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REVIEW ARTICLE

Weed management in oilseed crops- a review

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ABSTRACT

Oilseed crops are slow growing during the initial growth period. In oilseeds, weeds caused yield reduction by 15-60 percent. Hence it is very essential to control weeds during the critical period of crop-weed competition. Weed management options in the majority of oilseed crops are limited, therefore, adoptions of multiple options of weed management using 'little hammers' considering preventive, cultural, mechanical, chemical, and biotechnological approaches are important. Integrated weed management (IWM) is a system approach to minimize weed populations below the economic threshold level. Among different weed management practices, cultural practices minimized the crop-weed competition up to large extent. Further, mechanical measures and herbicidal weed management are 'large hammers' or single large methods of weed control, but that may lead to the development of another level of problems like shift in weed flora, development of difficult-to-control weeds, issues of herbicide resistance, establishment of perennial weeds, *etc*. Thus, the aforesaid problems can be overcome by suitably adopting IWM, since it mixes the use of different available weed control methods in a balanced way by managing the weeds effectively, and sustainably provides higher production without harming the environment.

Keywords: Castor, Groundnut, Linseed, Niger, Oilseed crops, Sesame, Soybean, Sunflower, Weed management

INTRODUCTION

Globally, about 374000 plant species are currently known. Once anyone grows plant species for economic purposes, invariably a variety of unwanted vegetation establishes and competes with the economic species for available resources. These unwanted and competitive plants are termed "weeds". Plant species grown for economic purpose has to encounter various biotic and abiotic stresses. Among these stresses, biotic stress causes yield loss by 20-40% Ghosh *et al.* (2021). Among biotic stresses, weeds are a major one and alone can cause a yield loss of 45% in the world context (Katiyar and Singh 2015) and 37% in the Indian context. Apart from weeds in India, yield loss due to insect-pests accounts for 29%, diseases 22%, and other pests 12% (Yaduraju 2006; Mishra *et al.* 2021). As per the study conducted at ICAR-Directorate of Weed Research, Jabalpur, India yield loss of about US$ 11 billion due to weeds in ten major field crops has been estimated (Gharde *et al.* 2018). This figure further increases when other crops and the indirect effect of weeds are taken into consideration.

India has achieved self-sufficiency in food production, but in reality, it can only be achieved by assuring a balanced diet to individuals. Oilseeds plays important role in human health as the oilseeds are rich in protein, and in addition, they contain a high level of fat. Oilseeds add important nutritional value to the diet due to high-quality protein and or vegetable oil, together with oil soluble vitamins like vitamin A. Oilseeds not only provide food- and nutritional-security but also provides raw materials to manufacturing industries. The major oilseeds crops are soybean, sunflower, rapeseed, cotton, groundnut, *etc*. and oil content ranges from about 20% in soybean to over 40% in sunflower, linseed (37-47%), rapeseeds (35-46%) and groundnut (46-51%). Among oilseed crops, soybean, rapeseed-mustard, and groundnut stand 1^{st}, 2^{nd} and 3^{rd} place, respectively in terms of area of cultivation. Crop-wise acreages, production, and productivity are stated in **Table 1**.

In crop production, biotic and abiotic stress are major yield-limiting factors. The yield loss caused by biotic stress ranges from 20-40% (Ghosh *et al.* 2021). Weeds are considered a major biotic stressor which accounts for 37% of yield loss followed by insect pests (29%), disease (22%), and other pests (12%) (Mishra *et al.* 2021). Weeds are unwanted plants that grow simultaneously with crops and offer severe competition for below-ground resources like nutrients and water, and above-ground resources like space and gases (Rao *et al.* 2014; Choudhary and Dixit 2021). Weeds are considered to be unwanted plants for various reasons, they grow profusely and

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Table 1. Area, production, and productivity of oilseed crops in India [https://www.sopa.org/ (2019-20)]

