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## Eco-friendly weed management options for organic farming: A review

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### Abstract

Weeds are the major biotic factor which cause significant reduction in crop yield. Weeds will compete with crop for nutrients, light, water etc. In accordance with weeds in organic production system, weeds as one of their most troublesome, time consuming and costly production problems. Application of high dose of inorganic herbicide led to more toxic accumulation besides causing degradation to the soil health, pollution of ground water table and extinct of natural enemies. Weeds are conventionally controlled by herbicides which led to herbicide persistence and resistance and shift of weed flora by alien weeds. So, organic weed management is much needed to exert higher crop productivity. In organic production weeds are be managed by use of clean seeds, composted manures and timely removal of weeds by cultural, physical, mechanical, thermal and biological means during critical crop-weed competition.

**Keywords:** Eco-friendly, management, organic, farming

### 1. Introduction

Weeds can be considered a significant problem in agriculture because they tend to decrease crop yields by increasing competition for water, sunlight and nutrients while serving as host plants for pests and diseases. Today, some farmers have a renewed interest in organic methods of managing weeds since the widespread use of agrochemicals has resulted in purported environmental, health problems and development of herbicide resistance weeds. Organic farmers cite weeds as the most significant production problem they encounter total crop losses due to weeds under the organic system. It is important to understand that an organic farmer must rely on cultural practices, mechanical control and biological methods for weed control.

### 2. Weed management strategies under organic farming

I). Preventive II). Cultural III). Physical IV). Mechanical V). Thermal VI). Biological

#### 2.1 Preventive methods

A sound prevention strategy is an essential component of an integrated weed management strategy. The saying 'An ounce of prevention is better than a pound of cure' is indeed very applicable to weed management. Weeds prevention strategies aim at preventing:

(i) initial introduction; (ii) infestation development and (iii) dispersal of weeds and their propagules. The formulation and practice of good weed prevention strategies may involve individual and group responsibilities as well as government-enacted laws to prevent the introduction and dissemination of weed propagules. Knowledge of the economic threshold and critical period of weed interference is essential. A sound knowledge of weed population dynamics and how it is affected by different weed management strategies is important in developing an optimum crop management strategy.

#### 2.2 Cultural methods

Cultural weed control options include crop rotation, increasing the competitive ability of a crop, delayed or early seeding, flooding, inclusion of green manure and cover crops, and intercropping. The ability of crops to compete against weeds could be increased by selecting the right crops and cultivars, considering the weeds present as well as the climate, ensuring rapid and uniform crop emergence through proper seedbed preparation, and by using the right seed and seeding depth, increasing planting density and adapting planting patterns wherever possible to crowd out weeds, adequate and localized resource application, and optimum

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management of the crop including insect pest and disease management. Monks *et al.*, (2008) <sup>[4]</sup> reported that cowpea was found to be a highly competitive crop due to its higher canopy spread (66 cm) and weed dry weight (1630 kg/ha) than groundnut, greengram, blackgram and soybean. At Anand Shah *et al.*, (2011) <sup>[9]</sup> conducted the experiment and found that intercropping of soybean with maize (1:1) recorded comparatively higher weed smothering efficiency of 51.2% than the maize with greengram (27.6%) at harvest stage.

### 2.1.1 Stale seedbed (SSB)

Through this method, weed seeds in the surface layer of the soil are induced to germinate and emerge before cropping so that a part of weed population could be eliminated by pre-plant shallow tillage. Sanbagavalli (2010) <sup>[8]</sup> reported nearly 30 per cent of weed seed bank depletion in cotton field and 15 - 20 per cent increased seed cotton yield could be obtained by adopting SSB technique in two consecutive years, when compared to conventional seedbed preparation.

### 2.1.2 Solarization

The principal interest in soil solarization as a method of weed management is increasing due to its effect on soil seed reserve, which is main source of weed problem. Direct killing of weed seed in the soil by lethal soil temperature built under transparent polyethylene mulch is the main mechanism of reducing weed seed population and weed emergence. Soil solarization process increases the soil temperature by 18-12 °C. Solarization is found to be highly effective in controlling parasitic weed like *Orabanche spp* from 70-100 per cent.

