Weed Management Strategies in Organic Farming

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Adoption of nutrient-responsive, high yielding crop cultivars together with the indiscriminate use of synthetic agrochemicals like fertilizers and insecticides led to deterioration of soil and environment. Therefore, it is vital to reduce environmental deterioration to the absolute minimum and increase the productivity of damaged soils. The practice of organic farming is one way to achieve this. Weeds generate more losses (34%) to agriculture than any other type of agricultural pest. Moreover, weeds can serve as a home for some plant viruses and host insects. The potential yield of the majority of cultivated crops is decreased by weeds because they naturally expand more quickly, occupy agricultural habitats, and do so. Since the widespread use of agro-chemicals has allegedly led to issues with the environment and human health, there is currently resurgence in interest in organic weed management techniques. Minimizing losses due to weeds, pests and diseases necessities farmers choice of synthetic chemicals usage which has several adverse effects on environment and human health. While herbicides are considered the main means of control in many countries of the world, there is increasing recognition that non chemical methods of weed control have numerous advantages. It's crucial to realize that weeds can never truly be eradicated under an organic system; they can only be managed. The main objective of a weed management strategy in an organic system is to lower weed competition and reproduction to a level that the farmer can tolerate. Non-chemical weed control techniques are to be encouraged for the protection of human health, the environment, and weeds that are resistant to herbicides.

Weed Management Strategies

An integrated weed management (IWM) strategy is to be used to manage weeds on an organic farm. To keep weed populations below the point at which they cause economic harm, and environmental quality preservation is the main objective of IWM.

Preventive Strategies

Prevention is the least expensive technique. This can be accomplished by planting weed-free seed, adopting adequate watering techniques and managing agricultural machines.

Cultural Strategies

1) **Tillage:** Tillage affects weed survival by burying whole plants and weed seed, exposing the root system to drying and cold, and reducing the food reserves of weed plants. Tillage also lessens compaction, prepares seed bed and incorporates fertilizer and wastes. Summer fallow and deep summer ploughing are viable cultural option to stop weed development in organic farming. Summer ploughings aid in managing the *Cyperus rotundus*. Weed occurrence is decreased by puddling in rice. Compared to no tillage and conventional tillage, deep tillage with mould board plough reduced the population of Phalaris *minor* by 13.7% and 8.5%, respectively.

2) **Crop rotation:** Crop rotation is the best cultural strategy for integrated weed management programme in organic farming to disrupt the weed's active growth cycle. Long rotations and diverse cropping systems are frequently followed by organic farmers to improve soil fertility and economic viability. Paddy crop rotation with sugarcane, vegetable crops, sunflower and pulses minimizes the weeds. Rice cultivation can fully eradicate wild oat. Sunflower and cotton encourage *striga* spp. to germinate, but because they are not hosts for this weed, they completely suppress it. Crop rotation is supposed to be an excellent practice for controlling various noxious and mimicry weeds such as *Phalaris minor*.

3) **Cover crops:** Weeds are suppressed by the crop's quick growth and dense ground coverage. Cover crops including defense against soil erosion, enhanced soil structure, increased soil fertility and weed control. Including cover crops into the

cropping system, such as rice bean, groundnut, rye, red clover, buckwheat, winter crops inhibit weed development because its ability to control weed growth, lower weed populations in the next crop. Moreover, cover crops can operate as a living mulch or organic mulch to further control weed growth during the growing season.

Fig 1. Crop rotation

4) **Intercropping:** The weeds can be successfully controlled using intercropping. Fast growing and early maturing intercrops like cowpeas or mung beans between two rows of the primary crop may be taken for this purpose. In addition to providing fodder, intercropping cowpea with maize and harvesting in 40-45 days after seeding effectively controls weeds. The weed problem is significantly reduced when soybean and peanuts are interplanted with upland rice, maize, or sorghum.

5) **Field scouting:** Short-term weed management decisions are made using the knowledge to lessen or prevent financial crop loss. In long- term field scouting is useful in evaluation of success or failures and for making wise decision in future weed management program.

