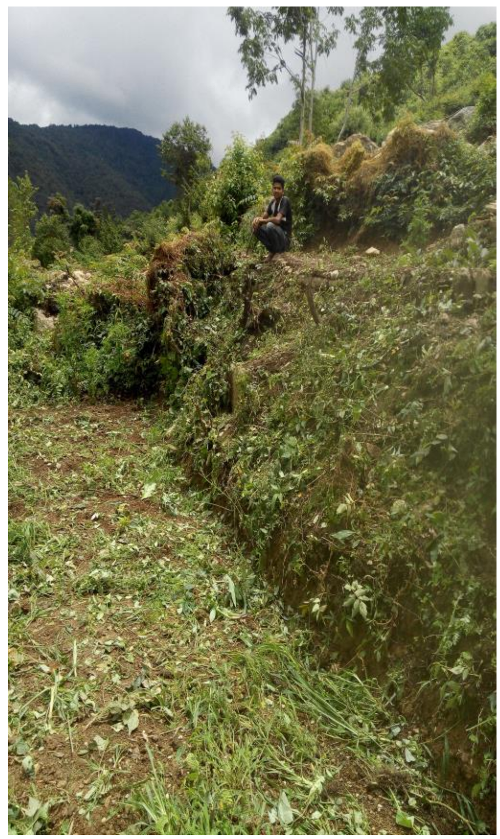
# Weed Management in Horticultural Crops



## 7. Weed Management in Horticultural Crops (HPH 205) 2 (1+1)

Weeds: Introduction, harmful and beneficial effects, classification, propagation and dissemination; Weed biology and ecology, crop weed association, crop weed competition and allelopathy. Concepts of weed prevention, control and eradication; Methods of weed control: physical, cultural, chemical and biological methods. Integrated weed management; Herbicides: advantages and limitation of herbicide usage in India, Herbicide classification, formulations, methods of application; Introduction to Adjuvants and their use in herbicides; Introduction to selectivity of herbicides; Compatibility of herbicides with other agro chemicals; Weed management in major field and horticultural crops, shift of weed flora in cropping systems, aquatic and problematic weeds and their control.

Practical: Identification of weeds; Survey of weeds in crop fields and other habitats; Preparation of herbarium of weeds; Calculations on weed control efficiency and weed index; Herbicide label information; Computation of herbicide doses; Study of herbicide application, equipment and calibration; Demonstration of methods of herbicide application; Preparation of list of commonly available herbicides; Study of phytotoxicity symptoms of herbicides in different crops; Biology of nut sedge, bermuda grass, parthenium and celosia; Economics of weed control practices; Tours and visits of problem areas.

## LECTURE I

**Aim:** To know weed definitions and their characteristics

**WEED**

**Definitions:**

Weed is a plant that originated under a natural environment and in response to imposed and natural environments, evolved and continues to do so as an interfering associate with our desired plant and activities.

Weed is a plant growing out of place and time. They are unwanted not useful, persistent and prolific, effectively competing with the beneficial and desirable crop plants for space, nutrients, sunlight and water, interfere with agricultural operations and thereby reducing the yield and quality of produce.

Weeds are unwanted and undeserved plants that interfere with the utilization of the land and water resources and thus adversely affect crop production and human welfare. **Thus a plant out of its place or a plant growing where it is not desired at that time is a weed**. This definition was given by Buchholtz in 1967.e.g. Bajra is a weed in pulse; Pulse is a weed in Bajra, Tomato is a weed in Brinjal field.

Weeds are all types of undesirable plants i.e. sedges, grasses, broad leaved weeds, aquatic plants, trees and parasitic flowering plants (*Striga*, *Orobanche*) affecting crop area and non- crop area (industrial side, road side, railway line, water tank, irrigation channel etc.).

Weeds are unwanted, pernicious and harmful plants which interfere with agricultural operations, increase labour, add to the cost of cultivation and reduce yield of crops. Weed has no species, but name was suggested **as a useless and harmful plant that persistently grows where it is quite unwanted.**

**Weed** is defined as the unwanted, undesirable plant, growing out of their proper place, which interfere with the utilization of natural resources, prolific, persistent, competitive, harmful and even poisonous in nature and can grow in adverse climatic conditions. (Jethro Tull: father of weed Science)

**Weediness:** Weediness is defined as the state or condition of a field, flower bed, lawn and so forth in which there is an abundance of weeds.

Weeds are plants that are unwanted in a given situation and may be harmful, dangerous or economically detrimental. Weeds are a serious threat to primary production and biodiversity. They reduce farm and forest productivity, displace native species and contribute significantly to land and water degradation. The costs of weeds to the natural environment are also high, with weed invasion being ranked second only to habitat loss in causing biodiversity decline.

Despite considerable government and private sector investment, weed invasion still represents a major threat to both the productive capacity of land and water and the integrity of our natural ecosystems. An efficient weed control programme can only be developed after the weed has been properly identified. Weeds can be managed using many different methods. The most effective management of weeds is usually achieved through collaboration and co-operation in partnerships between the community, land owners, agriculture, industry and the various levels of government, using a combination of methods in conjunction with a thorough follow-up campaign.

Weed management is an important component of plant protection improving the production potential of crops. It includes management of the weeds in a way that the crop sustains its production potential without being harmed by the weeds. Weed management is done through the mechanical, cultural and chemical means. Use of biological control methods in field crops is being considered, but still not much in use. Use of herbicides is an important method in the modern concept of weed-management technology. New hand-tools and implements have also been designed to assist in weed-management programme.

**Characteristics of weeds:**

- Weeds have rapid seedling growth and ability to reproduce when young e.g. Redroot Pigweed can flower and reproduce when it is less than eight inches tall.
- Weeds have quick maturation period or take only a short time in the vegetative phase *e.g.* **Canada thistle** can produce mature seeds in two weeks after flowering and **Russian thistle** seeds can germinate very quickly between $28^{0}$ -110 $^{0}$ F in late spring.
- Weeds may have dual mode of reproduction. Most weeds are angiosperms & reproduce by seeds and vegetatively too.
- Weeds have environmental plasticity. Many weeds are capable of tolerating and growing under a wide range of climatic and edaphic conditions.
- . Weeds are often self-compatible but self-pollination is not obligatory.
- If a weed is cross pollinated, this is accomplished by non- specified flower visitors or by wind.
- Weeds resist detrimental environmental factors. Most crop seed rot, if they do not germinate shortly after planting whereas, and weed seeds resist decay for long periods in soil and remain dormant for longer duration.

- Weed seeds exhibit several kinds of dormancy and escape the rigors of environment and germinate when conditions are more favourable for their survival. Many weeds have no special environment requirements for germination.
- Weeds often produce seeds of same size and shape as the crop seeds, making physical separation difficult and facilitating spread by men.
- Some annual weeds produce more than one seed flush per year and seed is produced as long as growing conditions permit.
- Each weed plant is capable of producing large number of seeds per plant and seed is produced over a wide range of environmental conditions.
- Many weeds have specially adapted long and short range seed dispersal mechanisms.
- Roots of some weeds are able to penetrate and emerge from deep in the soil, while most roots are in the upper foot of the soil *Canada thistle* roots routinely penetrate 3-6 feet and field bindweed roots upto 10 feet deep. Roots and rhizomes are capable of growing many feet per year.
- Roots and other vegetative parts of perennial weeds are vigorous with large food reserves, enabling them to withstand environmental stress.
- Perennials have bitterness in the lower stem nodes or in rhizomes and roots and, if severed vegetative organs will quickly regenerate in to whole plant.
- Many weeds have adaptation mechanism that repels grazing, such as spines, odd taste or odour.
- Weeds have great competitive ability for nutrients, light and water and can compete by special means (*e.g.* Rosette formation, climbing growth and allelopathy)
- Weeds are ubiquitous (present everywhere). They exist everywhere, where we practice agriculture.
- Weeds resist control, including herbicides.

## LECTURE II

**Aim:** To study the harmful and beneficial effects of weeds.

## HARMFUL AND BENEFICIAL EFFECTS OF WEEDS

### Harmful effects of weeds

Weeds have serious impacts on agricultural production. It is estimated that in general weeds cause 5% loss in agricultural production in most of the developed countries, 10% loss in less developed countries and 25% loss in least developed countries. In India, yield losses due to weeds are more than those from pest and diseases. Yield losses due to weeds vary with the crops. Every crop is exposed to severe competition from weeds. Most of these weeds are self-sown and they provide competition caused by their faster rate of growth in the initial stages of crop growth. In some crops, the yields are reduced by more than 50% due to weed infestation.

**Table: Losses caused by weeds in some of the important crops**

| Crop | Reduction in yields due to weeds (%) | Crop | Reduction in yield due to weeds (%) |
|---|---|---|---|
| Rice | 41.6 | Groundnut | 33.8 |
| Wheat | 16.0 | Sugarcane | 34.2 |
| Maize | 39.8 | Sugar beet | 70.3 |
| Millets | 29.5 | Carrot | 47.5 |
| Soybean | 30.5 | Cotton | 72.5 |
| Gram | 11.6 | Onion | 68.0 |
| Pea | 32.9 | Potato | 20.1 |

Weeds compete with crops for water soil, nutrients, light, and space, and thus reduce the crop yields. An estimate shows that weeds can deprive the crops 47% N, 42% P, 50% K, 39% Ca and 24% Mg of their nutrient uptake. Weeds also act as alternate hosts that harbour insects, pests, diseases and other microorganisms.

**Table: Alternate hosts of some of the pest and diseases are as given below**

| Crop | Pest | Alternate host |
|---|---|---|
| Sweet potato | Sweet potato weevil | *Convolvulus arvensis* |
| Potato | stalk borer, beetles and cutworms | *Chenopodium album* |

Some weeds release inhibitors of poisonous substances into the soil that may be harmful to the crop plants, human beings and livestock.

**Table: Health problems caused by weeds to humans**

| Health problem | Weed |
|---|---|
| Hay fever and Asthma | Pollen of *Ambrosia* and *Franseria* sp |
| Dermatitis | *Parthenium, Ambrosia* |
| Itching and Inflammation | *Utrica* sp |
| African sleeping sickness | Brush weeds |
| Malaria, encephalitis and filaria caused by mosquito | Aquatic weeds like *Pistia lanceolata, Salvinia auriculata* |

Weeds reduce the quality of marketable agricultural produce. Contamination of weed seeds of *Datura* sp, *Argemone* sp, *Brassica* sp etc., is harmful to human health and weed seeds present in the produce cause odd odour sometimes.

Weeds not only reduce yield but also interfere with agricultural operations. Weeds make mechanical sowing a difficult process and render harvesting difficult, leading to increased expenditure on labour, equipment and chemicals for their removal.

In aquatic environment, weeds block the flow of water in canals, water-transport system and drainage system, rendering navigation difficult. The dense growth of aquatic weeds pollutes water by deoxygenating it and killing the fishes.

Weeds are also a nuisance and a fire hazard along railway lines, roads, right-of-ways, airports, forests and industrial sites.

**Beneficial effects of weeds**

In spite of all the difficulties caused by weeds, they can offer some beneficial properties, particularly when occurring at low densities. These aspects should be utilized in the farming system, although this may make organic management more complicated than chemical based systems. Some of the potential benefits of weeds are listed below:

- Helping to conserve soil moisture and prevent erosion. A ground cover of weeds will reduce the amount of bare soil exposed helping to conserve nutrients, particularly nitrogen which could otherwise be leached away, especially on light soils.
- Food and shelter can be provided for natural enemies of pests and even alternative food sources for crop pests. The actual presence of weed cover may be a factor in increasing effectiveness of biological control of pests and reducing pest damage.
- Weeds can also be valuable indicators of growing conditions in a field, for example of water levels, compaction and pH.
- Weeds can be an important source of food for wildlife, especially birds. Bird populations have been declining on farmland over the last few decades and leaving weeds as a resource has been shown to help revive bird populations.

**LECTURE III**

**Aim:** To discuss about different classifications of weeds.

## CLASSIFICATION OF WEEDS

Out of 2,50,000 plant species, weeds constitute about 250 species, which are prominent in agricultural and non-agricultural system. Under world conditions about 30000 species are grouped as weeds which are classified as follows:

### I. Based on life span

Based on life span (Ontogeny), weeds are classified as Annual weeds, Biennial weeds and Perennial weeds.

#### a. Annual Weeds

Weeds that live only for a season or a year and complete their life cycle in that season or year are called as annual weeds.

These are small herbs with shallow roots and weak stems. Produces seeds in profusion and the mode of propagation is commonly through seeds. After seeding, the annuals die away and the seeds germinate and start the next generation in the next season or year following.

Most common field weeds are annuals. The examples are:

a. Monsoon annuals

*Commelina benghalensis, Boerhavia erecta*

b. Winter annuals

*Chenopodium album*

#### b. Biennials

They complete the vegetative growth in the first season, flower and set seeds in the succeeding season and then dies. These are found mainly in non-cropped areas.

e.g. *Alternanthera echinata, Daucus carota*

**c. Perennials**

Perennials live for more than two years and may live almost indefinitely. They adapt to withstand adverse environmental conditions. They propagate not only through seeds but also by underground stems, roots, rhizomes, tubers etc. and hence they are further classified into

i. Simple perennials: Plants propagated only by seeds *e.g. Sonchus arvensis*
ii. Bulbous perennials: Plants which possess a modified stem with scales and reproduce mainly from bulbs and seeds *e.g. Allium* sp.
iii. Corm perennials: Plants that possess a modified shoot and fleshy stem and reproduce through corm and seeds *e.g. Timothy* (*Phleum pratense*)

iv. Creeping perennials: They reproduce through seeds as well as with one of the followings:

a. Rhizome: Plants having underground stem – *Sorghum halepense*
b. Stolon: Plants having horizontal creeping stem above the ground – *Cynodon dactylon*
c. Roots: Plants having enlarged root system with numerous buds – *Convolvulus arvensis*
d. Tubers: Plants having modified rhizomes adapted for storage of food – *Cyperus rotundus*

**II. Based on ecological affinities**

**a. Wetland weeds**

They are tender annuals with semi-aquatic habit. They can thrive well under waterlogged and in partially dry conditions. Propagation is chiefly by seed *e.g. Ammania baccifera, Eclipta alba*

**b. Garden land weeds (Irrigated lands)**

These weeds neither require large quantities of water like wetland weeds nor can they successfully withstand extreme drought as dryland weeds *e.g. Trianthema portulacastrum, Digera arvensis*

**c. Dry lands weeds**

These are usually hardy plants with deep root system. They are adapted to withstand drought on account of mucilaginous nature of the stem and hairiness *e.g. Tribulus terrestris, Argemone mexicana.*

**III. Based on soil type (Edaphic)**

**(a) Weeds of black cotton soil:** These are often closely allied to those that grow in dry condition *e.g. Aristolochia bracteata*

**(b) Weeds of red soils:** They are like the weeds of garden lands consisting of various classes of plants e.g. *Commelina benghalensis*

**(c) Weeds of light, sandy or loamy soils:** Weeds those occur in soils having good drainage e.g. *Leucas aspera*

**(d) Weeds of laterite soils:** e.g. *Lantana camara, Spergula arvensis*

**IV. Based on place of occurrence**

**(a) Weeds of crop lands:** The majority of weeds infests the cultivated lands and cause hindrance to the farmers for successful crop production e.g. *Phalaris minor* in wheat

**(b) Weeds of pasture lands:** Weeds found in pasture / grazing grounds e.g. *Indigofera enneaphylla*

**(c) Weeds of waste lands:** Corners of fields, margins of channels etc., where weeds grow in profusion e.g. *Gynandropsis pentaphylla, Calotropis gigantean* etc.

**(d) Weeds of playgrounds, road-sides:** They are usually hardy, prostrate perennials, capable of withstanding any amount of trampling.e.g. *Alternanthera echinata, Tribulus terestris*

**V. Based on Origin**

**(a) Indigenous weeds:** All the native weeds of the country come under this group and most of the weeds are indigenous.e.g. *Acalypha indica, Abutilon indicum*

**(b) Introduced or Exotic weeds:** These are the weeds introduced from other countries. These weeds are normally troublesome and control becomes difficult.*e.g. Parthenium hysterophorus, Phalaris minor, Acanthospermum hispidum*

**VI. Based on cotyledon number**

Based on number of cotyledons they can be classified as dicots and monocots.

(a) Monocots e.g. *Panicum flavidum, Echinochloa colona*

(b) Dicots e.g. *Crotalaria verucosa, Indigofera viscosa*

**VII. Based on soil pH**

Based on pH of the soil the weeds can be classified into three categories.

(a) Acidophile – Acid soil weedse.g. *Rumex acetosella*

(b) Basophile – Saline & alkaline soil weeds e.g. *Taraxacum sp.*

(c) Neutrophile – Weeds of neutral soils e.g. *Acalypha indica*

**VIII. Based on morphology**

Based on the morphology of the plant, the weeds are also classified in to three categories. This is the most widely used classification by the weed scientists.

**(a) Grasses:** All the weeds which come under the family Poaceae are called as grasses which are characteristically having long narrow spiny leaves. The examples are *Echinocloa colonum, Cynodon dactylon.*

**(b) Sedges:** The weeds belonging to the family Cyperaceae come under this group. The leaves are mostly from the base having modified stem with or without tubers. The examples are *Cyperus rotundus, Fimbrystylis miliaceae.*

**(c) Broad leaved weeds:** This is the major group of weeds . All dicotyledon weeds are broad leaved weeds. The examples are *Flavaria australacica, Digera arvensis, Tridax procumbens*

**IX. Based on nature of stem**

Based on development of bark tissues on their stems and branches, weeds are classified as woody, semi-woody and herbaceous species.

**(a) Woody weeds:** Weeds include shrubs and under shrubs and are collectively called brush weeds e.g. *Lantana camera, Prosopis juliflora*

**(b) Semi-woody weeds:** e.g.*Croton sparsiflorus*

**(c) Herbaceous weeds:** Weeds have green, succulent stems and are of most common occurrence around us e.g. *Amaranthus viridis*

**X. Based on specificity**

Besides the various classes of weeds, a few others deserve special attention due to their specificity. They are: a). Poisonous weeds, b). Parasitic weeds and c). Aquatic weeds.

**a. Poisonous weeds**

The poisonous weeds cause ailment to livestock resulting in death and cause great loss. These weeds are harvested along with fodder or grass and fed to cattle or while grazing the cattle consume these poisonous plants e.g. *Datura fastuosa*, *D. stramonium* and *D. metel* are poisonous to animals and human beings. The berries of *Withania somnifera* and seeds of *Abrus precatorius* are poisonous.

**b. Parasitic weeds**

The parasite weeds are either total or partial which means, the weeds that depend completely on the host plant are termed as total parasites while the weeds that partially depend on host plant for minerals and capable of preparing its food from the green leaves are called as partial parasites. Those parasites which attack roots are termed as root parasites and those which attack shoot of other plants are called as stem parasites. The typical examples are;

- Total root parasite – *Orabanche cernua* on Tobacco
- Partial root parasite - *Striga lutea* on sugarcane and sorghum
- Total stem parasite - *Cuscuta chinensis* on lucerne and onion
- Partial stem parasite - *Cassytha filiformis* on orange trees and *Loranthus longiflorus* on mango and other trees.



**c. Aquatic weeds:**

Unwanted plants, which grow in water and complete at least a part of their life cycle in water are called as aquatic weeds. They are further grouped into four categories as submersed, emersed, marginal and floating weeds.

- *Submersed weeds:* These weeds are mostly vascular plants that produce all or most of their vegetative growth beneath the water surface, having true roots, stems and leave *e.g. Utricularia stellaris, Ceratophyllum demersum.*
- *Immersed weeds:* These plants are rooted in the bottom mud, with aerial stems and leaves at or above the water surface. The leaves are broad in many plants and sometimes like grasses. These leaves do not rise and fall with water level as in the case of floating weeds e.g. *Nelumbium speciosum, Jussieua repens.*
- *Marginal weeds:* Most of these plants are immersed weeds that can grow in moist shoreline areas with a depth of 60 to 90 cm water. These weeds vary in size, shape and habitat. The important genera that comes under this group are; *Typha, Polygonum, Cephalanthus, Scirpus, etc.*
- *Floating weeds:* These weeds have leaves that float on the water surface either singly or in cluster. Some weeds are free floating and some rooted at the mud bottom and the leaves rise and fall as the water level increases or decreases. *e.g. Eichhornia crassipes, Pistia stratiotes, Salvinia sp., Nymphaea pubescens*.

**LECTURE IV**

**Aim**: To study different methods of propagation and dissemination of weeds

**PROPAGATION OF WEED SEEDS**

**PROPAGATION**

Propagation is the process of multiplying or increasing the number of plants of the same species and at the same time perpetuating their desirable characteristics. There are two general methods of plant propagation: sexual and asexual propagation.

**Reproduction by seed**

Reproduction by seed is called sexual reproduction. It requires pollination and fertilization of an egg which results in seed that is capable of producing a new plant. Seed production varies greatly among and within weed species in part due to environmental variability between years, competition from neighboring plants, and genetic variability. For example, while Canada thistle has been observed to produce as few as 680 seeds per plant, Curly dock often produces more than 30,000 seeds per plant.

**Vegetative reproduction**

In vegetative (asexual) reproduction, a new plant develops from a vegetative organ such as a stem, root or leaf. Several modifications of these organs are common in perennial weeds, such as underground stems (rhizomes), above-ground stems (stolons), bulbs, corms, and tubers. Although vegetative structures generally do not survive as long in the soil as do seeds, very small structures can result in a new plant. Canada thistle, for example, can produce a new plant from as small as a 1/4-inch section of root.

Vegetative reproduction can be as prolific as seed production. Yellow nut-sedge (*Cyperus esculentus*) has been reported to produce more than 1,900 new plants and more than 6,800 tubers in 1 year.

Some of the vegetative propagules are described as follows:

- **Rhizome:** A horizontal, underground stem which can produce adventitious roots and shoots (i.e., new plants) at the nodes. A rhizome can be distinguished from a root because rhizomes have nodes, internodes, and scale leaves (rudimentary leaves). Roots do not have nodes or leaves. Johnson grass is example.
- **Stolon:** An above-ground stem that grows flat on the ground and can produce adventitious roots and shoots (i.e., new plants) at the nodes. Bermuda grass is example.
- **Tuber:** Enlarged terminal portion of rhizomes, possess extensive storage tissues and axillary buds. Yellow nut sedge is example.
- **Bulb:** Specialized underground storage organ consisting of fleshy leaves with a short stem at the base. Food storage in the leaves. Wild garlic is example.
- **Creeping roots**: Horizontal roots modified for food storage and vegetative reproduction (can give rise to shoots). Often deep in the soil. Carolina horse nettle is example.

**DISSEMINATION / DISPERSAL OF WEEDS**

- A plant seed is a unique genetic entity, a biological individual. However, a seed is in a diapause state, an essentially dormant condition, awaiting the ecological conditions that will allow it to grow into an plant, and produce its own seeds.
- Seeds must therefore germinate in a safe place, and then establish themselves as a young seedling, develop into a juvenile plant, and finally become a sexually mature adult that can pass its genetic material on to the next generation.
- The chances of a seed developing are generally enhanced if there is a mechanism for dispersing to an appropriate habitat at some distance away from the parent plant.
- The reason for dispersal is that closely related organisms have similar ecological requirements. Obviously, competition with the parent plant will be greatly reduced if its



seeds have a mechanism to disperse some distance away. Their ability to spread and remain viable in the soil for years makes eradication nearly impossible.

- Seeds have no way to move on their own, but they are excellent travellers. Plants have evolved various mechanisms that disperse their seeds effectively.
- Many species of plants have seeds with anatomical structures that make them very buoyant, so they can be dispersed over great distances by the winds.
- In the absence of proper means of their dispersal, weeds could not have moved from one country to another.
- An effective dispersal of weed seeds and fruits requires two essentials a successful dispersing agent and an effective adaptation to the new environment.

**There are two ways of looking at weed seed dispersal:**

- The expanding range and increasing population size of an invading weed species into a new area
- The part of the process by which an established and stabilized weed species in an area maintains itself within that area Dissemination includes two separate processes. They are dispersal (leaving mother plant) and post-dispersal events (subsequent movement). Dispersal of seed occurs in 4 dimensions *viz.*

1. Length
2. Width: Land/habitat/soil surface area phenomena
3. Height : soil depth, in the air
4. Time: shatters immediately after ripening (or) need harvesting activity to release seed

Common weed dispersal agents are Wind, Water, Animals, Human, Machinery, etc.