## 3. Physical methods

Hand hoeing and weeding, digging, mowing, cutting, dredging and churning and mulching are commonly followed physical weed management practices. Depending on weed and crop situation one or combination of these methods are used.

### 3.1 Hand weeding

Though it is the oldest method of management of weeds, it is still a practical and efficient method of eliminating weeds particularly annual and biennial weeds in cropped and non-cropped situations. Farmer's practice of hand weeding twice is found to keep the weed density below the threshold level and increased the yield about 65 per cent than control in brinjal (Umamaheswari, 2016) <sup>[11]</sup>.

### 3.2 Mulching

Covering or mulching the soil surface can reduce weed problems by preventing weed seed germination or by suppressing the growth of emerging seedlings. Mulching the soil surface can reduce weed problems by preventing weed seed germination or seedling growth by various mechanisms *viz.*, physical barrier, limiting light transmission below mulches, smothering effect, allelopathy of mulches and altering soil hydro thermal regimes. Mulches can be made from a number of materials *viz.*, living plant ground cover, loose particles of organic or inorganic matter spread over soil. In addition to weed control these mulches are known to improve soil fertility by nitrogen addition, reducing soil erosion, soil moisture conservation, increasing microbial population and soil organic carbon status, reducing pest and diseases by breaking mono-cropping and trap crops.

### 3.2.2 Living mulches

A living mulch consists of a dense stand of low growing species established prior to or after the crop. A living mulch of *Portulaca oleracea* L. seed broadcasted before transplanting *Brassica oleracea* suppressed weeds without affecting crop yield. Living mulches are sometimes referred to as cover crops, but they grow at least part of the time simultaneously with the crop. Cover crops are generally killed off prior to crop establishment. Living mulches are well suited to use in perennial crops such as fruit where self-reseeding is an advantage. Intercropping of Navathaniyam (a multi varietal seed mixture of nine crops *viz.*, two cereals, two pulses, two oilseeds, two spices and condiments and one nitrogen fixing green manure ploughed *in situ* as green manure) brought out a significant reduction in weed density as compared to control was found to be effective in controlling weeds of irrigated dry land crops (Somasundaram, 2012) <sup>[3, 10]</sup>.

### 3.2.3 Non-living mulches

Both natural and synthetic non-living mulches are used for weed control in agricultural as well as non-agricultural system. Gbadamosi *et al.* (2003) <sup>[2]</sup> found that the dry grass mulches were used to control weeds in vegetables which reduced weed growth upto 78 per cent. Bajaj and Yadav (2016) <sup>[1]</sup> revealed minimum weed dry weight and higher weed control efficiency 97.6 per cent was recorded under grass mulch (5 t ha<sup>-1</sup>) applied one week after germination of bhendi.

## 4. Mechanical methods

Mechanical weed control involves tillage as well as the cutting and pulling of weeds and is probably the oldest weed management tool. Most mechanical weed control methods, such as tillage, harrowing and brush weeding are used at very early weed growth stages. Many mechanical control methods become difficult after the cotyledon stage and their selectivity decreases with increasing crop and weed age. Thus, if the weeds have become too large, an intensive and aggressive adjustment of the implements is necessary to control the weeds, and by doing this one increases the risk of damaging the crop severely.

### 4.1 Tillage practices

Tillage influences the weed seed bank dynamics by physical mixing or by turning under the soil. Inversion tillage, such as mould board ploughing results in burial of large proportion of seeds in the tillage layer compared to non inversion tillage such as chisel. Weed seed burial deep fail to emerge resulting in low weed intensity in subsequent season following ploughing. Deep ploughing can also be effectively employed against perennial weed like *Cynodon dactylon* provided the rhizomes after tilling are collected and destroyed. However, reduction in tillage will allow accumulation of 40-80% of weed seeds in the top 0-5 cm soil layer resulting in more weed emergence compared to conventional tillage.