6) **Mulching:** The basic idea behind mulching is to keep the weeds' tops dark until their reserve food supply in the roots runs out and they starve. Clean straw, hay or manure, sawdust, crop stolons and black plastic are examples of mulch. With wheat cultivated after rice, straw management is crucial for weed control.

a) **Living mulch:** Clover is an example of a plant species that typically grows densely and low to the ground and is used as living mulch. Living mulches can be planted either before or after a crop has begun to grow. In order to prevent living mulch from competing with the actual crop, it is crucial to kill it or somehow regulate it. When transplanting broccoli, spread a live mulch made of *Portulaca oleracea* to control weeds without compromising crop output. Living mulch frequently has other goals besides weed control, such as enhancing soil fertility, reducing pest problems, or improving soil structure.

Fig.2 Mulching with Soil

b) **Organic mulch:** Several materials that can be produced on a farm, including as hay, straw, grass mulch, agricultural wastes, and livestock or poultry bedding, are used as organic mulches. There may also off-farm sources for other materials, like leaves, composted municipal trash, bark, and wood chips. Mulching with organic materials can improve soil structure, water infiltration, aggregate stability, and soil biological activity. It can also assist increase soil organic matter.

Fig.3 Mulching with Paddy straw

c) **Degradable plastic mulches:** Plastic mulch that degrade are either photodegradable or biodegradable. After the growing season,

degradable materials do not need to be removed from the field, and some can even be mixed into the soil to hasten the process. In nurseries and with some high-value crops, reusable materials, such as black polypropylene mulch, can be utilized to manage weeds over time.

7) **Stale seed bed preparation:** The steps in this weed control method are to provide a fine seedbed, allow weeds to grow, and then remove weed seedlings directly using light cultivation or flaming. This method aids in giving the crop a chance to emerge and flourish before the subsequent weed flush. This can be done 2-3 times before planting, if time permits.

8) **Soil solarization:** Soil solarization is a unique weed control method that heats the soil for several weeks using solar energy. Due to this polyethylene sheet coating, soil reaches high temperatures of 50-60 °C during the summer. When compared to non-solarized soil, solarized soil exhibits a considerable reduction in weed flora. Solarization involves heating the soil to destroy nuisance organisms like weed seeds, fungi, bacteria and nematodes.

9) **Sanitation and composting:** The introduction and spread of weeds can be minimized by paying special attention to agricultural sanitation and seed sources. When utilized in many locations, equipment and tools should be fully cleaned before being used in another area. Add weed free mulch and compost to field otherwise it may contain seeds that subsequently cause a problem.

10) **Selection of crop cultivars:** Selection of crop cultivars plays an important role in crop weed competition because of morphological features, canopy structures and relative growth rate. The traditional tall growing varieties perform better than modern dwarf varieties under unweeded situations and this is the reason that most of organic growers grow traditional tall varieties. A cultivar that provides early canopy cover and grows quickly outcompetes weeds.

11) **Sowing time:** An essential agronomic practice for managing weeds is changing the sowing window. Crop sowing is scheduled for a time when weed seed germination is unfavourable, but not far enough away to affect crop performance. Wheat seeded in October has less *Phalaris minor* infection.

12) **Seed rate/planting density:** In order to increase the early smothering capability of crop plants on weeds, increasing seed rate or planting density aims to produce more crop plants per unit area. Rice with a higher plant density (44 plants/m^2) has less weed biomass. Higher than usual seed rates can boost crop output and competitiveness, giving the crop the upper hand over weeds.

13) **Water management:** In transplanted rice, weeds can be controlled with a 15-day submergence interval. Due to the soil being wetted only around the plant base, drip irrigation in wider row crops minimizes the intensity of weeds and thus has minimal weed development. In dry areas, the alternate furrow technique also reduces weed intensity. Weed growth in a field is influenced by irrigation timing and technique. Careful irrigation management can lessen weed burden on crops effectively.

Mechanical Strategies

Mechanical method of weed control, such as hand weeding and pulling, include removing weeds using various tools and instruments. In general, hand weeding is most effective in light soils and is less effective when grassy weeds are present.

