

WEED MANAGEMENT STRATEGY IN ORGANIC FARMING

PATEL, D. D.*, PATEL, T.U., THANKI, J. D. AND ARAVADIA, M. K.

NAVSARI AGRICULTURAL UNIVERSITY
NAVSARI - 396 450, GUJARAT, INDIA

**E-mail: drpatel_76@yahoo.co.in*

ABSTRACT

Despite weeds are a serious threat to promotion of organic farming, relatively less attention is given to research on weed management. This article explores a scope of integration of conservation agriculture for weed control under organic farming. Limitation in the use of agro-chemicals under organic farming promotes intensive tillage for weed control. Effective weed management on organic farms requires extensive planning and preventing measure coupled with cultural method and crop rotations are the basis for successful organic farming and are necessary for breaking weed, insect and disease cycles. Appropriate crop rotations and cover crops management suppress weeds populations with smothering and allelopathic effects. Bio control and understanding of allelochemical may help the organic farming. Thus, cultural approaches integration under organic farming could be an option for weed, pest and soil management which leads to sustainable organic plant production. Monitoring weed growth stages also is critical in determining ideal cultivation times.

INTRODUCTION

Weeds are widely reported as a key constraint in organic agriculture, although not all organic growers believe weeds are a problem. Many farmers express less concern about weeds as their experience increases. Organic weed management relies on mechanical, biological and cultural methods, but these tools must be used in an integrated, multi-strand approach. In addition to direct and cultural techniques; timeliness, vigilance and an understanding of farm ecology are also important factors in effective weed management (Marshall, 1992).

Why Organic Weed Management?

Farmers have struggled with the presence of weeds in their fields since the beginning of agriculture. Weeds can be considered a significant problem because they tend to decrease crop yields by increasing competition for water, sunlight, and nutrients

while serving as host plants for pests and diseases. Since the invention of herbicides, farmers have used these chemicals to control weeds from their fields. Using herbicides not only increased crop yields but also reduced the labor required to remove weeds. Today, some farmers have a renewed interest in organic methods of managing weeds since the widespread use of agro-chemicals has resulted in purported environmental and health problems. It has also been found that in some cases herbicide use can cause some weed species to dominate fields because the weeds develop resistance to herbicides. In addition, some herbicides are capable of destroying weeds that are harmless to crops, resulting in a potential decrease in biodiversity on farms.

What is organic weed management?

Organic weed management is a holistic system involving an entirely different approach to managing a farming system. The

organic farmer is not interested in eliminating all weeds but wants to keep the weeds at a threshold levels that is both economical and manageable. A farmer who manages weeds organically must be intimately familiar with the type of weeds and their growth habits to determine which control methods to employ. If we are in the business of profitable organic crop production, then we need to manage weed species so that desirable plant species have the advantage. This requires an integrated weed management approach.

Integrated Weed Management

Integrated weed management involves the bringing together of a range of practices to manage a specific problem plant. There are four key principles that are fundamental to the integrated approach in organic systems.

- i. Knowledge of soil, crop and pasture plant systems,
- ii. Knowledge of weed species and how they may affect soil, crop and pasture systems,
- iii. Knowledge and appropriate use of available management options for weeds,
- iv. Monitoring the impact of management on the weed species and on the soil, crop or pasture

Developing a Weed Management Plan

Know the farming system

A successful weed management plan involves accurate knowledge of the crop or pasture system that is being operated. For example, a grazing enterprise requires high quality and vigorous pasture species (both legumes and grasses) to provide feed for livestock on a year round basis. Weed management in permanent pasture focuses on the maintenance of healthy soils and productive species that can compete effectively with less desirable plants. A cropping enterprise requires prepared paddocks so that the crop plants have the advantage over other plants and can yield to their optimum level. The principles of healthy soils and

vigorous species still apply in cropping enterprises but there are additional opportunities to use a wider range of management methods to reduce the influence of weeds.

Know the weed

It is essential that the characteristics of the weed species are known if a plan to manage the species is to be successful. Preliminary classification of weeds includes whether they are annual, biennial or perennial, and how and when they reproduce. Also, climate change directly affects the geographic range of species, the timing of species life cycle (phenology), the population dynamics of species, the decline and extinction of some species and the invasion of other species (Singh *et al.*, 2011).

Available Management Options

There is a wide range of management options available to producers to manage weeds in organic crop and pasture systems.