### 4.2 Night tillage

Many weeds require a flash of micro-seconds of red light in order to germinate. Night tillage may help to reduce weed germination to a significant extent. Weed seeds left on the soil surface germinate, which are lesser in number as compared to their active seed bank in soil.

Moradi Talebbeigi *et al.* (2016) [5] reported that night tillage reduced the weed population of common lambsquarter (*Chenopodium album* L.) and foxtail (*Setaria spp.*) by 38.6 and 22%, respectively than day tillage.

#### 4.3 Mowing

Mowing can be done in the interrow spaces. Regular mowing is needed to prevent the weed-crop competition and also to prevent the weeds to shift into reproductive phase thus preventing weeds' seed production for next generation

#### 4.4 Use of weeders

Use of mechanical / power weeder in agricultural operations is increasing because of non-availability of labours for weeding. The machineries like mini-weeders, power tillers, minitractor drawn rotavator are used for weeding in wider spaced crops like sugarcane, cotton, and orchards. Cono weeder is used for controlling the wet land weeds and getting more yields under the system of rice intensification (SRI). The mini weeder and power tillers are used for controlling different types of weeds in cotton crop.

#### 5. Thermal methods

Thermal weed management include fire, directed flaming, hot water, steam, microwave, infrared, ultraviolet radiation, electrocution and freezing. Heating results in the coagulation of proteins and bursting of protoplasm due to expansion, which kills the tissue. Weeds can also be killed by exposure to very low temperature, e.g. by exposing aquatic weeds to low air temperature by removing water from a pond or lake or by freezing terrestrial weeds using dry ice or liquid nitrogen. Hot water is employed by the recently developed aquacade vegetation control system.

#### 5.1 Infra - weeder

The Infra - weeder weed control equipment uses infrared heat to kill undesired vegetation. Infra-weeder equipment uses a propane- fuelled ceramic heating element that develops temperatures up to 1800 degrees Fahrenheit (1000 degrees Celsius), which applies infrared radiation to weeds.

#### 5.2 Pneumatic weed control

An implement has been developed that injects compressed air into the soil to loosen and uproot small weeds on either side of the crop row.

#### 5.3 Lasers

Light in the form of lasers has been shown to inhibit the growth of water hyacinth (*Eichornia crassipes*). The treatment did not generally kill the weed but treated plants were smaller, propagated fewer daughter plants and covered less water surface than the untreated. More recently, the possibility of using a CO<sub>2</sub> laser as a device for cutting down weeds has been demonstrated.

#### 5.4 Ultraviolet light

The use of ultraviolet light for weed control has been patented but remains at an experimental stage. When plants are irradiated with UV, almost all energy is absorbed in the outermost 0.1- 0.2 mm layer of the plant tissue. This results in heating of the plant tissue and thus can have effects similar to the damage to plants from flame weeding.

#### 6. Biological methods

Biological management of weeds involves the deliberate use of host-specific phytophagous insects and plant pathogens to reduce the population density of a target species below its economic injury level. Some promising examples in Indian context include; control of *Eupatorium odorata* by leaf eating caterpillar, *Lantana spp.* by *Telenomia scrupulosa*, *Salvania molesta* by *Pablinia achminata* (grass hopper); water hyacinth by *Neochetina eichhornea* and *N. bruchi*; Parthenium by *Zygomma bicolorata*. Fish under aquatic system and competitive crop plants also proved to be the successful biological control agents.

#### 6.1 Bio - herbicides

Bio-herbicides are biological control agents applied in similar ways of chemical herbicides to control weeds. Most commonly the micro-organism used is fungus and its prologues are spores or fragments of mycelia; in this case bio-herbicide is also called a myco-herbicide.