1) **Manual methods:** Mechanical removal is most efficient way to manage weeds in organic farming. This includes removing weeds by hand and using hand tools or instruments, such as a wheel hoe, to hand-weed. The best mechanical weed management methods involve burying weed seedlings to a depth of 1 cm and cutting them at the soil surface. But this method has a limitation because of manpower shortage. The most successful method for minimizing the buildup of weed dry matter was mechanical weeding performed twice at the 15 and 30 day stages. Due to rising labor costs and labour shortages during the busiest weeding times, mechanical weeding has now largely taken the role of manual weeding.

2) **Flame cultivation:** On the majority of organically grown crops, broadcast flame cultivation before sowing the crop can be employed successfully. It works better on a smooth dirt surface than one that is bumpy or cloddy. Moreover, it works better against broadleaf weeds than grasses, however it loses power as weeds get older. When flaming burns grasses and perennial weeds to the soil's surface, these weeds can occasionally sprout again. During flame cultivation, it is important to carefully seed or transplant crops to avoid disturbing the soil and promoting the germination and establishment of weed seeds.

Biological Strategies

The natural method for weed management in organic agriculture would seem to be biological control.

1) **Allelopathy:** Allelopathy, meaning mutual harm, is an interference mechanism in which a living or dead plant releases allelochemicals exerting an effect on associated plants which plays an important role in natural and managed ecosystems. Several plants express the allelopathic phenomenon through exudation of allelochemicals. For example, rye is among the most important allelopathic crops. Rye can be used to suppress weeds in a cropping system as a rotating crop, cover crop, or mulch, but the most popular way to do so is as a cover crop. Sorghum produces a number of allelochemicals, which are toxic to associated weeds. The most potent allelochemical released by the roots of sorghum is called sorgoleone. In sustainable agriculture, breeding new cultivars with high allelopathic potential may have a significant impact on biological weed management.

2) **Beneficial organisms:** Few studies have been done on the use of predatory, parasitic insects or microorganisms to control weed populations. A weevil for the aquatic weed salvinia, a rust for skeleton weed and possibly the most well-known natural enemy, a caterpillar (*Cactoblastis* sp.) to manage prickly pear have proven effective. Significant research is also being done on microbes and fungus (myco-herbicides) to be more successful in controlling particular weeds. Myco-herbicides are solutions containing pathogenic spores that are sprayed on plants using typical herbicide application tools.

Some biocontrol agents and commercial mycoherbicides used for weed control are indicated below.

Table 1: Fungal, viral and bacterial agents for weed control

Pathogens or agents	Weeds
Alteraria. destruens	*Cuscuta.* spp.
Alteraria. eichhorniae	*Eichhornia crassipes (Mart.) Solms*
Alteraria. helianthi	*Xanthium strumarium* L
Ascochyta caulina Cercospora chenopodii	*Chenopodium album* L.
Bipolaris setariae	*Eleusine indica* (L.) Gaertner
Cochliobolus lunatus	*Echinochloa crus-galli* (L.) P. Beauv.
Crytobagus singularis (weevil)	*Salvinia molesta*
Dichotomophthora indica D. portulacea	*Portulaca oleracea* L.
Exserohilum monoceras	*Echinochloa* spp.
Myrothecium verrucaria	*S. obtusifolia Portulaca* spp. *Euphorbia* spp.
Phoma chenopodicola	*C. album, Cirsium arvense, Setaria viridis*
Phomopsis convolvulus	*Convolvulus arvensis* L.
Phyllachora cyperi	*Cyperus rotundus* L.
Pyricularia sp.	*Digitaria sanguinalis* (L.) Scop.
P. grisea	*E. indica*
Pseudocercospora nigricans	*S. obtusifolia*
Sclerotinia sclerotiorum	Multiple species
Septoria tritici f. sp. *avenae*	*Avena fatua* L.
Pepino mosaic virus	*Solanum nigrum* L.
Araujia mosaic virus	*Araujia hortorum* E. Fourn.
Obuda pepper virus	*S. nigrum*
Pseudomonas syringae pv. *tagetis*	*C. arvense*
P. fluorescens strain WH6	Multiple weeds
P. fluorescens strain D7	*Bromus tectorum* L.
Zygrogramma bicolarata	*Parthenium hysterophorus*
Crocidosema lantana	*Lantana camara*
Dactylopius tomentosus (Cochineal scale)	*Opuntia dilleni*
Neochetina eichhornea N. Bruchi (Hyachinth weevil) *Sameodes alliguttalis* (Hyachinth moth)	*Eichhornea crassipes*

