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Weed management strategies for floriculture gardening

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Abstract
Weed management requires identifying pertinent species and understanding their biological characteristics so that management can be adapted to the weeds present in individual fields. Accurate identification is critical: identification of seedling weeds is necessary for selecting an appropriate post-emergence herbicide, while identifying mature weeds, often indicates which species will inhabit a particular field the following season. Most weed species in cropping systems are either broadleaves or grasses. Broadleaf species are generally easier to differentiate than grasses, especially at early growth stages.
Weed control is important early in the season, when weed competition can considerably reduce vigour, uniformity and overall yield. The period from emergence to four weeks has been found to be critical in the competition of weeds in many row crops. The methods used for controlling weeds have been divided into two broad categories, non-chemical and chemical. Many non-chemical weed management methods are intelligence farming practices. These practices are of increasing importance due to consumers' concerns about pesticide residues, potential environmental contamination from pesticides, and unavailability of many older herbicides.

Keywords: weed, identification, management, yield, competition, residues

Introduction
Numerous plant species are considered weeds in cropping systems. Weeds have many attributes undesirable to crop producers, not the least being the ability to reduce crop yields through competition for resources such as sunlight, water, nutrients, and space. Weeds also may harbor insects and provide a host for certain plant pathogens. Some weed species, such as wild garlic and eastern black nightshade, can reduce the quality of the harvested crop. Eliminating or reducing the deleterious effects of weeds on crops is the ultimate goal of weed management. Integrated weed management includes all practices that enhance a crop's competitive ability and decrease weeds' ability to reduce yield.
Weeds can be categorized according to their life cycle, or how long they live: annual, biennial, and perennial (Table 1). Knowledge of life cycles is important to reducing the potential for weeds to produce viable seed or vegetative structures that aid in weed dispersal (Table 2).

Table 1: Examples of weed species by life cycle.

Annuals		Biennials	Perennials	
Winter	Summer		Simple	Spreading
butterweed common chickweed downy brome field pennycress henbit horseweed little barley prickly lettuce purple deadnettle shepherd's-purse yellow rocket	Barnyard grass Bur cucumber common cocklebur common lambsquarters common ragweed crabgrass giant foxtail giant ragweed green foxtail jimsonweed kochia shattercane smartweed smooth pigweed tall morning glory velvetleaf water hemp yellow foxtail	bull thistle common burdock musk thistle poison hemlock teasel wild carrot	common milkweed curly dock dandelion field bindweed hedge bindweed honey vine milkweed horse nettle pokeweed smooth ground cherry	Canada thistle hemp dogbane Jerusalem artichoke Johnson grass perennial sow thistle quack grass swamp smartweed trumpet creeper wires tem muhly yellow nut sedge

Table 2: Characteristics of weed life cycles.

Weed type	Duration of life cycle	Overwintering State	Method of reproduction
Annual	1 yr	Seed	Seed
Biennial	2 yr	Rosette	Seed
Perennial	>2 yr	Seed, vegetative propagule	Seed, vegetative propagules

Annual plants: complete their life cycle (from seed to seed) in one year; they are sometimes further divided into winter annuals and summer annuals. Summer annual weeds emerge in the spring, grow in spring and summer, then flower and produce seed during late summer or early fall. These species are the most common weeds that grow in agronomic crops. Summer annual weeds can be controlled by various soil-applied herbicides before they emerge; they are easiest to control with poste emergence herbicides when they are small (about 4 inches or less). In general, most weeds become progressively harder to control with herbicides as they become larger.

Winter annual weeds emerge during late summer or fall, over winter in a vegetative state, then flower and produce seed the following spring. They are common in fields where no tillage is done after harvest and in fall-seeded small grains and forages. Controlling winter annual weeds with herbicides may be accomplished during late fall or early spring. It is best to control all existing weed vegetation (including winter and summer annuals) before planting corn or soybean in the spring or before fall-seeding small grains or forages.

Biennial plants: complete their life cycle over two years. Biennials emerge in the spring or summer, overwinter in a vegetative stage (often referred to as a rosette), then resume growth the following spring. Elongation of the flowering stalk (bolting) and seed production can vary by species; it occurs during the spring, summer, or fall of the second year. Biennial weeds are often best controlled with postemergence herbicides during the rosette stage of growth. Their susceptibility to herbicides generally decreases rapidly after the onset of bolting.

