

## Integrated Weed Management

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The agricultural growth rate has slowed down in India and increased agricultural productivity is needed to meet the increasing needs of the growing population. Low and stagnant yield per unit area across almost all crops has become a regular feature of Indian agriculture. Weeds are a major challenge for farmers worldwide, reducing crop yields and profitability. Traditionally, farmers have relied on chemical herbicides to control weeds, but this approach has proven to be costly and unsustainable in the long run. Over-reliance on herbicides can also lead to the development of weed resistance, rendering these chemicals ineffective. Weeds alone are known to account for nearly one third of the losses caused by various biotic stresses.

### **Economic losses due to weeds**

A recent study suggests that nearly one-third of oilseeds, half of the food grains, and an equal amount of pulses produced currently are lost due to weeds and proper weed management technologies if adapted can result in an additional production of 103 million tonnes of food grains, 15 mt of pulses, 10 mt of oilseeds and 52 mt of commercial crops, per annum, which in few cases are even equivalent to the existing annual production. Besides, huge amount of money is spent on controlling the weeds. At a conservative estimate, an amount of Rs. 100 billion is spent on weed management annually in India, in arable agriculture alone. The potential yield losses due to weeds can be as high as about 65% depending on the crop, degree of weed infestation, weed species and management practices. Thus, weed management would continue to play a key role to meet the growing food and fibre demands of increasing population in India.

### **Environmental impact of weeds**

In the agro ecosystems ideal environmental conditions provided for optimal crop productivity are being exploited by the associated weeds. Weeds interfere with crop production through their ability to compete for resources and their impact on product quality. Weeds not only cause huge reductions in crop yields but also increase cost of cultivation,

reduce input efficiency, interfere with agricultural operations, impair quality, act as alternate hosts for several insect-pests, diseases, affect aesthetic look of the ecosystem, native biodiversity, as well as affect human and cattle health and some weeds may also have allopathic effects .

### **Herbicide resistance in weeds**

Although herbicides have played a vital role in improving crop yields and overall production efficiency, over-reliance and repetitive use of the herbicides belonging to the same class can also led to the development of herbicide-resistant weed biotypes. In India, though herbicides are not used so extensively as in developed countries, but the continuous use of butachlor as well as isoproturon can lead to the development of resistance in *Echinochloa colona* and *Phalaris minor*, respectively, thereby posing a serious threat to the sustainability in rice-wheat system in the country.

### **Weed flora shift**

Changes in input availability and crop sequence have changed the component of weed flora. Increased adoption of resource conservation technologies like zero tillage, bed planting etc., will lead to reduced cost of cultivation, better management of problem weeds like *Phalaris minor* in rice-wheat system. In addition it may also result in weed flora shift favouring the perennial weeds besides increasing the herbicide use. So proper weed management strategies should be adopted.

Integrated weed management is a science-based decision-making process that combinations of the methods of weed control rather than a single method be exercised in coordinated way to bring down weed population below an economic threshold level. This method is more effective because the left over weeds with one method can be controlled with other method. So this method helps in reducing seed bank status in the field. With the adoption of this method, many problems such shift in weed flora, development of resistance in weed plants can be avoided. Integrated method of weed control is the need of the day and this method must be advocated in order to get long term relief from these undesirable plants. Integrated weed management approach is environmentally friendly as farmers are not entirely dependent on herbicides. IWM is particularly relevant for small-scale farmers who have limited access to expensive inputs such as herbicides. By using IWM, farmers can reduce

their reliance on herbicides, which can be costly and harmful to the environment, and instead use more sustainable and cost-effective methods.

### **Preventive strategies**

The preventive measures usually do not offer remedy over the already existing population and diversity of weeds in the crop fields, but they focus on the prevention of further introduction of weeds from different external sources/agents as well as perpetuation of weeds in forth-coming years from the existing stands of weeds in crop fields.

### **Pure and clean crop seeds and seed certification**

Before sowing, thorough sieving should be done in order to sieve out the weed seeds, broken, shrivelled grains and diseased seeds. Check seeds thoroughly and ensure that no weed seed is present. If it is not possible to separate out the weed seeds due to their similar size to that of crop seed, better reject that lot for seed purposes and use certified seed of crops.

