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Weed management strategies in organic farming

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Weeds pose a significant challenge to organic farming due to the absence of herbicides, leading to substantial crop losses. Effective weed management in organic farming should focus on reducing weed populations to manageable levels without attempting complete elimination. Strategies like cultural practices, including the stale seed-bed technique, soil solarization, and crop diversification, are essential. Manual, mechanical, and biological control methods play key roles in maintaining crop-weed competition balance. Integrated Weed Management (IWM), involving prevention, mechanical tools, and ecological practices, offers a sustainable and environment-friendly approach, promoting soil health and enhancing crop productivity.

Keywords: Integrated weed management, Organic farming, Weed management

THE cultivation of high yielding crop varieties are responsive to fertilizers and irrigation, however the new intensive cropping systems have brought to the forefront the problem of weeds, which cause tremendous losses to crops in terms of productivity and quality. Almost one-third of attainable production is endangered by the weed competition worldwide as compared to 18% and 16% respectively by insect-pests and pathogens in major field crops. In India, of the total loss caused by various pests in agriculture, weeds accounts for 37% followed by insects (29%), diseases (22%) and others including nematodes, rodents, mites, birds, etc. (12%). It has been estimated the weeds cause an actual yield loss worth USD 11 billion each year in 10 major field crops. In the absence of herbicides, weeds offer serious threats to organic crop production. However, as both public demands for organic produce and the area under organic farming have increased in recent years, there is an urgent need to develop and disseminate the sustainable weed management practices for organic farming. Our strategy should not be to eliminate the weeds from agro-ecosystem, but to reduce their population to a tolerable level. Also, the weed flora composition should be shifted to a less competitive weed species that are easy to manage so that the amount of crop damage by weeds could be reduced.

Weed management strategies

Weed management in organic crop production is a major challenge. In absence of herbicides in organic systems, the weed management is largely dependent on cultural and mechanical methods. Manual weeding is the most laborious and uneconomical. Therefore, greater emphasis is being placed on weed prevention, cultural and mechanical methods including tillage and pre-and post- sowing inter-cultivation operations.

Prevention of weed seeds

Majority of weeds in new areas are introduced from neighbouring farms along with grazing animals, tillage implements and harvesting machinery, weed seed contaminated crop seeds, irrigation water, etc. Use of clean (weed seed-free) crop seed for planting, thorough decomposed organic manures, cleaning of tillage implements and combine harvester before moving to new areas, regular cleaning of field bunds and irrigation channels and preventing weed seed rain are some of the precautionary approaches to be followed to reduce weed infestation. For example, sowing of wheat seed contaminated with *Phalaris minor* seed is a major cause of spreading *P. minor* in wheat. Combine harvesters moving from one field to another or even from one state to other states also contributed to *Phalaris* seeds dispersal.

Cultural methods

In organic farming practices, the approach to weed management involves the whole cropping system. Cultural practices that shift the balance of competition towards the crop usually disfavours weed occurrence

and improves crop yields. Any practice that provides vigorous uniform crop establishment usually assist in reducing weed prevalence. Factors that improve crop competitiveness include:

Stale seed-bed technique: This technique aims to flush out terminable weed seeds before cropping. The soil cultivation is done days or weeks before crop sowing. This depletes the seed bank in the surface soil layer and reduces subsequent weed emergence. With light rains before the onset of the monsoon or irrigation, several flushes of weeds are killed by light cultivation (1-2 cm soil depth) before crop sowing. This helps crop to emerge in almost weed-free environment, with a competitive advantage over late-emerging weed seedlings. This practice may reduce the weed density by 30-80% compared to standard seedbed preparation.

Soil solarization

Soil is a reservoir of weed seeds. Solarization is a method of heating the surface by using plastic sheets placed on moist soil to trap the soil radiation. It increases surface soil temperature by 8-10^{0}C as compared to non-solarized soils, and thereby reduces the germination of most of the annuals, some perennials and parasitic weeds, especially *Orobanche* spp. to a great extent. In addition, soil solarization also controls soil borne pests, enhances the availability of nutrients in soil and favours beneficial microflora. However, the perennials such as *Cynodon dactylon, Cyperus rotundus* and *Convolvulus arvensis*, gradually recover due to their deep rooted vegetative propogules in the soil. Weed seeds having hard seed coat such as *Melilotus* spp. are also not controlled by solarization.