Perennial species live longer than two years—theoretically, indefinitely. Some species reproduce almost exclusively by seed and are referred to as simple perennials. Other species can reproduce by both seed and various types of vegetative propagules (creeping roots, rhizomes, tubers, etc.). These types of perennials are referred to as creeping, or spreading, perennials.

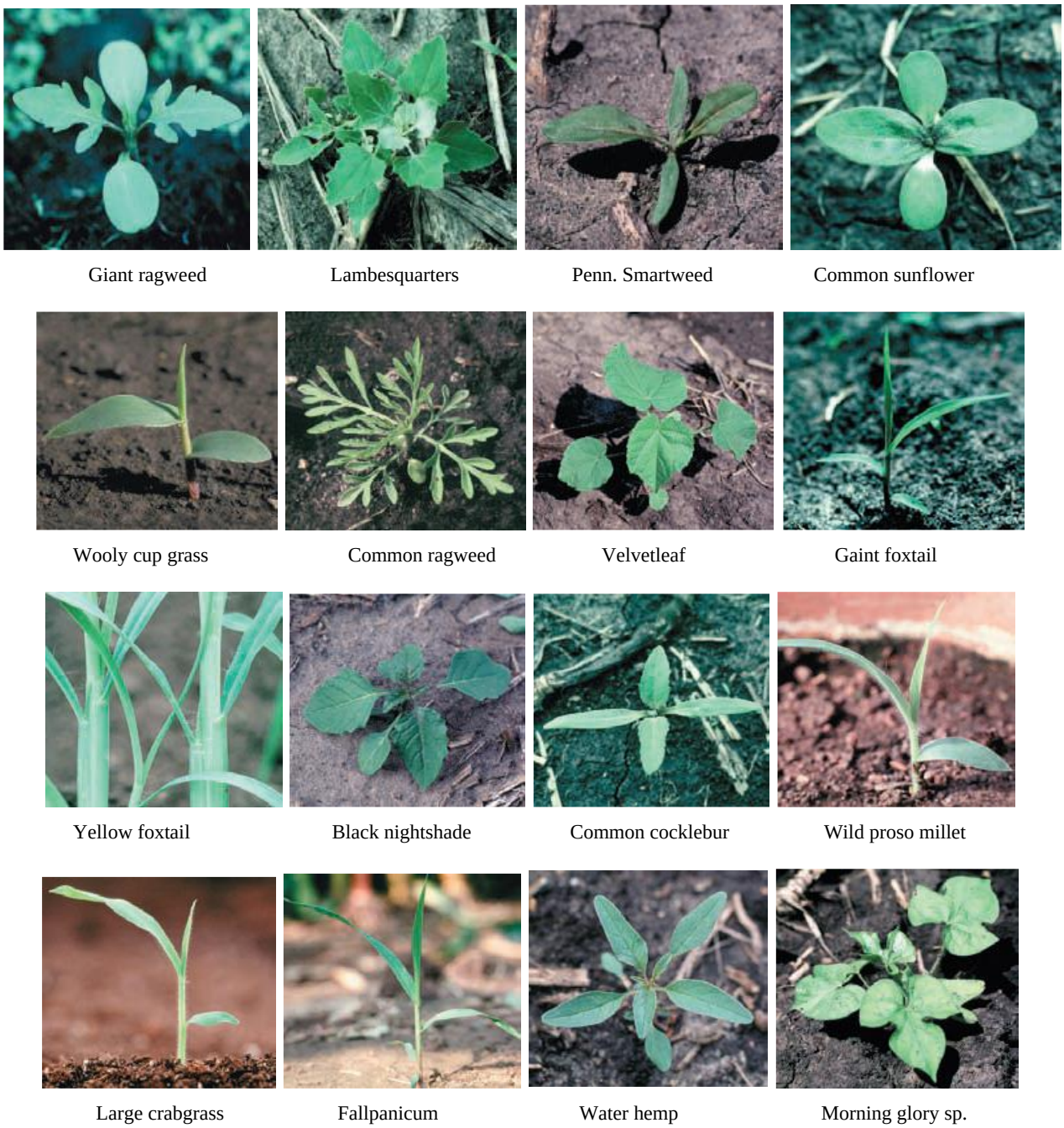
Perennial weed species often become established in no-till production fields and can cause great frustration with respect to how best to control or eradicate them. Without the option of mechanical weed control (i.e., tillage), perennial weed species are generally best controlled with post-emergence trans located herbicides. Which trans located herbicide is used, as well as when the application is made, can impact the success achieved. Perennial weed species are frequently difficult to control because they store food reserves in their root systems or underground storage structures. Controlling only what is above ground is usually not sufficient for satisfactory, long-term control; what is underground must be controlled as well. Trans located herbicides (those that can move into the roots) are usually the most effective chemical option to control perennial weeds, but when they are applied is very important. In the spring, perennials rely on stored food reserves to initiate new growth, so most of the food at this time of year is moving upward from the roots to support new vegetative development. Because of this upward movement, it's often difficult to get sufficient herbicide into the root when applications are made in early spring.