Table 2: Commercial Bio herbicides

Pathogens	Target Weed
Acremonium diospyri	Diospyros Virginian L. trees in rangelands
C. gloeosporioides f. sp. aeschynomene	Aeschynomene virginica (L.) (Northern joint vetch) in soybean and rice
A. cassiae	Cassia obtusifolia L., C. occidentalis L., in soybean & peanut
C. rodmanii	Eichhornia crassipes (Mart.) Solms
P. canaliculata	Cyperus esculentus L. in soybean, potato, corn, and cotton
C. coccodes	Abutilon theophrasti Medik. In corn and soybean
C. gloeosporioides f. sp. Malvae	Malva pusilla Sm. In wheat, lentil, and flax
Chondrostereum purpureum	Prunus serotina (Ehrh.) in forests
Emmalocera sp. stem boring moth	Echinochloa sp.in Rice and wheat
Gastrophysa, Beetle	Rumex sp. in Rice and wheat
Bactra verutana (Shoot boring moth)	*Cyprus rotundus in Rice and wheat*

Organic Herbicides

A limited number of natural substances can serve as herbicides on organic farms.

1) **Corn gluten meal:** Corn gluten meal, a byproduct of the manufacturing of cornflour, is the most extensively used commodity in the country. It is possible to use maize gluten meal as a pre-emergence herbicide. Redroot pigweed, black nightshade (*Solanum nigrum*), curly dock, purslane, common dandelion and smooth crabgrass are among the weeds that are adversely impacted by maize gluten meal. Barnyard grass and velvetleaf are the least susceptible weeds to corn gluten meal among those that have been studied. In general, grasses are less vulnerable to corn gluten meal than broadleaf plants.

Indigenous Practices

These are the indigenous weed management practices which the farmers have been using on their farms.

Calotropis: By maintaining chopped calotropis branches along irrigation channels or entrances, striga populations are reduced.

Cotton shells: Cotton ball shells can be used to suppress the noxious plant *Cyprus rotundus*. Before the rainy season, a 3-inch-thick coating of nutshells is spread around the pitch. Afterwards, to fully absorb it into the soil, the land is cultivated. This causes the weed's root or sedge to burn or die. For around two to three years, the field remains weed-free. Decomposition transforms it into organic manure and aids in boosting crop yield.

Coriander: *Striga asiatica* in sorghum is managed with coriander. The sorghum rows are interspersed with coriander seeds. For every three kg of sorghum seeds, 200 g of coriander seeds are sowed. When the coriander plants reach a certain size, the strands begin to wrap themselves around striga weed, which inhibits its growth.

Conclusion

Reducing the deleterious effects of weeds on crops is the ultimate goal of weed management. Integrated weed management includes all practices that enhance a crop's competitive ability and decrease weeds' ability to reduce yield. Today, there is a renewed interest in organic methods of managing weeds since the widespread use of agro-chemicals has resulted in purported environment and health problems. Therefore, It is important to understand that under an organic system, weeds will never be eliminated but only managed.

Effective weed management is the major challenge for successful organic farming. IWM comprising cultural, mechanical and biological practices are warranted for managing weeds in an eco-friendly way in organic farms. In addition to the growing concern for protection of environment, maintain biodiversity and protection of human and animal health, IWM approaches are also good ways of climate change mitigation. Careful selection of cropping systems (intercropping, crop rotation etc) and controlling weeds during critical period of crop-weed competition are important for sustainable weed management. Research efforts are required to develop location specific bio-herbicides for use in organic farms.