1. Preventive Approaches/Measures

i) Pure and clean crop seeds and seed certification

It is always advised to use pure and clean seeds of crops as possible. Clean crop seeds do not add seeds of the existing or new weed species to soil seed bank. It acts as an insurance/check against increasing weed (both existing and new weeds) problem in the long run. It reduces seed rain and further dissemination of weeds.

ii) Well-decomposed farm yard manure (FYM)/compost, sewage and sludge

Fresh or un-decomposed farm yard manure/compost is a source through which weed seeds are added to soil. Therefore, it should be always well-decomposed/well-rotten and free from weed seed. Sewage and sludge are good sources of organic matter and now-a-days are being used for organic agriculture. They, however, need to be treated properly towards making free from weed seeds before applying to crop field.

iii) Clean farm machineries, farm vehicles and farm animals

The farm machineries like tillage and harvest implements are another source from which weed seeds get into crop field. They should be cleaned properly and the soil sticking/adhered to the implements particularly ploughs, tractors must be removed before it is carried to another field. Accordingly similar treatment may be given to the farm animals since several weed seeds adhere/entangle with the furs and skins of animals by means of some hook like structures and disperse. These are very small efforts towards weed prevention and have hardly been ever evaluated or quantified.

iv) Clean irrigation channels & water and alternate irrigation system

It is necessary to keep clean the irrigation channels, ditch banks, and the irrigation systems free of weeds and weed seeds. Weedy irrigation channels, apart from dispersal of weeds, cause choking/plugging and wastage of valuable water. Irrigation water also needs to be clean or treated. Also keep the areas immediately around these areas weed-free. Eliminate low spots in the orchard and maintain drainage systems to prevent standing water. Repair leaking irrigation systems immediately, as moist sites encourage weed emergence and growth. Irrigation water carries soil and weed seeds to a crop field. Some sub-surface (drip) and over-head (sprinkler) irrigation systems may be installed as per feasibility and applicability in crops, soil and climatic conditions.

v) Clean farm bunds, roadsides, fences and other non-crop areas

Weeds on farm bunds, paths/roads and fences should be controlled occasionally always before they go for flowering to avoid weed perpetuation in the field. Similarly weeds not controlled by measures adopted should be removed from the field before they flowered.

vi) Transport of sand and soil

Sand, soil from an infested area should not be transported and used to a clean or cultivated area.

vii) Weed control in the nurseries

Proper weed control measures may be adopted in the nurseries of rice and vegetables. While uprooting crop seedlings, weed seedlings up-rooted may be removed before crop seedlings are taken to the main field. In transplanted rice, this could be an important mechanism of spread of weeds.

viii) Plant/Weed Quarantine Law

Weed law prevents dissemination by physical (manual or mechanical) ways of all weed species in general and noxious weeds in particular across regions, states or countries. It also prevents farmers from using mislabeled or contaminated crop seeds. Weed law exists only in Karnataka in India, which declares *Parthenium hysterophorus* as a noxious weed. Weed Quarantine Law enforces isolation of an area where a serious weed has established and prevents further movement of the weed into a non-infested area. Plant Quarantine (Regulation of Import into India) Order was enacted/issued in 2003 and till June 28, 2006 nine Amendments have been incorporated into it. This imposes regulation on the import of plants, plant products, soil, earth, clay, compost, sand, peat, sphagnum moss, germplasm, transgenics or genetically modified organisms, live insects, microbial cultures, wood or timber.

2.Physical (Manual & Mechanical) Methods

i) Hand Weeding/Hand Pulling

Hand weeding is the oldest method of weed control. It effectively controls annual weeds, but not perennial weeds.

ii) Hand Hoeing

Hand hoeing is a post-planting intercultural operation, which stirs the soil and makes it more loosened. It is effective against annual weeds but not for perennial weeds, since it cannot control the under-ground vegetative structures of perennial weeds.

iii) Tillage

The objectives of tillage to provide a good seed bed and a root bed for smooth germination and better root growth and subsequent rapid seedling establishment and to reduce/control initial flushes of weeds by means of exhausting weed seed bank remain unchanged. Adequate tillage checks and delays emergence of weeds and provides a more favourable environment for early crop establishment (Singh *et al.*, 2010).