Crop	Area (m ha)	Production (mt)	Productivity (kg/ha)
Rainy season			
Soybean	12.19	11.22	920
Groundnut	4.83	9.95	2062
Sesame	1.62	0.66	407
Castor seed	1.05	1.84	1752
Niger seed	0.14	0.04	301
Winter season			
Rapeseed & mustard	6.86	9.12	1329
Sunflower	0.23	0.21	921
Linseed	0.18	0.12	667
Safflower	0.05	0.04	808
	27.14	33.20	

reproduce aggressively. They need to be controlled effectively and on time in order to prevent loss or diminished crop yields. The major weeds of oilseed crops are detailed in **Table 2**. Weeds have the capabilities to adapt and grow even in adverse conditions and occupies areas that are not occupied by crop cultures. Many of the weeds have better below-ground parameters (longer, deeper, and heavier roots) allowing them to excerpt water and nutrients from deeper soil profiles (Choudhary *et al.* 2021). The yield loss caused by weeds under moisture stress conditions varies, in dryland, it ranges from 10-98% and sometimes complete crop failure (Ramamoorthy *et al.* 2004). In India, yield loss due to weeds varies with the cropping season, the highest in summer (36.5%) followed by the rainy season (31.5%) and the lowest in winter (22.7%) in some cases can cause complete devastation of the crop. Under adverse situations, weed problems are further aggravated and severe. Under this situation, weeds uptake more moisture and nutrients from the soil profile and are meagerly available to the crop plants resulting in lean and thin, and weak growth and can cause crop yield loss by 37-79% (Singh *et al.* 2016).

Importance of weed management in oilseed crops

The majority of oilseed crops are slow growing during their initial stage of development. This invites the weeds to emerge and establish, and compete for available resources. This ultimately reduces the crop yield and deteriorates the quality of the final product. An estimation was made using available literature that among ten major crop cultivation technologies sowing window contributes 23.0% to crop yield followed by weed management 17.2% and improved varieties (15.9%) and the rest technologies are in single digit (**Table 3**).

Table 2. Commonly infested annual weeds of oilseed crops in India

Weeds	Grasses	Broad-leaved	Sedges
Rainy season			
Dinebra retroflexa	√		
Digitaria sanguinalis	√		
Cynodon dactylon	√		
Panicum repens	√		
Echinochloa colona	√		
Setaria viridis	√		
Cenchrus biflorus	√		
Xanthium strumarium		√	
Euphorbia geniculata		√	
Amaranthus viridis		√	
Portulaca oleracea		√	
Conyza aegyptiaca		√	
Tribulus terristris		√	
Corchrus rarvensis		√	
Trianthema monogyna		√	
Cyperus rotundus			√
Cyperus iria			√
Winter weeds			
Avena fatua	√		
Cynodon dactylon	√		
Chenopodium album		√	
Chenopodium murale		√	
Argemone maxicana		√	
Anagallis arvensis		√	
Asphodelus tenuifolius		√	
Boerhavia spp.		√	
Brassica kaber		√	
Brassica sinensis		√	
Chrozophera perviflora		√	
Cirsium arvensis		√	
Euphorbia geniculata		√	
Euphorbia hirta		√	
Fumaria parviflora		√	
Lathyrus aphaca		√	
Medicago denticulata		√	
Melilotus alba		√	
Melilotus indica		√	
Melotropicum indicum		√	
Parthenium hysterophorus		√	
Physalis minima		√	
Solanum nigrum		√	
Spergula arvensis		√	
Vicia hirsuta		√	
Cyperus spp.			√

Crop weed competition and yield loss

Crop weed competition is a negative aspect where individuals compete for the resources available at the site, while both suffer and one suffers less which has better adaptability *i.e.* weeds. The competition between crops and weeds is presented in a line diagram (**Figure 1**) which is responsible for considerable yield loss in agriculture ecosystems (**Table 4**), and this varies based on the species, their

Table 3. Technology's contribution to crop yield

Technology	% Contribution
Land preparation	7.0
Organic manure	4.7
Improved varieties	15.9
Optimum seed rate	7.9
Time of sowing	23.0
Line sowing	9.6
Crop geometry	3.0
Fertilizers	8.3
Weed management	17.2
Plant protection	3.4