**(a) Wind**

Many seeds are well adapted to wind travel. Cottony coverings and parachute-like structures allow seeds to float with the wind. Examples of wind-dispersed seeds include common milkweed (*Asclepias syriaca),* common dandelion, Canada thistle, and perennial sowthistle (*Sonchus arvensis).* Weed seeds and fruits that disseminate through wind possess special organs to keep them afloat. Such organs are:

- Pappus – It is a parachute like modification of persistent calyx into hairs *e.g.* Asteraceae family weeds - *Tridax procumbens*
- Comose - Some weed seeds are covered with hairs, partially or fully *e.g. Calotropis* sp.
- Feathery, persistent styles - Styles are persistent and feathery e.g. *Anemone* sp.

- Baloon - Modified papery calyx that encloses the fruits loosely along with entrapped air *e.g. Physalis minima*
- Wings - One or more appendages that act as wings e.g. *Acer macrophyllum*

**Factors that influence wind dispersal:**

- seed weight
- seed shape
- structures (wings or pappus)
- height of release
- wind speed and turbulence

**(b) Water**

Aquatic weeds disperse largely through water. They may drift either as whole plants, plant fragments or as seeds with the water currents. Terrestrial weed seeds also disperse through irrigation and drainage water. Weed seed often moves with surface water runoff into irrigation water and ponds, where it is carried to other fields. Weeds growing in ditch banks along irrigation canals and ponds are the major source of weed seed contamination of irrigation water.

Weed seed often remains viable in water for several years, creating a "floating seed bank" and allowing weeds to disperse over large areas in moving water. Field bindweed seed, for example, remains over 50 per cent viable after being submerged in water for more than 4 years. Some seeds have special adaptations that aid in water travel. The seed pod of curly dock, for example, is equipped with pontoons that carry the floating seed.

**(c) Animals**

Several weed species produce seeds with barbs, hooks, spines, and rasps that cling to the fur of animals or to clothing and then can be dispersed to long distances. Farm animals carry weed seeds and fruits on their skin, hair and hooves. This is aided by special appendages such as Hooks (*Xanthium strumarium*), Stiff hairs (*Cenchrus* spp), Sharp spines (*Tribulus terrestris*) and Scarious bracts (*Achyranthus aspera*). Even ants carry a huge number of weed seeds. Donkeys eat *Prosophis julifera* pods.

Weed seeds are often ingested and passed through the digestive tracts of animals. Animal droppings provide an ideal nutrient and moisture environment for weed germination. Only a small percentage of the seed remains viable after exposure to an animal's digestive enzymes. The ingested weed seeds are passed in viable form with animal excreta (0.2% in chicks, 9.6% in calves, 8.7% in horses and 6.4% in sheep), which is dropped wherever the animal moves. This mechanism of weed dispersal is called **endozoochory** *e.g. Lantana* seeds by birds, *Loranthus* seeds stick on beaks of birds. Viable weed seeds are present in the dung of farm animals, which form part of the FYM. Besides, addition of mature weeds to compost pit as farm waste also act as source.

**(d) Dispersal by Man**

Man disperses numerous weed seeds and fruits with raw agricultural produce. Weeds mature at the same time and height along with crop. Due to their similar size and shape as that of crop seed man unknowingly harvest the weeds also, and aids in dispersal of weed seeds. Such weeds are called "Satellite weeds" *e.g. Avena fatua, Phalaris minor*.

**(e) Dispersal by machinery**

Weed seeds often are dispersed by tillage and harvesting equipments. Seeds move from field to field on the soil that sticks to tractor tires, and vegetative structures often travel on tillage and cultivation equipment and latter dropping them in other fields to start new infestation. Disc-type cultivation equipment is less likely to drag vegetative plant parts than are shovels or sweeps.

**(f) Intercontinental movement of weeds**

Introduction of weeds from one continent to another is through crop seed, feed stock, packing material and nursery stock *e.g. Parthenium hysterophorus*

**(g) Crop mimicry dispersal**

Weed seed adaptations to look like crop seed: plant body or seed same size, shape, and morphology as crop *e.g.* barnyard grass biotype looking like rice escapes hand weeding and is dispersed with rice. Nightshade fruit (berries) are same size, shape as dry beans, harvested and dispersed with beans.

**(h) As admixtures with crop seed, animal feed, hay, and straw**

Weeds probably are spread more commonly during the seeding of a new crop or in animal feed and bedding than by any other method. Seed labels often indicate a tiny percentage of weed seed, but consider this example. If a legume seed contains 0.001 percent dodder (a parasitic annual; *Cuscuta campestris)* seed by weight, there will be eight dodder seeds per 2 kg of legume seed. If the legume seed is sown in a field despite an extremely low dodder seed percentage by weight, the small size of the seed, combined with rapid early-season growth, could result in an infested legume field within a single season.



## LECTURE V

**Aim:** To study the biology and ecology of different weed species.

**WEED BIOLOGY AND ECOLOGY**

**WEED BIOLOGY**

Weed biology is the study of the establishment, growth, reproduction, and life cycles of weed species and weed societies/vegetation. Weed biology is an integrated science with the aim of minimizing the negative effects, as well as using and developing the positive effects, of weeds.

1. **Life Cycle -** Based on life cycle weeds are classified as annuals, biennials and perennials.

**Annuals**

Annuals complete their life cycle from seed in less than one year. There are two types: summer and winter annuals. Summer annuals germinate in the spring, mature, produce flowers and seeds and die before fall. Winter annuals germinate in the fall, overwinter in a seedling or rosette stage, mature, produce flowers and seeds, and die in the spring or early summer. Because of the seedling stage, annual weeds are generally easy to control.

**Biennials**

Biennials generally complete their life cycle in two years. The first year the seeds germinate and form a basal cluster of leaves and a tap root. The plant overwinters in this stage. During the second year the weed produces a flower stalk, sets seed and dies. Examples of biennial weed are evening primrose and wild carrot.

**Perennials**

Perennial weeds live for more than two years. These weeds are the most common in blueberry fields and generally the most difficult to control. Perennial weeds may reproduce primarily by seed (daisy); by both seed and roots (sheep sorrel); or primarily by vegetative means (bunchberry). Many perennial weeds grow in the same manner as the blueberry plant. Therefore, many of the production practices that promote blueberry growth (e.g. pruning) also promote growth of these weeds. Perennials which are low growing and spread vegetatively by interconnected underground root systems are the most difficult to control. Perennial weeds growing above the blueberries may be controlled by wiping or spot treatments with registered herbicides. Perennial weeds include both woody and herbaceous species.

1. **Growth Characters** – Based on growth characters weeds are classified as grasses, broadleaf weeds, ferns and herbaceous or woody weeds.

**Broadleaf**

Broadleaf weeds are annual, biennial or perennial plants which generally have two leaves (cotyledons) emerging upon germination. The leaves normally have a branching network of veins and the flowers have distinct petals.

**Grasses, Sedges and Rushes**

Grasses can be annual or perennial plants. They generally have narrow, upright, parallel-veined leaves. Grasses have jointed stems, usually hollow at the internodes and are circular in cross section.

Sedges are a large group of perennial (rarely annual) grass-like plants which are common in wet, poorly drained soils. Sedge stems are triangular in cross section, solid, and not jointed.

Rushes are annual or perennial plants similar in appearance to sedges with grass-like tufted leaves common at the plant base. Rush stems are hollow, circular in cross section, and not jointed. Like the sedge, this plant is also common in wet areas or poorly drained soil, but is also found in woodland and open fields.

**Ferns**

Ferns are primitive perennial plants that do not produce flowers and seeds. Ferns consist of a leaf or frond, a stalk and an expanded blade which may then be further subdivided several times. Ferns spread by long creeping rhizomes and/or by spores.

2. **Reproductive Strategy** – Based on reproductive strategy weeds are classified as seed, vegetative reproduction.

**Reproduction by seed**

Reproduction by seed is called sexual reproduction. It requires the fertilization of an egg by sperm, usually in the form of pollen. Pollination of the egg in a flower results in formation of seed that is capable of producing a new plant. Seed production varies greatly among and within weed species in part due to environmental variability between years, competition from neighboring plants, and genetic variability.

Through sexual reproduction abundant and small seeds are produced. Annual and biennial weeds depend on seed production, as the sole means of propagation and survival of perennial weeds are less dependent on this mechanism. For example, while Canada thistle has been observed to produce as few as 680 seeds per plant, curly dock often produces more than 30,000 seeds per plant.

The seed production capacity of some of the weeds is given in the table:

| **Ontogeny** | **Seeds/plant** | **Name of weed/crop** | **Seeds/plant** |
|---|---|---|---|
| Perennials | 16,629 | *Amaranthus retroflexus* | 1,96,405 |
| Biennials | 26,600 | *Solanum nigrum* | 1,78,000 |
| Annuals | 20,832 | *Chenopodium album* | 72,000 |

| | | | |
|---|---|---|---|
| | | *Trianthema portulacastrum* | 52,000 |
| | | Wheat & Rice | 90 to 100 |

A few weeds may produce seed through apomixis i.e without fertilization *e.g.* Ferns reproduce by spores.

**Vegetative Reproduction**

In vegetative (asexual) reproduction, a new plant develops from a vegetative organ such as a stem, root, or leaf. Several modifications of these organs are common in perennial weeds, such as underground stems (rhizomes), above-ground stems (stolons), bulbs, corms, and tubers. Although vegetative structures generally do not survive as long in the soil as do seeds, very small structures can result in a new plant. Vegetative reproduction can be as prolific as seed production.

**WEED ECOLOGY**

Weed ecology is the study of the interaction or relationship between a weed and its environment (other living organisms as well as abiotic factors). Ecology is concerned with growth characteristics and adaptations that enable weeds to survive the change in the environment. Man plays an important role in changing the environment by altering the crop husbandry practices and by maintaining weed free monocrop or multicrop culture. For effective weed control, the study on both biology and ecology of a weed species are important.

**The weed seed bank and seed dormancy**

Not only can weed seed and vegetative tissue travel great distances to infest new fields, but once in the soil, weed seed can remain viable for many years. In any given location, the weed seed bank contains a vast library of weed species and ecotypes that are adapted to a great range of environmental conditions and are ready to germinate given the proper signal. A study reported that a square foot of soil, 6 inches deep, contained 98 to 3,068 viable weed seeds. This represents between 4.3 million and 133 million viable seeds per acre.

The amount of time that a seed is capable of producing a seedling, or its viability, varies with weed species. In the extreme, lotus (*Nelumbo nucifera)* seeds found in a Manchurian lakebed were viable after 1,000 years. More commonly, the annual plant jimsonweed (*Datura stramonium)* has over 90 percent germination rate after 40 years in the soil.

Additionally, many weed seeds remain dormant in the soil until the conditions for germination and survival are appropriate for that particular seed. Dormancy is the seed's resting stage and is the primary method of weed seed dispersal in time. Some weed seeds have seed coats that are impermeable to water and/or oxygen or are mechanically resistant. Others contain immature embryos or have a waiting period (called after-ripening) that must be completed before the seed will germinate. Seed dormancy is affected by environmental conditions, including temperature, light, oxygen, and the presence of chemical inhibitors.

**Seed dormancy as survival mechanism**

Weed seeds possess a variety of special germination mechanisms adapted to changes in temperature, moisture, aeration, exposure to light, depth of burial of seeds etc., when conditions are unfavourable for germination, they can remain dormant or delay germination.

Conditions favourable for weeds seed germination are:

- Seeds of many weeds require an exposure to light for germination. This is regulated by bluish-green protein pigment called phytochrome.
- Many weed seeds germinate under aerobic conditions while some require anaerobic condition. Soil turnover during ploughing and other operations exposes the seeds to light and induces germination.
- Periodicity of germination is another specialised germination mechanism. *Amaranths sp.* have a definite pattern of peaks of germination at regular intervals.
- Summer annuals are favoured at higher temperature & winter annuals germinate at lower temperatures some weeds germinate freely throughout the year.

**Seed Dormancy:** Dormancy is a state of seeds and buds in which they are alive but not germinated. If all weed seeds were to germinate at one time, their seedlings could be destroyed. Dormancy allows storage of millions of weed seeds in soil and enables them to grow in flushes over years. In this context, the old gardeners saying "*One year seeding seven years weeding*" is very appropriate. In fact, weed seeds have been found viable even after 20-80 years of burial in soil. Weed seeds exhibit three types of dormancy:

**(1) Enforced Dormancy**: It is due to deep placement of weed seeds in soil during ploughing of the field. Weed seeds germinate readily when they are restored to top 3 to 5 cm. Enforced Dormancy is a non-specific character of seed. Cultivation encounters enforced dormancy by bringing the weeds to surface where they are exposed to light besides better aeration. High soil temperature and $NO_3$ content of surface soil may further help in breaking seed dormancy.

**(2) Innate dormancy:** It is a genetically controlled character and it is a feature of specific weed seeds which fail to germinate even if they are present in the top 3-5 cm soil and adequate soil moisture and temperature provided to them. The possible reasons are the presence of:

(i) Hard seed coats *e.g.*, *Setaria*, *Ipomoea*, *Xanthium* spp.

(ii) Immature embryos *e.g.*, *Polygonum*

In certain weed seeds particularly of Xerophytic origin, presence of inhibitors is responsible for innate dormancy. It can be overcome with passage of time, or under the influence of some climatic pressure.

**(3) Induced Dormancy:** Induced dormancy results from some sudden physiological change in normally non-dormant weed seeds under the impact of marked rise in temperature and or $CO_2$ content of soil, low $O_2$ pressure, water logging etc.

*Wild oat (Avena fatua) seeds exhibit all three kinds of dormancy*.

**PERSISTENCE OF WEEDS (ADAPTATION)**

Persistence is an adaptive potential of a weed that enables it to grow in any environment. In an agricultural situation, the cropping system with its (associated habitat) management practices, determines the persistence of weed species. It is largely influenced by climatic, edaphic (soil) and biotic factors, which affect its occurrence, abundance, range and distribution.

**Factors Affecting Persistence**

**A. Climatic factors**

Climate can effect variations in cuticle development, pubescence, vegetative growth, vigour, competitiveness *etc*. Climate thus has a profound effect on the persistence of weeds which can adapt to a wide variety of climates. The important climatic factors are light, temperature, rainfall, wind and humidity.

i) Light:

Light intensity, quality and duration are important in influencing the germination, growth, reproduction and distribution of weeds. Photoperiod governs flowering time, seed setting and maturation and on the evolution of various ecotypes within a weed species. Tolerance to shading is a major adaptation that enables weeds to persist.

ii) Temperature:

Temperature of atmosphere and soil affects the latitudinal and longitudinal distribution of weeds. Soil temperature affects seed germination and dormancy, which is a major survival mechanism of weeds.

iii) Rainfall:

Rainfall has a significant effect on weed persistence and distribution. More rainfall or less rainfall determines reproduction & survival.

iv) Wind:

Wind is a principal factor in the dissemination of weeds.

**B. Soil factors:**

Soil factors are soil water, aeration, temperature, pH and fertility level and cropping system. Some weed species are characteristically alkali plants, known as basophilic (pH 8.5) which can grow well in alkali soils and those grow in acidic soil is known as Acidophiles.

| Basophiles | | Acidophiles | Neutophiles |
|---|---|---|---|
| Alkaligrass | – *Puccinalia* spp. | *Cynodon dactylon* | common weeds |
| Quack grass | – *Agrophyron repens* | *Digitaria sanguinalis* | |

Several weed species of compositae family grow well in saline soils. A shift in soil pH, towards acid side due to continuous use of Ammonium sulphate as a 'N' source could cause a shift in the weed spectrum.

Many weeds can grow well in soils of low fertility level however, can adapt well to soils of high fertility also. Weeds also has adaptation to moist soil, drought condition etc.

**C. Biotic factors:** In a cropping situation, the major effects on weeds are those exerted by the crop as it competes for available resources. Once, a particular weed species is introduced, its persistence is determined by the degree of competition offered by the crop and also the agricultural practices associated with the growing of a crop may encourage or discourage specific weeds.

*e.g.* Ponding of water – *Cynodon* dies

Repeated cultivation – discourage nut sedge.

Crops that serve as hosts to parasitic weeds, (Sorghum – Striga) crop-induced stimulants are examples of other biotic factors.



## LECTURE VI

**Aim**: To study the weed competition with main crops for nutrients, moisture, light, space and losses caused by weeds

### CROP-WEED ASSOCIATION

Weeds possess many growth characteristics and adaptations which enable them to successfully exploit the numerous ecological niches left unoccupied by crop cultures. Weeds compete with themselves and with crop plant. Among the more important adaptations relevant to competitive advantage are properly synchronized germination, rapid establishment and growth of seedlings, tolerance to shading effects by the crop or by other weeds at the time of establishment, quick response to available soil moisture and nutrients, adaptation to the most severe climatic situations of the habitat, adaptations to the edaphic regime, relative immunity to post seeding soil disturbance, practices and resistance to herbicides that are used. In the initial stages of invasion by weeds of exposed ecological niches, only a very limited competition for resources by the crop and weed may occur, but as establishment of the crop-weed association is completed, competition for the available resources is more obvious.

Plant competition is a natural force whereby crop and weed plants tend to attain a maximum combined growth and yield, with the development of each species being to some extent at the expense of the other. It occurs when the demands of the plants for moisture, nutrients, light, and possibly carbon dioxide exceed the available supply. Competition may develop between crop and weed plants and also between individual plants of each. The ultimate outcome of competition usually results in the development of a characteristic crop-weed association. Crop plants and weeds may grow and mature in the state of mutual suppression that is often found in crops where no suitable herbicide is available to control the weeds. The weed suppresses the crop and result in reduction of yield. The crop also suppresses the weeds, a condition often found in row crop cultures. This is a logical sequence in a crop habitat where both cultural and herbicide methods provide effective control.

A principle of plant competition is that the first plants to occupy an area have an advantage over latecomers. This principle is of foremost consideration in practical weed control, where cropping practices are always directed to the establishment of the crop ahead of the weeds.

Competition and allelopathy are the main interactions which are of importance between crop and weed. Allelopathy is distinguished from competition because it depends on a chemical compound being added to the environment while competition involves removal or reduction of an essential factor or factors from the environment, which would have been otherwise utilized.

**CROP WEED COMPETITION**

Weeds appear much more adapted to agro-ecosystems than our crop plants. Without interference by man, weeds would easily wipe out the crop plants. This is because of their competition for nutrients, moisture, light and space which are the principle factors of production of crop. Generally, an increase in on kilogram of weed growth will decrease one kilogram of crop growth.

**1. Competition for Nutrients**

Weeds usually absorb mineral nutrients faster than many crop plants and accumulate them in their tissues in relatively larger amounts.

- *Amaranthus* sp. accumulates over 3% N on dry weight basis and is termed as "nitrophil".
- *Achyranths aspera*, a 'P' accumulates over 1.5% $P_2O_5$
- *Chenopodium* sp & *Portulaca* sp. are 'K' lovers with over 1.3% $K_2O$ in dry matter

**Mineral composition of certain common weeds on dry matter basis:**

| **S.No** | **Species** | **N(%)** | **$P_2O_5$(%)** | **$K_2O$(%)** |
|---|---|---|---|---|
| 1. | *Achyranthus aspera* | 2.21 | 1.63 | 1.32 |
| 2. | *Amaranthus viridis* | 3.16 | 0.06 | 4.51 |
| 3. | *Chenopodium album* | 2.59 | 0.37 | 4.34 |
| 4. | *Cynodon dactylon* | 1.72 | 0.25 | 1.75 |
| 5. | *Cyperus rotundus* | 2.17 | 0.26 | 2.73 |
| **Crop plants** | | | | |
| 1. | Rice | 1.13 | 0.34 | 1.10 |
| 2. | Sugarcane | 0.33 | 0.19 | 0.67 |
| 3. | Wheat | 1.33 | 0.59 | 1.44 |



- The associated weed is responsive to nitrogen and it utilizes more of the applied 'N' than the crop e.g. The 'N' uptake by *Echinochloa crusgalli* is more than rice.
- Nutrient removal by weeds leads to huge loss of nutrients in each crop season, which is often twice that of crop plants. For instance at early stages of maize cultivation, the weeds found to remove 9 times more of N, 10 times more of P and 7 times more of K.

**2. Competition for moisture**

- In general, for producing equal amounts of dry matter, weeds transpire more water than do most of our crop plants. It becomes increasingly critical with increasing soil moisture stress, as found in arid and semi-arid areas.
- As a rule, $C_4$ plants utilize water more efficiently resulting in more biomass per unit of water. *Cynodon dactylon* had almost twice as high transpiration rate as pearl millet.
- In weedy fields soil moisture may be exhausted by the time the crop reaches the fruiting stage, i.e. the peak consumptive use period of the crop, causing significant loss in crop yields.

**3. Competition for light**

- It may commence very early in the cop season if a dense weed growth smothers the crop seedlings.
- It becomes important element of crop-weed competition when moisture and nutrients are plentiful.
- In dry land agriculture in years of normal rainfall the crop-weed competition is limited to nitrogen and light.
- Unlike competition for nutrients and moisture once weeds shade a crop plant, increased light intensity cannot benefit it.

**4. Competition for space ($CO_2$)**

Crop-weed competition for space is the requirement for $CO_2$ and the competition may occur under extremely crowded plant community condition. A more efficient utilization of $CO_2$ by $C_4$ type weeds may contribute to their rapid growth over $C_3$ type of crops.

**LOSSES CAUSED BY WEEDS**

**1. Reduction in crop yield**

Weeds compete with crop plants for nutrients, soil moisture, space and sunlight. In general an increase in one kilogram weed growth corresponds to reduction in one kilogram of crop growth. Depending on type of weed, intensity of infestation, period of infestation, the ability of crop to compete and climatic conditions the loss varies.

Among the pests weeds account for 45 % reduction in yield while the insects 30%, diseases 20% and other pests 5%.

**2. Loss in crop quality**

If a crop contains weed seeds it is to be rejected, especially when the crop is grown for seed. For example, the wild oat weed seeds are similar in size and shape of the crops like barley, wheat, and its admixture may lead to rejection for seed purpose. Contamination by poisonous weed seeds is unacceptable and increases costs of crop cleaning. The leafy vegetables much suffers due to weed problem as the leafy weed mixture spoil the economic value.

**3. Weeds as reservoirs of pests and diseases**

Weeds form a part of community of organisms in a given area. Consequently, they are food sources for some animals, and are themselves susceptible to many pests and diseases. However, because of their close association with crop they may serve as important reservoirs or alternate host of pests and diseases.

**4. Interference in crop handling**

Some weeds can make the operation of agricultural machinery more difficult, more costly and even impossible. Heavy infestation of *Cynadon dactylon* causes poor ploughing performance.

**5. Reduction in land value**

Heavy infestation by perennial weeds could make the land unsuitable are less suitable for cultivation resulting in loss in its monetary value. Thousands of hectare of cultivable area in rice growing regions of India have been abandoned or not being regularly cultivated due to severe infestation of nutgrass (*Cyperus rotundus*) and other perennial grasses.

**6. Limitation of crop choice**

When certain weeds show heavy infestation, it will limit the growth of a particular crop. The high infestation of parasitic weeds such as *Striga lutea* may limit the growing of sorghum or sugarcane.

**7. Loss of human efficiency**

Weeds reduce human efficiency through physical discomfort caused by allergies and poisoning. Weeds such as congress grass (*Parthenium hysterophorus*) causes itching. Thorny weeds like *Solanum* spp. restrict movement of farm workers in carrying out farm practices such as fertilizer application, insect and disease control measures, irrigation, harvesting etc.

**8. Problems due to aquatic weeds**

The aquatic weeds that grow along the irrigation canals, channels and streams restricts the flow of water. Weed obstruction cause reduction in velocity of flow and increases stagnation of water and may lead to high siltation and reduced carrying capacity. Aquatic weeds form breeding grounds for obnoxious insects like mosquitoes. They reduce recreational value by interfering with fishing, swimming, boating, hunting and navigation on streams and canals.

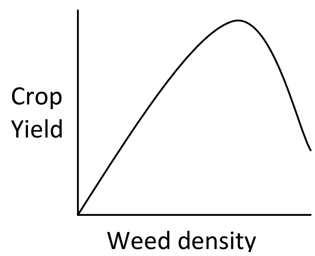
**9. Other problems**

Weeds are troublesome not only in crop plants but also in play grounds and road sides etc. *Alternanthera echinata* and *Tribulus terresstris* occurs in many playgrounds causing annoyance to players and spectators.