Tillage brings about alterations in the physical, chemical and biological properties of soil and thus, it favours crop growth and influences competition behavior. Frequent tillage encourages proliferation and perpetuation of annual weeds more, whereas no/zero-tilled fallow land experiences more perennial weeds. Tillage breaks, cuts or tears off weeds and exposes them to desiccation by sun. It reduces population of perennial weeds by exhausting food reserves of the vegetative structures. It removes standing/existing weeds, renders up-soil down and down-soil up and lateral movement of soil, buries surface weeds, distributes weed seeds across horizontal and vertical (depth-wise) plane/axis in soil and reduces the density of weed seeds in a given area. It helps to prepare a good seedbed and root bed for smooth germination and better root growth and rapid seedling establishment. Excessive tillage, however, encourages soil erosion, more in light soil.

iv) Conservation tillage

Now-a-days minimum tillage, zero tillage is being increasingly encouraged for certain problems encountered in the world agriculture, *e.g.* soil erosion, soil organic matter loss, soil compaction by heavy farm machineries like tractor, energy/fuel crisis and more time requirement for land preparation. Minimum or zero tillage has been already employed in certain crops like maize, soybean in USA and rice in some South-east Asian countries. A kind of zero tillage is practiced in wheat after rice under the rice-wheat system in

India and has profound influence on the advancement of time of sowing of wheat and weed competition. The rice-wheat cropping system with zero tillage is the best cropping system with lower risk as it has major benefits such as improving water use efficiency, reduced cost due to saving in the fuel and labour, timely planting of crops, results in higher yield, reduced weed density and has positive environmental impact (Singh *et al.*, 2010).

v) Mowing and Slashing

The concept behind mowing and slashing is prevention of weed seed production and dissemination through concurrent control of the existing weeds or wild vegetation (mainly their top/tall growth) usually under non-crop situations such as canal bunds, farm roads, parks and lawns. The great benefit from mowing and slashing is the recycling of organic matter if the cut green-biomass of weeds is left as such on the soil surface and not taken away.

vi) Flooding

Flooding creates anaerobic condition, which prevents/reduces weed seed germination and root respiration of already germinated weeds and kills plants by reducing oxygen supply for growth. It could be followed under both cropped (but not all crops) and non-crop situations if cost economics permits. Flooding constitutes an important mechanism/aspect of weed management in rice.

vii) Burning, flaming and heating

Burning is practiced mainly under non-crop situation towards non-selective control of weeds or unwanted vegetation. Flaming, on the contrary, could be used both selectively and non-selectively. Flame is directed towards the ground and injury to crops is avoided. Crop plants can withstand heat of the burner, whereas small succulent weeds cannot. Crop plants should be taller than weeds. It has been used successfully for selective weed control in alfalfa, cotton, sugarcane and soybean. Heating soil through solarization or residue

burning is another aspect for weed control in crops in recent years

viii) **Cheeling and Digging**

Cheeling simply means cutting and scraping of the top growth of weeds by the cheel hoe at the soil surface. Digging is useful for controlling perennial weeds like nut grass, hariali etc. Digging is very useful for removing the underground propagation parts of weeds from the deeper layer of soil digging, hand collection and destruction of underground parts of weeds is adopted when noxious weeds are observed in the patches in the field. It is not economical on large areas as it is costly and time consuming method.

ix) **Chaining and Dredging**

These methods are useful for controlling aquatic weeds. Removing of weeds along with their roots and rhizomes from the water with the help of mechanical force is called dredging. The floating aquatic weeds are removed by changing. A heavy chain is pulled over the water bodies to collect the weeds.

x) **Mulching**

Mulching has enough bearing towards weed suppression in cropped and non-cropped situations. The lack of sunlight inhibits photosynthesis of the germinating weeds and causes them to die. Mulches also provide an effective barrier to weed emergence, the germinated weeds find it difficult to penetrate the thick layer of mulch. Mulching is very effective against most annual weeds and some perennial weeds such as *Cynodon dactylon*, *Sorghum halepense*. Mulching also serves to limit water evaporation from soil, improve tilth and reduce erosion. The surface retention of rice residue of 5.0 and 7.5 t/ha reduced the weed dry weight in wheat by 23.4-30.3 and 35.5-44.1%, respectively (Chhokar *et al.*, 2009).