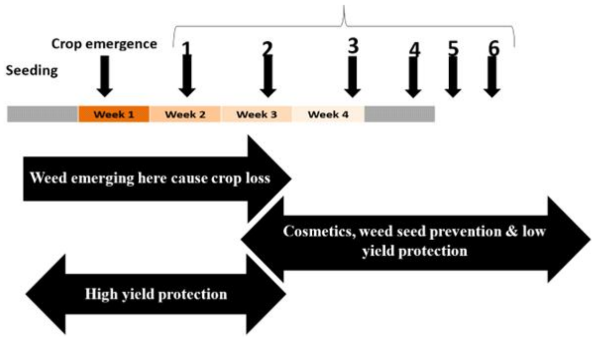

Figure 1. Critical period of crop weed competition

densities, duration of weed competition, and soil and climatic factors prevailing at the site. Initial one-third part of the life of the crop is critical where the maximum competition took place and suffers maximum and attain irreversible losses. However, weeds emerging after the critical weed-free period will less effect on yield, but management efforts after the critical weed-free period may make harvest more efficient, reduce weed seed bank and reduce weed problems in subsequent years. The reduction in the economic yield of oilseed crops due to crop weed competition is presented below (**Table 4**).

Nutrient mining by weeds in oilseed crops

Nutrients are important resources required to complete the life of a crop. Excessive growth of weeds offers competition for nutrients. The majority of the weeds compete aggressively for soil N and K. Weed accumulates more nutrients from the soil profile and thus has higher nutrient content than the crop plants (Reddy *et al.* 2018). Weeds and the majority of oilseed crop have extensive root system they can uptake water and nutrients from deeper layer and complete life, still, they pose a serious threat to crops (Berger *et al.* 2008). Most of the oilseeds are grown under limited moisture, and under the condition, limits the nutrient uptake by plants even though they are available in plenty. However, plant expenses more energy to develop and proliferate the root system for better extraction of water and nutrients from the deeper soil profile. The nutrients mining by weeds is detailed in **Table 5**.

Water extraction by weeds in oilseed crops

Under limited water availability, soil moisture is a limiting factor, presence of weeds offers more competition to the crops. Normally, weed plants take three times higher water than crop plants to accumulate a unit quantity of biomass Mishra and Choudhary (2022). The transpiration coefficient of weeds is far more than that of crop plants thus offering more stress to the crop plants (**Table 6**). The majority of weeds have a deep root system and they can uptake water from a deeper soil profile (Maganti

Table 4. Critical period of crop weed competition and yield loss due weeds in oilseed crops days after sowing (DAS)

Crop	Critical period	Reference	Yield loss (%)	Reference
Sesame	15-45 DAS	Duary and Hazra (2013)	15-40	Mishra (1997)
Groundnut	21-56 DAS	Everman *et al.* (2008)	15-75	Priya *et al.* (2013)
Sunflower	30-45 DAS	Reddy *et al.* (2008)	54.6	Wanjari *et al.* (2001)
Castor	30-60 DAS	Mishra (1997)	30-35	Mishra (1997)
Safflower	15-45 DAS	Mishra (1997)	35-60	Mishra (1997)
Rapeseed & mustard	15-40 DAS	Sekhawat *et al.* (2012)	10-58	Banga and Yadav (2001)
Linseed	20-45 DAS	Mishra (1997)	30-40	Mishra (1997)
Soybean	30-45 DAS	Chhokar and Balyan (1999)	74	Chhokar and Balyan (1999)

Table 5. Nutrient mining by weeds in different oilseed crops

Crop	Nutrient removal (kg/ha)			Reference
	N	P_2O_5	K_2O	
Sesame	45	6.9	36	Bhadauria *et al.* (2012)
Groundnut	15-39	5-9	21-24	Harikesh *et al.* (2021)
Sunflower	42	15.5	45.4	Sumathi *et al.* (2009)
Castor	45-60	3-9	35-88	Kalaichelvi and Kumar (2016); Nayak *et al.* (2016)
Safflower	15-28	2-5	15-45	Tewari *et al.* (2008)
Rapeseed & mustard	20-22	2-3	10-12	Mukherjee (2014); Kalita *et al.* (2017)
Linseed	30-32	2-3	11-13	Dwiwedi and Puhup (2019)
Soybean	26-65	3-11	43-102	Sharma *et al.* (2016)