### **Well-decomposed FYM, compost, sewage and sludge**

Use well decomposed FYM where a composting temperature of 65 to 90<sup>o</sup> C should be maintained for 4-5 months. Treat the FYM with chemicals like acrocyanamide, SMDC (metham), DMTT (mylone) and ammonium thiocyanate (synthetic urea). Sewage and sludge need to be treated properly towards making free from weed seeds before applying to crop fields.

### **Prevent movement of weeds through machinery etc.**

Clean the harvesters, seed cleaners, hay balers and other farm implements before moving them from infested area. Avoid use of gravel, sand and soil from weed infested area. Inspection of nursery stock for presence of weed seeds, tubers, rhizomes of perennial weeds. Don't permit live stock from weed infested area to clean areas.

### **Keep non crop area clean**

Keep irrigation & drainage channel, fence lines, road sides, fence corners and all other non cropped areas free from weeds. Prevent the dissemination of mature seeds to the main land.

### **Use vigilance**

A farmer should inspect his farm periodically for strange looking new weed. Farmer knows the weed flora in his field. So when a new weed species is seen then prevents its establishment. So that it does not add to existing weed flora.

### **Follow legal & quarantine measures**

Quarantine measures should be strict. Legal measures are necessary to check interstate and inter country movement of noxious weeds.

### **Physical (Mechanical & Manual) Methods**

#### **Hand weeding**

Removal of weeds either manually or by using tools like khurpi or sickle, when weeds grown upto some extent and the method is effective against annuals and biennials and controls only upper portion of the perennial.

#### **Hand hoeing**

Taking out the weeds with the help of khurpi or hand hoes. Hoeing by cutting the crown part gives proper control. *Convolvulus arvensis* which has shallow root system can be controlled.

#### **Digging**

Digging is very useful in the case of perennial weeds to remove the underground propagating parts of weeds from the deeper layer of the soil. They can be eliminated by digging with crowbar or Pick axe etc.

#### **Mowing**

It is cutting of uniform growth from the entire area up to the ground level. Effective against erect and herbaceous weeds. It is useful more in non cropped areas than cropped areas. Mowing improves aesthetic value of an area.

#### **Cutting**

Cutting is the topping/cutting of the weeds little above ground level. It is done with help of axes and saws. It is mostly practiced against brushes and trees.

#### **Dredging**

Mechanical pulling of aquatic weeds along with their roots & rhizomes from the mud.

#### **Chaining**

Very big & heavy chain is pulled over the bottom of a ditch with tractors along with embankments of ditch. With rubbing action of chain weeds can be fragmented & collected by nets and hooks.

### **Burning**

It is cheapest method to eliminate the mature unwanted vegetation in non-cropped areas and range lands. Coagulation of protoplasm occurs with which plant dies.

### **Flaming**

It is the momentary exposure of green weeds to as high as 1000<sup>o</sup> C from flame throwers to control in row weeds. Flaming is used in western countries for selective weed control in crops like cotton, onion, soybean and fruit orchards.

### **Soil Solarisation**

It is effective against weeds which are produced from seeds. It doesn't involve any tillage of the field. Covering the soil with transparent, very thin plastic sheets of 20-25mm polyethylene (PE) film during hottest part of summer months for 2-4 weeks. This increases the temperature by 10-12<sup>o</sup> C over the un-filmed control fields. Then weeds seeds are desiccated which are present at top 5 cm soil depth.

### **Tillage**

Tillage removes weeds from the soil resulting in their death. It may weaken plants through injury of root and stem pruning, reducing their competitiveness or regenerative capacity: Pre plant tillage helps in burying the existing weeds. Bring the weed seeds to the soil surface for germination and their subsequent destruction by suitable secondary tillage implements. Incorporation of pre-plant herbicides. Post plant tillage (row cultivation) helps in mixing of manures and fertilizers & control of weeds, soil and water conservation.

### **Mulching**

The mulch provides a physical barrier on the soil surface and must block nearly all light reaching the surface so that the weeds which emerge beneath the mulch do not have sufficient light to survive. Polythene sheets, natural materials like paddy husk, ground nut shells, saw dust etc. are used as mulching material. The efficiency of polythene sheet is more (more polythene) if it is applied in continuous sheet. It is effective against annual weeds and perennial weeds.