xi) **Soil solarization**

The basic principle/phenomenon behind soil solarization is that light received from the sun is in the form of electromagnetic

short waves, which easily pass through the transparent colourless polyethene films and reach to soil. As a result, earth/soil is heated up and emits long-wave terrestrial radiation, which, however, cannot pass through transparent polyethene films and results in build-up or trapping of heat (Katan *et. al.*, 1976; Yaduraju, 1997). A decrease in the heat loss of soil through evaporation and convection is the main cause of increase in soil temperature by transparent polyethene films. Water droplets formed on the inner surface, highly reduce the transmittance of transparent polyethene films to long-wave terrestrial radiation and induce increased green house effect. Air is a bad conductor of heat and, therefore, its insulation effect should be minimized or nil by laying plastic films very close to the soil. A good land preparation ensuring fine tilth and smooth and even surface of soil is a pre-requisite to reduce air spaces in between the polyethene film and soil for effective solarization. Surface soil temperature may increase up to 55-60°C due to solarization during hot summer months (Kumar *et. at.*, 1993), which proves lethal to many weed seeds and vegetative propagules, insects, nematodes and disease pathogens and causes them to die. Solarization for a minimum period of 2 weeks during hot summer months (May and June in India) is sufficient to control weeds, but it may be continued to several weeks together for prolonged effect. It may control weeds in crops in the wet-season (*kharif*) as well as subsequently in the winter (*rabi*). It also controls soil-borne plant pathogens like *Fusarium*, *Verticillium*, *Pvthium*, *Rhizoctonia*, *Scierotium*, *Phytophthora* (Abdel Rahim *et. al.*, 1988; Al Masoum *et. al.*, 1998).

Thinner (25-50 μ thickness) and white transparent polyethenes are more effective than thicker (200-400 μ) and black polyethenes. It is, however, a costly affair in field crops, which are usually not cash crop.



Hand Weeding/Hand Pulling



Hand Hoeing



Tillage



Conservation tillage



Flooding



Mulching



Soil solarization



Cropping Practice



Stale seed bed technique

3. Cultural/Ecological Approaches/Methods

Cultural/ecological method of weed control exploits the crop's competitive behavior, growing environment and crop management practices towards smothering of weeds. It is differently known as "*crop competition method*". Fryer (1983) stated, "*A good crop is the best weed killer*". Therefore, the farmers should adopt a good crop husbandry. Every practice needs to be adopted with due care and should result in or aim at boosting up of initial growth of crops.

i) Crop species and variety

Crops having good weed smothering ability may be opted for cultivation. Cowpea due to its initial faster growth and canopy coverage smothers weeds very effectively than green gram and black gram. It has higher weed smothering capability. Barley is more competitive to weeds than wheat mainly because of greater root proliferation at the initial 20-25 days after sowing. Barley also contains allelochemical e.g. gamine, which influences/intensifies its competition with weeds. Pavlychenko (1940) observed that barley competed with *Avenafatua*, *Brassica kabera* and *Polygonum convolvulus* more effectively than either wheat or oat (*Avena sativa*). Similarly, sorghum possesses allelochemical HCN (hydrocyanic acid) in shoot and foliage and allelopathic to *Abutilon theophrasti*, *Amuranthus hybridus*, *Setaria viridis*, *Borinus pectinatus* (Putnam, 1985), while in maize major source of allelochemicals is root exudates and maize is allelopathic to *Chenopodium album*, *Amaranthus retroflexus*. The allelochemicals add to their competition potential/behaviour with weeds. Cereals because of their tall stature prove more competitive against short-stature weeds (e.g. wheat more competitive to/against *Melilotus indica/alba*, *Spergula arvensis*, *Coronopus didymus*, *Fumaria purviflora*, *Polygonum plebejum*, *Oenothera biennis*, *Sisymbrium irio* etc.; maize and sorghum against *Commelina benghalensis*, *Digera arvensis*, *Trianthema*

portulacastrum / monogyna etc.) than short-statured pulses and legumes and oilseeds. Like crop plants, crop cultivars too vary in their ability to compete with weeds, basically on the same principles as crop plants do. Gill and Mehra (1981) also observed significant reduction in growth (density, dry weight and height) of *Phalaris minor*, *Chenopodium album* and *Melilotus indica* in association with tall wheat genotype (C 306) compared to 3-gene dwarf variety (WL 1562).

ii) Sowing of Crop (Time, method and rate of sowing and row spacing)

a) Time of sowing

Time of sowing of crops influences weed competition. If initial big flush of weeds germinating at one point of time is bypassed through manipulation of the time of sowing of a crop, a little earlier or later than its normal time of sowing, the crop may germinate and have initial growth under almost weed-free or less weedy environment. For example, weeds pose more competition when wheat is sown on October than on November or December (Kolar and Mehra. 1992).