Better control of perennial broadleaf species can be achieved when postemergence trans located herbicides are applied about the time the plants begin to flower. Another good time to treat perennial weed species is early to mid-fall. As day length shortens and temperatures fall, perennial plant species begin to move food back into their roots, and more trans located herbicide moves to the root as well.

Scout: agronomic production fields for weeds several times each season. In no-till fields, determine which winter annual or early-emerging summer annual species are present prior to any herbicide application so that herbicide selection and application rates can be optimized for the species present before planting. Knowing when weed species begin to emerge can vastly improve your management program if you practice timely scouting and subsequent control tactics. Weed emergence can, and often does, vary somewhat from year to year. Weeds such as smartweed and kochia emerge during early spring, while morning glory species can emerge during mid-summer (see Figure 6 for emergence sequences for weed species common in corn and soybean). Some species, such as velvetleaf, tend to have a relatively short period of emergence, whereas others, such as water hemp, tend to emerge over a relatively long part of the growing season.

Weed Interference

Weed management strategies attempt to limit the deleterious effects weeds have when growing with crop plants. Most common is competition with the crop for available growth factors (light, water, etc.). Whatever quantities weeds use are unavailable for use by the crop. If weeds can use a sufficient amount of some growth factor, crop yield can be, and often is, adversely impacted. Currently the most common method of managing weeds is herbicides. Many options are available, each with distinct advantages and disadvantages. There are also several methods by which herbicides can be applied. Whatever the herbicide or method of application, the goal is to prevent weeds from contributing to crop yield loss by reducing the amount of competition exerted by the weeds. The concept of competition between weeds and crops has received a great deal of recent attention from farmers and herbicide manufacturers alike. A particular point of interest focuses on when competition (from weeds) should be removed so that yields are not adversely impacted. Soilappliedresidual herbicides can be used to eliminate any early-season weed competition, but some farmers would rather use only postemergence herbicides to control weeds. Is one method better than another at reducing weed interference? What research is needed to determine how and when competition reduces crop yield? How should results of such research be interpreted? Those involved in managing weeds have long recognized their harmful effects on crop growth and productivity through competing for light, moisture, nutrients, and space.



Herbicides: continue to be a powerful tool for controlling weeds. However, there is a growing desire to be less dependent on "herbicidal" control of weeds. Herbicides are viewed as expensive; some weeds have developed resistance to various herbicides, and there is growing public concern regarding the environmental/ health effects of pesticides.

Integrated weed management (IWM): is an approach to weed control that attempts to address these concerns. The approach is driven by the need to maximize crop yields and profits while simultaneously protecting natural resources and minimizing environmental effects. IWM strives to be less dependent on herbicides by relying on the combination of many agronomic tactics to control weeds. These tactics include the following:

- practices that favor crop competition
- diversified production systems that make it difficult for weeds to adapt
- practices that limit the spread of weed species
- optimal herbicide use

Agronomic practices that favor crop competition

Seeding shortly after seed bed preparation Seeding should occur as soon as possible after seed bed preparations are complete to prevent weeds from getting a "head start" on the crop. The earlier weeds emerge relative to the crop, the greater the crop yield loss. Any practice that enables the crop to emerge as early as possible ahead of the weeds will favor crop yield and reduce weed seed production.