**FACTORS AFFECTING THE COMPETITIVE ABILITY OF CROPS AGAINST WEEDS**

**1. Density of weeds**: Increase in density of weeds and ultimately decrease in yield is a normal phenomenon. However, it is not linear as few weeds do not affect the yields so much as other weed does and hence, it is a sigmoidal relationship.




**2. Crop density**: Increase in plant population decreases weed growth and reduce competition until they are self-competitive. Crop density and rectangularity are very important in determining the quantum and quality of crop environment available for the growth of weeds. Wide row spacing with simultaneous high, intra-row crop plant population may induce dense weed growth. In this respect, square planting of crops in which there are equal row and plant spacing should be ideal in reducing intra-crop plant competition.

**3. Type of weeds species:** The type of weeds that occur in a particular crop influences the competition. Occurrence of a particular species of weed greatly influences the competition between the crop & weed. For example *E. crusgalli* in rice, *Setaria viridis* in corn and *Xanthium* sp. in soybean affects the crop yield. *Flavaria australasica* offers more competition than the grasses

**4. Type of crop species and their varieties**: Crops and their varieties differ in their competing ability with weeds e.g., the decreasing order of weed competing ability is as: barley, rice, wheat and oat. High tolerance of barley to competition from weeds is assigned to its ability to develop more roots that are extensive during initial three weeks growth period than the others.

Fast canopy forming and tall crops suffer less from weed competition than the slow growing and short stature crops. Dwarf and semi-dwarf varieties of crops are usually more susceptible to competition from weeds than the tall varieties because they grow slowly at initial stage. In addition, their short stature covers the weeds less effectively. When we compare the crop-weed competition between two varieties of groundnut TMV 2 (Bunch) and TMV 3 (Spreading), TMV 2 incurred a loss of over 30% pod yield under uncontrolled weed - crop competition while TMV 3 lost only about 15% of its yield. The main reason is due to the spreading nature of TMV 3, which smothered weeds. Longer duration cultivars of rice have been found more competitive to weeds than the short duration ones.

**5. Soil factors:** Soil type, soil fertility, soil moisture and soil reaction influences the crop weed competition. Elevated soil fertility usually stimulates weeds more than the crop, reducing thus crop yields. Fertilizer application of weedy crop could increase crop yields to a much lower level than the yield increase obtained when a weed free crop is applied with fertilizer.

Weeds are adapted to grow well and compete with crops, in both moisture stress and ample moisture conditions. Removal of an intense moisture stress may thus benefit crops more than the weeds leading to increased yields. If the weeds were already present at the time of irrigation, they would grow so luxuriantly as to completely over power the crops. If the crop in irrigated after it has grown 15 cm or more in a weed free environment irrigation could hasten closing in of crop rows, thus suppressing weeds.

Abnormal soil reactions often aggravate weed competition. Specific weed species suited to different soil reactions exist with us, our crops grow best only in a specified range of soil pH.

***6.* Climate**: Adverse weather condition e.g. drought, excessive rains, extremes of temperature, will favour weeds since most of our crop plants are susceptible to climatic stresses. It is further intensified when crop cultivation is stratified over marginal lands. All such stresses weaken crops inherent capacity to fight weeds.

***7.* Time of germination**: In general, when the time of germination of crop coincides with the emergence of first flush of weeds, it leads to intense Crop-Weed interference. Sugarcane takes about one month to complete its germination phase while weeds require very less time to complete its germination.

Weed seeds germinate most readily from 1.25 cm of soil and few weeds can germinate even from 15cm depth. Therefore, planting method that dries the top 3 to 5 cm of soil rapidly enough to deny weed seeds opportunity to absorb moisture for their germination usually postpones weed emergence until the first irrigation. By this time the crop plants are well established to compete with late germinating weeds.

***8.* Cropping practices**: Cropping practices, such as method of planting crops, crop density and geometry and crop species and varieties have pronounced effects on Crop-Weed interference.



***9.* Crop maturity*:*** Maturity of the crop is yet another factor which affects competition between weeds & crop. As the age of the crop increases, the competition for weeds decreases due to its good establishment. Timely weeding in the early growth stages of the crop enhances the yield significantly.

**Critical period of weed competition**

Critical period of weed competition is defined as the shortest time span during the crop growth when weeding results in highest Economic returns.

The critical period of crop-weed competition is the period from the time of sowing up to, which the crop is to be maintained in a weed free environment to get the highest economical yield. The weed competition in crop field is invariably severe in early stages of crop than at later stages. Generally in a crop of 100 days duration, the first 35 days after sowing should be maintained in a weed free condition. There is no need to attempt for a weed free condition throughout the life period of the crop, as it will entail unnecessary additional expenditure without proportionate increase in yield.



**LECTURE-VII**

**Aim:** To study the factors affecting crop weed competition/interference and allelopathic effects.

**FACTORS AFFECTING CROP WEED COMPETITION/INTERFERENCE**

**1. Period of weed growth:**

It is important to note that when the crop-weed competition is critical; when the weed must be removed and when they may be allowed to grow without fear of any appreciable crop damage. The weeds that germinate and grow at the same time as the crop seeds are most successful competitors. If weeds are controlled at early period of crop growth, the optimum crop yield could be harvested which may be quite close to the maximum. The critical weed free period may, however, vary somewhat with the crop situation. Weeds should be removed at an early stage or at younger stages otherwise they compete severely. A little delay in weeding results in infestation of the crop for major parts of their critical growth periods. In situations, where weeds germinate late (as in dry land wheat/sorghum), late stage weeding is more useful than their early weeding. The same is also true for crops like grams and peas that are irrigated for considerable period after planting. There is less competition when weeds are either removed early or they germinate slowly because crop plant become sturdy and can tolerate competition. On other hand, when the weeds germinate along with crops, the crop plants are usually smothered by the weed completely e.g. direct sown rice suffers severe competition from the weeds than the transplanted crop of rice.

**2. Intensity of weeds:**

In general, increase in the weed intensity results in reduction of the growth and yield of crops. There has to be some minimum amount of weed growth in terms of either population or yield in the field to exert a minimum biological stress on the crop performance. To maintain zero weed growth is too costly and cannot be achieved.

**3. Weed species:**

Different weeds differ in their ability to compete with the crop at similar density levels. This is primarily because of difference in their growth habits as well as due to the allelopathic affects which they may exert on the germination and growth for the crope.g. at early stage of growth, Cocklebur (*Xanthium strumarium*) is a better competitor of crops than many grass weeds because it posess broad leaves that shade the ground heavily. In dry areas Canada thistle (*Cirsium arvense)* and Field bind weed (*Convolvulus arvensis*) are more competitive than annual weeds because of their deep roots and early heavy shoot growth.

**4. Soil fertility:**

Since weeds compete with crops for mineral nutrients, particularly nitrogen. Addition of fertilizers, manures and other amendments will lessen weed-stress on crop. Methods and time of application of fertilizer to the crop fields are important in determining whether the added fertilizers will suppress or increase weed growth in fields. Band application of fertilizer will also decide the weed growth. Application of fertilizer early in the crop season when weed growth is negligible is more beneficial to crop than when weeds are already grown up. Weeds can grossly alter the fertilizer response curves of the crops.

**5. Soil moisture status:**

Water supplied to weedy crop fields either through irrigation or through rainfall is equally accessible to both the crop and weeds. Irrigation is expected to increase the yields of both the crops and weed, if the fields are initially under stress. Increase in yield of the crop (weedy and weed free) by rains or irrigation have been found to differ with the crop and weed species, weed growth etc. Higher water use efficiency of the crops has been noted in weed free plots than in the weedy plots because of higher level of crop yield in the weed free plots. Time of rain or first irrigation after planting of the crops is an important factor determining the intensity of the crop weed competitione.g. If a crop is irrigated when the plants are 15 cm tall it can compete with weed that germinated with 1$^{st}$ irrigation or rain, whereas when fields are irrigated immediately after planting of crops it induces early flush of weed which is highly detrimental to the crop growth. In water logged soils, many weeds survive much better than the most crop plants and compete severely with them.

**6. Soil Reaction:**

Some of the weed species tolerate abnormal soil reactions much better than others. Some weeds grow vigorously on abnormal pH soil, where majority of our crop plant will be stunted in growth. Weed crop competition is more intense on high or low pH soils than on normal pH soils. Addition of soil amendments to raise or lower the pH soils, therefore vigorate crop growth, tilting the balance of weed crop competition in favour of the crops.

**7. Climate influence:**

Climate and seasonal variations are greatly responsible for inducing wide differences in weed-crop competitions. Adverse weather conditions e.g. drought, excessive rain, continuous rain, extreme of temperature intensify the weed crop interference, since most of our crop varieties are highly susceptible to such climate influence whereas the weeds are tolerant to these stresses. Weeds germinate at different times at different places. Weed emergence in the fields is more rapid in soils kept continuously wet by rainfall than those that dried three days after planting. The differences in germination of weed are narrowed as the temperature increases because the weed seeds absorb enough moisture in the first three days wet period itself before the soil dries up.

1. **Cropping practices:**

   It includes:

   I. Date and method of planting of crop
   II. Crop density and rectangularity
   III. Crop species and varieties.

**i) Date and method of planting of crop**:

Longer the period or interval between the emergence of crops and weeds lesser will be the weed crop interference. Weed seeds germinate most readily from top 1.25 cm of soil or up to 2.5 cm depth. Only few weeds such as Barnyard grass and cocklebur may germinate even from 10 cm depth of soil. Therefore, a planting method that dries the top 3-5 cm of soil rapidly is enough to deny weed seeds the opportunity to absorb moisture for their germination which usually post pones weed emergence until 1$^{st}$ irrigation is given. By this time, the crop plants are well established to compete with the late maturing weeds. In other cases, when the planting method which leaves the top most soil wet, weed seeds absorb enough moisture to germinate which induces severe weed crop competition.

**ii). Crop density and rectangularity:**

In low plant population resulting from low seed rate, faulty germination or loss of crop seedlings, weed growth is dense and weed crop competition intense. Wide row spacing may also induce dense weed growth. It can weaken the crop plants and intensify weed crop interference further. Square planting should be ideal in reducing the intra plant competition in crops. Competition among individuals of same species of plant is comparatively weaker than competition among individual of different species.

**iii). Crop species and varieties**:

Crops and varieties differ in their habitat often to weeds to grow as well as in their ability to with stand weed competition. Such differences among crop spp. may result from either their inherent morphological and physiological features or from differences in their cultivation requirements e.g. Barley is found more tolerant to interference by weeds than wheat and wheat more tolerant than oats. Linseed is more sensitive to the presence of weed than to other winter grains. High tolerance of barley to crop weed competition may be due to development of extensive seminal and crown roots during its first three weeks after planting. Fast canopy forming and tall crops suffer less from weed competition than slow growing or short stature crop. Dwarf varieties of crops are more susceptible to weed crop competition than the tall because initially they grow slowly.

## ALLELOPATHY

Allelopathy is the detrimental effects of chemicals or exudates produced by one (living) plant species on the germination, growth or development of another plant species (or even microorganisms) sharing the same habitat.

Allelopathy does not form any aspect of crop-weed competition, rather, it causes crop-weed interference, it includes competition as well as possible allelopathy.

Allelo chemicals are produced by plants as end products, by-products and metabolites liberalised from the plants; they belong to phenolic acids, flavanoides, and other aromatic compounds viz., terpenoids, steroids, alkaloids and organic cyanides.

**Allelopathic Effects of Weeds on Crops**

(1) Maize:



- Leaves & inflorescence of *Parthenium* sp. affect the germination and seedling growth
- Tubers of *Cyperus esculentus* affect the dry matter production

(2) Sorghum:

- Stem of *Solanum* affects germination  and seedling growth
- Leaves and inflorescence of *Parthenium* affect germination and seedling growth

(3) Wheat:

- Seeds of wild oat affect germination and early seedling growth
- Leaves of *Parthenium* affects general growth
- Tubers of *C. rotundus* affect dry matter production
- Green and dried leaves of *Argemone mexicana* affect germination & seedling growth

(4) Sunflower:

- Seeds of *Datura* affect germination & growth

**Allelopathic Effects of crop plants on weeds**

(i) Root exudation of maize inhibits the growth of *Chenopodium album*

(ii) The cold water extracts of wheat straw when applied to weeds reduce germination and growth of *Abutilon* sp.

**Allelopathic effects of weeds on weeds**

- Extract of leaf leachate of decaying leaves of *Polygonum* contains flavonoides which are toxic to germination, root and hypocotyls growth of weeds like *Amaranthus spinosus*
- Inhibitor secreted by decaying rhizomes of *Sorghum halepense* affect the growth of *Digitaria sanguinalis* and *Amaranthus* sp.

**Factors influencing allelopathy**

a. Plant factors

i. Plant density: Higher the crop density the lesser will be the allelo chemicals it encounters

ii. Life cycle: If weed emerges later there will be less problem of allelochemicals

iii. Plant age: The release of allelochemicals occurs only at critical stage *e.g.* in case of *Parthenium*, allelopathy occurs during its rosette & flowering stage.

iv. Plant habit: The allelopathic interference is higher in perennial weeds.

v. Plant habitat: Cultivated soil has higher values of allelopathy than uncultivated soil.

b. Climatic factors: The soil & air temperature as well as soil moisture influence the allelo chemicals potential

c. Soil factors: Physico-chemical and biological properties influence the presence of allelochemicals.

d. Stress factors: Abiotic and Biotic stresses may also influence the activity of allelochemcals

**Mechanism of action of allelochemicals**

- Interfere with cell elongation
- Interfere with photosynthesis
- Interfere with respiration
- Interfere with mineral ion uptake
- Interfere with protein and nucleic acid metabolism

Use of Allelopathy in biological control of weeds:

1. Use of cover crop for biological control
2. Use of alleopathic chemicals as bio-herbicides



## LECTURE VIII

**Aim:** To study different methods of weed control.

**WEED CONTROL:**

*Weed control includes many techniques used to limit weed infestation and minimize competition. Weed control technique attempt to achieve a balance between cost of control and crop yield loss, but weed control is used only after the problem exist.*

**Weed management:** *Weed management is an approach in which weed prevention and weed control have companion roles. Weed management is the combination of the techniques of prevention, eradication and control to manage the weed in a cropping system* or --environment.

or

*It is defined as a system of farming, using all available knowledge and tools to produce crops which are free from economically damaging competitive vegetation*

| **Weed Control Methods** | | | | | |
|---|---|---|---|---|---|
| **Preventive** | **Curative** | | | | |
| • Sowing of weed free seeds.<br>• Use of clean implements.<br>• Removal of weed along the canal and irrigation channel<br>• Care in transplanting | Eradication | Control | | | |
| | | Mechanical | Cultural | Biological | Chemical |

| | | | | | |
|---|---|---|---|---|---|
| of seedling/plantlets.<br>• Use of well rotten manure<br>• Avoiding passing of cattle from weed infested area.<br>• Crop management practices.<br>• Enforcement of Weed Laws.<br>• Quarantine methods and use of pre-emergence herbicides. | | -Hoeing,<br>-Hand weeding<br>-Digging,<br>-Mowing.<br>-Burning,<br>-Mulching | -Selection of crop,<br>-Crop rotation,<br>-Use of compost or manure,<br>-Allowing the land to fallow,<br>-Pre-sowing irrigation,<br>-Sowing time,<br>-Orientation of<br>-sowing/transplanting | -Plants-parasites,<br>-Predators and<br>-<br>Pathogens | |

**WEED CONTROL METHODS: There are two broad methods of weed control:**

**1. Preventive methods**

**2. Curative methods**

**i) Eradication**

**ii) Control measures**

**1. Preventive Method:** Prevention of introduction and spread of weeds in an entirely new locality is termed as preventive method. It is essential to know that how weeds disseminate. By taking following measures weed spread can be prevented from entering into a new locality.

**I) Sowing of weed free clean seed:** The seed contaminated with weed seed is a good source of spread of weeds. It becomes hard to separate the weed-seed from the crop seed. For example, cruciferous crops like radish, cauliflower, cabbage, broccoli etc. are well mixed with the seed of Satyanashi *(Argemone mexicana*). Such impure seed should be discarded for sowing.

**II) Use of clean implements:** While operating agricultural implements like cultivator, harrow, and seed drill etc. in weed infested field, care must be taken that multiplication part of weed like rhizome, bulb, tubers, stem is not being carried along. The agricultural implements should be cleaned properly. Only then these should be used in other fields. This helps in controlling spread of the weeds.

**III) Removal of weeds along canal and irrigation channel:** Weed seed get transported through water and reach the field. Removal of weeds growing along the sides of canal or irrigation channel is necessary.



**IV) Care in transplanting of seedling/plantlets:** Many horticultural plants like all transplanted vegetables,flowers, and fruits are transplanted in the field with soil attached to their root. Infestation of soil with weed may contaminate a new field.

**V) Use of well rotten manure:** Weed seeds have good viability. The seed of hirankhuri (*Convolvulus arvensis* ) remain viable for as long as 50 years. Doob (*Cynodon dactylon*) and motha (*Cyperus rotundus*) seed viability lasts for two and five years, respectively. For making manure the cowdung is generally heaped. If the heaping period is short, the seed do not lose its viability and grows in the field wherever manure is applied. So only well rotten manure should be used.

**VI) Avoiding passing of cattle from weed infested area:** Grazing in weed infested field followed by allowing passage of cattle in new field favours dissemination of weed seed. The weed seeds after passing through alimentary canal of the animal come out through dung, where it gives rise to weed. Some weed seeds also stick to the legs and skin of the animals and get transported to some other place where it germinate and grow as a weed.

**VII) Crop management practices.** All such practices which favour the growth of main crop only disfavour the growth of weed. The following management practices have smothering effect on weed and must find place in crop land to prevent weed spread:

- Proper crop rotation prevents establishment of weeds.
- Higher plant population per unit area smothers the growth of weed.
- Proper placement of fertilizer in the root zone of the seed favours the growth of crop only. The weeds deprive of nutrients and their growth is restricted.
- Fast and vigorous growing varieties by virtue of their larger leaf canopy cause smothering effect on the growth of weed. Such crops should receive preference to prevent spread of the weed.

**VIII) Enforcement of weed Laws:** In India, many noxious weeds grow in the fields and pose great economic and health hazard. Noxious weeds are those perennial weeds which are reproduced by seeds,stem,roots,and other reproductive parts as well and are very difficult to control.*Parthenium hysterophorus, Striga sp.,Cyperus rotundus,Cynodon dactylon* etc.are noxious weeds that grow in many horticultural crops.In India , no weed laws are in force except in Karnataka where Parthenium has been declared as a noxious weed.

**IX) Quarantine Laws.** Quarantine laws impose legal restrictions on the movement of the agricultural material. If there were adequate quarantine laws, the Parthenium and Argemone which widely grows in vegetable and flower field may not have entered India. Creating isolation between widely weed infested area and new area is essential by enforcing and observing quarantine properly.

**X) Use of pre-emergence herbicides:** Herbicides which are used before the emergence of weeds either before or after planting of crop, is a good preventive measure for preventing weed infestation. Such herbicides either inhibit seed germination or kill young seedlings before they get established.

**2. Curative methods**

**i) Eradication:** Eradication means elimination of weeds after they have become established in an area and control methods are adopted where prevention and eradication have failed, so control measure as a rule eradicate the weeds and make it possible to raise the crops in spite of their presence. Constant control measures applied for several years help in practical elimination of weeds. Eradication is however, impractical and if practiced in large scale it may be possible to eradicate certain weeds which are limiting in their spread.

**II) Methods of weed control:** Methods of weed control can be decided by the habits of weed which concern with life cycle and methods of propagation by the habitat which mean magnitude of the problem

**Habit-** Concern its life cycle and methods of propagation

**Habitat-** Means place where it thrives best

**Distribution-** Means the magnitude of the problem

**A. Physical/Mechanical methods of weed control**

a) Prevention from spread

b) Destruction of top growth

c) Destruction of underground part

d) Destruction of weed seeds in the soil

**a) Preventing from spread:**

**Use of clean seed**: Certified and pure seeds should be used for the sowing purpose. Most of the seeds are full of impurities which help in the spread of weeds year after year. There should be a rule to stop the sale of uncertified seeds.

**Prevention of seed production in weed contaminated and nearby waste areas:** Weeds growing in waste lands, along roadside, fences, ditches etc produce seeds which are carried to adjoining areas of cultivated fields. Such areas should be properly controlled to prevent the formation of weed seeds.

**b) Destruction of weed growth:**

**Hand pulling**: Efficient method of weed control. Effective in destruction of weeds growing within the rows. This method should be adopted before seed formation takes place.

**Hand hoeing:** Old practice. Eliminates weeds from rows and help in stirring up of soil for soil aeration. Labour consuming process. Shallow rooted weeds are easily eliminated.

**Tillage**: Practical, oldest and widely practised method. If timely practised, it prevents the seed production. It is effective in perennial weeds. It is followed for crops grown in lines. Frequent tillage destroys the soil structure and thus is less favourable for growth. It is important in seed bed preparation of field crops but restricted in orchards.

**Blind tillage:** It means tillage of the soil after seeding the crop, either before the crop plants are up or while they are in the early stages of growth. Used in most of the crops and cereals. Various types of harrows are used in field even though seedlings of crop plants are not above the ground and repeated until plants are well advanced. This process results in increasing the grain yields.

**Ploughing:** It helps in burying of annual, biennial and perennial weeds. Ploughing is practiced before the seeding of crops and top growth of the weeds is checked by it. Deep ploughing in summer is effective in exposing the roots to the sun rays and killing them.

**Mowing:** Means removing the top growth of weeds growing in lawn/roadside and exhausting them to death. Repeated mowing prevents seed production and also starve the underground parts. It may require 1-3 years to control tall and perennial weeds by repeated and frequent cutting. Best time is when the underground root reserves are at the lowest level. Mowing removes apical dominance and repeated cutting hastens food depletion and death of the plant. Effective in tall growing plants. It favours short growing weeds plants by removing competition.

**Harrowing:** Successful in removal and destruction of small weeds. Adopted, where the surface of the soil is quite smooth, dry and free from obstruction. Objective is to loosen or cut the root system enough so that plant dies from desiccation (water losses) before it can re-establish its roots.

**Disking:** Adopted successfully in destroying the weeds by cutting and burring them in the soil after the crops are harvested.

**Spudding:** Spud is a tool with a long *chisel like* blade designed especially for the removal of weeds from the lawns without disturbing the soil.

**Burning:** Noxious weeds like dodder (*Cuscutta)* are destroyed by burning. It destroys the useful vegetation also and affects the soil.

**Pasturing and grazing:** Continued grazing of the tops of the weeds by animals prevents seed formation and ultimately exhausts the underground parts. Grazing should be allowed in a controlled manner to allow grazing on a limited area so that all weeds are grazed and not the tasty ones.

**c) Destruction of underground parts:**

**Hand digging**: Removal of underground parts like roots and rhizomes by hand digging, but it is an expensive method. Applied in small patches where noxious weeds have been found to grow.

**Summer fallow**: Continuous clearing of the land throughout summer without growing a crop. Effective if top growth of the weeds is removed at regular intervals to starve the roots. Fields may be ploughed, or disked. Employed in dry farming areas where crop depends on monsoon. It helps in the absorption of precipitation by the soil and in the retention of absorbed moisture.

**d) Destruction of weed seeds in the soil:**

Some of the weed seeds remain buried in the soil for years without losing their viability and come up and produce new crops. Steps should be taken to destroy the weeds and to clean the fields.

**Deep ploughing:** weed seeds which are buried below are exposed to the surface if deep ploughing is practised during summers. Such weed seeds are induced to germinate and once they come up, it is easy to control them.

**Harrowing and shallow cultivation:** These methods induce many seeds to germinate and can be destroyed during the preparation of seed beds.

**B. Cropping and cultural method:-**

**Important cultural practices are:**

a) **Crop rotation:** Many weeds thrive well and prove troublesome if the same crop is grown year after year. Crop rotation or changing the habitat interferes with the normal life cycle of many weeds. 3-5 years crop rotation should be practiced. *e.g:*

**I.** 1st year - Clean cultivated or tall crops- sugarcane and maize.

**II.** 2nd year - Grain crops like wheat, barley etc.

**III.** 3rd year- Grass land (used for pasture)

**b) Crop competition:** Simplest method of weed control. Weeds are strong competitors. They take the lion's share of the plant nutrients. For every one kg of weed growth, soil produces about one pound less of crop. Thick crops strongly compete for nutrients by weeds. Most common smother crops are Sorghum (fodder), Clovers, Lucerne Soya bean and Sun hemps. Fodder crops are smothering as their frequent cuttings destroy the top growth of weeds before they set seeds. Smother crop weakens the underground parts of the weeds and they are easily killed by the cultivation that fellows.