b) Method of sowing

Line sowing usually encounters less weed infestation and provides more ease of controlling them than broad-casting method. In the summer season, furrow planting of crops is also a useful method of reducing weed problem. It is because in this method the irrigation water is restricted initially to the seeded furrows. This leaves the inter-row space dry where weeds fail to germinate.

c) Rate of sowing

Seeding rate and per cent viability and germination of seeds usually determine crop density. Normally higher the density of a crop, lower is the weed competition and vice-versa.

e) Smothering

Row spacing greatly affects weed competition in crops. Optimum closer row-space reduces weed competition in crops. A quick growing dense crop can successfully compete with weeds. Fast growing and fast

shading crop is called smother crop. Sweet potatoes, Lucerne, soybean, sun hemp, etc are good smother crops. These crops cover the field within short period due to higher plant density, fast growth and canopy coverage suppress weeds by fast shading effect and also make the under ground parts of weed feeble. The smother crops are sown at close spacing with high plant population to suppress weeds.

iii) Crop Rotation

Crop rotation is defined as the practice of growing different crops in sequence on the same piece of land year after year. It is an age-old, time-honoured and multi-tested useful practice. Crop rotation is considered as a “panacea” as for controlling several insect pests, diseases and weeds under crop field ecosystems so for maintaining soil health and sustained crop production. Crop rotation regularly changes crop and microclimate in each field. Crop growth pattern, cultural practices, weed control techniques, type and intensity of tillage/ cultivation for land preparation for crops vary frequently in rotation and this variation creates a barrier for further proliferation of crop associated weeds (weeds associated with the crop grown earlier). All these destroy the continuity in crop-weed association/affiliation operating over the years and affect weed population and growth. However, the adoption level of crop rotation by the farmers is not encouraging mainly because of some socio-economic reasons. Switching over to a crop is hardly preferred by the farmers unless it serves their purposes. They are not ready to forego/sacrifice the crop being grown since long time on the same piece of land. Crop rotation is highly effective against parasitic weeds such as *Striga hermonthica/asiatica* (mainly in sorghum and maize), *Orobanche rainosa* (in Brassicas & solanaceous crops), *Orobanche cernua* (in tobacco), *Orobanche crenata* (in faba bean), *Cuscuta chinensis* (in alfalfa), *Cuscuta epilinuin* (in linseed), *Cuscuta campestris* (in niger) (Parker, 1979;

Parker and Riches, 1993) and crop-associated weeds like *Avena ludoviciana/fatua* and *Phalaris minor* (in wheat), *Cichorium intybus* and *Coronopus didymus* (in Egyptian clover/berseem), *Echinochloa colona/crusgalli* (in rice) (Gupta, 1998). Mustard/gobhi sarson, vegetable pea, potato, Egyptian clover/berseem if adopted in sequence after rice during winter season, *Phalaris* problem could be reduced to a great extent in North-western wheat belt of India (Singh and Singh, 2006).

vi) Cropping Practice

Inter-croppings like sugarcane + greengram / blackgram / gram, maize + soybean / blackgram, sorghum + cowpea, wheat + gram are reported beneficial towards weed control. However, it should not be viewed that once inter-cropping done, there is no need of weed control measure any more. Initial weed control before crop establishment may be equally important in inter-cropping too. Compton (1982) stated that an inter-cropping system to become efficient in terms of production and weed control, must balance the reduction in the economic value of the principal crop against the economic value and weed control value of the inter-crop.

a) Live mulch/cover crop

Live mulch is nothing but a living cover maintained by growing a cover crop. A food crop is directly planted in it without destroying the established cover by tillage. Intercrop having good weed smothering ability can also be introduced in inter-rows of an economic crop. These practices are age-old and time-honoured in many respects. An established perennial legume cover suppresses weeds, reduces weed seed bank in soil, reduces soil and organic matter loss by erosion, add up N into soil and thereby reduces N requirement of concurrent crop, provides favourable condition for earthworm activity, increases infiltration of water, reduces soil compaction and may provide fodder for cattle and livestock after crop harvest and also in the

dry season. Usually legume crops are the best choice for live mulch.

b) Trap and Catch Crops

Trap and catch crops should be included in crop rotation particularly for controlling parasitic weeds *Striga* and *Orobancha*, but not for *Cuscuta*. Trap crops are nothing but false hosts, which exude striga germination stimulants and induce striga seed germination, but after germination, striga may die-out for want/lack of attachment with the host roots. This is called suicidal germination. Cotton, soybean, sunflower, cowpea, jute, pigeon pea, chick pea and groundnut are trap crops for striga. Trap crops are usually not sacrificed but harvested as a crop. A combination of several trap crops together (as inter-cropping/mixed cropping) may be planted under a rotation programme in the same piece of land as against the usual practice of taking only a single trap crop.