Shallow seeding and good "on row" packing

Seeding as shallow as conditions permit is key to rapid emergence. If moisture conditions are good, seed should not be seeded deeper than a 1 inch. When soils are dry, seeding down 1 and 2 inches, may prove advantageous. But seeding deep, particularly into cold soils, will likely delay emergence, increasing the crop's susceptibility to seedling diseases and the effects of herbicide residues. Unfortunately, seeding depth can be quite variable for many openers, especially when the recommended ground speed is exceeded. Information regarding seeding depth control for many openers is available from the Prairie Agricultural Machinery Institute.

Drilling in a crop with good "on row" packing results in better crop establishment compared to broadcast seeding, particularly in a dry spring. On row packing squeezes the soil like a sponge, providing better moisture conditions for crop germination while leaving the soil between the rows loose and less than ideal for germinating weed seeds.

Seeding early

Early seeded crops have a yield advantage because they can capitalize on early moisture and longer days. Thus, delaying seeding so that initial flushes of weeds can be controlled is not an effective weed control strategy in conventional systems. The cost in yield by waiting to control a weed flush exceeds the cost of applying an in-crop herbicide.

Row spacing

Reported effects of row spacing on crop yield and weed management have been variable. However, crop emergence and competitiveness in wider row spacing may be reduced as a result of inter-plant competition and fertilizer burn in single shoot-systems.

Seeding at an optimum rate

The optimum seeding rate is influenced by a multitude of environmental and economic factors. During drought, lower than normal seeding rates may actually increase crop yield by reducing inter-plant competition for soil moisture. When conditions are ideal, higher than normal seed ingrates can increase crop competitiveness and yield. Studies have shown that increasing the normally recommended seeding rate by 50 per cent reduced weed biomass. The practicality of raising seeding rates obviously depends on seed costs.

Vigorous seed and competitive varieties

Planting vigorous seed will help to produce a competitive crop, particularly when conditions for germination and seedling growth are less that ideal (i.e. cold dry soils, flea beetles, disease, herbicide carry-over). Several seed labs can provide a seed vigor test, which is an evaluation of how quickly and uniformly a seed lot will germinate under cold, stressful conditions. Simply testing for germination is not enough since the loss of seed vigor precedes the loss of the seed's ability to germinate. Seed vigor can change substantially with time, so tests should be conducted no earlier than three to four months before seeding. Crop vigor and competitiveness against weeds can differ between varieties, hybrid varieties are typically more competitive than open pollinated varieties.

Fertilizer placement

Crop competition against weeds is increased when nitrogen is banded instead of broadcast. Banding places the fertilizer where the crop has greater access to it over surface germinating weeds.

Removing weeds early

Studies have determined that the yields of pea, canola and cereal crops are maximized when weeds are removed early, delaying weed removal from 1 to 3 weeks after crop emergence can reduce yield by 5 to 55 per cent, depending on weed pressure and environmental conditions.

Diversified production systems

Production systems that create diversity in cropping patterns, tillage and herbicide use make it difficult for weeds to adapt. Rotating between annual provides an opportunity to rotate between herbicide groups, thereby slowing the development of weed resistance. Unfortunately, weeds still persist in an annual crop rotation, and the use of herbicides for weed control is heavily relied upon. The weeds persist because they have adapted to the consistent timing of herbicide use, crop emergence and harvest of an annual crop rotation. Diverse crop rotations that include annual crops, perennial forages, winter cereals and silage crops create variation in cropping patterns (i.e. seeding and harvest dates), making it difficult for weeds to adapt.

Table 3: Commonly infested annual weeds of flower crops in India

Weed	
Summer annuals	
Setaria verticillata	**Winter annuals**
Dactyloctenium Aegyptium	*Phalaris minor*
Eleucine indica	*Avena ludoviciana*
Digitaria sanguinalis	*Lolium temulentum*
Echinochloa Colona	*Polypogen monspeliensis*
Trianthema portulacastrum	*Poaannua*
Cucumis Callosus	*Sonchus arvensis*
Amaranthus viridis	*Rumex dentatus*
Digera arvensis	*Euphorbia simplex*
Euphorbia microphylla	*Chenopodium album*
Phyllanthus niruri	*Melilotus alba*
Portulaca oleracea	*Stellaria media*
Commelina benghalensis	*Coronopus didymus*
Cannabis sativa	*Malva parviflora*
Setaria verticillata	