### **Flooding**

Flood kills weeds by excluding oxygen from their environment. Flooding is a worldwide crop husbandry method of controlling weeds in rice fields.

### **Cultural Methods**

#### **Proper crop stand and early seedling vigour**

Lack of adequate plant population is prone to heavy weed infestation, which becomes, difficult to control later. Therefore practices like a). Selection of most adopted crops and crop varieties b). Use of high viable seeds c). Pre plant seed and soil treatment with pesticides, dormancy breaking chemicals and germination boosters d). Adequate seed rates are very important to obtain proper and uniform crop stand capable of offering competition to the weeds.

#### **Selective crop simulation**

Vigorous crop plants compete better with weeds as they close the ground very quickly. Selective simulation can be achieved by a) application of soil amendments like gypsum or lime may correct the soil conditions in favour of crop growth b) addition of FYM or synthetic soil conditioners to very light or heavy soils may improve the soil structure and maintaining better air water relationships and ultimately it improving the crop growth c) manures and fertilizers application of proper kind in adequate quantities improve the crop growth. d) Inoculation of crop seeds with suitable nitrogen fixing and phosphorous solubilising organisms may helps in selective simulation of some crops e.g. Legume crop and non legume weed. Selective simulation in wide row crops like maize, sugarcane, cotton can be achieved by foliar application of nutrients.

#### **Proper planting method**

Any planting method that leaves the soil surface rough and dry will discourage early growth. Plough planting (minimum tillage) methods proved to be very useful to reduce early weed growth. In summer, furrow planting of crops reduce the weed problems. Because in this method irrigation water restricted initially to the furrow only. In transplanted crops farmers get opportunity to prepare weed free main field.

#### **Planting time**

Peak period of germination of seasonal weeds coincides with crop plants. So little earlier or later than normal time of sowing is beneficial by reducing early crop weed

competition. For example using photo insensitive varieties we can make adjustments with regarding to time of planting.

### **Crop rotation**

Growing of different crops in recurrent succession on the same land is called as crop rotation. Monocropping favors persistence and association of some weeds. Crop rotation is effective in controlling of crop associated and crop bound weeds such as *Avena fatua* in wheat and *Cuscuta* in lucerne. Wheat-pea and gram break the *Avena* wheat, grain crop rotation control *Cuscuta*. The *Orobanchae sp.* In mustard can be controlled by crop rotation.

### **Stale Seedbed**

This is achieved by soaking a well prepared field with either irrigation or rain and allowing the weeds to germinate. These weeds are controlled by using contact herbicides like paraquat and by mechanical methods then sow the crop. Here the advantage is the crop is germinated in weed free environment. In this way, weed seed bank is exhausted.

### **Smother crop / Competitive crop**

This crop germinates very quickly and develop large canopy, capable of efficient photosynthesis within short period. They possess both surface and deep roots. Competitive crop cover the ground quickly than non competitive crop. e.g., Cowpea, Lucerne, berseem, millets.

### **Growing of intercrops**

Inter cropping suppresses weeds better than sole cropping and thus provides an opportunity to utilize crops themselves as tools of weed management. Many short duration pulses viz., green gram and soybean effectively smother weeds without causing reduction in the yield of main crop.

### **Minimum tillage**

Deep and frequent tillage may be useful for some reasons but it serves to bring more of dominant weed seeds and rhizomes to the soil surface. Preserve the new weed seeds deep in the soil for the future. Zero tillage completely avoids burying of weed seeds and reduces persistence of annual weeds but it induces vigorous growth of perennial weeds.

### **Summer fallowing**

The practice of summer tillage or off-season tillage is one of the effective cultural methods to check the growth of perennial weed population in crop cultivation. In the month

of April, May and June farmers expose their lands to sun in order to control many soil born pests, including weeds. Roots, rhizomes and tubers of shallow rooted perennials like Bermuda grass and nut sedge.

### History of Herbicide Development

Common salt, ash etc. have been used for centuries to control weeds on roadsides, fence rows & pathways. Selective control of weeds in Agriculture was first conceived in 1896 with the chance observation of French farmer that Bordeaux mixture sprayed on Grape vine to control downy mildew damaged certain broad leaved weeds. A real breakthrough in selective weed control was achieved In 1945, with the discovery of 2,4-D & MCPA in USA & England independently by P.W.Zimmerman and A.E.Hitchcock. Both 2,4-D and MCPA were found highly selective for cereals and phytotoxic to broad leaved weeds. In Agriculturally developed countries, herbicides form over 45% of the total pesticides used. In India, share of herbicides is only 8% of the total pesticides consumed.