v) Scheduling of Irrigation

No scheduling for irrigation arises under rainfed condition. However, it is an important aspect towards reduction of weed competition under irrigated agriculture. Time and method of irrigation affect weed emergence and growth, submergence controls many weeds, drip irrigation reduces weed proliferation leaving less soil area wetted near the tree crops and alternate furrow lessens weeds in dry furrows. Irrigation methods, e.g. border strip, check basin, ridge and furrow, FIRBS (furrow-irrigated raised bed system), drip and sprinkler also have inherent varying weed smothering ability and therefore, variable effects on weeds.

vi) Stale seed bed technique

Stale seed bed is one where initial 1 to 2 flushes of weeds are destroyed by harrowing before planting or sowing of the crop. This is achieved by soaking a well prepared field with either irrigation or after receiving rain and allowing the weeds to germinate. These newly emerged weeds are destroyed by harrow with spike tooth or blade harrow. This should be

followed immediately by sowing the crop. Non selective herbicides like Glyphosphate or paraquat can be used to destroy weeds instead of harrowing or paraquat can be used to destroy weeds instead of harrowing or light tillage.

vii) Summer Fallowing

Deep ploughing after harvest of the rabi crop and exposing underground part of weeds to strong sunlight during summer months is helpful for destroying many annual and perennial weeds. Fallowing is a cheap and effective practice of weed control (Moody, 1975). Fallowing during summer accompanied by 3-4 tillage (of which the first one should be a deep tillage) exposes weed seeds, underground vegetative structures of perennial weeds (e.g. *Cyperus rotundus*, *Cynodon dactylon*, *Digitaria abyssinica* (~ *scalarum*), *Cirsium arvense* or *Convolvulus arvensis*), insects, pathogens, nematodes to the hot sun and kill them by solarization. Mere fallowing, however, may not yield a good result.

viii) Residue Incorporation into Soil

Crop residue management research either through incorporation or by burning has been taken up in significant scale towards nutrient recycling under nutrient management system. It has hardly been investigated towards crop or weed allelopathy and on weed management aspect.

ix) Lowering Area under bunds

Reduction in area under bund and water channels of crop fields is essential to minimize weed infestation as weeds on bunds and channels are often ignored by the farmers since they do not compete directly with crops.

4. Biological Control

The biological control of weeds involves the use of living organisms, such as insect, herbivorous fish, other animals, disease organisms, and competitive plants to limit their infestations. An important aspect of biological weed control is that at a time, it is applicable to the control of only one major

weed species that has spread widely. With perennial weeds the main objective of bio-control is the destruction of the existing vegetation, in the case of annual weeds prevention of their seed production is generally more important.

Kinds of classical bio-agents

Four kinds of bio agents have thus far been successfully used for controlling weeds, both terrestrial and aquatic. These are (i) insects, (ii) carpfish, (iii) fungi, and (iv) competitive plants.

Sr. No.	Name of Weed	Bioagent
1	Lantana (<i>Lantana camara</i> L.)	<i>Hypena jussalis</i> Guenoe
2	Prickly pear (<i>Opuntia</i> spp.)	<i>Dactylopius tomentosus</i> Auct. (<i>D. ceylonicus</i> Green) 'cichineal scale insect'
3	Alligator weed (<i>Alternanthera philoxeroides</i>)	Flea beetle (<i>Agasicles hygrophyla</i> Selman Vogt)
4	Water hyacinth (<i>Eichhornia crassipes</i>)	Hyacinth moth, <i>Sameodes albiguttalis</i> B. Benner
5	Salvinia (<i>Salvinia molessta</i>)	Culionid beetle (<i>Cyrtobagous salviniae</i> Sands)

Under classical biological control of parthenium in India, three insect species were imported in 1983 from Mexico, out of which only host-specific leaf-feeding beetle *Zygogramma bicolorata* Pallister (Coleoptera: Chrysomelidae) was proved successful. *Zygogramma bicolorata* has established in many parts of the country and has been found responsible to decrease the parthenium densities in different parts of India. Also cassia tora and *C. sericea* have been recommended most suitable plant species for management of

parthenium in wasteland, on the road side and community land (Sushilkumar, 2009).

