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Review Article

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Eco-friendly Weed Management Options for Crop Production: A Review

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ABSTRACT

Weed competition is a major limiting factor for the productivity of crops. Weeds deplete nutrients, water and light their by reduce the crop yields drastically. Hence, weed management has became main concern to achieve higher productivity of crops. As the weed cause nearly 37 per cent of the total loss, every attempt has to be made to contain the weed menace and uphold the production. Weed management takes away nearly one third of total cost of production of field crops. In India, the manual weed control is quite popular and effective. Of late, labour has become scarce and costly due to industrilization, diversification of agriculture and urbanization. The usage of herbicides in India and elsewhere in the world is increasing due to possible benefits to farmers and continuous use of the same group of herbicides over a period of time on a same piece of land leads to ecological imbalance in terms of weed shift and environmental pollution. The complexity of these situations has resulted in a need to develop a wholistic sustainable ecofriendly weed management programme throughout the farming period. This article reviews the ecofriendly weed management tool which is the best option for effective weed control and that are socially acceptable, environmentally benign, cost-effective and leads to higher productivity of crops.

Key words: *Ecofriendly, Cultural, Physical, Biological, Productivity*

INTRODUCTION

India is the second most populous country in the world. With the increasing population, the cultivable land resource is shrinking day to day. To meet the food, fibre, fuel, fodder and other needs of the growing population, the productivity of agricultural land and soil health needs to be improved. Green revolution in the post-independence era has shown path to developing countries for self-sufficiency in food but sustaining agricultural production against the finite natural resource base demands has shifted from the **"resource degrading"** chemical agriculture to a **"resource protective"** biological *i.e.,* eco-friendly agriculture.Green revolution technologies leads not only reduction in productivity but also deterioration of soil health as well as natural ecosystem. Thus, apart from quantity, quality will be the important factor. Such varieties of concern and problems of modern Indian agriculture gave birth to various new concepts of farming such as organic farming, natural farming, biodynamic agriculture, eco-farming, *etc.*

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The essential concept of these practices remains the same, *i.e.*, back to nature, where the philosophy is to feed the soil rather than the crops to maintain soil health and it is a means of giving back to the nature what has been taken from it. Therefore, for sustaining the productivity of the crop, maintaining the soil health and healthy ecosystem, there is need for adoption of an eco-friendly weed management options for crop production.

Approaches for eco-friendly weed management

Physical, mechanical, cultural and biological methods are commonly used for weed management. Physical force either manual, animal or mechanical power is used to pull out or kill the weeds effectively. Depending on weed and crop situation, these methods are used. It includes Tillage, hand weeding, hand pulling, inter cultivation (hoeing) digging, sickling, mowing, cutting, chaining, dredging, burning and flaming.

Physical and mechanical methods of weed management

Tillage systems

The inversion of soil by following conventional tillage resulted in deeper placement of weed seeds which could not emerge out, causing a significant reduction in the population of weeds and which ultimately reduced the fresh weed biomass as compared to zero tillage. Therefore higher maize grain yield can be obtained with conventional tillage[16]. Off-season land management contributed significantly reduction in weed biomass in rice-rice sequence system and raising a green manure crop of *Sesbania aculeata* in the off-season and ploughing it *in situ* at the age of 45 days, before the cultivation of rice in the first season as well as in the second season, helped in reducing weed competition in both the rice crops. Off-season land management such as summer ploughing or raising green manure contributed significantly to depleting the weed seed reserves in the soil and which ultimately higher productivity of crops[9]. Similar results were reported by Mahantesh *et al*[11]., they observed that minimum tillage is less disturbance and falling of weed seeds on the surface of soil both weed population and weed dry weight was significantly higher compared to reduced and conventional tillage treatments. Satisfactory weed control in conventional tillage treatment may be attributed to the stimulatory effect of tillage in inducing weed seed germination and it might be due to the greater deposition of weed seed at soil surface and ploughing each time might kill the germinated weeds and which ultimately higher grain yield (3030 kg/ha) of finger millet. Bhuvaneswari *et al*[3]., conducted an experiment to evaluate non-chemical weed management methods in organically grown maize-sunflower cropping system. Lower total weed density and dry weight were recorded with twin wheel hoe weeding at 20 DAS + hand weeding at 40 DAS, which was on par with twin wheel hoe weeding at 20 and 40 DAS. Twin wheel hoe weeding at 20 DAS + hand weeding at 40 DAS registered higher weed control efficiency in maize and sunflower (93.5 and 94.7 %), respectively. Higher yield was obtained with twin wheel hoe weeding at 20 DAS + hand weeding at 40 DAS in maize and sunflower (61.8 and 61.1 %) and over unweeded control. All the treatments significantly reduced the weed density and dry weight over weedy check. Season long weed competition in weedy check caused a yield reduction up to 60 per cent compared to hand weeding. Hand weeding was most effective in reducing the weed growth and increasing the kapas yield with profitability of cotton followed by intercultivation at 20, 40 and 60 DAS[13]. The increased in grain yield (4.98 t/ha) of rice due to cross ploughing at 25 DAS (repeating twice in the same time) might be due to the thinning of plants as well as suppression of weeds at the early stage as well as cross ploughing provides conditions for more tillers per plant and better aeration in the root zone. Increase in available nutrients from the incorporation of weed biomass. Thus, cross ploughing helps to prevent oxygen deficiency and carbon dioxide toxicity as rice was grown in the water logged condition which enhanced the growth and yield of rice[4].