**c) Mulching:** Straw mulching is practised to check weed growth. Paper mulch is used in pineapple (but is expensive).

**d) Clean cultivation:** It results in removal of the tops of perennial weeds and it gradually weakens and destroys their underground parts. Cultivation must be thorough and at short intervals so that surface growth of weeds is checked. The removal of surface growth results in non-manufacturing of food to replenish (feed) the roots.

**Implements used for row cultivation:**

**Spike tooth harrow:** or drag harrow or peg tooth harrow uproot the germinating weed seedlings, break soil crust and stir the soil upto 1-5 cm depth. It is made of 23 cm long steel pegs (or spikes) fix on a frame. It is a commercial method of controlling weed seedlings in maize, cotton, soybeans, ground nut and grain sorghum,. It can be used any time after planting the crop till the crop plants are 7-10 cm tall. It does not injure crop seedlings.

**Spring-tine harrows:** or spring tooth harrow has elliptical spring like tines with triangular and sharp free ends, used like spike tooth harrow but stir the soil upto 7.5 cm depth.

**Rotary hoe cultivator:** is made up of two gang pairs/groups of hoe wheels or spiders one placed behind the other within each gang. There are row units with space within them to save the rows of crop seedlings. It is a tractor drawn implement for active soil movement to dislodge weeds. It is employed to destroy germinating weeds and grasses in the rows as well as those growing close to young crop plants.

**Wheel hoe:** It comprises of wheel, two handle and a tine with reversible shovel or a three prong fork or rake as its cutting tool. It is manually operating weeding tool suitable for weeding small vegetable garden.

**Blade-harrow (Bak Khar):** is bullock drawn, row cultivator implement. Its cutting tool is 30-95 cm long 5-6 cm wide sharp blades works like sweep of a cultivator. It cuts the weeds 7.5-10 cm below the ground and leaves them on soil surface as mulch. Used on heavy black soil.

**Cultivator (horse hoe):** is efficient row weeding implement. These vary in size from single row five lined cultivators to multilined tractor drawn cultivators capable of weeding several crop grown at a time. This can cover several hectares area in a day with a bullock drawn five lined cultivator. Used for inter-row weeding in wide row crops. Its tines are fitted with shovels or sweeps as the cutting tool. They cut the roots up to 7-10 cm below the grounds.

They control the established weeds. More effective at the time when weeds are in the seedling stage.

**Rice rotary weeders:** is used for rice crop. They are single or double row weeders .It works manually. They can work both parallel and across the crop rows. In single row rotary rice weeder, one man can weed about one hectare of rice in 12 hours.

**Implement for pre- plant control of weeds:**

Weeds are controlled either before preparation of soil bed or continued suppression of weeds in the crop season. The objectives are achieved by proper pre plant tillage in two stages, first a primary tillage of the field with a suitable soil inverting plough/disc and secondary tillage with light soil stirring implements like disc harrow, wooden ploughs, cultivators, spike-tooth harrow, weed mulcher and soil surgeon etc. The primary tillage buries the weedy vegetation and exposes their roots/rhizomes at the soil surface while the secondary tillage breaks the clods, exposes the vegetative propagules of weeds further for their subsequent collection by hook plankers or by manual labour. Corrugated rollers and other surface packing and smothering implements act against weed seedlings.

**C. BIOLOGICAL CONTROL**

Use of living organism's viz., insects, disease organisms, herbivorous fish, snails or even competitive plants for the control of weeds is called biological control. In biological control method, it is not possible to eradicate weeds but weed population can be reduced. This method is not useful to control all types of weeds. Introduced weeds are best targets for biological control.

**Qualities of bio-agent:**

- The bio-agent must feed or affect only one host and not other useful plants
- It must be free of predators or parasites.
- It must readily adapt to environment conditions.
- The bio-agent must be capable of seeking out itself to the host.
- It must be able to kill the weed or atleast prevent its reproduction in some direct or indirect way.
- It must possess reproductive capacity sufficient to overtake the increase of its host species, without too much delay.

**Merits:**

- Least harm to the environment
- No residual effect
- Relatively cheaper and comparatively long lasting effect
- Will not affect non-targeted plants and safer in usage

**Demerits:**

- Multiplication is costlier

- Control is very slow
- Success of control is very limited
- Very few host specific bio-agents are available at present

**Mode of action**

- Differential growth habits, competitive ability of crops and varieties prevent weed establishment *e.g.* Groundnut, cowpea fast growing and so good weed suppresser.
- Insects kill the plants by exhausting plant food reserves, defoliation, boring and weakening structure of the plant.
- Pathogenic organisms damage the host plants through enzymatic degradation of cell constituents, production of toxins, disturbance of harmone systems, obstruction in the translocation of food materials and minerals and malfunctioning of physiological processes.

**Outstanding and feasible examples of biological weed control**

- Larvae of *Coctoblastis cactorum*, a moth borer, control prickly pear *Opuntia* sp. The larvae tunnel through the plants and destroy it. In India it is controlled by cochinial insects *Dactylopius indicus* and *D. tomentosus*
- *Lantana camara* is controlled by larvae of C*rocidosema lantana*, a moth bores into the flower, stems, eat flowers and fruits.
- *Cuscuta* spp. is controlled by M*elanagromyza cuscutae*
- *Cyperus rotundus* - *Bactra verutana* a moth borer
- *Ludiwigia parviflora* is completely denuded by *Altica cynanea* (steel blue beetle)
- Herbivorous fish Tilapia controls algae. Common carp, a non-herbivorous fish controls sub-mersed aquatic weeds. It is apparently due to uprooting of plants while in search of food. Snails prefer submersed weeds.

**Bio-Herbicides/ Myco-herbicides:**

The use of plant pathogens which are expected to kill the targeted weeds are known as bio-herbicides. These are native pathogen, cultured artificially and sprayed just like post-emergence herbicides each season on target weed, particularly in crop areas. Fungal pathogens of weeds have been used to a larger extent than bacterial, viral or nematode pathogens, because, bacteria and virus are unable to actively penetrate the host and require natural opening or vectors to initiate disease in plants.

Here the specific fungal spores or their fermentation product is sprayed against the targeted weeds. Some registered myco-herbicides in western countries are tabulated below

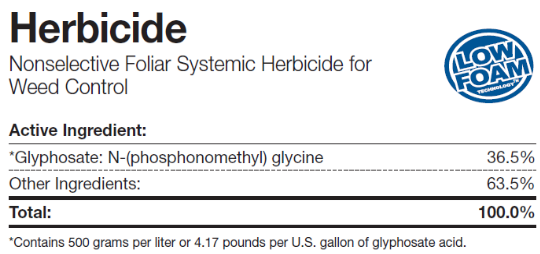
 

| No | Product | Content | Target weed |
|---|---|---|---|
| 1 | Devine | A liquid suspension of fungal spores of *Phytophthora palmivora* causes root rot. | Strangle vine (*Morrenia odorata*) in citrus |
| 2 | Collego | Wettable powder containing fungal spores of *Colletotrichum gloeosporoides* causes stem and leaf blight | Joint vetch (*Aeschyomone virginica*) in rice, soybean |
| 3 | Bipolaris | A suspension of fungal spores of *Bipolaris sorghicola* | Jhonson grass (*Sorghum halepense*) |
| 4 | Biolophos | A microbial toxin produced as fermentation product of *Steptomyces hygroscopicus* | Non-specific, general vegetation |



## LECTURE IX



**Herbicide**
Nonselective Foliar Systemic Herbicide for Weed Control

**Active Ingredient:**

| | |
|---|---|
| *Glyphosate: N-(phosphonomethyl) glycine | 36.5% |
| Other Ingredients: | 63.5% |
| **Total:** | **100.0%** |

*Contains 500 grams per liter or 4.17 pounds per U.S. gallon of glyphosate acid.

**Aim:** To study the chemical weed control, advantages, disadvantages and classification of herbicides.

### CHEMICAL CONTROL

Using chemicals, generally referred to as herbicides, for the control of weeds is called chemical weed control. The discovery of 2, 4-D sodium salt in 1944 is a land mark in herbicide usage.

**Merits**

- Herbicide can be recommended for adverse soil and climatic conditions, as manual weeding is highly impossible during monsoon season.
- Herbicide can control weeds even before they emerge from the soil so that crops can germinate and grow in completely weed-free environment at early stages. It is usually not possible with physical weed comfort.
- Weeds, which resemble like crop in vegetative phase, may escape in manual weeding. However, these weeds are controlled by herbicides.
- Herbicide is highly suitable for broadcasted and closely spaced crops.
- Controls the weeds without any injury to the root system of the associated standing crop especially in plantation crops like Tea and Coffee.
- Reduces the need for pre- planting tillage
- Controls many perennial weed species
- Herbicides control the weed in the field itself or *in-situ* controlling whereas mechanical method may lead to dispersal of weed species through seed
- It is profitable where labour is scarce and expensive
- Suited for minimum tillage concept
- Highly economical

**Demerits**

- Pollutes the environment
- Affects the soil microbes if the dose exceeds

- Herbicide causes drift effect to the adjoining field
- It requires certain amount of minimum technical knowledge for calibration
- Leaves residual effects
- Some herbicide is highly costlier
- Suitable herbicides are not available for mixed and inter-cropping system.

**ADVANTAGES OF HERBICIDES**

***A. On weed control***

- They kill unwanted plants.
- They are easy to use
- Herbicides can be used on closely planted crops where other methods cannot be used.
- Most of the time one application of the herbicide is enough whereas other methods have to be continually used.
- They work fast. They can be removed quickly in critical situations.
- Herbicides are relatively cheap, and most of the time cheaper than manual weeding.

**B. On crop growth**

- They can destroy plants bearing diseases.
- They help the crops grow by destroying the weed that causes harmful effects which include competition for water, nutrients and light; interference of weeds with crop growth by the release of toxins; modification of soil and air temperatures and the harbouring of pests.
- They can be safely used as the manual and mechanical removing of weeds can destroy the crop.

**C. Others**

- They are relatively safe on lands which may erode.
- Non-selective herbicides can effectively clear fields, where houses and roads can then be built.

**DISADVANTAGES OF HERBICIDES**

**A. Effects of Herbicides on environment**

Herbicides vary greatly in chemical composition and in the degree of threat they pose to the environment. Many of the herbicides are highly persistant. It is widely recognised that the main reason accounting for residues of certain herbicides like simazine and other triazines in ground and surface water was the widespread use of these herbicides at high doses on hard surfaces.

a) **Soil:** Some herbicides are non-biodegradable and are harmful for a long period of time. Heavy dose of herbicides affect microbial population of the soil. With herbicides targeting amino acid synthesis in both plants and microbes, there is a possibility that N2 fixation may be inhibited by the application of certain herbicides.

b) **Water:** The improper use of pesticides and herbicides may also cause the storm water infiltration into groundwater. When these pesticides and herbicides contaminants dissolve in storm water they infiltrate the groundwater and then the surface waters, such as ponds, streams, rivers and lakes. These chemicals may also find their way into the soil and deeper groundwater units polluting them.

c) **Living organisms**: Most herbicides are specifically plant poisons, and are not very toxic to animals. However, by changing the vegetation of treated sites, herbicide use also changes the habitat of birds, mammals, insects, and other animals through changes in the nature of their habitat. Herbivores may eat the plants treated with herbicides and then carnivores eat the herbivores. The toxic herbicide would be passed up the food chain increasing in concentration each time resulting in cancers and even deaths.

Anxiety about chemical residues in the environment has increased greatly in the last decade. These fears and concern about possible litigation have led many land managers to reappraise their weed control strategies. Change has also been forced on them by the decrease in the number of approved herbicides as a result of the high cost of registration. In addition, approval has been withdrawn from more toxic and persistent herbicides.

**B. Effects of Herbicides on Humans**

Among the many effects of pesticides and herbicides, perhaps the most alarming is the danger they pose to human health. People are directly affected by toxicity of some herbicides, during the course of their occupation (i.e., when spraying pesticides), or indirectly affected when exposed through drift or residues on food, and wildlife.

a) Pesticides and herbicides can cause a number of health problems such as heart congestion, lung and kidney damage, low blood pressure, muscle damage, weight loss and adrenal glands damage.

b) Arbitrary and indiscriminate usage of herbicides and pesticides can result in endometriosis, a common cause of infertility in women.



c) Herbicides and pesticides have been suspected by the National Cancer Research Institute as a probable cause of certain cancers (i.e., cancers of the brain, prostrate, stomach and lip, as well as leukemia, skin melanomas, etc.) especially among farmers.

d) The National Academy of Sciences reported that infants and children, because of their developing physiology, are susceptible to the negative effects of herbicides and pesticides in comparison to adults.

**C. Effect of herbicides on crop plant**

An important problem with broadcast applications is that they are non-selective. They are toxic to a wide variety of plant species, and not just the weeds. If herbicides are not used properly, damage may be caused to crop plants, especially if too large dose is used, or if spraying occurs during a time when the crop species is sensitive to the herbicide. Unintended but economically important damage to crop plants is sometimes a consequence of the inappropriate use of herbicides.

**D. Build-up of resistant biotypes**

Apart from their effect on the environment, another major problem with herbicides has been the build-up of herbicide-resistant biotypes where the same herbicide has been used repeatedly for a number of years. This problem was not clearly foreseen at the start of the herbicide revolution but, since the early 1980s, triazine resistance has developed in most countries where these herbicides have been used. The usefulness of a number of other herbicides, including paraquat, dichlofopmethyl and sulfonylurea types has been affected by the development of resistant biotypes.

Methods of dealing with this problem include prevention of weed seed shedding, crop rotation, herbicide rotation, control of weed escapes and tillage practices. Crop rotation is not relevant in an amenity situation where the 'crops' are usually perennial but other control measures may be appropriate in certain situations. If weeds are prevented from setting seed, resistant biotypes cannot develop.

This could be achieved if land managers were made more aware of the threat of resistant biotypes and made greater efforts in intensively managed areas to prevent weeds from shedding seeds by the use of a rotation of herbicides supplemented by physical means such as mulching, hand hoeing and hand weeding.

Modern, intensively managed agricultural and forestry systems have an intrinsic reliance on the use of herbicides and other pesticides. Unfortunately, the use of herbicides and other pesticides carries risks to humans through exposure to these potentially toxic chemicals, and to ecosystems through direct toxicity caused to non-target species, and through changes in habitat. Nevertheless, until newer and more pest-specific solutions to weed-management problems are developed, there will be a continued reliance on herbicides in agriculture, forestry, and for other purposes, such as lawn care.

**Principles of chemical weed control**

The selectivity exhibited by certain chemicals to cultivated crops in controlling its associated weeds without affecting the crops forms basis for the chemical weed control. Such selectivity may be due to differences in the morphology, differential absorption, differential translocation, differential deactivation etc.

## CLASSIFICATION OF HERBICIDES

### 1) Based on Method of application

i) **Soil applied herbicides**: Herbicide act through root and other underground parts of weeds.*e.g.* Fluchloralin

ii) **Foliage applied herbicides**: Herbicide primarily active on the plant foliage *e.g.*Glyphosate, Paraquat

### 2) Based on Mode of action

i) **Selective herbicide**: A herbicide is considered as selective when in a mixed growth of plant species, it kills some species without injuring the others.e.g. Atrazine

ii) **Non-selective herbicide:** It destroys majority of treated vegetatione.g. Paraquat

### 3) Based on mobility

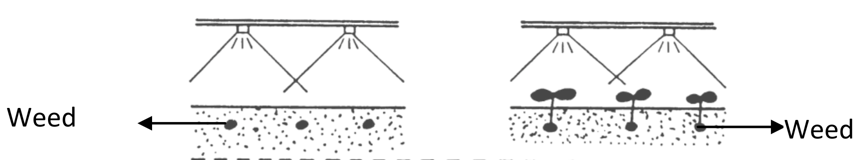
i) **Contact herbicide:** A contact herbicide kills those plant parts with which it comes in direct contact *e.g.* Paraquat

ii) **Translocated herbicide/Systemic Herbicide:** Herbicide which tends to move from treated part to untreated areas through xylem / phloem tissues depending on the nature of its molecule. *e.g.* Glyphosate

### 4) Based on Time of application

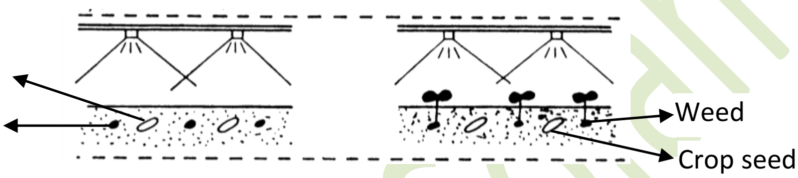
#### i) Pre - plant application

Application of herbicides before the crop is planted or sown. Soil application as well as foliar application is done here. For example, fluchloralin can be applied to soil and incorporated before sowing rainfed groundnut while glyphosate can be applied on the foliage of perennial weeds like *Cyperus rotundus* before planting of any crop.



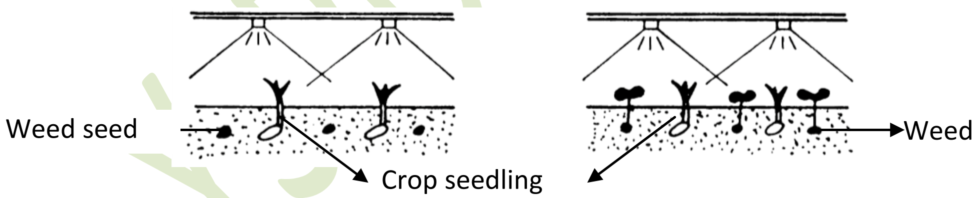
**ii) Pre – emergence**

Application of herbicides before a crop or weed has emerged. In case of annual crops application is done after the sowing of the crop but before the emergence of weeds and this is referred as pre-emergence to the crop while in the case perennial crops it can be said as pre-emergence to weeds. For example soil application by spraying of atrazine on 3rd DAT to sugarcane can be termed as pre-emergence to cane crop while soil application by spraying the same immediately after a rain to control a new flush of weeds in a inter-cultivated orchard can be specified as pre-emergence to weed.e.g. Atrazine, Pendimethalin, Butachlor, Thiobencarb, Pretilachlor




**iii) Post – emergence**

Herbicide application after the emergence of crop or weed is referred as post-emergence application. When the weeds grow before the crop plants have emerged through the soil and are killed with a herbicide then it is called as early post-emergence. For example spraying 2, 4-D Na salt to control parasitic weed striga in sugarcane is called as post-emergence while spraying of paraquat to control emerged weeds after 10-15 days after planting potato can be called as early post-emergence.e.g. Glyphosate, Paraquat, 2,4-D Na Salt.




iv) **Early post emergence**: Another application of herbicide in the slow growing crops like potato, sugarcane, 2-3 week after sowing is classified as early post emergence.

**5) Based on molecular structure:**

Inorganic compounds

Organic compounds

**Herbicide formulation:**

Herbicides in their natural state may be solid, liquid, volatile, non-volatile, soluble or insoluble. Hence these have to be made in forms suitable and safe for their field use. An herbicide formulation is prepared by the manufacturer by blending the active ingredient with substances like solvents, inert carriers, surfactants, stickers, stabilizers etc.

**Objectives in herbicide formulations are;**

- Ease of handling
- High controlled activity on the target plants

**Need for preparing herbicide formulation**

- To have a product with physical properties suitable for use in a variety of types of application equipment and conditions.
- To prepare a product which is effective and economically feasible to use
- To prepare a product which is suitable for storage under local conditions?

**Types of formulation**

I. **Emulsifiable concentrates (EC):** A concentrated herbicide formulation containing organic solvent and adjuvants to facilitate emulsification with water *e.g.,* Butachlor

ii. **Wettable powders (WP)**: A herbicide is absorbed by an inert carrier together with an added surface acting agent. The material is finely ground so that it may form a suspension when agitated with a required volume of water *e.g*., Atrazine

iii. **Granules (G)**: The inert material (carrier) is given a granular shape and the herbicide (active ingredient) is mixed with sand, clay, vermiculite, finely ground plant parts (ground corn cobs) as carrier material *e.g.* Alachlor granules.

iv. **Water soluble concentrates (WSC):***e.g*. paraquat



## LECTURE X

**Aim:** To study the different methods of herbicide application.

**METHODS OF HERBICIDE APPLICATION**

1. Spraying
2. Broadcasting

**Factors determining the methods of application are:**

- Weed-crop situation
- Type of herbicides
- Mode of action and selectivity
- Environmental factors
- Cost and convenience of application

**Depending on the target site, the herbicides are classified into**

1. Soil applied herbicides
2. Foliage applied or foliar herbicides

**Different methods by which these herbicides are applied are tabulated below:**

| | Soil application | | Foliar application |
|---|---|---|---|
| i. | Surface | i. | Blanket spray |
| ii. | Sub surface | ii. | Directed spray |
| iii. | Band | iii. | Protected spray |
| iv. | Fumigation | iv. | Spot treatment |
| v. | Herbigation | | |

1. **Soil application of herbicides:**

   **(i) Surface application**

Soil active herbicides are applied uniformly on the surface of the soil either by spraying or by broadcasting. The applied herbicides are either left undisturbed or incorporated in to the soil. Incorporation is done to prevent the volatilization and photo-decomposition of the herbicides.

*e.g.* Fluchoralin – Left undisturbed under irrigated condition

- Incorporated under rainfed condition

**(ii). Subsurface application**

It is the application of herbicides in a concentrated band, about 7-10 cm below the soil surface for controlling perennial weeds. For this special type of nozzles introduced below the soil under the cover of a sweep hood.

*e.g.* Carbamate herbicides to control *Cyperus rotundus*

Nitralin herbicides to control *Convolvulus arvensis*

**(iii). Band application**

Application to a restricted band along the crop rows leaving an untreated band in the inter-rows. Later inter-rows are cultivated to remove the weeds. Saving in cost is possible here. For example when a 30 cm wide band of a herbicide applied over a crop row that were spaced 90 cm apart, then two-third cost is saved.

**(iv). Fumigation**

Application of volatile chemicals in to confined spaces or in to the soil to produce gas that will destroy weed seeds is called fumigation. Herbicides used for fumigation are called as fumigants. These are good for killing perennial weeds and as well for eliminating weed seeds. e.g. Methyl bromide, Metham

**(v). Herbigation**

It is the application of herbicides with irigation water both by surface and sprinkler systems. In India farmers apply fluchloralin for chillies and tomato, while in western countries application of EPTC with sprinkler irrigation water is very common in Lucerne.

**2. Foliar application**

**(i) Blanket spray**

It is the uniform application of herbicides to standing crops without considering the location of the crop. Only highly selective herbicides are used here *e.g.* Spraying 2,4-Ethyl Ester to rice three weeks after transplanting.

**(ii). Directed spray**

It is the application of herbicides on weeds in between rows of crops by directing the spray only on weeds avoiding the crop. This could be possible by use of protective shield or hood. For example, spraying of glyphosate in between rows of tapioca using hood to control *Cyperus rotundus*.

**(iii). Protected spray**

It is a method of applying non-selective herbicides on weeds by covering the crops which are wide spaced with polyethylene covers etc. This is expensive and laborious. However, farmers are using this technique for spraying glyphosate to control weeds in jasmine, cassava, banana.

**(iv). Spot treatment**

It is usually done on small areas having serious weed infestation to kill it and to prevent its spread. Rope wick applicator and Herbicide glove are useful here.

## LECTURE XI


**Aim:** To know about antidotes and adjuvants.

**ANTIDOTES**

Chemicals which are used to inactivate the applied herbicides are called as antidotes *e.g.* Paraquat spray can be inactivated by spraying 1% ferric chloride

**SAFENERS / PROTECTANTS**

Substances used for protecting crop plants, which are otherwise susceptible or less tolerant to some herbicides at doses required for good weed control.

*e.g.*, Naphthalic anhydride (NA) – 0.5g / kg of seed for rice to protect against molinate and alachlor

**Mode of Action**: Safeners enter the target plants and compete there with herbicide molecules for a binding site on some native enzyme.

**ADJUVANTS**

Adjuvants are chemicals employed to improve the herbicidal effects, sometimes making a difference between satisfactory and unsatisfactory weed control.