Table 6. Transpiration coefficient and water use efficiency (WUE) values for various weeds (Norris 1996; Mishra and Choudhary 2022)

Weed species	C_3 or C_4	Transpiration coefficient	WUE
Xanthium strumarium	C_3	415	3.41
Bromus intermis	C_3	977	1.02
Chenopodium album	C_3	658	1.52
Polygonum aviculare	C_3	678	1.47
Panicum capillare	C_4	254	3.94
Portulaca oleracea	C_4	281	3.56
Amaranthus retroflexus	C_4	305	3.28
Salsola tragus	C_4	314	3.18

et al. 2005). However, water loss from soil profile also depends on the types of weeds, their densities, root structures, weed physiology, and weed competition period (Shoup and Holman 2010). Thus, the adoption of suitable weed management is a prerequisite in adverse climatic situations to get optimum crop yields.

Strategies for weed management in oilseed crops

It is important to understand the biology and ecology of the weeds and the time period of crop weed competition for successful weed management in oilseed crops. There are many factors like local situations, environmental conditions, labour availability, weed pressure, and nature of the crop, those need to be taken into consideration while planning weed management strategies. However, weed management is an approach in which weed prevention and weed control have companion roles. Weed management is the combination of the techniques of prevention, eradication, and control to manage weed in a cropping system or environment.

There are many methods by which weed severity can be minimized, that are **Table 7.**

The selection of weed management practices largely depends on the availability of resources, costing of methods, and environmental conditions. Chemical methods of weed control are very effective in certain cases and have great scope provided the herbicides are cheap, efficient, and easily available.

Chemical method of weed management

The selectivity exhibited by certain chemicals to cultivated crops in controlling their associated weeds without affecting the crops forms basis for the chemical weed control. Such selectivity may be due to differences in morphology, differential absorption, differential translocation, differential deactivation, *etc*. Herbicides offer great scope for minimizing the cost of weed control irrespective of the situation and offer a good weed control alternative to cultural or mechanical methods in oilseed crops. However, herbicide-based weed management is relatively poorly developed in the majority of oilseed crops (except soybean and groundnut). Use of herbicides provides broad-spectrum weed control with higher selectivity. Use of pre-emergence (PE) herbicide assumes greater importance given their effectiveness from the initial stages of crop growth and later emergence can be tackled by applying selective post-emergence (PoE) herbicides (Choudhary *et al.* 2021; Choudhary and Dixit 2021). The pre-requisite for a chemical method of weed management is scouting the field and based on weeds herbicides need to be chosen. Likewise, the following 5Rs (right source, right herbicide, right dose, right time, and right application method) are also equally important to get the best control. The list of herbicides commonly used for weed control in oilseed crops is listed in **Table 8**.

Table 7. (A): Preventive measures and (B): curative measures (eradication and control measures) (Choudhary 2022)

Weed control methods				
(a) Preventive	(b) Curative			
	Control			
	Mechanical	Cultural	Biological	Chemical
• Sowing of weed-free seeds. • Use of clean implements. • Removal of weeds along the canal and irrigation channel. • Care in transplanting seedlings/plantlets. • Use of well-rotten manure. • Avoiding passing of cattle. from weed-infested areas. • Crop management practices. • Enforcement of Weed Laws. • Quarantine methods and use of pre-emergence herbicides.	-Tillage -Hoeing -Hand weeding -Digging -Mowing -Burning -Mulching -Soil solarization	-Selection of crops and varieties -Stale seedbed -Sowing window -Planting geometry -Crop rotation -Use of compost or manure -Cover or smother crop -Water management, -Intercropping -Nutrient management -Orientation of sowing/transplanting	-Plants-parasites -Predators and - Pathogens	Detailed below