Digging and mowing:

Digging is very useful in case of perennial weeds to remove the underground propagating parts of weeds from the deeper layer of the soil. Sickling is also done by hand with the help of sickle to remove the top growth of weeds to prevent seed production and to starve the underground parts. It is popular in sloppy areas where only the tall weed growth is sickled leaving the root system to hold the soil in place to prevent soil erosion. Mowing is a machine-operated practice mostly done on roadsides and in lawns.

Flooding, chaining and dredging

Flooding is successful against weed species sensitive to longer periods of submergence in water. Flooding kills plants by reducing oxygen availability for plant growth. The success of flooding depends upon complete submergence of weeds for longer periods. And chaining and dredging is very useful techniques for removal of aquatic weeds very effectively.

Cultural method of weed management

This method includes crop rotation, cover crops, intercropping, planting pattern, variety selection, water management, stale seed bed techniques and seed rate. These practices if used properly helped in controlling weeds effectively.

Crop rotation and intercropping systems

The possibility of certain weed species or group of species occurring is greater if the same crop is grown year after year. In many instances, crop rotation can eliminate or at least reduce difficult weed problems. The obnoxious weeds like *Cyperus rotundus* can be controlled effectively by including low land rice in crop rotation.

Inter cropping suppresses weeds better than sole cropping and thus provides an opportunity to utilize crops themselves as tools of weed management. Many short duration pulses *viz*., green gram, cowpea and soybean effectively smother the weeds without causing reduction in the yield of main crop. For this instance, monoculturing of tobacco has resulted significantly higher orobanche dry weight of 239.2 kg/ha when compared to all other rotations. Because of higher weed parasitisation yield of tobacco was significantly reduced. Whereas, among the different rotations fallowed, rotation of tobacco with intercropping of peanut, pigeonpea has reported significantly lower orobanche dry weight, which in turn has resulted in significantly higher yield of tobacco 1555 kg /ha[1]. While the lowest weed density was observed in maize + bean and maize + cowpea intercropping. In Athens, the weed density in maize + bean and maize + cowpea systems was 15.33 and 13.33 m^{-2}, respectively. In Mavrica, the weed density in maize + bean and maize + cowpea systems was 16.44 and 18.00 m^{-2}, This could be mainly attributed to maize–legume intercropping led to a higher soil canopy cover (leaf area index) than sole crops. The lowest values for PAR were received in sole crops. Thus, in maize–legume intercrops the decrease in available light for weeds led to a reduction of weed density and dry matter, compared to sole crops. Intercropping of maize and legumes considerably reduced the weed density in the intercrop compared with the maize pure stand, respectively. Among the intercropping systems, maize + cowpea (1:5) recorded the lower weed population and weed dry weight and highest weed control efficiency. It may be due to cowpea is having a wider canopy can suppress the weed population by adopting in the ratio of maize + cowpea (1:5) as compared to rest of the treatments, but with respect to maize equivalent yield were higher in maize + french bean (1:2) because of price of french is more compared to cowpea[5]. Similar results were obtained with adopting maize + soybean (1:1) systems where the system where the system recorded lower weed dry weight 20.86, higher weed smothering efficiency (51.16 %) and grain equivalent yield 3526 kg/ha), but higher net returns were observed with maize + greengram cropping systems reported by Shaha[15] *et al.*