Table 4: Commonly infested perennial weeds of flower crops in India

Weed	
Summer perennials	**Winter perennials**
Sorghum halepense	*Convolvulus arvensis*
Cynodon dactylon	*Cuscuta reflexa*
Cyperus rotundus	*Cuscuta chinensis*
Parthenium hysterophorus	*Orobanche aegyptiaca*
	Cirsium arvense

Methods of weed control

Weed control is important early in the season when weed competition can substantially reduce vigour, uniformity and overall yield. The period from emergence to four weeks has been found to be critical in the competition of weed sin many row crops. The methods used for controlling weeds have been divided into two broad categories, non-chemical and chemical. Many non-chemical weed management methods are common sense farming practices. The sepractices are of increasing importance due to consumers' concerns about pesticide residues, potential environmental contamination from pesticides, and unavailability of many older herbicides.

Non-chemical methods

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

Preventive methods

These methods are closely connected with crop rotations and necessary when no direct measures of weed control can be taken for economic reasons. They are based on a reduction in the soil seed and propagule bank and the early awareness of the infestations. It is necessary to avoid the invasion of new species through the use of clean planting material and to prevent seed dispersal on the irrigation water, implements and machines. A written record of the history of weed infestation in the field is very useful. Another aspect is to impede perennial weed dispersal (or parasitic weeds) through the use of treatments and tillage and the use of drainage tillage to prevent propagation of some species (Phragmites spp., Equisetum spp., Juncus spp.) that need high moisture levels. It is also necessary to scout the field edges to prevent invasions, acting only when necessary, and bearing in mind the usefulness of the edges and borders to control erosion and hosting useful fauna.

Cultural methods

One should aim to establish avigorous crop that competes effectively with weeds. This approach starts with land selection. A generalrule is not to plant vegetables on land with a history of heavy weed infestation, especially of perennial weeds.

Stale seedbed: Stale ('false') seedbeds are sometimes used when other selective weed control practices are limited or unavailable. Success depends on controlling the first flush of emerged weeds before crop emergence, and onminimal disturbance, which reduces subsequent weed flushes. It consists of preparation of a seedbed 2-3 weeks before planting to achieve maximum weed-seed germination near the soil surface. These seedlings are killed by light cultivation or by apply in gnon-residual herbicides glyphosate and para quat just before or after planting, but before crop emergence. The crop is planted with minimum soil disturbance to avoid exposing new weed seed to favourable germination conditions. The pre-germination should occur as close as possible to the date of planting to ensure that changes in weather conditions do not have an opportunity to change the spectrum of weeds (cool vs. warm season) in the field.

Planting to moisture: The majority of small seeded weeds germinate in upper 1 to 2 inches of soil. This aspect of the germination ecology of weeds can be exploited for control of these weeds. After the weeds are killed by cultivation, the top 1 to 2 inches of soil are allowed to dry and form a 'dust mulch'. At planting, the dust mulch is pushed away and large seeded crops can be planted into the zone of soil moisture. These seeds can germinate, grow, and provide partial shading of the soil surface without supplemental irrigations that would otherwise provide for an early flush of weeds.

Crop rotation: Crop rotation is a key control method to reduce weed problems. It was considered for a long time to be a basic practice for obtaining healthy crops and good yields. This concept was mistakenly eliminated with the use of more agrochemicals. At present, however, crop rotation is gaining interest and is of value in the context of integrated crop management. Weeds tend to thrive with crops of similar growth requirements. Cultural practices designed to contribute to the crop may also benefit the growth and development of weeds. Monoculture results in a build-up of weed species that are adapted to the growing conditions of the crop. When diverse crops are used in a rotation, weed germination and growth cycles are disrupted by variations in cultural practices associated with each crop (tillage, planting dates, crop competition, and weed control methods). Traditionally, potato was included in the rotation to reduce weed problems before a less competitive crop was grown. Introducing a fallow in the rotation is essential to reduce difficult weeds like perennials. It is best to alternate legumes with grasses, row crops with close planted crops and heavy feeders with light feeders.

The broad principles of ideal crop rotations are given below:

1. Alternating crops with a different type of vegetation
2. Alternating grass and dicot crops.
3. Alternating different crop cycles.
4. Avoiding succeeding crops of the same family.
5. Alternating poor and high weed competitors.
6. Avoiding problematic weeds in specific crops.