**Table 1:** Commercial mycoherbicides

| Trade Name | Pathogen   | Weed controlled                   |
|------------|--|-----------------------------------|
| Devine     | <i>Phytophthora palmivora</i>                        | Strangle vine in citrus           |
| Collego    | <i>Colletotrichum gloeosporioides</i>                | Joint vetch in rice and soybean   |
| Biopolaris | <i>Bipolaris sorghicola</i>                          | Johnson grass                     |
| Biolophos  | <i>Streptomyces hygroscopicus</i>                    | General vegetation (Non-Specific) |
| LUBAO 11   | <i>Colletotrichum gloeosporioides f.sp. cuscutae</i> | <i>Cuscuta spp.</i>               |
| ABG 5003   | <i>Cercospora rodmanii</i>                           | <i>Eichhornea crassipes</i>       |
| Biochon    | <i>Chondrostereum purpureum</i>                      | <i>Prunus serotina</i>            |

#### 7. Allelopathy in weed management

Allelopathy could be used to suppress weeds by using companion or rotational crops, mulching with plant residues, applying plant extracts or by incorporating allelopathic potential in crop cultivars using plant improvement techniques. Muhammad *et al.*, (2011) reported that sunflower plant extract application was found to be reduce the weed population.

- **Use of cover crops for bio-control:** *Parthenium* incorporated into soil reduces the growth of *Cynodon dactylon*. Leachate of dry menthe (cumin) controls most of the weeds. Velvet bean suppress purple nut sedge.
- **Use of allelopathic chemicals as natural herbicides:**

Xanthotoxin inhibits germination and growth of *Lactuca sativa*. AAL Toxin - *Alternaria alternate lycopersicii* is effective against dicot weeds at low concentration.

#### 8. Integration of non - chemical weed management options

A sound weed management plan should have a strategy to prevent the introduction and dissemination of weeds, enhance the ability of crops to compete with weeds, and combine a variety of weed management options to prevent weeds from adapting to any one of the control practice. Gnanasoundari and Somasundaram (2012) [3, 10] reported that application of rice bran at

2 t ha<sup>-1</sup> on 3 DAT followed by hand weeding on 35 DAT

positively influenced the growth and yield of rice. Umamaheswari (2016) [11] concluded that trenching of corn flour at 1t ha<sup>-1</sup> or spraying of sunflower dried stalk solution at

1:10 (w/v) basis along with one hand weeding will be a viable and ecologically sustainable options to maintain less weed competition in organic Brinjal.

**Table 2:** Effect of different organic weed management practices on weeds

| Weed management practice  | Effect on weed  |
|---|---|
| Tillage   | Kills growing weeds; damages perennial roots & rhizomes; buries seeds too deeply to emerge; brings weed seeds to surface. |
| Stale seedbed   | Flushes weeds from the soil before planting.  |
| Crop cultivar choice  | Suppress weeds  |
| Competitive cultivars   | Improves competitive ability of crop against weeds.   |
| Cover crops / Intercrops  | Suppress weeds, improves soil health  |
| Crop rotation   | Disrupt the development of crop weed association  |
| Using transplants   | Competitive advantage to crop   |
| Allelopathy   | Suppress weeds  |
| Planting arrangement (Sowing time /Plant density / row spacing & row orientation) | Competitive advantage to crop / Suppress weeds by shading   |
| Organic nutrient sources for fertility enhancement                                | Faster-growing weeds due to slow release of nutrient sources.   |
| Post - planting cultivation   | Removes weeds from the crop.  |
| Drip irrigation   | Directs water to the crops rather than to weeds.  |
| Mulch   | Smothers / delays emergence of weeds  |
| Rapid cleanup after harvest   | Prevents seed set by residual weeds.  |

## 9. Conclusion

The recent upsurge in environmental awareness of the public, interest in organic food production and some problems with herbicide use, has led to a range of sustainable techniques being developed for non-chemical weed control. Management of weeds in organic systems is a long and complex process to ensure the success of the organic farm, we have to maintain weed database of individual farm and understand effective management techniques. It is important to understand that under an organic farming, weeds could never be eliminated but only managed.

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