Planting pattern

Lack of adequate plant population is prone to heavy weed infestation, which becomes, difficult to control later. Therefore practices

like selection of quality seed, right method of sowing, adequate seed rate protection of seed from soil borne pests and diseases *etc*. are very important to obtain proper and uniform crop stand capable of offering competition to the weeds. Singh *et al*[16]., reported that higher population were recorded lower total weed dry weight as compared to wider spacing mainly because of higher population can cover more surface area to suppress the weed population and one more thing is limiting the passage of solar radiation, rainfall and changing climate which ultimately reduced the dry weight of weeds as compared to wider spacing. Higher single cane weight was recorded with wider spacing mainly because of plant to plant competition was very less (intraplant competition) as compared to closer spacing, but higher cane yield can obtained with optimum population. Jamshidi *et al*[6]., reported that increasing the maize density from 7.5 to 9 plants/m^2 reduced the weed biomass by 21.5 %. Furthermore, cowpea acted as living mulch, reducing weed biomass up to 45.5 % and 39.6 % when intercropped with maize at a density of 7.5 and 9 plants/m^2, respectively. Under weed-free conditions, an increase in maize density from 7.5 to 9 plants/m^2 resulted in maize grain yield increasing from 8.92 to 9.40 t/ha; however, the addition of cowpea only increased the maize grain yield by about 4.2 %, on an average under these conditions. By contrast, under weed-infested conditions, there was a large decrease in maize grain yield (up to 32 %), but intercropping with cowpea reduced this to 16 per cent.

Variety selection

Variety should have vigorous and fast growing ability to better competitors with weeds. Among the genotypes, RNR 2465 recorded lower weed biomass as compared to other genotypes mainly due to genotype have more vigorous, and fast growing ability that compete with weeds during the early stage of crop growth and other reason may be produced more tillers per plant to cover more area to suppress the weed population which ultimately reduced weed biomass as compared to other genotypes. Significantly higher rice grain yield, gross returns and net returns were observed with RNR 2465 genotypes as compared to other genotypes[13].

Stale seed bed techniques

A stale seed bed is one where initial one or two flushes of weeds are destroyed before planting of a crop. This is achieved by soaking a well prepared field with either irrigation or rain and allowing the weeds to germinate. At this stage a shallow tillage may be used to destroy the dense flush of young weed seedlings. This may be followed immediately by sowing this technique allows the crop to germinate in almost weed free environment. Stale seed bed technique + one hand weeding at 30 DAS were recorded lower weed density and dry weight of weeds as compared to other treatments. Hence higher pod yield can be achieved with treatment receiving stale seed bed + HW at 30 DAS as compared to other treatments. Similar results were reported by Patil *et a1*[12]., One irrigation was given to stale seedbed plots and weeds were allowed to germinate. The germinated weeds were removed by passing cultivator cris-cross one day before transplanting of the fingermillet along with two intercultivations at 20 and 35 DAP, recorded higher weed control efficiency this is due to effective management of weeds which ultimately resulted in higher grain yield, gross returns and net returns of fingermillet.

Mulching

Mulch is a protective covering material maintained on soil surface and it has smothering effect on weed control by excluding light from the photosynthetic portions of a plant and thus inhibiting the top growth. It is very effective against annual weeds and some perennial weeds like *Cynodon dactylon*. To be effective the mulch should be thick enough to prevent light transmission. For instance, Rice bran application (@ 5 t/ha) showed effective suppression of different weed species and weed biomass which ultimately enhanced rice grain (6.94 t/ha) yield[2]. Mahajan *et al*[10]., reported that plastic mulch (25 micron) was recorded lower weed density and dry weight of weeds as compared to other mulchs, it may be due to higher

temperature which destroyed the existing weed flora hence higher baby corn yield.