Cover crops: Rapid development and dense ground covering by the crop will suppress weeds. The inclusion of cover crops in the cropping system can suppress weed growth. Highly competitive crops may be grown as short duration 'smother' crops within the rotation. Additionally, cover crop residues on the soil surface will suppress weeds by shading and cooling the soil. When choosing a cover crop, consideration should always be given to how the cover crop will affect the succeeding crop. In addition, decomposing cover crop residues may release allelo chemicals that inhibit the germination and development of weed seeds. The cover-crop systems tend to control small seeded annual broadleaf weeds the best.

Planting patterns: Crop population, spatial arrangement, and the choice of cultivar (variety) can affect weed growth. Narrow row spacing and proper plant density assure that the crop rapidly closes the canopy. A closed canopy shades out late emerging weeds and prevents germination of weed seeds requiring light. Similarly, fast-growing cultivars can have a competitive edge over the weeds. Weeds seldom pose a problem once the canopy closure occurs.

Planting time: The crop planted at the right time showed more competitiveness towards weeds than late planted crop. Crops may be divided into warm and cool-season plants, depending on the optimal temperature for their growth. The planting date effects the time of emergence and early seedling vigour of the crop, which are important in determining crop competitiveness. Cool-season crops germinate at cooler soil temperatures and thus compete better against early emerging weeds than do warm-season crops. The crop should be planted at time when the temperatures are favourable for crop growth.

Mulching: Mulching or covering the soil surface can prevent weed seed germination by blocking light transmission preventing seed germination. Mulches may be classified as either natural or organic (straw, bark, compost) or synthetic (plastic). As natural mulches are difficult to apply over large areas, they are best for small, specialized areas. Natural mulches should be spread evenly at least 1.5 inches thick over the soil to prevent light penetration; weeds can easily manage to reach the surface if the layer is not thick enough. Allelopathic chemicals in natural mulch also can physically suppress seedling emergence. Some manual weeding may be required along with the practice of mulching. Natural mulch

materials must be free of weed seeds and other pest organisms and be heavy enough that they are not easily displaced by wind or water. A major advantage of natural mulches is their biodegradability adding organic matter to the soil. The use of plastic mulching is very popular in many areas. Plastic mulches have been developed that filter out photo synthetically active radiation, but let through infrared light to warm the soil. These infrared transmitting mulches have been shown to be effective at controlling weeds. Synthetic mulches control weeds within the row, conserve moisture, increase soil temperature, and are easy to apply. Black plastic mulches are the most common and are particularly effective in improving early season growth of warm-season crops. Better early season growth of these crops improves their competitive ability against weeds. plastic mulches used in combination with trickle irrigation also improve water use efficiency. The biggestd is advantage of plastic mulch is disposal, as many landfills do not accept it. Photodegradable plastic mulches have been developed, but their season long persistence is a problem. Also, photodegradable mulches just degrade into smaller pieces of plastic that still contaminate the environment. Biodegradable Plastic mulches are not yet widely available.

Mulching generally prevents the germination of light sensitive weeds like Ageratum conyzoides, Portulacaoleraceae etc. Some perennial weeds are not controlled (e.g. Cyperus spp., Convolvulus arvensis) by this process and for them inter-row cultivation herbicidal treatments are necessary.

Solarisation: In this process, moist soil is covered with a clear, thin transparent plastic sheet, to trap the soil radiation for 30-45 days. Solarization works when the heat created under the plastic film becomes intense enough to kill weed seeds. The maximal soil temperature reaches nearly 60°C under polyethylene covered plots. The factors involved in solarization are soil temperature, moisture and probably gases due to which solarization reduces the germination, establishment and biomass of heat sensitive weed species. Results are often variable, depending on weather conditions. In Northern India, high soil temperature (50-60°C) can develop in soil covered with transparent polyethylene sheets in May-June. Cold (high latitude) or cloudy places are usually not suitable for implementing solarization. Some species can tolerate Solarization (e.g. deep rooted perennials, viz. Sorghum halepense, Cyperus rotundus, and also some big weed seeds suchas legumes). After solarisation, the use of deep or mouldboard tillage must be avoided and the sowing should be done with minimal soil disturbance. This system is more suitable for small areas, but is widely used under plastic green house conditions.