Bioherbicide philosophy of weed control

Bioherbicides are pathogens cultured artificially and made available in sprayable formulations; just like a chemical herbicide. Some Commercial Myco-herbicides in use abroad include colleto, de-vine, bio-lyphos and bipolaris etc.

Allelopathy and chemical weed management

1. Development of novel biopesticides, namely herbicides, insecticides or fungicides from allelochemicals or allelopathic agents assumes paramount importance. The weed has phenolics, flavonoids, alkaloids, pseudoguaianolides and oils, many of which have been implicated in allelopathy (Pandey, 2009).
 - a. Bialaphos, a microbial toxin/allelochemical is found in a bacterium *Streptomyces hygroscopicus*. Its synthetic analogue glufosinate-AM is extensively used for weed control in cropped and non-crop situations.
 - b. From *Salvia* sp (sage), 1,8-cineole is released, which has phytotoxic effect. Cinmethylin is a synthetic herbicide and has structural similarity with it. Cinmethylin controls annual grasses and some broad-leaved weeds and is recommended for weed control in rice.
 - c. A natural herbicide AAL-toxin is a metabolite produced by *Alternaria alternata* f. sp. *Lycopersici*, a pathogen (fungus) causing stem canker of tomato (Zimdahl, 1999).
2. A number of crops and crop cultivars have been reported with their alleged allelopathic effects. Therefore,

adoption of crops or crop's cultivars more allelopathic to weeds may reduce the cost of weed control in particular and the cost of cultivation as a whole. For example, sorghum residues have been applied to control weeds in subsequent rotational crops (Putnam, 1994).

3. Application of the residues of allelopathic crop plants as mulches or adoption of an allelopathic crop in rotational sequence and allowing its residues to remain in the field has enough importance to bring down weed population to lower level provided the residues are not allelopathic to the crop in rotation.
4. Utilizing a companion crop/plant (Putnam, 1885; Zimdahl, 1999) that is selectively allelopathic to weeds and does not interfere appreciably with crop growth has enough bearing towards weed control in the fields. In several intercropping situations such as sorghum + cowpea, maize + cowpea/soybean and agro-forestry/agro-silvi-pastoral systems, a clear advantage in weed control is obtained, but it requires to be authenticated and quantified through enough research.

5. Chemical Control

Herbicides are chemicals that kill or suppress plants by affecting their physiological processes. Only a limited number of herbicides are organically acceptable, and these include contact materials such as acetic acid (vinegar), citric acid, and solutions of sodium nitrate, as well as a pre-emergence material, corn gluten. Herbicides can be used for selective weed control by manipulating the timing of application or placement of material, or by exploiting differences in the chemical tolerances of the crop and the target weed. Weeds that emerge before the crop can be killed with contact herbicides (acetic acid,

etc.). These herbicides kill plants that have emerged, but have no residual activity on those that emerge later. Corn gluten is a pre-emergence material that is applied / to the soil to suppress weeds as they germinate. Currently, the efficacy of these organically acceptable herbicides is marginal at best.

Monitoring

Monitoring is an important aspect of weed management. It helps farmers to identify a site's major weed issues and hotspots, select appropriate management techniques, and determine the best timing of treatments (eg. soon after germination to prevent weed establishment or at the start of flowering to prevent seed set). Monitoring also reveals the effectiveness of weed control techniques. This is necessary for fine-tuning of weed management programs. For monitoring to be of value, it is important that weeds are identified correctly. Guides are available to help with this. Weed surveys and mapping are also a useful way to document a farm weed status for future reference.

CONCLUSION

Effective weed management on organic farms requires extensive planning and preventing measure coupled with cultural method and crop rotations are the basis for successful organic farming and are necessary for breaking weed, insect, and disease cycles. Bio control and understanding of allelochemical may help the organic farming. Monitoring weed growth stages also is critical in determining ideal cultivation times.