Solarization

By increasing the solarization period weeds density decreased significantly in the level of surface plantation. The high temperature and the period time of exposing at the mercy of this temperature are the main factors to decrease weeds population in the soil. The compression mean of solarization period effects on weeds density showed the highest weed density was pertained to evidence treatment (without covering), which had no significant difference with 1, 2 and 3 weeks of solarizations. Also the lowest rate of weed density observed at 6 weeks of solarization, which reduced the weed density about 89.5 % compared to evidence treatment. 6th weeks of soil solarization comparing the durability of soil solarization using cover polyethylene clear or black polyethylene sheets, clear polyethylene reduced *Orobanche* shoot count as compared to non solarized solarizing for more weeks. The result clearly showed that, 6th week is more effective yield of tomato was seed by soil solarization as an excellent and alternative means of solarization and a higher yield 60000 kg per ha.

Biological methods of weed control

Use of living organism's *viz.,* insects, fungi, bacteria disease organisms, herbivorous fish, snails or even competitive plants for the control of weeds is called biological control. In biological method, it is not possible to eradicate weeds but weed population can be reduced. This method is not useful to control all types of weeds. Introduced weeds are best targets for biological control. Jeyalakshmi *et al*[7]., reported that pre-emergence and post-emergence application of *Fusarium oxysporum* and *Fusarium moniliforme* individually to the soil as sand maize inoculums at 5 per cent, respectively resulted in complete inhibition of seedling emergence of *Parthenium* compared to others. Karthik *et al*[8]., reported that weevils are introduced in to the plants a week before the spray of the fungal pathogen in order to enough weevil feeding scares to serve as entry point for fungal spores after a week plants were sprayed with a spore suspension of each fungus with 0.2 %. Treated plants observed daily for the appearance of typical symptoms. Among the treatments, *Colletotrichum spp* + *Neochetina bruchi* were recorded more foliar damage as compared to other treatments.

Integrated weed management (IWM)

An integrated weed management may be defined as the combination of two or more weed-control methods at low input levels to reduce weed competition in a given cropping system below the economical threshold level. It has proved to be a valuable concept in a few cases, though much is still to be done to extend it to the small farmers' level. Integrated Weed Management (IWM) approach aims at minimizing the residue problem in plant, soil, air and water. IWM involves the utilization of a combination of mechanical, cultural and biological methods of weed management in a planned sequence, so designed as not to affect the ecosystem. The nature and intensity of the species to be controlled, the sequence of crops that are raised in the rotation, the standard of crop husbandry, and the ready and timely availability of any method and the economics of different weed-management techniques are some of the potent considerations that determine the success for the exploitation of the IWM approach.

Weed biomass was significantly influenced by various weed management strategies. Weed biomasses were highest in the weedy check with the values of 1272.3 kg/ha and followed by only rice straw mulch plot (742.6 kg/ha). The weed free check recorded the lowest weed biomasses and was statistically differs from all other treatments. Plots raised under rice straw mulch + one hand weeding at 6 weeks after sowing, two hands weeding at 3and 6 WAS, significantly reduced weed biomasses compared to weedy check (314.90 and 285.30 kg/ha, respectively). Weed control efficiency and weed index weed free check recorded significantly higher weed control efficiency (96.1 %) followed by rice straw mulch + one hand weeding at 6WAS, (75.4 %), which was on par with two hand weeding at 3 and 6 WAS. Weedy check

recorded significantly lowest weed control efficiency over all other treatments. Highest weed index was recorded in weedy check (51.1 %) over all the treatments. Among the integrated, rice straw mulch + one hand weeding at 6 WAS gave higher groundnut yield (999.2 kg/ha) compare to other weed control treatments Wuraola *et al*[17]. Satyareddy *et al*[14]., reported that hand weeding at 25 & 45 DAS were recorded. lower weed density and significantly higher net return and benefit cost ration were obtained with intercropping with coriander.

CONCLUSION

Ecofriendly weed management is the best option for effective weed control and that are socially acceptable, environmentally benign, cost-effective and also higher productivity of most of the crops in a sustainable manner.

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