Mechanical method: Mechanical removal of weeds is both time consuming and labor-intensive but is one of the most effective methods. Mechanical weed management starts with seedbed preparation. Moldboard plowing is usually the first step inmechanically managing weeds. It is particularlyuseful in controlling emerged annual weeds. Animportant second step is often rotary hoeing for mechanically managing weeds. Rotary hoeing needs to be done after the weeds germinate but before they emerge; it controls only small-seeded weeds. Once the crops have emerged or trans plants are established, a row cultivator may be used to manage emerged weeds. Adjust the cultivators weeps or teeth to dislodge or cover as many weed seedlings as possible. Seedling weeds can be killed by cultivating 1-2 inches deep. The best weed control is obtained with a row cultivator in relatively dry soils by throwing soil into the crop row to cover small weed seedlings. Avoid crop injury from poor cultivation, which reduces crop yields. Relying Entirely on mechanical practices to manage weeds is difficult on large acreages. Also, several weed se specially perennials, are extremely difficult to manage unless herbicides are combined with non chemical approaches. The tillage operations for seed bed preparation should be planned keeping in view with the type of weeds present in the field. When annual weeds are predominant (crucifers, solanaceous, grass weeds) the objectives are unearthing and fragmentation. This must be achieved through shallow cultivation. Ifweeds have no dormant seeds (Bromus spp.), deepploughing to bury the seeds will be advisable. If the seeds produced are dormant, this is not a good practice, because they will be viable again when they return to the soil surface after further cultivation. When perennial weeds are present, adequate tools willedpendon the types of rooting. Pivot roots (Rumex spp.) or bourgeon roots (*Cirsium* spp.) require fragmentation and this can be achieved by using a cultivator. Fragile rhizomes (*Sorghum Halepense*) require dragging and exposure at the soil surface for their depletion, but flexible rhizomes (*Cynodon Dactylon*) require dragging and removal from the field. This can be done with acultivator or harrow. Tubers (Cyperus rotundus) orbulbs (*Oxalis* spp.) require cutting when rhizomes are present and need to be dugup for exposure to adverse conditions (frost or drought). This can be done with the mouldboard or disk ploughing. Chisel Ploughing is useful for draining wet fields and reducing the infestation of deep-rooted hygrophilous perennials (Phragmites, Equisetum, Juncus). This is why reliable weed information is always necessary.

Chemical method

Herbicides offer a great scope for minimizing the cost of weed control irrespective of the situationand offer a good weed control alternative to culturalor mechanical methods in horticultural crops. Chemical control, however, is relatively poorlydeveloped in floriculture crops as they tend to be grown in relatively small areas, hence making use of herbicides expensive and uneconomical. With this method, less labour is required; this allows the transfer of labour to other activities. Usage of preemergence herbicides assumes greater importance in view of their effectiveness from the initial stages of crop growth, which is the most critical period of weed competition. The weed semerging later also compete with the crop and reduce its productivity and need for post-emergence herbicides or other non-chemical approaches described above. However, the herbicides alone could not provide long term control of a wide range of weed flora present in a field. This necessitates the use of an integrated approach for long term control of weeds. Several herbicides are often labeled for a crop. Scouting in your area to determine which weeds are present can allow you to select the herbicide that can give you the best control. Potential Environmental hazards must be considered when selecting a herbicide. Herbicide labels contain in formation on these hazards. The details of herbicides commonly used for weed control in flower corps are listed (Table 5). If an user is not familar with the use of herbicdes, it requires preliminary tests to verify its effectiveness in local conditions and selectivity to available crop cultivars.

Good practices during the use of herbicides

A summary of a 'decalogue' of good practices in the use of herbicides is provided below:

- Periodically inspect the fields and assess the weed of importance. Identify correctly the major weeds.
- The weed and crop stage of growth must be taken into account.
- Careful selection of the product and dosage, bearing in mind points one and two.
- Read the product label and follow the recommendations.
- Avoid adverse conditions at the time off application: wind, temperatures, rainfall. Do not delay treatment.
- Quality of the spraying is obtained by the correct calculation of dosage (surface to be treated must be well measured) and by the spraying quipment, which must be calibrated and in good condition (especially nozzles).
- Band or patch application to save herbicide and reduce residues.
- Keep to the environmental norms: avoid spills, drift, respect the edges, water ways, and sensitive areas. Rinse all empty cans or containers thrice and do not re-use them.
- To avoid propagation of resistant species, the same herbicide or herbicides with the same mode of action must not be used repeatedly.