### Biological Methods

Utilization of natural living organism, such as insects, herbivorous fish, other animals, disease organisms and competitive plants to limit their growth. 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. The control *Opuntia spp*(prickly pear) in Australia and lantana in Hawaii with certain insect bioagents are two spectacular examples of early period biological control of weeds.

### Allelopathy as a Weed Management

Allelopathy is a natural technique that may be considered as a tool for biological weed control in crop production. Allelochemicals may be used to develop new tools to combat the evolution of herbicide resistance in weeds. Sunflower extracts completely inhibited seed germination of white mustard (*Sinapis alba* L.). An annuionone isolated from aqueous extract of sunflower (cv. Suncross-42 leaves) reduced the growth of all five selected weed species: *Phalaris minor* Retz., *Chenopodium album* L., *Coronopis didymus* L., *Medicago polymorpha* L. and *Rumex dentatus* L.

### Yield losses due to weeds in some important crops

Crop	Yield loss range (%)	Crop	Yield loss range (%)
Rice	9.1 – 51.4	Sugarcane	14.1 – 71.7

Wheat	6.3 – 34.8	Linseed	30.9 – 39.1
Maize	29.5 – 74.0	Cotton	20.7 – 61.0
Millets	6.2 – 81.9	Carrot	70.2 – 78.0
Groundnut	29.7 – 32.9	Peas	25.3 – 35.5

### Different bio-agents used for weed control

Weed	Bio-agent	Reporting Country	Kind of bio agent
<i>Chondrillajuncea</i>	<i>Puccinachondrillina</i>	Australia	Plant pathogen
<i>Eupatorium riparium</i>	<i>Entylomacompositarum</i>	USA	Plant pathogen
<i>Hydrillaverticillata</i>	<i>Hydreliapakistanae</i>	USA	Shoot fly
<i>Orobanchecernua</i>	<i>Sclerotinia sp.</i>	USA	Plant pathogen
<i>Partheniumhysterophorus</i>	i) <i>Zygommatibicola</i>	India	Leaf eating beetle
	ii) <i>Epiblemastrenuana</i>	Australia	Stem galling insect
	iii) <i>Conotrachelus sp.</i>	Australia	Stem galling insect
<i>Rumex spp.</i>	i) <i>Uromycesrumicis</i>	USA	Plant pathogen
	ii) <i>Gastrophysaviridula</i>	USA	Beetle
<i>Tribulusterrestris</i>	<i>Microlarinuslareynii</i> and <i>M. lypriformis</i>	USA	Pod weevil
<i>Cirsiumarvense</i>	<i>Septoria cirsii</i>		Plant pathogen
<i>Cyperusrotundus</i>	<i>Bactra verutana</i>	India, Pakistan, USA	Shoot boring moth
<i>Echinochloa spp.</i> (In rice fields)	i) <i>Emmalocera sp.</i>	.	i) Stem boring moth
	ii) <i>Tripes spp</i>		ii) Shrimp

### Some Commercial Mycoherbicides used in weed control

Product	Content	Weed controlled
De-Vine	A liquid suspension of fungal spores of <i>Phytophthorapalmivora</i> . It causes root rot in the weed.	Strangler-vine. ( <i>Morrentiaodorata</i> ) in citrus orchards.

Collego	Wettable powder containing fungal spores of <i>Colletotrichumgloesporiodes</i> Sub sp. <i>aeschynomone</i>	Jointvetch ( <i>Aeschynomone sp</i> ). In rice fields. The bioherbicide causes stem and leaf blight in the weed.
Bipolaris	A suspension of fungal spores of <i>Bipolarissorghicola</i> .	Johnson grass ( <i>Sorghum halepense</i> )
Biolophos	A microbial toxin produced as fermentation product of <i>Streptomyceshygroscopicus</i> .	Non-specific, general vegetation.
Luboa-2	<i>Colletotrichumgloesporiodes</i> Spp. <i>Cuscuta</i>	<i>Cuscuta</i>

**Crop yield losses caused by weeds and other pests in India**