**Mode of Action***:* Adjuvants aid the herbicide availability at the action site in plants. Some important kinds of adjuvants are:

1. **Surfactant ( Surface active agents) are:**

i. Wetting agents- Aid in wetting the waxy leaf surface with aqueous herbicide sprays

ii. Spreaders - spreading the hydrophilic herbicides uniformly over the foliage

iii. Penetrates - the penetration of herbicide into the target leaves and stems

A water drop is held as a ball on a waxy leaf surface. (Take water in a beaker, if you dip a leaf of *Cynodon dactylon* and pull it back, you can see the leaf without wetting. But if you add a drop of surfactant you can readily wet the foliage.). With the addition of surfactant, the water drop flattens down to wet the leaf surface and let the herbicide act properly.

## 2. Stabilizing agents:

These include:

1) **Emulsifiers:**

A substance which stabilizes (reduces the tendency to separate) a suspension of droplets of one liquid which otherwise would not mix with the first one. It substitutes for constant agitation of spray liquids during field operation *e.g.* ABS, Solvaid, 15-5-3, 15-5-9.

2) **Dispersing agents**:

They stabilize suspensions. They keep fine parricides of wettable powder in suspension in water even after initial vigorous agitation has been withdrawn. They act by increasing the hydration of fine particles of WP laden with the herbicides.

**3) Coupling agents (Solvents and co-solvents):**

Chemical that is used to solubalize a herbicide in a concentrated form; the resulting solution is soluble with water in all proportions *e.g.*, 2,4-D is insoluble in water, but it can be dissolved in polyethylene glycol to make it water soluble.

Common solvents: Benzene, acetone, petroleum ether, carbon tetrachloride

**4) Humicants (Hygroscopic agents):**

Humicants prevent rapid drying of herbicide sprays on the foliage, thus providing an extended opportunity of herbicide absorption e.g. glycerol.

**5) Deposit builders (Stickers or filming agents)**

Chemicals added to herbicide concentrates to hold the toxicant in intimate contact with the plant surface. They also reduce washing off of the toxicant from the treated foliage by rain e.*g.* several petroleum oils, Du pont spreader sticker, Citowett.

**6) Compatibility agents**

Used to intimately mix fertilizers and pesticides in spray liquids *e.g.* Compex

**7) Activators (Synergists)**

These are the chemicals having cooperative action with herbicides. The resultant phytotoxicity is more than the effect of the two working independently.

e.g., Paraffinic oils, Ammonium thiocyanate, Urea and Ammonium chloride to enhance 2,4 –D phytotoxicity

**8. Drift control agents**

Herbicide spray drifts may pose serious hazards to non-target plants *e.g.*, 2,4-D on cotton. Solution is to spray herbicide liquids in large droplets. Drift control agents are:

**i. Thickening agents:**

It is a large molecules organic compound which in aqueous systems behaves like a gel making the spray liquid viscous. The thickened sprays produce large sized drops that are less susceptible to spray drifts than the usual aqueous sprays *e.g.* Sodium alginate, hydroxyethyl cellulose and dacagin.

**ii. Particulating agent:**

Comprise particles of a lightly cross linked swellable polymer. It imbibes liquids both water and oil to form a particulate aqueous and particulate oils *e.g.* Norbak.

**iii. Foams:**

Foams are liquid interphase surrounding small packets of gases usually air in herbicide spray. Low expansion foams are under trial as drift control agents.

## HERBICIDE PERSISTENCE IN SOILS:

Herbicides applied to the soil are directly affected by the soil characteristics. For effective action, the chemical must remain active near the root zone to kill both germinating seeds and deep rooted plants.

**Factors affecting herbicide persistence in the soil**:

**1. Leaching:**

The extent of leaching is determined mainly by solubility of the herbicide in water, the amount of water passing downward and adsorption relationship between the herbicide in the soil.

**2. Volatility:**

The ester forms of 2, 4-D is volatile and the vapours or fumes frequently cause injury to the neighboring susceptible crops.

**3. Micro-organism decomposition:**

Organic herbicides are decomposed by soil microorganism. A warm moist, well aerated and fertile soil is most favourable to micro-organisms. Soil pH also influences microorganisms. Medium to high pH accelerates the action of bacteria. Soil rich in organic matter and clay content hold the herbicide for a longer time than the sand or sandy soils.

**4. Adsorption on the soil colloids:**

Different soil types have different adsorptive capacities. The rate of herbicide application is correlated with adsorptive capacity of soil. For examples:

a. Soils high in organic matter require large amounts of pre-emergence and soil sterilants herbicides for weed control.

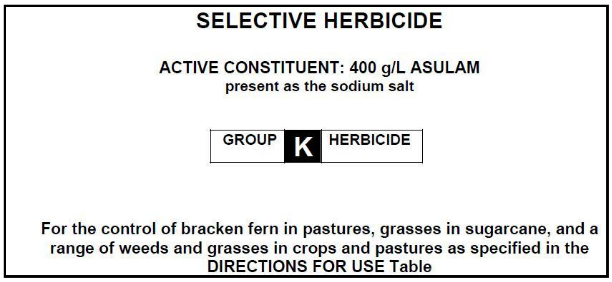
b. Soils high in clay contents require more herbicides quantity than sandy soils for pre-emergence or soil sterilant weed control.

c. Soils high in organic matter or clay contents tend to hold the herbicide for longer time than sands. The absorbed herbicide may be released so slowly that the chemical is not effective as herbicide.



## LECTURE XII




**Aim:** To Study the selectivity and mode of action of herbicides

### SELECTIVITY AND MODE OF ACTION OF HERBICIDES

Selective herbicides have been used extensively since the introduction of 2,4-D in the late '40s. They have been one of the miracles of modem agriculture, releasing thousands of people from the drudgery of hand weeding. A selective herbicide is one that kills or retards the growth of an unwanted plant or "weed" while causing little or no injury to desirable species. 2,4-D used in turf will kill many of the broadleaf weeds that infest turf while not significantly injuring the turf grass. But selectivity is a fickle, dynamic process. Excessive rates of 2,4-D applied to stressed turf grass may injure the turf. Selectivity has always depended on proper herbicide application. Normally herbicides work selectively within a given rate of application. Too little herbicide and no weed control, too much and crop injury may occur. But selectivity is more complex than this. It is a dynamic process that involves the interaction of the plant, the herbicide, and the environment.

#### 1) The Plant:

Factors that involve plant response include: genetic inheritance, age, growth rate, morphology, physiology, and biochemistry. The genetic make-up of a plant determines how that plant responds to herbicides and its environment. The age of the plant often determines how well an herbicide works, older plants are generally much more difficult to control than seedlings.

Pre-emergence herbicides often work only on plants during the germination process and will have little effect on older plants. Plants which are growing rapidly are usually more susceptible to herbicides. The morphology of a plant can help to determine its susceptibility to herbicides. Annual weeds in a deep rooted crop can be controlled because the herbicide is concentrated in the first inch of soil where the weeds and weed seeds are. Weeds with exposed growing points may be killed by contact sprays, while grasses with protected growing points may be burned back, but escape permanent injury. Certain leaf properties can allow better spray retention and thus better kill (broadleaf species vs. grasses or hairy vs. smooth leaves). Sprays tend to be retained on pigweed and mustard leaves and bounce off of onion or grass species.

The physiology of a plant can determine how much of an herbicide will be absorbed onto the plant and the speed with which it is transported to its site of action. Plants with thick waxy cuticles or hairy leaf surfaces may not absorb sufficient herbicide to be injured. Wetting agents in herbicide formulations are used to combat these leaf characteristics and increase absorption. The transport rate of herbicides in plants varies. Usually susceptible plants transport herbicide more readily than resistant ones. Some plants can adsorb herbicides along the transport pathway, preventing them from reaching their site of action.

Biochemical reactions also account for selectivity. Most herbicides have a biochemical reaction within susceptible plants which accounts for their herbicidal activity. They may bind to critical enzymes within susceptible plants and block important metabolic processes (glyphosate), they may block photosynthesis (diuron) or respiration, or they may affect cell division (trifluralin). Herbicides may be absorbed as relatively innocuous chemicals (2,4-DB) and activated to deadly compounds (2,4-D) within susceptible plants. Other herbicides (atrazine) may be detoxified within some plants while killing weeds which fail to metabolize the herbicide.

**2). The Herbicide**

Herbicides are quite specific in their structures as to whether or not herbicidal activity is possible. Slight changes in conformation or structure will alter herbicidal activity. Trifluralin and benefin differ in only a methyl group moved from one side of the molecule to the other, yet trifluralin is about twice as active as benefin. Esters of phenoxy (MCPP etc.) acids are usually much more active than are amines. The manner of formulation of an herbicide can affect its selectivity. The most extreme case of this might be granular formulations which bounce off desirable plants to reach the soil where they then limit germinating weeds. Other substances known as adjuvants or surfactants are often added to improve the application properties of a liquid formulation and increase activity. The manner in which an herbicide is applied can affect its selectivity.

When a broad-spectrum post emergence herbicide like Glyphosate is applied as a shielded, directed, or wicked application within a susceptible crop, susceptible foliage is avoided and selectivity is achieved with this normally non-selective herbicide. Herbicides can be grouped into families based on the type of action that they have within affected plants **(**their mode of action).

**3). The Environment**

There are many ways that the environment interacts with herbicide selectivity. The soil determines how much of soil applied herbicides are available for activity. Sandy soils, with low organic content, are much more active and conversely less selective than clay soils with high organic content at a given rate of herbicide application.

Irrigation or rainfall amount and timing influence the depth to which herbicides may move in the soil and plant growth and stress, all of which can increase or decrease herbicide selectivity. Temperature affects the rate of herbicide transport, the rate of biochemical reactions, plant growth, plant stress, and ultimately herbicide selectivity. Wind, relative humidity, insects, plant pathogens, and nutritional status also affect plant growth and stress which can increase or decrease herbicide selectivity.

**MODE OF ACTION**

The term mode of action refers to the sequence of events from absorption into plants to plant death. The mode of action of the herbicide influences how the herbicide is applied. For example, contact herbicides that disrupt cell membranes, such as Acifluorfen (Blazer) or Paraquat (Gramoxone Extra), need to be applied post emergence to leaf tissue in order to be effective. Seedling growth inhibitors, such as trifluralin (Treflan) and Alachlor (Lasso), need to be applied to the soil to effectively control newly germinated seedlings.

To be effective, herbicides must 1) adequately contact plants; 2) be absorbed by plants; 3) move within the plants to the site of action, without being deactivated; and 4) reach toxic levels at the site of action. The application method used, whether pre plant incorporated, pre emergence, or post emergence, determines whether the herbicide will contact germinating seedlings, roots, shoots, or leaves of plants.

**The herbicide families listed below are grouped on the basis their mode of action**

**1. The Growth Regulator Herbicides** (2,4-D, MCPP, Dicamba, and Triclopyr). These are mostly foliar applied herbicides which are systemic and translocate in both the xylem and phloem of the plant. They mimic natural plant auxins, causing abnormal growth and disruption of the conductive tissues of the plant. The injury from this family of herbicides consists of twisted, malformed leaves and stems.

**2. The inhibitors of amino acid synthesis** (Glyphosate, Halosulfuron, Hmazethapyr, and Sulfometuron). Both foliar and soil applied herbicides are in this family. Glyphosate translocates in the phloem with photosynthates produced in the leaves. Others in this family move readily after root or foliar absorption. These herbicides inhibit certain enzymes critical to the production of amino acids. Amino acids are the building blocks of proteins. Once protein production stops, growth stops. Symptoms are stunting and symptoms associated with lack of critical proteins.

**3. Cell membrane disrupters -** with soil activity (oxyfluorfen, lactofen, and acifluorfen). Soil and foliar applied with limited movement in soil. These herbicides enter the plant through leaves, stems, and roots, but are limited in their movement once they enter the plant. Membrane damage is due to lipid peroxidation. Symptoms are necrosis of leaves and stem.

**4. Lipid biosynthesis inhibitors** (diclofop, fluazifop, sethoxydim, and clethodim). Foliar applied Diclofop has both soil and foliar activity. Herbicides in this family move in both the xylem and phloem of the plant and inhibit enzymes critical in the production of lipids. Lipids are necessary to form plant membranes which are essential to growth and metabolic processes. Symptoms include stunting and death of tissue within the growing points of plants.

**5. Pigment inhibitors** (norflurazon, fluridone, and amitrol). Soil applied and move in the xylem except amitrol, which moves in both phloem and xylem. These herbicides inhibit carotinoid biosyntehsis, leaving chlorophyll unprotected from photooxidation. This results in foliage which lacks color. Symptoms include albino or bleached appearance of foliage.

**6. Growth inhibitors of shoots** (thiocarbamate herbicides including: EPTC, cycloate, pebulate, and molinate). Soil applied and somewhat volatile, requiring incorporation. Enter the plant through the roots and translocated through the xylem with the transpiration stream to the growing points in the shoot. Mode of action is unclear, but affects developing leaves in growing points of susceptible plants. Symptoms include stunting and distortion of seedling leaves.

**7. Herbicides which disrupt cell division** (trifluralin, DCPA, Dithiopyr, Oryzalin, Pronamide, Pendimethalin, and Napropamide). All are soil applied, with limited movement in the soil. Absorbed through roots or emerging shoot tips. Once absorption takes place, movement is limited (site of action is near the site of absorption). These herbicides inhibit cell division or mitosis, except pronamide and napropamide which stop cell division before mitosis. Symptoms include stunting and swollen root tips.

**8. Cell membrane disrupters -** no soil activity (Paraquat, Diquat, Glufosinate, acids, oils, soaps). These herbicides are foliar applied with no soil activity. They enter the plant through the leaves and stems and do not move significantly within the plant once absorbed. These herbicides either act directly on cell membranes (acids, soaps. oils) or react with a plant process to form destructive compounds which result in membrane damage. Symptoms include rapid necrosis of the leaves and stem.

**9. Inhibitors of photosynthesis** (Atrazine, Simazine, Metribuzin, Cyanazine, Prometryn, Diuron, Linuron, Tebuthiuron, and Bromocil). These are soil applied herbicides, however, all except Simazine also have foliar activity. They move readily in the plant in the xylem with the transpiration stream where they concentrate in the leaves at the site of photosynthesis. Once there they block the electron transport system of photosynthesis, causing a build up of destructive high energy products which destroy chlorophyll and ultimately the leaf tissues. Symptoms include chlorotic (yellowed ) leaves which become necrotic.



## LECTURE XIII

**Aim:** To study chemical classification of herbicides and recent trends in weed management

### CHEMICAL CLASSIFICATION OF HERBICIDES

Prior to the widespread use of chemical herbicides, mechanical control and cultural controls, such as altering soil pH, salinity, or fertility levels were used to control weeds.

The first widely used herbicide was 2,4-dichlorophenoxyacetic acid, often abbreviated 2,4-D which kills many broadleaf plants while leaving grasses largely unaffected (high doses of 2,4-D at crucial growth periods can harm grass crops such as maize or cereals). The low cost of 2,4-D has led to continued usage today and it remains one of the most commonly used herbicides in the world.

In 1950s triazine family of herbicides, which includes atrazine was introduced. Atrazine does not break down readily (within a few weeks) after being applied to soils of above neutral pH. Atrazine is said to have carryover, a generally undesirable property for herbicides. Glyphosate, frequently sold under the brand name Roundup, was introduced in 1974 for non-selective weed control. It is now a major herbicide in selective weed control in growing crop plants due to the development of crop plants that are resistant to it.

Many modern chemical herbicides for agriculture are specifically formulated to decompose within a short period after application. This is desirable as it allows crops which may be affected by the herbicide to be grown on the land in future seasons. However, herbicides with low residual activity (i.e., that decompose quickly) often do not provide season-long weed control.

**List of herbicides with their common name and chemical name**

| S.No | Common Name | Trade Name | Chemical Name |
|---|---|---|---|
| **Aliphatic carboxylic** | | | |
| 1 | Acrolein | Aqualin | 2-propenal |
| 2 | Allyl alcohol | **Allyl** alcohol | 2-propen-1-ol |
| 3 | TCA | TCA | |
| 4 | Dalapon | Dalapon, Dowpan | |
| **Phenoxy Carboxylic** | | | |
| 1 | 2,4,D | 2,4,D; Fernoxone | 2,4-dichlorophenoxyacetic acid |
| 2 | 2,4,5 T | Weedar; Weedone | 2,4,5-trichlorophenoxy acetic acid |
| **Phenyl acetic acid** | | | |
| 1 | Fenac | Fenac | 2,3,6-trichlorophenyl acetic acid |
| **Benzoic acid** | | | |
| 1 | Dicamba | Banvel | 2-methoxy - 3,6-dichloro benzoic acid |
| 2 | 2,3,6 - TBA | Trysben; Benzac | 2,3,6-trichlorobenzoic acid |
| **Phthalic acid** | | | |
| 1 | Naptalam | Alanap; Peach thin 322 | *N*-1-naphthylphthalamic acid |
| 2 | Endothol | Aquathal; Hydrothal | |
| **Phenol** | | | |
| 1 | PCP | Premerge; DNBP | Pentachlorophenol |
| 2 | Dinoseb | Basanite | 2-*sec*-butyl-4,6-dinitrophenol |
| **Dinitroaniline** | | | |
| 1 | Fluchloralin | Basalin | *N*-propyl -*N*(2-chloroethyl)- 4-(trifluoromethyl) - 2,6 dinitro-aniline |
| 2 | Isopropalin | Paarlon | *N*,*N*-dipropyl- 4-isopropyl -2,6-dinitro aniline |
| 3 | Pendimethalin | Prowl; Herbadex; Stomp | *N*-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitroaniline |
| 4 | Trifluralin | Treflan | *N*,*N*-dipropyl-4-(trifluoromethyl) - 2,6-dinitroaniline |
| **Benzonitrile** | | | |
| 1 | Dichlobenil | Casoron | 2,6, - dinitrobenzonitrile |
| 2 | Bromoxynil | Brominol; Butril | 3,5-dibromo-4-hydroxybenzonitrile |
| **Triazines** | | | |
| 1 | Atrazine | Aatres; Gesprim | 2-chloro-*4*-ethylamino-6-isopropylamino-S -triazine |
| 2 | Simazine | Princep; gesatop; Tapazine | 2-chloro-4,6-bis(ethylamino) -S -triazine |



| | | | |
|---|---|---|---|
| **Urea** | | | |
| 1 | Diuron | Karmex | 3-(3,4-dichlorophenyl)-1,1-dimethylurea |
| 2 | Monuron | Telvar | 3-(4-chlorophenyl)-1,1-dimethylurea |
| 3 | Isoproturon | Tolkan; Arelon | 3-(4-isopropylphenyl)-1,1-dimethylurea |
| **Phenyl Carbamate** | | | |
| 1 | Phenmedipham | Betanol | 3-(methoxycarbonyl)amino]phenyl (3-methylphenyl)carbamate |
| 2 | Propham | Chem -hoe | Isopropyl phenylcarbamate |
| **Thiocarbamate** | | | |
| 1 | Butylate | Bolero; Saturn | *S*-ethyl diisobutyl thiocarbamate |
| 2 | Thiobencarb | Odram; Saturn | *S*-4-chlorobenzyl diethyl(thiocarbamate) |
| 3 | Metham | Vapam; VPM | Sodium methyl dithiocarbomate |
| **Acid amide** | | | |
| 1 | Alachlor | Lasso | 2-chloro-2′,6′-diethyl-*N*-methoxymethylacetanilide |
| 2 | Butachlor | Machete; Delchlor | *N*-butoxymethyl-2-chloro-2′,6′-diethylacetanilide |
| **Organic arsenical** | | | |
| 1 | Cacodylic acid | Phyto 138; Eras | Dimethyl arsonic acid |
| 2 | MAA | Ansar | Methane arsonic acid |
| **Uracil** | | | |
| 1 | Bromacil | Hyvar-X; Krovar -1 | 5-bromo-3-sec-butyl-6-methyluracil |
| **Diphenyl ether** | | | |
| 1 | Nitrofen | TOK E 25 | 2,4-dichlorophenyl p-nitrophenyl ether |
| 2 | Oxyfluoren | Goal | 2- choloro – 1-(3-ethoxy-4nitrophenoxy) -4-(trifluoro methyl) benzene |
| **Bipyridilium** | | | |
| 1 | Diquat | Reglone | 6,7-dihydrodipyrido[1,2-*a*:2′,1′-*a*]pyrazinediium |
| 2 | Paraquat | Gramaxone | 1,1′-dimethyl-4,4′-bipyridinium |
| **Unclassified** | | | |
| 1 | Glyphosate | Round up; Glycel | N-(phosphanomethyl) glycine |
| 2 | Picloram | Tordon | 4-amino 3,5,6 –trichloro picolinic acid |
| **Inorganic herbicides** | | | |
| 1 | Ammoniumsulphamate | | |
| 2 | Sodium arsenite | | |



## LOW VOLUME HERBICIDES

Herbicides play an important role in weed control on agricultural and non agricultural surfaces. They are mainly applied by sprayers (foliar application) that consist of a herbicide tank, a pressure generator, spray nozzles, pipes and connectors. Foliar application of herbicides entails spraying the leaves of target plants during the growing season with a low concentration of herbicide in a water carrier.

Among all possible weed control methods, the use of herbicides is principally associated with risks for human health and the environment. Because of this there is much discussion about the use of herbicides. Reduction in use of herbicides will reduce associated risks. It is expected that herbicide use can be much reduced when herbicides are applied according to best possible practices i.e. application of minimal doses of herbicide adjusted to weed, weather, herbicide and sprayer conditions.

Low volume herbicide application has many benefits. Besides its cost-effectiveness for the landowner, the low volume solution is also environmentally friendly. The spray can be applied with a hand-powered, backpack sprayer or larger, motorized sprayers.

This type of application method has numerous advantages:

- With low volume foliar, only the targeted species are treated.
- Low volume foliar application is also extremely low profile. No large trucks, no noisy spray devices, only professional employees with backpacks.
- Low volume foliar also allows for a lower application cost due to the lower volume of mix being applied and is extremely effective due to the higher concentration of herbicide being applied to each individual plant.

## HERBICIDE MIXTURES

It involves mixing of two or more herbicides used for effective and economical weed control.

**Advantages of Mixture**

- A mixture will broaden the spectrum of herbicidal action and kill a variety of weeds
- It may increase the effectiveness;
- In a mixture one herbicide may prevent rapid degradation of the other and increase its efficacy
- A mixture offers the possibility of reducing the dose of each of the herbicide necessary for weed control leading to low residue

***Two types of mixtures***

1. Tank mixtures made with the desired herbicides and rates before application e.g., Anilophos + 2,4-D EE – rice

**2.** Ready mix – formulated by the manufacturer. Ready mix available in the world market e.g., 2,4-D+Glyphosate, Paraquat+2,4,-D, Atrazine+metolachlor, paraquat+oxyfluorfen.

## HERBICIDE ROTATION

The practice of following a systematic, rotational sequence of herbicide used in the same field to prevent or control formation of herbicide resistant weeds.

In a rotational programme a soil-applied or foliage applied herbicide or both are used in a sequence to take care of annual as well as perennial weeds. The choice of herbicide depends on the tolerance of crops to particular herbicides, type of weed spectrum, intensity of weed infestation, soil and climatic factors etc.,

The best rotational programme will aim at maximum cumulative cost benefit ratio and least residual problems and least build-up of tolerant weeds.

**Advantages**

- Helps in preventing emergence of tolerant weed species (herbicide is captured in vacuole and inactivated excluding the herbicide from site of action).
- Reduces the quantities of herbicide required for optimum weed control over the years.
- Provides most effective weed control for the duration of crop growth.
- Reduces the building up of herbicide residue problems.
- It offers high cumulative cost-benefit ratio over the years

Weed survey and mapping may be done every year and if any shift in weed flora, appropriate changes in herbicide rotation should be made.

## HERBICIDE TOLERANCE AND RESISTANCE

**Herbicide Resistance**: Naturally occurring inheritable ability of some weed biotypes within a population to survive a herbicide treatment that would, under conditions of use effectively control the weed population (Rubin, 1991)

- *Senecio vulgaris* resistance to triazine group of herbicide was noticed during 1970.
- Worldwide 183 weeds have developed resistance to herbicides till 1997.
- In India the most common example is *Phalaris minor* .
- The highest resistance in 61 weed species was recorded for Atrazine.
- USA alone found to have 49 herbicide resistant weeds, the highest in the world.

- **Tolerance**: The term tolerance refers to the partial resistance and presently the usage of the term is discouraged due to inconsistency in quantifying the degree of tolerance.