Tillage

Weed problem begins with weed seed in soil. The major objective of tillage includes weed control, preparation of proper tilth for sowing, and crop residue management. Tillage directly affects the weed seed bank by physical mixing of soil and in turn reduces the weed number. Tillage influences the vertical distribution of weed seeds in the soil layer. Tillage also helps in uprooting and burying the emerged weeds. Summer ploughing has been found to reduce the density and biomass of perennial, difficult to control weeds such as *Cyperus rotundus* and *Cynodon dactylon* significantly and increase the yield of subsequent crops. A change in tillage methods influences species composition, either by direct killing of weeds, by redistributing weed seeds in different soil depths, or by changing the soil environment and thereby affecting the weed seed germination and emergence. Conservation tillage practices such as zero/minimum tillage are gaining importance nowadays. Zero/minimum tillage favours weed seeds build up in upper soil layers (0–5 cm soil depth), while conventional tillage distributes the weed seeds in different soil layers. Weed seeds buried deep germinate but fail to emerge due to thick soil layer over it, resulting in death of weed seedling. Conservation agriculture, zero tillage with retention of crop residues on soil surface and crop diversification have been found very effective in managing annual weeds in many cropping systems. Zero tillage reduces the emergence of *Phalaris minor* but favours *Rumex dentatus* and *Malva parviflora* in wheat in Indo-Gangetic Plains of India.

Crop residue management and mulching

Crop residues present on the soil surface can influence weed seed germination and seedling emergence. The quantity, quality and distribution of crop residues present on soil surface influences weed seed germination and seedling emergence by interfering with solar radiation availability, creating physical barrier, through allelopathy as well as improving soil and moisture conservation and soil tilth. Weed population and biomass decreases with the increasing amounts of crop residues on the soil surface under conservation agricultural system. Retaining crop residue on the soil surface under ZT system suppresses weed seedling emergence, delays the time of emergence,

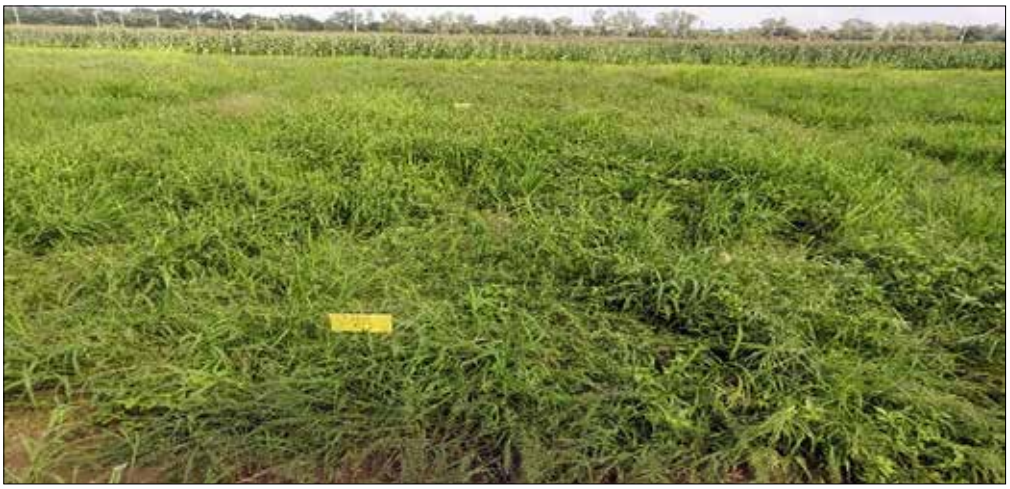
ZT wheat sowing

Maize + cowpea intercropping

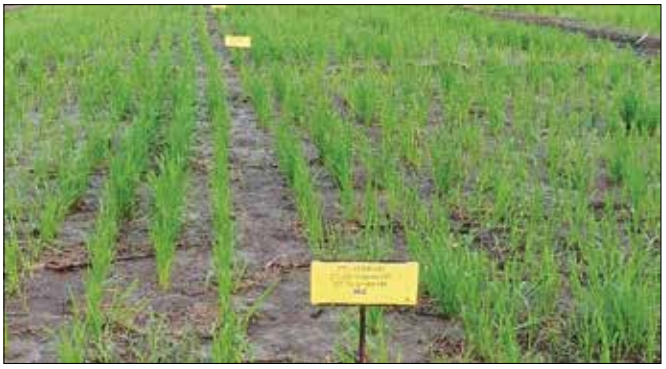
and allows the crop to gain an advantage over weeds. Burning of rice straw before wheat seeding is a common practice in northern India. Retaining crop residues on soil surface instead of burning will help in moisture conservation and weed suppression. Retaining a residue load of 5.0 - 7.5 t/ha reduced the infestation of *Phalaris minor*, *Chenopodium album* and *Rumex dentatus* by 45-88%. Mulching or covering the soil surface can prevent weed seed germination by blocking light transmission. In widely spaced crops straw mulching, polythene mulching, etc. have been found effective for weed suppression.

