germinating weed seed or may not be used on certain soil types. In such cases directed sprays are used to obtain effective weed control and improve harvest efficiency.

Spot Treatment

Spot treatments are used for weeds which are localized in certain areas but are not widespread over the entire area. When only isolated areas of weeds are present, this is the most economical and best method to control and prevent their spread to other areas.

Prevention

If effective weed control has been achieved using the previously discussed methods, one further step should be considered. This is preventing weeds from re-infesting the area.

Knowledge of how weeds enter the field is important. Weed seed may be distributed in crop seed, hay, straw, by wind, water, animals, machinery and other ways.

Fence rows, ditches, and ditch banks are often neglected when controlling weeds in crops. Weed seed produced in these areas may move into the field and start new weed infestations. As it is difficult to prevent weed seed from blowing into the field, or being carried by birds or water, if the weeds can be stopped from growing and producing seed in these adjacent areas, it will reduce the possibility of infestation or re-infestation.

Care should be taken not to move aquatic weeds from one body of water to another in boats, on boat trailers, and on mechanical equipment such as draglines. Many aquatic weeds have the potential to establish populations rapidly and cause problems in adjacent waters. Do not use mechanical equipment to control an infestation of a plant such as Hydrilla that covers only a small percentage of a body of water, as fragmentation of the plant can cause rapid infestation of the remainder of the water body.

Certified, registered, and foundation seed, or clean planting material cannot be over emphasized in preventing weeds from infesting fields. It is also important to clean equipment before entering fields or when moving from one field to another. Soil on tractor tires or other areas of equipment may contain large numbers of weed seed. Cultivators and mowers should be cleaned to prevent the movement of vegetative plant parts such as rhizomes and stolons from different areas in the fields or from field to field. Although a few plants remaining in the field or in fence rows, or in a body of water, may not appear significant it should be remembered that many weeds produce extremely large quantities of seed. For example, one redroot pigweed plant may produce as many as 117,000 seed or one mullein plant may produce over 220,000 seed. Hydrilla may produce over 10 million reproductive propagules (turions) per acre (0.405 ha).

Herbicides

Herbicides may be classified in several ways depending on where and how they are applied and their action in or on the plant. Herbicides may be either foliage applied or soil applied. They may kill by contact or may be translocated through a plant.

Herbicides may also be selective or non-selective. Some herbicides may be effective either foliage applied or soil applied. Whether a herbicide is selective or non-selective may depend on several factors, such as the crop or weed present, time of application, the method of application, and rate of application.

For example, paraquat would usually be described as a foliage applied, contact, non-selective herbicide; while atrazine would usually be described as a soil applied, translocated, selective herbicide.

Foliage Applied Herbicides

Foliage applied herbicides may be applied to the leaves, stems or shoots of plants. Herbicides that kill only those parts of the plants which the spray touches are contact herbicides.

The herbicide may be taken into the plant and moved through-out the plant, resulting in plant injury or death. These are translocated herbicides. For example, if a drop of paraquat were applied to the leaf tip of a young tomato plant then only that leaf tip would be killed; however, if a drop of 2,4-D were applied to the leaf tip of a young tomato plant then other areas of the plant would express symptoms due to translocation of the 2,4-D throughout the plant.

For foliage applied herbicides to be effective they must enter the plant and this entrance may be influenced by factors, such as the shape or orientation of the leaf, roughness of the leaf surface, pubescence (hairs) on the leaves, presence of wax, or the formulation of the herbicide. For example, it is difficult to obtain good coverage of plants with narrow upright leaves such as wild onion since the herbicide bounces or runs off, while plants with prostrate leaves such as wild mustard are much easier to cover.

The presence of pubescence on the leaf may result in a herbicide not reaching the leaf surface but remaining suspended on the hairs. In such cases, the addition of a surfactant may be useful in reducing the surface tension of the water droplet and allowing it to spread through the hairs onto the leaf surface where it may be absorbed.

On waxy leaf surfaces the formulation of the herbicide may be important. For example, the amine formulations of phenoxy herbicides are not highly soluble in wax and are not as effective on plants with waxy leaves as are ester formulations which are soluble in wax.

Contact herbicides are most effective on annual weeds but are not usually effective on perennials. Translocated herbicides may be effective on annuals or perennials.

Soil Applied Herbicides

Soil applied herbicides primarily enter plants through the root system and many factors influence the effectiveness of soil applied herbicides. Factors such as tolerance of the crop or weed to the herbicide, depth of weed and crop seed, amount of sand, silt, clay and organic matter of the soil, amount and time of rainfall, and temperature are a few factors which may influence effectiveness.

One example of herbicide tolerance is the use of atrazine in corn. When atrazine is applied to a field of corn, it may enter both the corn and the weeds; however, corn has the ability to detoxify atrazine, whereas many weed species cannot, thus resulting in selective weed control.

Although soil applied herbicides must be moved into the soil to be effective, the amount of movement in the soil can be used to achieve selectivity. For example, if the problem weeds are in the upper 1 inch of soil and the crop seed can be planted at a depth of 2 inches, then a herbicide which does not move rapidly in the soil, or can be incorporated to a depth of 1 inch, can be used, thus resulting in the crop seed remaining below the zone of herbicide.

Persistence of herbicides is extremely important in the duration of weed control, and also in determining what crop can be planted later in the season. The persistence of herbicides applied to the soil may be influenced by numerous factors such as microbial decomposition, chemical decomposition, adsorption, leaching, volatilization and photodecomposition.

Soil type is extremely important. Soluble herbicides applied to sandy soils may be rapidly leached out of the zone containing weed seed and into the zone of germination or roots of the crop thus resulting in poor weed control and damage to the crop. In fine textured soils or organic soils, herbicides may be so tightly adsorbed that they are not available for weed control or they may be released so slowly that they are not in a concentration great enough to kill the weeds. This lack of release may also increase the persistence of herbicides into the following crop in fine textured or organic soils.

Herbicides which specify incorporation into the soil may do so to improve the contact of the herbicide with the seed and also to minimize the loss of the herbicides by volatilization and photodecomposition. Some herbicides, if not incorporated soon after application may be lost from the soil surface.

One of the major factors influencing herbicide persistence in the soil are microorganisms. These organisms may use the organic herbicides as a source of carbon for their food supply. The specific herbicide, microorganism present, temperature, water, oxygen, and mineral nutrients are all important in the persistence of the herbicide.

Generally the fastest degradation of herbicides is achieved in warm, moist, well aerated, fertile soils at pH ranges favorable to crop growth. The greatest persistence of herbicides may be expected if the soil is cold, dry, poorly aerated, and generally unfavorable to the growth of the microorganisms.