- **Gross Resistance**: When a weed biotype exhibits resistant to two or more herbicides due to the presence of a single herbicide mechanism.
- **Multiple resistance**: It is a situation where resistant plants posses two or more distinct resistant mechanism to a single herbicide or groups of herbicides.

**Basic principles of herbicide resistance**

1. Time, dose and method of application of herbicide variation
2. Variation in phenotypes of a population
3. Genetic variation by mutation or activation of pre-existing genes

**Conditions favourable for development of Herbicide resistance**

- Repeated use of same herbicide or use of herbicide with same mode of action due to the practices of monoculture
- Areas where minimum/zero tillage is followed
- Fields where farmers rely on only herbicides for high degree/level of weed control including nurseries, orchards
- Non-crop situations like road sides, railway tracks etc. where herbicides are repeated used may be at higher doses than cropped situation

**Resistance was exhibited in crop is due to:**

- Herbicide metabolism by crops making them inactive
- Absence of certain metabolic process in crops compared to weeds and thus tolerating the herbicides
- Crops couples the herbicide molecule



# LECTURE XIV

**Aim**: To study integrated weed management, shift of weed flora in cropping systems and compatibility of herbicides with other agro chemicals

## INTEGRATED WEED MANAGEMENT (IWM)

Integrated weed management may be defined as the combination of two or more weed-control methods at low input levels to reduce weed competition in a given cropping system below the economical threshold level. It has proved to be a valuable concept in a few cases, though much is still to be done to extend it to the small farmers' level.

Integrated Weed Management (IWM) approach aims at minimizing the residue problem in plant, soil, air and water. An IWM involves the utilization of a combination of mechanical, chemical and cultural practices of weed management in a planned sequence, so designed as not to affect the ecosystem. The nature and intensity of the species to be controlled, the sequence of crops that are raised in the rotation, the standard of crop husbandry, and the ready and timely availability of any method and the economics of different weed-management techniques are some of the potent considerations that determine the success for the exploitation of the IWM approach.

**Why IWM?**

- One method of weed control may be effective and economical in a situation and it may not be so in other situation.
- No single herbicide is effective in controlling wide range of weed flora
- Continuous use of same herbicide creates resistance in escaped weed flora or causes shift in the flora.
- Continuous use of only one practice may result in some undesirable effects *e.g.* Rice wheat cropping system - *Phalaris minor*
- Only one method of weed control may lead to increase in population of particular weed.
- Indiscriminate herbicide use and its effects on the environment and human health.

**Concept**

- It uses a variety of technologies in a single weed management with the objective to produce optimum crop yield at a minimum cost taking in to consideration ecological and socio-economic constraints under a given agro-ecosystem.
- It is a system in which two or more methods are used to control a weed. These methods may include cultural practices, natural enemies and selective herbicides.

**FAO Definition:**

IWM is a method whereby all economically, ecologically and toxicologically justifiable methods are employed to keep the harmful organisms below the threshold level of economic damage, keeping in the foreground the conscious employment of natural limiting factors.

IWM is the rational use of direct and indirect control methods to provide cost-effective weed control. Such an approach is the most attractive alternative from agronomic, economic and ecological point of view.

Among the commonly suggested indirect methods are land preparation, water management, plant spacing, seed rate, cultivar use, and fertilizer application. Direct methods include manual, cultural, mechanical and chemical methods of weed control.

The essential factor in any IWM programme is the number of indirect and direct methods that can be combined economically in a given situation. For example, increased frequency of ploughing and harrowing does not eliminate the need for direct weed control. It is, therefore, more cost-effective to use fewer pre-planting harrowing and combine them with direct weed control methods.

There is experimental evidence that illustrates that better weed control is achieved if different weed control practices are used in combination rather than if they are applied separately.

**Good IWM should be:**

- Flexible enough to incorporate innovations and practical experiences of local farmers.
- Developed for the whole farm and not for just one or two fields and hence it should be extended to irrigation channels, road sides and other non-crop surroundings on the farm from where most weeds find their way in to the crop fields.
- Economically viable and practically feasible.

**Advantages of IWM**

- It shifts the crop-weed competition in favour of crop
- Prevents weed shift towards perennial nature
- Prevents resistance in weeds to herbicides
- No danger of herbicide residue in soil or plant
- No environmental pollution
- Gives higher net return
- Suitable for high cropping intensity

**COMPATIBILITY OF HERBICIDES WITH OTHER AGRO CHEMICALS**

Simultaneous or sequential application of herbicides, insecticides, fungicides, antidotes, fertilizers etc., is followed in a single cropping season. These chemicals may undergo a change in physical and chemical characters, which could lead to enhancement or reduction in the efficacy of one or more compounds. The interaction effects were seen much later in the growing season or in the next season due to build-up of persistent chemicals or their residues in the soil. Knowledge on the interactions of various chemicals can be helpful in the formulation and adoption of a sound and effective plant protection programme. It can also help to exploit the synergistic and antagonistic interactions between various pesticides for an effective eradication of weed and other pest problems. When two or more chemicals accumulate in the plant, they may interact and bring out responses. These responses are classified as additive, synergistic, antagonistic, independent and enhancement effects.

i) **Additive effect:** It is the total effect of a combination, which is equal to the sum of the effects of the components taken independently.

ii) **Synergistic effect:** The total effect of a combination is greater or more prolonged than the sum of the effects of the two taken independently *e.g.* The mixture of 2,4-D and Chlorpropham is synergistic on monocot species generally resistant to 2,4-D. Similarly, low rates of 2,4-D and Picloram have synergistic response on *Convolvulus arvensis.* Atrazine and Alachlor combination, which shows synergism is widely used for an effective control in corn.

iii) **Antagonistic effect:** The total effect of a combination is smaller than the effect of the most active component applied alone e.g. Combination of EPTC with 2,4-D, 2,4,5-T or dicamba have antagonistic responses in sorghum and giant foxtail. Similarly, chlorpropham and 2,4-D have antagonism. When simazine or atrazine is added to glyphosate solution and sprayed the glyphosate activity is reduced. This is due to the physical binding within the spray solution rather than from biological interactions within the plant.

iv) **Independent effect:** The total effect of a combination is equal to the effect of the most active component applied alone

v) **Enhancement effect:** The effect of a herbicide and non-toxic adjuvant applied in combination on a plant is said to have an enhancement effect if the response is greater than that obtained when the herbicide is used at the same rates without the adjuvant *e.g.* Mixing Ammonium sulphate with Glyphosate.

**Herbicide-moisture interaction**

Soil applied herbicides fail when there is a dry spell of 10-15 days after their application. Pre-emergence herbicides may be lost by photo-decomposition, volatilization and wind blowing while some amount of water is desirable to activate the soil applied herbicides, excess of it may leach the herbicide to the crop seed and root zone. This may injure the crops and on other side, results in poor weed control. Heavy showers may wash down herbicides from the foliage.

Continuous wet weather may induce herbicide injury in certain crops by turning them highly succulent e.g. Maize plants are normally tolerant to Atrazine but they become susceptible in wet weather, particularly when air temperature is low. Extra succulence has been found to increase atrazine absorption and low temperature decreases its metabolism inside the plants. Quality of water used may also determine herbicide action. Dusty water reduces action of paraquat. Calcium chloride rich water reduces glyphoste phytotoxicity.

**Herbicide-insecticide interaction**

These chemicals are usually not harmful at recommended rates. The tolerance of plants to a herbicide may be altered in the presence of an insecticide and vice versa. The phyto-toxicity of monuron and diuron on cotton and oats is increased when applied with phorate. Phorate interacts antagonistically with trifluralin to increase cotton yield, by stimulating secondary roots in the zone of pesticide incorporation.

Propanil interacts with certain carbamate and phosphate insecticides used as seed treatments on rice. But chlorinated hydrocarbon insecticides as seed treatment have not interacted with propanil. When propanil is applied at intervals between 7 and 56 days after carbofuron treatment, it results in greater injury to rice vegetatively.

**Herbicide-pathogens / fungicides interaction**

Herbicides interact with fungicides also. In sterilized soil, chloroxuron is not causing any apparent injury to pea plants, while in the presence of *Rhizoctonia solani* in unsterilized soil it causes injury. Oxadiazon reduces the incidence of stem rot caused by the soil borne pathogen *Sclerotium rolfsii* L. in groundnut. Diuron and triazine which inhibit photosynthesis may make the plants more susceptible to tobacco mosaic virus. On the other hand, diuron may decrease the incidence of root rot in wheat.

**Herbicide-fertilizer interaction**

Herbicides have been found to interact with fertilizers in fields *e.g.*, fast growing weeds that are getting ample nitrogen show great susceptibility to 2,4-D, glyphosate than slow growing weeds on poor fertility lands. The activity of glyphosate is increased when ammonium sulphate is tank mixed. Nitrogen invigorate (put life and energy in to) the meristamatic activity in crops so much that they susceptible to herbicides. High rates of atrazine are more toxic to maize and sorghum when appled with high rates of phosphorus.

**Herbicide-microbes interaction**

Microorganisms play a major role in the persistence behaviour of herbicides in the soil. The soil microorganisms have the capacity to detoxify and inactivate the herbicides present in the soil. Some groups of herbicides more easily degrade through microbes than others. The difference lies in the molecular configuration of the herbicide. The microorganisms involved in herbicide degradation include bacteria, fungi, algae, moulds etc. Of these, bacteria predominates and include the members of the genera *Agrobacterium, Arthrobacter, Achromobacterium.*

*Bacillus, Pseudomonas, Streptomyces, Flavobacterium, Rhizobium* etc. The fungi include those of the genera *Fusarium, Penicillium* etc.

## SHIFT OF WEED FLORA IN CROPPING SYSTEMS

Shifts in weeds are not new. Weed shifts have happened as long as humans have cultivated crops. Weedy and invasive species can easily adapt to changes in production practices in order to take advantage of the available niches. Weeds are well equipped to flourish in disturbed agricultural systems. Weeds are genetically diverse and can readily take advantage of the variety of conditions created by any crop production system. Therefore, one key to reducing the predominance of any given weed species isto increase the diversity of crops within the cropping system, or at least the diversity of weed management practices within the cropping system.

A change from conventional tillage to a conservation tillage system can lead to shifts in weed species composition. Weed shifts can also occur both within a population of a certain species (e.g., surviving mutants), or within a plant community (e.g., certain species). A weed species shift can result in the emergence of weeds tolerant of existing weed management practices. A need to recognise and understand shifts in weed populations in various cropping systems is important. An understanding of crop production effects on weed species shifts can lead to development of improved weed management strategies.

### Weed shift

A weed shift is the change in the composition or relative frequencies of weeds in a weed population (all individuals of a single species in a defined area) or community (all plant populations in a defined area) in response to natural or human-made environmental changes in an agricultural system.

Weed shifts occur when weed management practices do not control an entire weed community or population. The management practice could be herbicide use or any other practice such as tillage, manure application, or harvest schedule that brings about a change in weed species composition.

Some species or biotypes are killed by (or susceptible to) the weed management practice, others are not affected by the management practice (tolerant or resistant), and still others do not encounter the management practice (dormant at application). Those species that are not controlled can grow, reproduce, and increase in the community; resulting in a weed shift. Any cultural, physiological, biological, or chemical practice that modifies the growing environment without controlling all species equally can result in a weed shift.

In the case of chemical weed control, no single herbicide controls all weeds, as weeds differ in their susceptibility to an herbicide. Susceptible weeds are largely eliminated over time with continued use of the same herbicide. This allows inherently tolerant weed species to remain, which often thrive and proliferate with the reduced competition. As a result, there is a gradual shift to tolerant weed species when practices are continuously used that are not effective against those species. A weed shift does not necessarily have to be a shift to a different species. For example, with a foliar herbicide without residual activity like glyphosate, there could also be a shift within a weed species to a late emerging biotype that emerges after application.

**Weed resistance**

In contrast to weed shift, weed resistance is a change in the population of weeds that were previously susceptible to an herbicide, turning them into a population of the same species that is no longer controlled by that herbicide. While weed shifts occur with any agronomic practice (crop rotation, tillage, frequent harvest or use of particular herbicide), the evolution of weed resistance is only the result of continued herbicide application. The use of a single class herbicide application continuously over time creates selection pressure so that resistant individuals of a species survive and reproduce, while susceptible ones are killed.

A weed shift is far more common than weed resistance, and ordinarily take less time to develop. If an herbicide does not control all the weeds, the tendency is to quickly jump to the conclusion that resistance has occurred.

A common misconception is that weed resistance is intrinsically linked to genetically engineered crops. However, this is not correct. The occurrence of weed shifts and weed resistance is not unique to genetically engineered crops. Weed shifts and resistance are caused by the practices (for example repeated use of single herbicide) that may accompany a genetically engineered crop and not the GE crop itself. Similarly, there is another belief that resistance is transferred from Ge crop to weed species. However, unless the crop is genetically very closely related to naturally occuring weed, weed resiatnce cannot be transferred from crop to weed.

Transgenic herbicide resistance crops have greater potential to foster weed shifts and weed resistant since a grower is more likely to use single herbicide in transgenic herbicide resistance crops. The increase in acreage of these crops could increase the potential for weed shifts and weed resistance in the cropping systems utilizing transgenic herbicide resistance crops.

**Weed management principles to reduce weed shifts and resistance**

**Weed identification**

Effective weed management practices begin with proper identification to assess the competiveness of the weeds present and to select the proper herbicide if one is needed. A weed management strategy to prevent weed shifts and weed resistance requires knowledge of the composition of weeds present. Identification of young seedlings is particularly important because seedlingS of weeds are easier to control.

**Frequent monitoring for escapes**

It is difficult to detect an emerging weed shift or weed resistance problem if fields are not frequently monitored for weeds that escapes current weed management practices. Identification and frequent monitoring can detect problem weeds early and guide management practices, including herbicide selection, rate and timing.

**Herbicide rate and timing**

In weed management programme the grower must be sure to use the proper herbicide rate for the particular weeds species as they may be sometimes tolerant to lower doses. And also the time of application of the herbicide dose is important it treat the weeds when they are small, because after crossing certain stage they may be tolerant to that particular herbicide or dosage.

**Crop Rotation**

One of the most effective practices for preventing weed shifts and weed resistance is crop rotation, which allows growers to modify selection pressure imposed on weeds. Crops differ in their ability to compete with weeds; some weeds are a problem in some crops, while they are less problematic in others. Rotation therefore would not favor any particular weed spectrum. Crop rotation also allows the use of different weed control practices, such as cultivation and application of herbicides with different sites of action. As a result, no single weed spices or biotype should become dominant.

**Agronomic Practices**

In addition to crop rotation, several management practices may have an impact on the selection of problem weed populations. If problem weeds germinate at a specific time of year, crop seeding date can be shifted to avoid these weed populations. Delaying irrigation after can reduce germination of certain summer annual weeds. However, this practice only works on some soil types and water stress resistant crops only. Harvest management can, assist in eliminating or suppressing problem weed populations in some cases, but harvest must occur before weed seed production to prevent weed proliferation.

**Rotation of Herbicides**

Weed shifts occur because herbicides are not equally effective against all weed species and herbicides differ greatly in the weed spectrum they control. A weed species that is not controlled will survive and increase in density following repeated use of one herbicide. Therefore herbicides rotation is recommended. Rotation of herbicides reduces weed shifts, provided the rotational herbicide is highly effective against the weed species that is not controlled with the primary herbicide. The grower should rotate to an herbicide with a complimentary spectrum of weed control, along with a different mechanism of action and therefore a different herbicide binding site. Weed susceptibility charts are useful to help develop an effective herbicide binding site and herbicide rotation scheme. In addition, publications on herbicide chemical families are available to assist growers in choosing herbicides with different mechanisms of action.

Rotating herbicides is also an effective strategy for resistance management. Within a weed species there are different biotypes, each with its own genetic makeup, enabling some of them to survive a particular herbicide application. The susceptible weeds in a population are killed, while the resistant ones survives, set seed, and increase over time. Using an effective herbicide with a different mode of action from the one to which the weeds are resistant, however, controls both the susceptible and resistant biotypes. This prevents reproduction and slows the spread of the resistant biotype.

Frequency of rotation depends on weed species and escapes. There is no definitive rule on how often herbicides should be rotated. It is better to rotate at least once on the middle years or more often for perennial crop. It can also be modified depending upon actual observations of evolving weed problems. The key point, which cannot be overemphasized, is the importance of thorough monitoring for weed escapes. Producers should stay alert to the appearance of weed species shifts and evolution of resistant weeds. Weed resistance should be confirmed by controlled studies conducted by a weed scientist. However in these situations, it is imperative to prevent reproduction of a potentially resistant biotype. Treat weed escapes with alternative herbicides or other effective control measure.



## LECTURE XV

**Aim:** To study different problematic weeds and their control

**PROBLEMATIC WEEDS**

Weed control practices often have an effect on the weeds, on a year by year basis. Before the development of herbicides, growers relied heavily on tillage as a tool for controlling and suppressing weeds. Once herbicides became a valuable tool, some of the problem weeds found in predominantly tillage based management practices began to fade and new problematic weeds began to fill the gap. As our habits change, specific weeds will exploit the new niches we create and become the more dominant species.

Some of the weeds like *Cyperus rotundus*, *Cynodon dactylon*, *Eleusine indica* etc., are listed as world's worst weeds. *Cyperus rotundus* is the most problamatic weed present in 92 countries, followed by *Cynodon dactylon* in 80 countries. Both weeds are perennial, mainly propagated by vegetative means and also by seeds. *Cyperus rotundus* is a problem weed in 52 crops while *Eleusine indica* in 46 crops.

**Table: Some of the world's worst weeds are listed below**

| **Weed Ranking** | **Common Name** | **Botanical Name** | **Occurrence in no. of** | |
|---|---|---|---|---|
| | | | **Crops** | **Countries** |
| 1 | Nut grass | *Cyperus rotundus* | 52 | 92 |
| 2 | Bermuda grass | *Cynodon dactylon* | 40 | 80 |
| 3 | Banyard grass | *Echinochloa colonum* | 36 | 61 |
| 4 | Jungle grass | *Echinochloa crusgalli* | 35 | 60 |
| 5 | Goose grass | *Eleusine indica* | 46 | 60 |
| 6 | Jhonson grass | *Sorghum halepense* | 30 | 53 |
| 7 | - | *Imperata cylindrica* | 35 | 73 |
| 8 | Water hyacinth | *Eichornia crassipes* | - | - |
| 9 | - | *Portulaca oleracea* | 45 | 81 |
| 10 | Fat hen | *Chenopodium album* | 40 | 47 |
| 11 | Large crab grass | *Digitaria saugunialis* | 33 | 56 |
| 12 | Field bind weed | *Convolvulus arvensis* | 32 | 44 |

**Perennial and Problematic weed management**

**Prevention**

The most basic and effective of all methods to control perennial weeds is prevention. As discussed earlier, there are several means of weed seed dispersal, most of which can be prevented. Ensuring clean crop seed, animal feed, and hay is the most important measure in preventing seed dispersal. Other methods of prevention include cleaning field machinery and harvest equipment when moving between fields, proper long-term manure storage to reduce seed viability after passing through animals' digestive tracts, and maintenance of weed-free irrigation water.

Crop rotation can be another effective method to prevent the establishment of perennial weeds. The most effective crop rotations for this purpose include not only crops that compete well with perennial weeds, but also those that allow the use of herbicides to control perennial seedlings.

**Mechanical weed control**

Cultivation, when combined with other management tactics, can be used to control seedlings before energy-storing vegetative tissue has accumulated. Mechanical control no longer is effective after energy has been stored in underground vegetative tissue. In fact, cultivation of established perennials can spread weeds by cutting roots and moving them to new areas.

Perennial weeds are more common in reduced-tillage fields, where there is little soil disturbance to disrupt the development of below-ground storage organs. Once perennial weeds are established in reduced-tillage fields, cultivation is ineffective and might increase the spread of vegetative roots.

In pasture and forage crops, frequent mowing or cutting can prevent weed seed production and reduce the amount of energy stored in below-ground structures. Most important, maintenance of a vigorous crop stand through proper fertility and water management, seeding density, and variety selection will allow the competitive ability of the crop to suppress perennial weed growth. This simple "hands-off" approach requires little additional input or management, but can greatly reduce weed seed production and root rowth.

**Chemical weed control**

Perennial weed control with herbicides must be repeated for 2 to 3 years and combined with other management tactics such as mowing. The key is to get the herbicide into the roots. Herbicide activity relies on foliar absorption and transport from the leaves to the root system. Young leaves move nutrients from the root in an upward, above-ground direction, while more mature leaves transport photosynthetic products to the root system for storage. Thus, the most effective herbicide activity occurs as the product is transported to the roots with the products of photosynthesis.

Herbicides are most effective on perennial weeds in the early fall, when weeds are transporting energy to the roots before winter dormancy. Treatment just before and during flower bud initiation also is effective, as the herbicide will be carried with photosynthetic products to the roots. To ensure the presence of sufficient mature foliage, apply post emergent herbicides either 1 to 2 weeks before cultivation or mowing, or after weed regrowth is at least 8 inches tall.

**Biological weed control**

Biological control is a slow process, and results are not guaranteed. Therefore, it is used most appropriately as a component of an integrated weed management system that relies on multiple tactics for perennial weed control. For example, the fungus *Concholiobolus lunatus* kills barnyard grass seedlings with fewer than two leaves, but growth of larger plants is only slowed and plants recover. However, when the fungus is combined with a sub lethal dose of Atrazine (a dose that injures but does not kill the barnyard grass), larger barnyard grass plants can be controlled better than when Atrazine is used alone.

**Integrated weed management**

Management of perennial weeds is most successful when multiple tactics are employed, such as the combination of chemical, mechanical, and cultural control. Integrated weed management, when combined with prevention and control of weeds outside of crop production areas, provides the best long-term management of perennial weeds.

## SOME PROBLEMATIC AND NOXIOUS WEEDS AND THEIR MANAGEMENT

**Grasses**

**1. *Cynodon dactylon* (L.) pers. (Bermuda grass, doob)**

**Biology and Habitat:** Cynodon dactylon is a perennial weed growing largely from rootstocks and stolons. Although it produces seeds, yet these are not important in its dispersal. Bermuda grass rootstocks from dense sod inside the soil and its stolons creep over the land, extensively. The grass grows round the year, but it is particularly vigorous under warm and moist conditions.

**Control:**

In the semi arid tropics, exposoure of Cynodon dactylon rhizomes to hot Sun during summer months by deep tillage of the infested land, is an effective method of controlling the weed. It takes about 7-14 days to desiccate the exposed rhizomes where after a second tillage operation to further expose the Bermuda grass rhizome is required. Bermuda grass control by summer tillage can be improved by pre conditioning it by the application of herbicide e.g. Dalapon, Diuron, Glyphosate, Amitrole-T, and Uracils. These herbicide will aid in achieving a longer lasting and more complete kill of the weed by translocating to the underground rhizomes of the weeds.

**2. *Sorghum halepense* (L.) Pers. (Johnson grass, baru).**

**Biology and Habitat:** Sorghum halepense is a perennial, robust grass with upto 2m high culms. It reproduces from stout, deep rhizomes and plentiful seeds. The rhizomes may be found as deep as three meter in soil, though 35-37 cm depth in more common. A piece of Johnson grass rhizome dragged to a new spot forms a new colony quickly. The food reserves in the rhizomes are lowest when the aerial shoots are 26-33 days old. At this time the Johnson grass shoots are in boot stage and about 30-35 cm in height. Ripe seeds are produced in large numbers during the winter months and are disseminated extensively with wind. Thereafter, the old grass clumps undergo dormancy. The new seedlings appear in summer and these begin forming rhizomes within 3-4 weeks. The rhizome development is fast after the plants have formed the seed heads.

**Control:** In humid regions effective control of Sorghum halepense has been obtained from the earlier cited tillage cum herbicide system. Cultivation should begin in hot weather when Johnson grass is 30-40 cm tall. The weed should be allowed to regrow to the same height and then treated with two sprays of Dalapon at 5-7.5kg/ha each, using 0.5% of a suitable wetting agent, at an interval of 7-10 day. After two weeks, disc the treated field. To control Johnson grass from seeds, the crops should be treated with suitable soil active herbicides.

**3. *Avena* spp. (wild oat, jungli jai)**

**Biology and Habitat:** There are three common species of wild oat, namely, *Avena fatua* L., *A. ludoviciana* Dur, and *A. sterilis-macrocarpa* L. of these, in India the first two species are of common occurrence. *A. sterilis* is the principal wild oat species in Africa.