Crop diversification

Crop diversification in time (crop rotation) and space (intercropping) are important components of ecological weed management. These help in reducing weed population and weed biomass production to a great extent. Diversifying crop canopies and root architecture by mixing crops and cultivars create the growing environment detrimental for weed growth and favour crop growth. Diversification of cropping system also allows changes in tillage and other weed management practices that affect weed species differently. Diversification of upland direct-seeded rice-wheat system with maize-wheat system has resulted in significant decrease in weed population during rainy season. The effect was more pronounced in zero tillage condition than tilled condition. Diversification also helps in managing herbicide resistant weed biotypes to a great extent. Parasitic weeds such as *Striga*, *Orobanche* and *Cuscuta* are largely managed by crop rotation; as effective herbicides are not available. Mulching and



Problem of grassy weeds in a long-term direct-seeded rice (DSR)



Maize in place of DSR

DSR 2 years after maize

cover cropping help in weed eradication by directly suppressing weeds and indirectly favouring crop growth by creating better soil conditions. Diversification of rice-wheat system with inclusion of summer mung bean has an enormous potential to reduce the weed seedbank by offering greater soil cover during fallow period, besides restoring the soil fertility, increasing profitability and nutritional security of small and marginal farmers. This practice over time, can help in reducing the weed seedbank and provide long-term weed management.

In addition to crop rotation, intercropping of short duration pulses like cowpea, rice bean, greengram and soybean in wider spaced crops like maize, pigeonpea, cotton, etc. effectively smother weeds without causing reduction in the yield of main crops. Intercropping provides opportunity to utilize crops themselves as tools of weed management. Weed suppressing ability of intercrops is dependent upon the component crops and cultivars selected, crop density, relative proportion of the component crops, their spatial arrangement and the fertility and moisture status of the soil.

Effect of crop diversification in rice-wheat system

Cover cropping

The fast growth and dense ground covering by the crop will suppress weeds. The inclusion of highly competitive short duration cover crops like cowpea, sunhemp, *dhaincha*, etc. in cropping system may be grown as 'smother' crops within the rotation. Cover crop residues on the soil surface suppresses weeds by shading, and improve soil health. The cover crop residues may release allelochemicals that inhibit the germination and development of weed seeds in succeeding crops.

Cover cropping of *Dhaincha*

Competitive crops and cultivars

Crops differ in relative growth rate, spreading habit, height, canopy structure and inherent competitive character and accordingly differ in their weed suppressing ability. A quick growing and early canopy-producing crop would be expected to be better competitors against weeds than crops lacking these characters. Tall cultivars compete better for sun light than short cultivars. Using high yielding crop variety competitive against weeds in combination with other methods of weed control is one of the most economical approaches to attain optimal crop yield. Hybrid rice varieties have shown more weed suppression that the open pollinated. Rice varieties such as Purna, Swarna Shreya, Sadabahar and DRR 47 and field pea variety JP 885 have been found promising in weed suppression.

Weed suppressive rice cultivar Purna

Planting time

Planting time considerably influences the occurrence and manifestation of weed species. In timely sown winter pulses like chickpea, the population of broad-leaved weeds such as *Chenopodium album, Medicago denticulata*, etc. are reduced to a great extent. Early planting of wheat encourages the problem of wild oat and broad-leaved weeds while late sowing increases the infestation of *P. minor*. Hence, the planting time should be so adjusted that it is unfavorable for the weed growth without reducing the crop yields.

Planting geometry and plant density

Planting density and pattern modify crop canopy structure and in turn influence weed suppressing ability of the crop. Variation in spacing brings difference in microclimate, viz. light intensity, evaporation and

temperature at soil surface. The increased shading of soil surface created by narrow row spacing and higher plant population reduce weed emergence and suppress weed growth.