Practices limiting weed spread

The easiest and cheapest way to control weeds is to prevent their introduction to the field. This goal can be accomplished a number of ways:

- Asking your dealer for a "Certificate of Seed Analysis." This certificate lists the weed seeds present in that seedlot.
- Cleaning equipment (e.g. combines) before moving to another field.
- Tarping grain loads to prevent weed seeds from blowing out during transport.
- Controlling weeds such as Canada thistle and scentless chamomile in ditches, field edges and around sloughs.
- Composting manure (one year minimum) to reduce the viability of many weed seeds.
- Monitoring fields. It may be possible to eradicate new lyintroduced weeds with spot spraying while populations are still low.
- Using chaff wagons to collect weed seed blowing out the back of the combine.

Table 5: List of herbicides for use in flower crops

Crop	Herbicide	Dose (kg/ha)	Time of application	Reference
Gladliolus	Oxyfluorfen	0.25	PRE	Manuja *et al*. (2005)
	Alachlor	1.0	PRE	Manuja *et al*. (2005)
	Atrazine	1-2	PRE	Chahal *et al*. (1994)
	Pendimethalin	0.75-1.0	PRE	Bhat and Sheikh (2015)
	Metribuzin	0.5	PRE	Rao *et al*. (2014)
	Butachlor	1.5	PRE	Rao *et al*. (2014)
	Pendimethalin + Metribuzin	0.75+0.3	PRE	Jankiram*et al*. (2014)
	Oxyflurofen	0.5	PPI	Yadav and Bose (1987)
	Glyphosate	1.0	POST-directed	Manuja *et al*. (2005)
Gerbera	Pendimethalin	1.0	PRE	Shalini and Patil (2006)
	Alachlor	1.5	PRE	Shalini and Patil (2006)
Rose	Diuron	2-2.5	PRE	Yaduraju *et al*. (1997), Rajamani *et al*. (1992)
	Glyphosate	0.5	POST- directed	Rajamani*et al*. (1992)
	Oxyfluorfen	1.0	PRE	Rajamani (1992)
	Atrazin	1.0-2.0	PRE	Kumar and Singh (2013)
	Metribuzine	0.75-1.50	PRE	Kumar and Singh (2013)
China aster	Oxyfluorfen	0.1	PRE	Kumar and Gowda (2010)
	Metolachlor	1.0	PRE	Kumar and Gowda (2010)
Marigold	Trifluralin	1.0	PPI	Kumar *et al*. (2010)
Tuberose	Metolachlor	2.0	PRE	Murthy and Gowda (1993)
	Pendimethalin	1.25	PRE	Murthy and Gowda (1993)
Winter annuals	Pendimethalin	0.50	PRE	Badhesha (2003)
(*Helichrysum-bracteaum, Coreopsis lanceolate Chrysanthemum carinatum)*				

PP- Pre-plant incorporation; PRE- Pre-emergence; POST- Post-emergence

Optimal herbicide use

Herbicides continue to be the most powerful tool for weed control. However, an integrated approach to weed management creates an opportunity to reduce herbicide rates or, in some instances, to forgo the herbicide altogether. The reduction of herbicide rates is not without risk. There is no recourse with herbicide companies regarding poor herbicide performance if label rates have not been followed. Still, farmers often cut rates as a cost saving strategy. The effectiveness of a cut rate will depend on the herbicide, weed species present, weed pressure, environmental conditions and, of course, the competitiveness of the crop stand. If weed pressure is high or the weeds are under stress (i.e. drought), it is probably not a good idea to cut back on herbicide rate.

Summary

Integrated weed management (IWM) is a sustainable cost effective approach to weed control that is constantly evolving. The approach combines many agronomic principles to favor crop competitiveness, create diversity in cropping patterns and prevents the introduction of new weed species. Using IWM creates an opportunity to use herbicides more judiciously, increasing economic returns and slowing the development of weed resistance to herbicides.

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