Wild oat is a serious weed of mainly wheat and barley although it may infest other winter corps too. It is so because in small grains it survives by mimicry during its vegetative phase. Botanically it can be distinguished from wheat plants by its large ligules, absence of auricles and anti-clockwise twist of its leaves. (The wheat leaves show clock-wise twist). But none of these characters can be used to identify wild oat while weeding it out form the wheat (And barley) fields.

**Control:** Adoption of crop rotation involving non-graminaceous winter crops, where wild oat shows itself distinctly, is a practical way of reducing the weed populations. From wheat and barley plots the weed can be pulled out only after it has shown its typical panicle when large areas of weed and barley are involved, herbicides are to employ to reduce wildoat infestation. In these crops herbicides such as diallate, triallate and barban were recommended for wild oat control in the past. In recent years, superior herbicides e.g. clodinafop, fenoxaprop, mesosulfuron and tralkoxydim have replaced the older herbicides.

**4. *Phalaris minor* Retz. (Littleseed canarygrass, gullidanda, vanri)**

**Biology and Habitat:** Phalaris minor, an annual invasive alien, weed, has spread wildly in many wheat growing areas of the world. Like wildoat, it mimics wheat and barley plants and sets seeds at almost the same height and time as the crop. Each plant of canary grass produced about 300-460, shiny black, very small, flat seeds which readily contaminate the wheat seeds.

**Control:** Unlike wild oat, the seed of canary grass can be separated from wheat and barley seeds by sieving. Crop rotation involving broadleaf winter crop, and in certain area winter maize, offer farmer chance to hoe out this grass at a very early crop stage. From winter grain crops the canary grass plants can be pulled out only when they first shows their foxtail-like spikes in Feburary,peeping through their flag leaves. Certain herbicides have exhibited adequate selectivity between P. *minor* and wheat (or barley).Some such herbicides are Methibenzuron, Metoxuron, Isoproturon, and Terbutryn.

**5. *Striga* spp. (Striga, witchweed,agia)**

**Biology and habitat**: Striga is an annual, parasitic herb, propagating from seeds. A stimulus from a suitable host root exudates, continuously for 24-28 hours, is needed to trigger the germination process in Striga seeds. Upon germination, Striga produces 2-3 mm long radicles. The radicles then from haustoria on the nearby host roosts and continue extending their growth involving the whole root system of the crop plant; sucking water, nutrients and other food material from them. Each Striga plant may produce over a million seeds, about 30 days after its emergence. The Striga seeds are as dust particles.

There are 23 species of Striga on record in the world but, of these only three are considered notorious. These are: S. asiatica, S. hermonthica and S. densiflora.

**Control:** Techniques to reduce seed production in Striga have been recommended. Even hand pulling before Striga plants put forth their flowers can be helpful in this respect, but it is impracticable in cases of severe infestations. Directed applications of 2,4-D is a practical alternative to this for breaking future plantations of Striga .Its amine salt is applied at 0.5-0.75 kg/ha,2-3 times during the crop season to destroy flushes of Striga in its vegetative phase. Dicamba and bentazon need be tried as more potent alternatives to 2,4-D for Striga control.Preemergent granular Atrazine is also reported effective against Striga.

**6. *Orobanche* spp.**

**Biology and Habitat:** These are four major parasitic species of broomrape. These are; O. cernua on tobacco and sunflower, O.ramossa and O.aegyptiaca on tomato and like crops.Broomrape is an annual, parasitic herb propagating by seeds. The host root exudates induce germination of broomrape seeds within soil. The parasite seedling then infects the nearby host roots forming haustoria on them. Soon thereafter the broomrape emerges through the soil as pale shoots, devoid of chlorophyll. Broom rape is thus a total parasite. Its clones are fleshy at the base, and they develop several tubercles which grow into separate flowering shoots. Each broomrape plants may produce over half a million seeds in a short period of about eight weeks. The broomrape seeds disseminate by wind, birds and farm animals. They can remain dormant in soil for 2-12 years.

Control: Crop breeding for introducing Orabanche resistance has made only limited headway, thus far. Pepper is generally regarded as a suitable trap crop for some species of Orabanche. Trap cropping, however has a very limited scope for broomrape control in the present cropping systems. Hand –weeding at weekly intervals is effective in preventing its further, but it is too costly an operation.

Herbicidal control of Orabanche has been found possible with allyl alcohol applied at 0.1-3.2% spray, about 2-4 weeks after transplanting tobacco. Also, preplant soil treatment with Dalapon, Linuron, or metobromuron has been found to keep tobacco free from this parasite to acceptable levels. Orabanche shoots have been further found susceptible to Glyphosate and terbutol at their usual application rates, as well as to several vegetable oils.

**7. *Cuscuta* spp. (dodder, akashbel)**

Family: Convolvulaceae

Biology and Habitat: There are at least 170 species of *Cuscutta*, an invasive alien parasitic weed, in the world. Of these, C. *campestris*, *C. reflexa* and *C.hyalina* are most common. Cuscuta is a complete parasite, twining, golden yellow, wiry stems, rudimentary scaly leaves, and small clusters of minute, bell-shaped flowers. The dodder stems contain carotenoid pigment capable of conducting only limited phtosysthesis.Germination of dodder seeds does not require any stimulation form the host crop. They germinate readily in moist soil and produce wiry plumules.The plumules try to strike nearby plant roots and stubbles. Then they travel upward in search of a suitable host shoot, as yellow seedlings. A single dodder seedling can grow 2 km or more in length.

**Control:** Cuscuta is one of the very few weeds that can be controlled hand foot by adopting crop rotations; replacing its host crop with a non host crop for a couple of years. This is the most pragmatic approach to control this parasitic weed. Among the selective herbicides, dodder has been found susceptible to chloropham, pronamide, Glyphosate, dichlobenil, Fluchloralin, pendimethalin, imazaquin and metolachlor. Choice amongst these shall depend upon their specific selectivity to the host crop in question.Pronamide has been reported particularly useful in killing Cuscutta growing on niger. It is applied at 2kg/ha, about 20 days after sowing of the crop.

**8. *Loranthus* spp.**

Family: Loranthaceae

**Biology and Habitat:** Loranthus is a stem semi-parasite of certain tropical and subtropical trees and bushes like, mango citrus, sapota, jackfruit and tea. In India alone about 60 species of Loranthus are on record. Of these *L. longiflourus* var *.falcatus* is the most damaging. Loranthus seeds are spread by birds to fresh tree branches.

**Control:** The control measure of Loranthus is to bore two rows of holes down the infected tree reaching the sap wood in each hole a mixture of 8g copper sulphate and 1g 2,4-D powder is pushed in. This treatment is supposed to free the tree from the Loranthus for a period upto 4 years.

**9. *Convolvulus arvensis* L. (field bindweed, hirankhuri)**

Family: Convolvulaceae

**Biology and Habitat***:* *C.arvensis* is a vigrous, twinning or trailing, perennial herb. It reproduces by seeds and creeping roots which may be as deep as 6-9 m. Though it is an evergreen plant, in excessive drought conditions it under goes dormancy. The seeds have long dormancy period in semiarid region. It binds the crop plants and makes their harvesting extremely cumbersome.

**Control:** In fallow fields summer tillage with overlapping sweeps every time the bindweed plants are 14-18 days old, followed by competitive cropping with fodder crops, forms good cultural method of its control.The cultivation should begin at early bud stage of the weed. Its last growth may be treated at the early bud stage with 2,4-D at 0.5-1.0 kg/ha.

In winter grains 2,4-D has been used for long to control bindweed sufficiently well to permit acceptable crop harvests. It is applied twice during the crop season, once each at the tillering and stiff dough stages of the crop. Beside after crop harvest the left over bindweed plants are recommended to be treated **with** 0.2—0.3% spray of mixture of 2,4-D and Silvex (2:1).

**10. *Cirsium arvense* (L.) Scop (Canadathistle, keteli)**

Family: Asteraceae

**Biology and habitat:** *Cirsium arvense* is a perennial, dioceous rough herb, with somewhat spiny leaves. It grows up to 150 cm tall, in dense stands of as much as 45 shoots/sq m ground area. The weed has a worldwide distribution in the temperate regions. In India it is problematic in winter season crops in certain areas . It remains dormant during the late summer and rainy period. The thistle propagates through its extensive root system and seeds. Its roots may reach as much as 5m deep, though about 50% of the root biomass is concentrated in the top 30 cm soil. Root segments, as small as 0.3 × 1.2 cm in length are capable of producing new plants and a 19 days old seedling can form adventurous root buds.

**Control:** Lucerne and berseem (Egyptian clover) form very good smother crops for the control of canadathistle. Their multicuts weaken the thistle plants sufficiently to discourage their propagation. In open crops like chickpea and mustard, on the other hand, the farmers get sufficient opportunity to physically remove 2-3 flushes of the thistle. However, in the close row crops like the winter grains, Canadathistle controlis difficult by such means and it is necessary here to resort to the use of selective herbicides. Some suitable herbicides for the purpose are 2, 4-D, MCPB and sulfonylureas. MCPB can alcobe used in pea to control this weed.

**11. *Lantana camara***

Family: Verbenaceae

**Biology and habitat:** Lantana camara is a perennial, evergreen, invasive alien shrub that spread readily by its abundant seeds shallow crown buds. The weed is native to Mexico. In India, it was initially introduced in 1809 from Sri Lanka as a hardy, ornamental hedge, bearing multicolour flowers. But then it escaped to open pastures, river beds, wastelands, cultivable lands, and forests, where it easily displaced the indigenous vegetation ,thereby adversely affecting the grazing grounds and other land utilities ( Prakash,1995).The seeds of lantana camara regenerates quickly from the crown buds after cuttings, trampling, or burning, to form to dense , impenetrable thickets. Lantana leaves contain a toxic compound, lantad-C, which causes lesions and changes in blood plasma of the animals compelled to graze upon it.

**Control:** Biological control of lantana has widely practiced in Australia and Hawaii in particular, although it has not proved successful in India, thus far.

Herbicidal control of lantana, though possible, has not met with great acceptance. The plant is susceptible to the commonly known brush killers. In India a spray of Glyphosate (0.75-1.0%) on the new growth of lantana occurring after burning or slashing its thickets has been found encouraging in extirpating the weed in Himachal Pradesh.

**12. *Ageratum* spp. (billgoatweed, neela phulnu, pudeni, ujaru and ukhal buti**)

Family: Asteraceae

**Biology and habitat:** Ageratum is an invasive alien weed that is native to tropical America. Its two species, namely A. conyzoides (L.) and A. houstonanium (mill.) are common in India. While A.conyzoides is an annual species invading both crop and non crop lands, the latter is a common perennial species infesting largely undisturbed areas likes the road sides, field boundaries, pasture land, orchards and water channels.

The perennial species of Ageratum (A. houstonanium) multiplies by stem and roots, besides numerous seeds, capable of remaining dormant in soil for up to three months

Control: Ageratum is susceptible to common herbicides used in maize and other kharif crops, like Atrazine and Alachlor. In non crop areas, it can be damaged severely with a non-selective herbicide like Glyphosate.

**13. *Parthenium hysterophorus* L. (carrot grass, chandni)**

**Family: Asteraceae**

**Biology and Habitat:** P. hysterophorus is an annual invasive alien plant, with wide amplitude of ecological adoptability; being both photo and thermo-insensitve.It reproduces it self freely from numerous seeds (5000-10000 per plant), beside its crown bud which put forth new shoots as and when the mother shoot is cut. Thus , the weed spreads by leaps and bounds in any new, neglected area. The weed is notorious for causing allergic dermatitis and mental depressions in human beings. the main toxin responsible for such effects of the weed is parthenin, present in a concentration as high as 0.33 % ( d.w.b). In dry summer months Parthenium tends to stunt its growth and remain in rosette form. It shoots up new growth in the rainy season and grows fast through the winter, attaining a height about 90 cm, with profuse branching. The plant flowers and sets seeds throughout its growing period.

**Control:** Chemical control of Parthenium infestations is found scientifically possible with certain herbicides, particularly, 2, 4-D esters (2-5kg /ha), Diquat (0.5-1.0%) Glyphosate (0.5-1.0%), chlorimuron (0.02-0.04% kg/ha), metribuzin (0.3-0.5%) and metsulfuron (0.035-0.045% kg/ha).Of these herbicide, metribuzin is the latest recommended against P. hysterophorus.

Finding that the major P. hysterophorus problem ca not be addressed to with the herbicides for economic and feasibility reasons, the scientist laid stress on its biological control. After testing different possible bioagents for several years. Mexican beetle zygogramma bicolorata was finally accepted as the most effective bioagents for damaging the established carrotgrass infestations on the vast non crop lands of the country.

**14. *Solanum elaeagnifolium* Cav. w. (wild brinjal, silver leaf nightshade, white weed)**

Family: Solanaceae

**Biology and habitat**: silver leaf nightshade is a deep rooted, perennial weed with erect and branched stems covered with fine hair and orange colour prickles. Its leaves are silvery white due to numerous white hairs. The flower is purple to violet. The plant grows profusely during the rainy season, infesting roadsides, garden lands and neglected dry lands. Its root pieces can give rise to new plants In India, the weed is presently noxious in her southern states .The weed is native is South West USA and Mexico. It is poisonous to livestock.

**Control:** The weed has been found susceptible to 2, 4-D and Glyphosate but it regrows after about 2 weeks of the treatment. Further research has shown that dicamba can translocate to the root of this weed and, thus, it holds good promise against it (Velu and kempuchetty,1991).

**15. *Cyperus* spp. (nut sedge, motha)**

Family: cyperaceae

**Biology and habitat:** There are two common species of nut sedge, namely, Cyperus esculantus L. (yellow nut sedge) and C. rotundus L. (purple nut sedge). A purple nut sedge possesses a prominent basal bulb just below the ground level. This basal bulb produces a chain of tubers which ramify as deep as 60cm in soil. But in yellow nut sedge, instead of a basal bulb, there are crown buds a little below the soil surface which gives rise to cluster of short rhizomes ending to small tubers. When mother shoot of yellow nut sedge are destroyed by tillage, new Arial shoots are borne by these crown buds. In purple nut sedge, on the contrary, the new shoots arise from the tubers.

The chief mode of propagation of yellow nut sedge if fro seed, which are 90-95% viable. Its tubers are small and slow growing. In variance with this, the purple nut sedge seeds are of very low viability (2-10%) but its tubers are prominent and grow rapidly. During the first one month growth of purple nut sedge, a mother tuber can produce four daughter tubers and in three months the tuber population may reach almost 100. This makes purple nut sedge much more problematic than yellow nut sedge.

**Control:** Nutsedge is found susceptible to tillage. In summer fallows, hot weather cultivations can desiccate the tuber to death. Crowbar and overlapping sweeps are good for this purpose. A tuber exposed to summer Sun in the arid and semi arid tropics, is desiccated in about 14 days if the soil was completely dry. The nut sedge tuber desiccation can be greatly improved by supplementing tillage with 2,4-D (2-4 kg/ha) at the last cultivation before the onset of monsoon. Several herbicide like 2,4-D, amitrole-T, liquid Atrazine, bentszon,salt of MAA, Paraquat, Propanil and Linuron are effective on nut sedge shoot but they seldom achieve extended control of weed beyond 1-2 weeks. These herbicides are employed for post emergence treatments in specific crops. Glyphosate is much more effective in this respect since it is translocated to its tuber to checks its regeneration (Thakur et al., 1993).

**LECTURE XVI**
**Weed Management in Fruit and Vegetable Crops**

## A. WEED MANAGEMENT IN FRUIT CROPS

**Tropical and Subtropical fruit crops:**

**I. Mango:** Mango *(Mangifera indica* L.*)* occupies major area under fruits in the country. It is adaptable to a wide range of soils and climatic conditions provided severe and recurring frosts in winter do not endanger the young trees (Anon., 1980). There are numbers of varieties grown in India and some are of export quality. Veneer grafting and stone grafting are found to be the best method for mango propagation. The major monocot weeds that occur in mango orchards are *Cynodon dactylon* and *Cyperus rotundus* and dicot weeds are *Bidens pilosa*, *Tridax procumbens* and *Phyllanthus maderaspatensis.*

**Control:**

**1.Hand weeding:**

Usually, manual method of weed control is adopted at this time due to young nature of mango plants by employing women labour. They use small hand tools *(khoorpi)* for removing weeds in basins and between rows of plants.

**2. Mechanical method:**

When the orchard comes of age between 8 and 10 years, mechanical method of weeding by using bullock drawn implements or tractors and tillers with special weeding tools attachments are employed for effective weed control. The type and nature of tools used in mechanical method depend upon the row spacing adopted for orchard. And in an average type of mango orchard, three to four ploughing (machine or bullock drawn) are enough in a year.

**3. Cover cropping:** Cover cropping is another practice followed in mango orchard to suppress the growth of weeds, to bring additional income to the grower until the trees begin to bear and improve the health of trees if the intercrops grown are of right type. The recommended intercrops in mango orchards for summer season are bottle gourd, bitter gourd, onion, chilies, cowpea, black gram and green gram. For winter season, the intercrops suggested are peas, turnip, cauliflower, carrot, radish and gram.

**4. Chemical control:** Herbicides have been used to some extent in mango to control weeds. Application of Paraquat (3.0kg a.i./ha) or Diuron as pre-emergent treatment at 6.67 and 8.9 kg/ha gives good control of weeds in mango. Or Bromocil and Dalapon were also effective for controlling dicot and monocot weeds respectively. One spray of Atrazine or Diuron at 2.0 kg a.i./ha as pre-emergent treatment to soil and one spray of Paraquat as post –emergent spray on weeds at 3.0kg a.i./ha have been found effective for controlling both monocot and dicot weeds in one to five years old mango orchard.

II. **Banana:** The banana crop is sensitive to grasses especially in the early stages of their growth compare to herbaceous dicot weeds. The major monocot weeds of banana fields are *Cyperus rotundus, Cynodon dactylon, Digitaria marginata, and Eleusine aegyptium*, and the dicot weed are *Euphorbia* spp, *Polygonum plebejum*, *Portulaca oleracea, and Mimosa pudica*.

**Control:**

Banana crop has superficial root system and thus heavy machinery for its cultivation must be avoided. It therefore, becomes imperative to think other methods of weed control for this crop.

1. **Hand weeding:** Manual method of weed control by women labour using hand operated tools is the common method of weed control.
2. **Mulching:** Mulching appears to be another effective method of weed control. Generally, organic mulches like dried leaves and inorganic mulches like black polythene are used.
3. **Cover cropping:** Growing cover crops to suppress weeds is also another way of controlling weeds in this crop. Inter cropping with ginger, cowpea, colocasia and tapioca in various varieties of banana have been reported.
4. **Chemical method:** Herbicide have been used to weed control in banana. In banana good control of both grassy and broad leaf weeds for 4-5 months with there pre-emergent spray of diuron at 2.0 kg a.i./ha. Paraquat at 1.8 kg a.i. /ha was used as a post emergence spray on 6-9 inches tall weeds in banana and control them for two months. Herbicide application was found to be more economical than hand weeding (6 hand weeding per year were necessary in banana crop.

**Pineapple:** The structure of pineapple plants with radical leaves allows much of the sunshine to fall underneath and around the plants resulting in the growth of sun loving perennial grassy weed especially in the first 6 months from the date of planting. The predominant weeds during this time are *Cyperus* spp. *Cynodon dactylon* and *Digitaria marginata* among monocots, and *Lagasca mollis*, *Portulaca oleracea* and *Mollugo pentaphylla* among dicots.

**Control:**

1. **Hand weeding:** Due to thorny nature of pineapple leaves, manual weeding is extremely difficult. The spaces between inter-rows and plants are weeded by mans and women labours using hand operated implements like *khurpi* (Hand hoe) and cutlasses. But weed control is not satisfactory in this method.

2. **Mechanical weed control:** The mechanical weed control using spade is done by men labours when earthing up operation is done to cover the shallow expose pineapple plant after 2-3 months of planting, especially in the hill grown pineapple. Even in plains, earthing up becomes necessary as pineapple plants need irrigation once a week or 10 days.
3. **Cultural method:** Mulching with black polythene is a very effective method of weed control especially in Hawaii Islands. In our own country, this method is limited to very small areas. Growing intercrops in between rows of pineapple is not popular.
4. **Chemical method:** chemical weed control using herbicides holds promise in pineapple crop. Excellent control of both monocot and dicot weeds in pineapple var. kew with a combination of Bromocil and Diuron at 2.0 + 2.0 kg a.i./ha when given as pre-emergent treatment. The frequency of application this combination treatment had to be increased to three to four times under such conditions to get year round control of weeds. Herbicides treatment increased the yield in pineapple compared to hand weeded plots. Bromacil at 3.0 kg/ha as pre-emergent spray, fifteen days after planting of pineapple, to be effective for controlling weeds up to 90 days. Very good control can be achieved with wide spectrum of weed flora in pine apple plots treated with Diuron at 2.0 kg a.i. /ha.

   Application of Glyphosate at 1.5 kg/ha along with one hand weeding was most effective control of predominant weeds such as *Digitaria marginata,* and *Eleusine indica* among monocots, and *Galinsoga parviflora, Ageratum cozyzoides* and *Biden pilosa* among dicots.

**III. Grape:** Grape (*Vitis vinifera* L.) vine is grown in West and South India especially in Maharashtra and Andhra Pradesh, to a great extent. The varieties gown are Anab-e- Shahi and Thomson Seedless. The grapes are grown on different training systems depending upon the varieties and the purpose for which they are grown. These different systems allow the growth of various types of weeds. In Bower system, soon after pruning of grapes, there is lot of sunshine underneath which allows the growth of *Cyperus rotundus* and *Oxalis corniculata?* After sometime, the vegetative growth of grape increases and shades the underneath space with result *Polygon plebejum, Euphorbia geniculata, Amaranthus viridis, Portiulaca oleracea, Oxalis* sp. And *Mullugo pentaphylla among dicots and Digitaria marginata, Eleusine indica*, and *Setaria glauca* among monocots come up. In Trellis system of training, plenty of sunshine is available for weeds to grow around and *Cynodon dactylon* is the *major* weed.

**Control:**

Control of weeds in grape is very important to maintain the yield and quality levels as it is a commercially important crop.

1. **Hand weeding:** *Euphorbia geniculata* and *E. hirta*, which appear as major weeds, carry fungal and insect pests and act as alternative hosts. The usual method of weed control is manual by employing women labour. They use *khurpi*, a small hand operated implement, to remove the weeds.
2. **Mechanical method:** In mechanical method of weed control bullock drawn implement is very common in Maharashtra. In scientific orchard management, motor run tractors and power trillers are used to cultivate the inter rows of grape. But in young orchards, the root system of grape being shallow, mechanical methods using machinery becomes difficult. In such cases, usage of spade for hoeing is preferred.
3. **Mulching:** Mulching with inorganic materials like black polythene film and organic materials like *sarkanda*, wheat and rice straw, sugar cane trash, dried leaves and saw dust have been advocated for conserving soil moisture and fostering rapid growth of plants. *Sarkanda* was found to be the best mulch for grape in Punjab and black polythene in Tamil Nadu.
4. **Cover cropping:** The general cover crops grown in grape orchards are cowpea, French beans, cucurbits, sun hemp and mung.
5. **Chemical weed control:** Chemical weed control using herbicides has been tried in grape by several workers. These worker have used either Simazine, Atrazine, Diuron, Dalapon, Oxyflurofen, Paraquat, or Glyphosate. Except Paraquat and Glyphosate, which were used as post-emergent sprays, all other herbicides were used pre-emergent to weeds. One spray of Atrazine or Simazine or Diuron at 2.0 kg a.i./ha as pre-emergent spray followed after six months by two post-emergent sprays of Paraquat at 2.0 kg a.i./ha at three monthly intervals for grape cv. Banglore Blue. Oxyflurofen at 1.0 kg a.i./ha as pre-emergent spray and Glyphosate at 3.0 kg a.i./has post-emergent spray proved very effective for controlling weeds for four and six months respectively in grape cv. Anab-e-Shahi. Herbicides in mulched vineyards have also been tried successfully.

**IV. Papaya:** The important monocot weeds that occur in papaya field are *Cynodon dactylon, Cyperus rotundus, Eleusine indica, Chloris barbata and Digitaria marginata.* The dicot weeds are *Parthenium hysterophorus, Lagasca mollis, Croton bonplandianum, Euphorbia geniculata, Phyllanthus niruri* and *Evolvus alsinoides.*

1. **Hand weeding:** The main method of weed control practiced in papaya is by employing women labour to remove the weeds manually by using *khurpi*.