Nutrient management

Crops and weeds compete for the same nutrient from the soil. Many a times weeds are more efficient than the crop plants in absorbing the soil nutrients. It has been observed that the level of soil fertility determines the relative competitiveness between the crop and weeds. Rooting depth and root area of plants determine the relative competitiveness for nutrients. Nutrient management strategies significantly influence the crop-weed interaction by affecting crop and weed growth, and density and composition of weed flora. It has been reported that farmyard manure (FYM) and other organic manures are major source of weed seeds that get into the soil. Poultry manure with higher N content has been reported to reduce the weeds due to its phytotoxic character. Chicken manure is effective in reducing parasitic weed *Orobanche* infestation. Use of soil amendments (cattle manure and potato compost and alternating years of legume green manure) substantially reduce the weed biomass, possibly by improving crop competitiveness.

Water management

Proper water management can reduce weeds in both wet and dry seasons. More weeds emerge earlier at high soil moisture than at low moisture level. Many weeds cannot germinate under flooded conditions. This is used as weed control method especially in rice crop. Maintaining 5 cm of water in rice field throughout the crop season creates anaerobic condition, which is unfavourable for weed seed germination. Method of irrigation also influences the weed density. In drip irrigation the weed density is greatly reduced due to the wetting of soil near the plant base only.

Plant geometry and plant density

Planting density and pattern modify crop canopy structure and in turn influence weed smothering ability of the crop. Narrow row spacing will bring variation in microclimate, viz; light intensity, evaporation and temperature at soil surface. Bi-directional sowing and closer row spacing (15 cm) are quite effective in suppressing the growth of *Phalaris minor* in wheat.

Manual and mechanical weeding

Manual weeding using traditional hand weeding tools is still a common method of weed control on small-scale crops in most of the developing countries. Hand weeding is feasible on small areas where sufficient work-force is available at relatively cheaper rates, and in high value crops. Mechanical weeders include cultivating tools such as hoes, harrows, power-operated weeders and cutting tools like mowers. In direct-seeded rice under upland conditions, weeds are controlled by tools like *khurpi* or hand hoe/blade, hoe/wheel hoe. In line sown/transplanted rice, rotary weeder or cono-weeder is also effective in controlling weeds. The success of mechanical weeding depends upon the stage of weeds, crop geometry and climatic conditions.

Biological control

The control of pests through biological agents is environmentally benign and ecologically acceptable. The control of *Parthenium hysterophorous* with Mexican beetle *Zygogramma bicolorata*, water hyacinth with weevil *Neochetina* spp. and *Salvinia molesta* with *Cyrtobagous salviniae* are some of the successful examples of biocontrol in India. Several mycoherbicides using different fungus such as *Colletotrichum gloesporioides* f. sp. *aeschynomene* for the control of northern jointvetch (*Aeschynomene virginica*) have also been developed and evaluated in other countries.

Successful control of *Salvinia molesta* by insect bio-agent *Cyrtobagus salviniae*

Utilization of weeds

Weeds like Water hyacinth, Eupatorium, Lantana, Parthenium, Ipomoea, etc., are widely spreading in farm environment, ponds, forest plantation, grassland and roadside at the cost of many other useful vegetation. Proper utilization of such biomass through appropriate technology may help in supplementing chemical fertilizers and adding organic matter to the soil. The tender and succulent portion of many of the dominant weeds with wider C:N ratio may also be utilized for vermicompost preparation which has enough potentiality for use in the production of organic tea as well as for vegetable farming.

Integrated weed management

Although manual weeding is the most predominant practice followed in India, there is ample scope for reducing the labour requirement by integrating several

preventive, mechanical and cultural methods of weed management. Integrated weed management (IWM) system is more effective and ecologically sustainable. However, this system is knowledge intensive, requiring better understanding of the weed biology and eco-physiology of crop-weed interaction. IWM practices should take in to account all aspects of the cropping system as a part of integrated crop management (ICM). The basic principle in IWM is to manipulate the crop-weed relationship in favour of the crop at the expense of the weeds.

SUMMARY

Weeds are dynamic in nature, and offer a serious threat to organic crop production. Weed management in organic farming requires extensive planning and management. It must involve different techniques and strategies, with the unified goal of achieving economically acceptable weed control and crop yields. Major emphasis needs to be given to prevent weed problems and use ecological factors that suppress weeds. Other farm management practices that maintain soil health and produce vigorous crop plants to suppress weeds need to be integrated. Therefore, an integrated approach involving all cultural practices, aiming to optimize the whole cropping system rather than the weed control *per se* is required for sustainable weed management in organic farming.

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