REFERENCES

- Abdel-Rahim, M. F., Satour. M. M., Michail, K. Y., El-Eraki, S. A., Grinstein, A., Chen, Y., and Katan, J. (1988). Effectiveness of soil solarization in furrow-irrigated Egyptian soils. *Plant Dis.*, 72:143-146.
- Al Masoum. A. A., Hashim, A. A., Jaafer, K. and Al Asaal, A. 1998. Effect of two mulch types for solarization on soil temperature. *AMA, Agricultural*

- Mechanization in Asia, Africa and Latin America*, **29**(4): 73-75.
- Chhokar, R. S., Singh, S., Sharma, R. K. and Singh, M. (2009). Influence of straw management on *Phalaris minor* Retz. control. *Indian J. Weed Sci.*, **41**(3&4):150-156.
- Compton, J.A.F. (1982). *Small farm Weed Control*. An Annotated Bibliography, IPPC and Intermediate Technology Publication Ltd., London.
- Fryer, J. D. (1983). In : Recent Advances in Weed Research. W.W. Fletcher (ed.) CAB, London.
- Gill, H. S. and Mehra, S. P. (1981). Growth and development of *Phalaris minor*, *Chenopodium album* and *Melilotus indica* in wheat crop ecosystem. In: *Proceedings 8th Asian Pacific Weed Science Society Conference*, pp : 175-179.
- Gupta O. P. (1998). *Modern Weed Management*, Agro Botanica Publishers, Bikaner, India, pp: 488.
- Katan, J., Greenberger, A., Alon. H. and Grinstein. A. (1976). Solar heating of polyethene mulching for the control of diseases caused by soil borne pathogens. *Phytopath.*, **66**: 683-686.
- Kumar. B, Yaduraju, N. T., Ahuja, K. N. and Prasad, D. (1993). Effect of soil solarization on weeds and nematodes under tropical Indian conditions. *Weed Res.*, **33**: 423-429.
- Kolar, J. S. and Mehra. S. P. (1992). Changing scenario of weed flora in agro-ecosystems of Punjab. In : *Changing Scenario of Our Environment*. G. S. Dhaliwal et. al (eds). PAU. Ludhiana. India: 252-262.
- Marshall, T. (1992). Weed control in organic farming systems. In "*Proceedings of the First International Weed Control Congress*", pp. 311-314. (Weed Science Society of Victoria, Melbourne).
- Moody, K. (1975). Weeds in shifting cultivation. *PANS*, **21** : 188-194.
- Pandey, D. K. (2009). Allelochemicals in parthenium in response to biological activity and the environment. *Indian J. Weed Sci.*, **41**(3&4): 111-123.
- Parker, C. (1979). *Integrated Weed Control in Sorghum*. FAO Plant Production and Protection Paper No. 19, Rome, Italy, pp : 110-119.
- Parker. C. and Riches, C. R. (1993). *Parasitic Weeds of the World: Biology and Control*. CAB International. Wallingford, UK.
- Pavlychenko. T. K. (1940). Investigations relating to weed control in western Canada. Impt. Bur. Pastures and forage crops. Wales, *Great Britain. Herbage Pub. Serv. Bull.* 27.
- Putnam, A. R. (1985). *Weed Allelopathy*. Chapter 5, pp 131-155. In : *Weed Physiology*, Vol. 1, Reproduction and Ecophysiology. S. O. Duke (ed.). CRC Press. Boca Raton, Florida.
- Putnam, A. R. (1994). *Phytotoxicity of Plant Residues*. pp 285-314. In : P. W. Unger(ed.). *Managing Agricultural Residues*. Lewis Pubs., CRC Press, Boca Raton, Florida.
- Singh, R. P. and Singh. R. K. (2006). Ecological approaches in weed management. In : *Extended Summaries (Voluntary Articles)*, Golden Jubilee National Symposium on Conservation Agriculture and Environment" jointly organized by the Indian Society of Agronomy, Division of Agronomy, IARI, New Delhi and Banaras Hindu University (BHU) at the Banaras Hindu University. Varanasi, India on October 26-28, pp 301-304.
- Singh, R. P., Singh, R. K. and Singh, M. K. (2011). Impact of climate and carbon dioxide change on weed and their management- A review. *Indian J. Weed Sci.*, **43**(172):1-11.

-
- Singh V. P., Kumar, A. and Banga Akshita (2010). Current status of zero tillage in weed management. *Indian J. Weed Sci.*, **42**(1 & 2):1-9.
- Sushilkumar (2009). Biological control of parthenium in India: status and prospects. *Indian J. Weed Sci.*, **41**(1 & 2): 1-18.
- Yaduraju, N. T. (1997). Soil Solarization —A Novel Method of Weed Control. Division of Agronomy, Indian Agricultural Research Institute, New Delhi — 110 012. India.
- Zimdahl. R. L. (1999). Fundamentals of Weed Science. 2nd edn., Academic Press, San Diego, CA., pp 556.