2. **Mechanical method:** As papaya has shallow root system, use of heavy machinery to plough the interspaces to reduce the intensity of weeds in not safe. Thus, spades are used for hoeing in the basins. Even shallow ploughing by bullock drawn implements can be done.
3. **Mulching:** The old dried leaves and other organic materials are used for mulching in the basins of papaya.
4. **Cover cropping :** growing cover crops in papaya orchards is another way of controlling weeds. When papaya grown as a main crop, low growing vegetables like chillies, onion and tomatoes can be grow as intercrops for about six months with advantage. Afterwards, the tree grows bigger and shades the underneath ground and makes it impossible to grow any vegetables.
5. **Chemical control:** Use of herbicides to control weeds in papaya is not so common the Fluchloralin or Alachlor or Butachlor at 2.0 kg a.i./ha as pre-emergent treatment soon after transplanting of papaya seedlings, controlled all weeds including *Cynodon dactylon and Cyperus rotundus* for a period of four months under sandy loam soil conditions. Chemical weeding was found economical than the conventional hand weeding. For good control of monocot and dicot weeds with Diuron and Ametryn (2.0 and 4.0 kg a.i./ha respectively) applied 3 months after planting of papaya followed by repeat application of the same every two months.

**V. Citrus:** The predominant weeds of citrus fields are *Cynodon dactylon, Cyperus* spp., *Digitaria marginata, Eleusine indica, Setaria* spp., *Imperata cylindra* among monocots and *Amaranthus caturus, Biden pilosa, Lagasca mollis, Acanthospermum hispidium, Euphorbia* Spp., *Borreria articularis* and *Evolulus alsinoides* among dicots. `

**Control:** Weeding at regular interval to reduce the competition of weeds with trees and to avoid harbouring of dangerous fungal and insect pests, to which the citrus trees are highly prone, should be carried out.

1. **Hand weeding:** Various methods of weed control are practiced in India in citrus orchards. In young citrus orchards, manual method of weed control using hand operated implements like *khurpi* and cutlasses is very popular with growers. Both women and men labours are employed for this purpose.
2. **Mechanical method:** In established orchards, cultivation and hoeing helps in eradication of weeds and conservation of soil moisture. In closely planted orchards, ploughing by bullock drawn or motor run implements becomes difficult. In such cases, cultivation in done by

hoeing with the spade. Three to four ploughing in a year in closely planted orchards are enough for an average type of citrus plantation. Heavy machinery like tractor and power tillers must be avoided for ploughing in citrus orchards because of their shallow root system which can damage during the ploughing operation.

3. **Mulching:** Mulching the citrus basins with organic and inorganic materials is another common method of controlling weeds.
4. **Cover cropping/ intercropping:** Growing cover crops to reduce the density of weeds in the inter-rows of citrus plants is also popular with growers in our country. Intercropping also brings more money to the grower and improves the health of the trees if the intercrops grown are of right type. For summer season, vegetables like *tinda*, bottle gourd, onion, chillies, mung, cowpea and cotton are recommended for growing in 3 to 4 years old citrus orchards. In winter season, vegetables like pea, turnip, cauliflower, carrot, radish, and gram are grown. Wheat and maize as intercrops in citrus orchards. Intercropped citrus with green manure crops and observed that they were helpful in maintaining organic matter content and moisture in soil besides improving N content to a great extent.
5. **Chemical weed control:** Chemical weed control using herbicides has been successfully tried in citrus. Bromacil and diuron combination at 2.0 kg a.i./ha each to be superior to single spray and got weed control upto 4 months. Gesatop application at the rate of 5.0 kg/ha and casagard at 4.0 kg/ha controlled both monocot and dicot weeds very effectively. Pre-emergence herbicides such as monouron and diuron at 1.5 and 2.5 kg/acre respectively cotrolled the weeds effectively in sweet orange orchards. Pre-emergent application of diuron at 6.67 and 8.90 kg/ha can control all weeds in citrus.

**VI. Sapota:** The predominant weeds of sapota fields are *Setaria glauca, Digitaria marginata, Andropogn* sp., *Heterogon contortus* and *Cymbopogon caesius* among monocots and *Oxalis corniculata* among dicots.

**Control:** The removal of weeds in young sapota orchards is done manually by labours using small hand operated implements.

1. **Mechanical control:** In established orchards, with enough space in between plants, the removal of weeds and the loosening of the soil is done by ploughing or harrowing once or twice a year either by bullock drawn implements or by motor run tractors or tillers.
2. **Inter –cropping:** Inter-cropping of vegetables, viz., cowpea, French beans and peas in inter-rows and ginger in basins may also be taken up for the first six to ten years.

3. **Chemical control:** Bromacil and diuron combination at 2.0 kg a.i./ha to be very effective for controlling weeds in established sapota orchards for a period of 4-5 months.

**VII. Guava:** The problematic weeds of guava fields are *Cynodon dactylon and Cyperus rotundus* among monocots and *Bidens pilosa, Tridax procumbens, Acanthospermum hispidum* and *Lagasca mollis* among dicots. As reported earlier, *Cynodon dactylon* caused 50 per cent reduction in plant height of guava.

**Control:**

1. **Hand weeding:** The young guava orchards are weeded manually by women labour using hand operated implements.
2. **Mulching:** In established orchards, mulching with in organic and organic materials have been tried. The dried leaves are usually mulched into the soil in the basins soon after one or two rains. The growing of green manure crop during the rest of the year are recommended.
3. **Chemical control:** 2,4-D alone at 3.0 kg/ha or 2,4-D(2.0 kg/ha) in combination with gramoxone (1.5 l/ha) to be the most effective herbicides for controlling weeds in established guava orchards.

**VIII. Litchi:** Litchi (*Litchi chinensis* Sonn.) orchards need atleasts 3 to 4 cultivation in a year to keep them weed-free. As litchi trees have shallow roots, deep tillage must be avoided. The growing intercrops like legumes during pre-bearing stage of litchi would give good income to the grower besides improving the health of trees. But the roots of intercrops should not be allowed to compete with the main crop for nutrients.

**Temperate Fruit Crops**

**I. Apple:** Apple *(Malus domestica* Borkh*)* grows mostly in the temperate regions of Jammu & Kashmir, Himachal Pradesh and Uttrakhandand and to small extent in Nilgiris Hills of Tamil Nadu. *Rosa moschata, Rosa eglantaria, Rubus* spp. and *Berberis* spp. are some of the predominant weeds of apple orchards.

**Control:**

1. **Mulching:** In newly established trees, the need for weed control is greater and that use of black polythene mulch proved just as effective as good chemical treatments. Increase in yield upto 40 per cent was also realized in apple under this treatment.
2. **Intercrops:** Growing intercrops in rows between the trees and in the basins of apple trees to suppress weeds and to supplement the income is very common in India. The intercrops

grown are mustard (oil yielding), wheat, oat and, to some extent, barley. Mulching with black polythene and oat leaves in apple basins indicated that oak leaves were the best for suppressing weeds.

3. **Chemical control:** *Rosa rubignosa* and *Berberis sp.* can be controlled with the spray of gramoxone at 500 ppm + Ansar 529 at 1000 ppm when applied as post-emergent spray. Gramoxone (3.75 kg/ha) was found to be the most efficient post- emergent herbicides out of a number of herbicides tested in apple orchards. And also in apple orchards, found that an application of Aminotriazole (5.0 kg/ha) and Simazine (5.0 kg/ha) as pre-emergent spray resulted in the elimination of broad leaf weeds and increases in the density of grasses. The diuron at 2.0 kg/ha and nitrofen at 5.0 kg/ha to be highly effective and economical in controlling *Oxalis latifolia.* Simazine at 1.0-2.0 kg, nitrofen at 0.5-1.0 kg and Diuron 0.8 kg/ha to be very effective for controlling weeds in apple nursery which resulted in increased number of saleable grafts. Weed control in non-bearing apple orchards with Diuron at 5.0 kg/ha applied as pre-emergent treatment or Dalapon at 8.0 kg/ha applied as pre-emergent treatment.

**II. Peach:** A suitable cover or green manure crop may be sown in rainy season after the fruits are picked and ploughed–under during winter. Peach trees growing in straw mulched strips, 3 m wide, grew at a faster rate than the control under permanent pasture and produced twice as many fruits of larger size in their fourth and fifth seasons.

**Control**

1. **Mechanical methods:** Ploughing of whole orchard with bullock drawn implement or motor run implement is also the best for controlling weeds in peach orchards.
2. **Intercropping:** Intercropping peach orchards with mung, pea and onion reduced the density of weeds both in basins and inter-rows.
3. **Chemical control:** Gramoxone at 500 ppm, mixture or 2,4,5-T at 100 ppm and Gramoxone at 500 ppm controlled the shrubby weeds of *Rosa moschata, Rubus* sp. and *Berberis* sp. effectively. Weed control in peach orchards with the combination of dalapon at 10 kg/ha and 2,4-D at 1.0 kg/ha when applied in two split doses. The residues brought about significant suppression of weeds in the next season also. Weed control and crop growth with terbacil at 3.0 and 4.0 kg/ha. *Commelina nudifera, Ageratum conyzoides* and *Euphorbia hirta* were controlled well by 5.0 kg/ha Simazine and 3-5 kg/ha Atrazine.

**III. Apricot:** Cultivation by bullock drawn implements or motor run implements and cover cropping the inter-rows with mustard and wheat to reduce the density of weed population is very common.

**Control:**

1. **Chemical control:** In apricot chemical weed control, Simazine or Diuron at 2.0, 4.0 and 6.0 kg/ha checked the emergence of grasses and broad leaf weeds for 90 days. Best control was achieved with 4.0 and 6.0 kg/ha Simazine.

**IV. Plum:** Chemical weed control provides an excellent opportunity in keeping the plum plantations free from undesirable vegetation and improving the health of of trees resulting in higher productivity. Hand weeding is to be superior to herbicides application. Simazine, diuron and bromacil singly at 5.0-7.5 kg/ha and terbacil at 3.0-4.0 kg/ha got effective weed control in old trees of plums. Excellent control of weeds can be achieved in plum orchards with simazine at 5.0 kg/ha.

**V. Pear:** Herbicides in pear orchards that krenite (fosamine) at 15-30 l/ha with 5-10 per cent regrowth after one year comparable that on plots treated with 2, 4, 5-T at 1.0 litre in 400 litres of water per hectare. Fosamine affected much more than 2, 4, 5-T.

**VI. Strawberry, raspberry and blue berry:** The cultivated varieties of strawberry (*Fragaria* spp.) grown in India are all imported. The land is prepared by ploughing deep followed by harrowing. Bulky organic manures are added. The weeds are controlled by light hoeing as land when the runners form. When plants blossom in spring, straw is used to bed the plantation to keep the fruits off the soil. After fruiting, straw and weeds are removed, and all runners are cut off. Hoeing is continued. Strawberry is rotated with vegetables every three years to reduce the density of weeds. Opaque plastic mulch suppressed weeds, conserved soil moisture, increased soil temperature in cool weather and reduced them in warm weather and increased the yields in strawberry. Black polythene mulch controlled annual weeds well but not perennial weeds like *Agropyron repens* and *Oxalis* spp. Annual weeds germinating after planting strawberry in late March had no effect on crop growth if removed by late May. Dense weed cover thereafter severely inhibited stolon growth, virtually eliminating it if allowed to remain beyond mid august. 8.0 lb/acre DCPA with 4.0 lb/acre chloroxuron or 4.0 lb/acre diphenamid effectively controlled important weeds like *Cyperus compressus*, *Digitaria ciliaris* and *Eleusine indica* in strawberry.

## B. WEED MANAGEMENT IN VEGETABLE CROPS

Traditional vegetable-growing areas are usually situated adjacent to waterways, flood plains, river deltas, marsh zones, and, if herbicides are used, their environmental impact and usage conditions must be taken into account. Another aspect related to the complexity of herbicide use is its soil persistence that can seriously affect the next crops in the rotation as a result of soil residues or carryover. Vegetable rotations are very fast and intensive in many places, and herbicide toxicity can affect the next crop if the cycle of the previous crop is short enough.

We have to consider all these aspects, as well as consumer concerns on the probable presence of pesticide residues in fruit, leaves and roots of these crops and the strict limitations for marketing and export that can invalidate the hard labour and endurance of many workers. Therefore, a careful use of herbicide is compulsory, and good field practices must be followed, especially when recognition of a labelled production is desired. There is a great interest in the integration of tilling practices with chemical control because of the reduction of the herbicide impact and the cost of hand-labour.

### SEED BEDS

Many vegetables are grown in seed beds to develop suitable seedlings for transplanting in the field. Soils dedicated to seed beds are usually light, with good tilth, and fertilized to obtain a good plant emergence. Seed beds are usually flood-irrigated and plastic-protected. Here we add some possibilities for weed management.

**Stale seed beds**

Stale seed beds are sometimes used for vegetables when other selective weed-control practices are limited or unavailable. Basically, this technique consists of the following points:

- Preparation of a seedbed 2-3 weeks before planting to achieve maximum weed-seed germination near the soil surface.
- Planting the crop with minimum soil disturbance to avoid exposing new weed seed to favourable germination conditions.
- Treating the field with a non-residual herbicide to kill all germinated weeds just before or after planting, but before crop emergence.

**Solarisation:**

Soil solarisation is a broad-spectrum control method, which is simple, economically feasible and environmentally friendly. It is an effective method for the control of many weeds. It does not affect soil properties and usually produces higher yields (Campiglia *et al.* 2000). There are also some disadvantages in its implementation. For example, previous irrigation is a requirement, (or frequent and abundant rain) and the soil must be kept solarized (non-producing) for a period of at least one month. Results are often variable, depending on weather conditions. Cold (high latitude) or cloudy places are usually not suitable for implementing solarization.

Some species can tolerate solarization (e.g. deep rooted perennials: *Sorghum halepense, Cyperus rotundus, Equisetum* spp. and also some big weed seeds such as legumes).

The soil must be clean, surface-levelled and wet, previously to being covered with a thin (0.1-0.2 mm) transparent plastic sheet and very well sealed. The soil must be kept covered during the warmer and sunnier months (30-45 days). Soil temperatures must reach above 40° C to exert a good effect on weed seeds.

After solarization the plastic must be recovered, and the use of deep or mould board tillage must be avoided. This system is more suitable for small areas of vegetables, but it has been mechanized for extensive areas of tomatoes. Soil solarization is widely used under plastic greenhouse conditions.

**Chemical control in seed beds**

There are even less registered herbicides for seed beds than for planting crops. Herbicide treatments under plastic cover are always hazardous and careful application should be carried out. Under plastic, high levels of moisture and elevated temperature are common and plants grow very gently. Selectivity could be easily lost and phytotoxicity symptoms may occur, while sometimes they are just temporary. The effects are often erratic. The best way to deal with it is to be prudent and make some trials before a general treatment.

**Table: Selective pre-emergence and early post-emergence herbicides for vegetable seedbeds:**

| **a) Pre-emergence** | | |
|---|---|---|
| Herbicide | **Dose (kg a.i./ ha)** | Crop |
| Clomazone | 0.18 - 0.27 | Pepper, cucumber |
| DCPA | 6.0 - 7.5 | Onion, cole crops, lettuce |
| Metribuzin | 0.15 - 0.5 | Tomato |
| Napropamide | 1.0 - 2.0 | Tomato, pepper, eggplant |
| Pendimethalin | 1.0 - 1.6 1.0 - 2.5 | Onion, garlic Lettuce |
| Propachlor | 5.2 - 6.5 | Onion, cole crops |
| **b) Post-emergence** (crops with at least 3 leaves) | | |
| Clomazone | 0.27 -0.36 | Pepper |
| Ioxinil | 0.36 | Onion, garlic, leek |
| Linuron | 0.5 - 1.0 | Asparagus, carrots |
| Metribuzin | 0.075 - 0.150 | Tomato |
| Oxifluorfen | 0.18 - 0.24 | Onion, garlic |
| Rimsulfuron | 0.0075 -0.015 | Tomato |

**DIRECT-SEEDED AND TRANSPLANTED CROPS**

**Weed identification**

Dicotyledons (most broad-leaf weeds) and monocotyledons (e.g. grasses) are the two main plant types. Weed grouping has a significant impact on the potential for management. The more closely related a weed is to the host crop, the harder it will be to manage.

**Table: Weed and crop family groupings (Monocotyledons - 'M')**

| **Family** | **Weed examples** | **Related crops** |
|---|---|---|
| Apiaceae | Slender celery | celery, carrot, parsley |

| | | |
|---|---|---|
| | (*Ciclospermum leptophyllum*)<br>Australian carrot (*Daucus glochidiatus*) | |
| Amaranthaceae | amaranthus (*Amaranthus* spp.) | Chinese amaranthus |
| Asteraceae | billygoat weed (*Ageratum* spp.)<br>sowthistle (*Sonchus oleraceus*)<br>cobbler's pegs (*Bidens pilosa*)<br>fleabanes (*Conyza* spp.)<br>parthenium (*Parthenium hysterophorus*)<br>potato weed (*Galinsoga parviflora*) | lettuce, artichokes |
| Brassicaceae | wild turnip (*Brassica tournefortii*)<br>wild radish (*Raphanus raphanistrum*)<br>turnip weed (*Rapistrum rugosum*)<br>shepherd's purse (*Capsella bursa-pastoris*) peppercress (*Lepidium* spp.)<br>lesser swinecress (*Coronopus didymus*) | cabbage, cauliflower, broccoli, brussels sprouts, Chinese cabbage |
| Chenopodiaceae | Fat hen (*Chenopodium* spp.) | beetroot |
| Convulvulaceae | bell vine (*Ipomoea plebia*)<br>bindweed (*Convolvulus erubescens*) | sweetpotato |
| Euphorbiaceae | caster oil plant (*Riccinus communis*)<br>caustic<br>creeper (*Euphorbia drummondii*) | cassava |
| Fabaceae | rattlepod (*Crotalaria* spp.)<br>vetch (*Vicia monantha*)<br>medics (*Medicago* spp.) | peas, beans |
| Liliaceae | onion weed *(Nothoscordum gracile)* | onion, garlic |
| Malvaceae | small-flowered mallow (*Malva parviflora*)<br>sida (*Sida* spp.) bladder ketmia (*Hibiscus trionum*) anoda weed (*Anoda cristata*) | okra, rosella, cotton |
| Solanaceae | apple of Peru (*Nicandra physalodes*)<br>nightshades (*Solanum* spp.)<br>thornapples (*Datura* spp.) | tomato, potato, capsicum, eggplant |

**Crop rotation:**

Crop rotation is the programmed succession of different crops during a period of time in the same plot or field. It is a key control method to reduce weed infestation in vegetables. Crop rotation was considered for a long time to be a basic practice for obtaining healthy crops and good yields. At present, however, crop rotation is gaining interest and is of value in the context of integrated crop management. Classically, crop rotations are applied as follows:



- Alternating crops with a different type of vegetation: leaf crops (lettuce, spinach, cole), root crops (carrots, potatoes, radish), bulb crops (leeks, onion, garlic), fruit crops (squash, pepper, melon).
- Alternating grass and dicots, such as maize and vegetables.
- Alternating different crop cycles: winter cereals and summer vegetables.
- Avoiding succeeding crops of the same family: *Apiaceae* (celery, carrots), *Solanaceae* (potato, tomato).
- Alternating poor- (carrot, onion) and high-weed competitors (maize, potato).
- Avoiding problematic weeds in specific crops (e.g. *Malvaceae* in celery or carrots, parasitic and perennials in general).

**Examples of crop rotations are as follow (Zaragoza *et al.* 1994):**

| | |
|---|---|
| • In temperate regions: | Pepper - onion - winter cereal |
| | Melon - beans - spinach – tomato |
| | Tomato - cereal – fallow |
| | Lettuce - tomato – cauliflower |
| | Potato - beans - cole - tomato- carrots |
| | Melon - artichoke (x 2) - beans - red beet - wheat - cole |
| • In tropical regions: | Tomato - okra - green bean |
| | Sweet potato - maize - mung bean |

Introducing a fallow in the rotation is essential for the control difficult weeds (e.g. perennials), cleaning the field with appropriate tillage or using a broad-spectrum herbicide. It is also important to avoid the emission of weed seeds or other propagules.

**Mixed cropping**

Growing two or more crops at the same time and adjacent to one another is called mixed cropping, or intercropping. The advantages are a better use of space, light and other resources, a physical protection, a favourable thermal balance, better plant defence against some pests and fewer weed problems because the soil is better covered. Sometimes the results are less productive than cultivating just one crop alone. Some examples are:

➢ In temperate regions:
- lettuce + carrots;
- cole crops + leeks, onion, celery, tomato;
- maize + beans, soya.

➢ In tropical regions: this technique is very well adapted to the traditional agricultural system:
- maize + beans + squash,

- tomato + pigeon pea,
- sugar cane + onion, tomato.

**Preventive measures**

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 weed situation in the fields is very useful. Another aspect is to impede perennial weed dispersal (or parasitic weeds) through the opportune use of treatments and tillage and the use of drainage tillage to prevent propagation of some species that need high moisture levels. *(Phragmites* spp., *Equisetum* spp., *Juncus* spp.) It is also necessary to scout the field edges to prevent invasions.

**Land preparation and tillage**

Suitable land preparation depends on a good knowledge of the weed species prevalent in the field. When annual weeds are predominant (Crucifers, *Solanum*, grass weeds) the objectives are unearthing and fragmentation. This must be achieved through shallow cultivation. If weeds have no dormant seeds (*Bromus* spp.), deep ploughing 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 will depend on the types of rooting. Pivot roots *(Rumex* spp.) or bourgeon roots *(Cirsium* spp.) require fragmentation and this can be achieved by using a rotovator or 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 a cultivator or harrow.

Tubers (*Cyperus rotundus)* or bulbs (*Oxalis* spp.) require cutting when rhizomes are present and need to be dug up for exposure to adverse conditions (frost or drought). This can be done with mould board or disk ploughing. Chisel ploughing is useful for draining wet fields and reducing the infestation of deep-rooted hygrophilous perennials (*Phragmites, Equisetum, Juncus).*

**Mulching material**

The use of plastic mulching is very popular in many vegetable-growing areas. A non-transparent plastic is used to impede the transmission of photosynthetic radiation through the plastic to the weeds so that the development of weeds is then arrested.

**Chemical weed control**

The best approach to minimize inputs and to avoid any environmental problems is to apply herbicides in the crop row to a width of 10-30 cm. Many herbicides are effective in the control of perennial weeds. Sometimes a combination of two herbicides having a different weed-control spectrum may be used. Mixtures of different herbicide are possible to achieve better efficacy, but previous trials are necessary. Their foliar activity is enhanced by adding a non-ionic surfactant or adjuvant. The use of any herbicide in vegetables requires previous tests to verify its effectiveness in local conditions and selectivity to available crop cultivars.

In general pendimethalin 3.3 l/ha or Fluchloralin at 2 lit/ha or metolachlor 2 l/ha as pre-emergence herbicide is recommended for most of the vegetable crops, followed by one hand weeding 30 days after transplanting.

**Table: Selective herbicides for weed control in vegetable crops:**

| Herbicide | Dose<br>kg a.i./ha | Treatment moment | Crops |
|---|---|---|---|
| Alachlor | 2.4 | Pre emergence | Brassica crops, onion |
| Ethalfluralin | 0.8-1.7 | Pre Plantation | Tomato, pepper, beans, squash |
| Linuron | 0.50-1.25 | Pre emergence | Carrot, artichoke, asparagus, faba bean |
| Metribuzin | 0.10-0.35 | Pre/Post emergence | Tomato, carrots, peas |
| Oxyfluorfen | 0.36-0.48 | Pre/Post emergence | Onion, garlic, cole crops |
| Oxyfluorfen | 0.24-0.48 | Pre Plantation | Tomato, pepper |
| Pendimethalin | 1.32-1.65 | Pre Plantation | Artichoke, cole, lettuce, leek, pepper, tomato, onion, green peas |
| Rimsulfuron | 7.5-15(g) | Post emergence | Tomato |
| Trifluralin | 0.59-1.44 | Pre-plant incorporated | Beans, carrots, celery, cole crops, artichoke, onion, pepper, tomato |

**Hand weeding:**

Apart from chemical weeding, one hand weeding is done 30 days after transplanting.

**Biological control:**

Myco-herbicides are a preparation containing pathogenic spores applied as a spray with standard herbicide application equipment.

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