While using herbicide one has to be very careful, as residues from the application of herbicides to previous crops can cause a problem in oilseed crops *e.g.*, atrazine applied to a previous maize crop can reduce soybean stand and yield. Likewise, imazethapyr applied during rainy season crops may reduce the plant stand of mustard and seed yield. Some herbicides are effective in the temperate region but their efficacy is comparatively less in the tropical and sub-tropical regions and sometimes may be toxic also such as metribuzin and bentazone. Therefore, herbicides must be tested under different agro-

Table 8. List of herbicides for use in oilseed crops

Crop	Herbicide	Dose (kg/ha)	Time of application	Reference
Soybean	Metribuzin	0.50	PE	Malik *et al.* (2005); Rathore *et al.* (2006); Panda *et al.* (2015); Choudhary and Kumar (2016); Patel *et al.* (2016); Saharan *et al.* (2016); Sharma *et al.* (2016); Parmar *et al.* (2016); Thirumalaikumar *et al.* (2017); Choudhary and Choudhury (2018); Virk *et al.* (2018); Andhale and Kathmale (2019); Jadhav and Kashid (2019); Patel *et al.* (2021); Meena *et al.* (2022); Binjha *et al.* (2022)
	Pendimethalin + imazethapyr	1.00	PE	
	Diclosulam	0.022-0.026	PE	
	Metolachlor	1.00	PE	
	Sulfentrazone	0.72	PE	
	Sulfentrazone + clomazone	0.35+0.375	PE	
	Na-acifluorfen + clodinafop	0.245	PoE	
	Imazethapyr	0.10	PoE	
	Propaquizafop + imazethapyr	0.125	PoE	
	Imazethapyr + imazamox	0.070	PoE	
	Haloxyfop-methyl	0.108-0.135	PoE	
	Fomesafen + quizalofop	0.180+0.045	PoE	
	Quizalofop + chlorimuron	0.0375+0.009	PoE	
	Fluthiacet-methyl	0.0136	PoE	
	Chlorimuron + fenoxaprop	0.009 + 0.08	PoE	
	Fomesafen + fluazifop	0.22-0.25	PoE	
	Bentazone	0.96	PoE	
Groundnut	Pendimethalin	0.678	PE	Malunjkar *et al.* (2012); Choudhary *et al.* (2016); Shweta *et al.* (2016); Poonia *et al.* (2016); Dixit *et al.* (2016); Singh *et al.* (2017); Kumar et al (2019); Kumar *et al.* (2020); Patel *et al.* (2020); Mudalagiriyappa *et al.* (2021); Regar *et al.* (2021); Sridhar *et al.* (2021); Charitha *et al.* (2022); Lakshmidevi *et al.* (2022)
	Diclosulam	0.022-0.026	PE	
	Imazethapyr	0.10-0.15	E PoE	
	Fenoxaprop	0.079	PoE	
	Fluazifop-p-butyl	0.125-0.25	PoE	
	Fomesafen + fluazifop	0.22-0.25	PoE	
	Imazethapyr + imazamox	0.07	PoE	
	Propaquizafop + imazethapyr	0.125	PoE	
	Imazethapyr + chlorimuron	0.10+0.024	PoE	
	Quizalofop + imazethapyr	0.0328+0.0626	PoE	
Rapeseed and mustard	Pendimethalin	0.678	PE	Mukherjee (2014); Kumar *et al.* (2012); Banga *et al.* (2004); Bazaya *et al.* (2004); Yadav and poonia (2005); Sarkar *et al.* (2005); Choudhary *et al.* (2016); Choudhary and Bhagawati (2019); Singh *et al.* (2020); Chisi *et al.* (2021); Yernaidu *et al.* (2022) Mishra *et al.* (2021); Mishra and Choudhary (2022); Choudhary and Meena (2022)
	Oxyfluorfen	0.15-0.25	PE	
	Oxadiargyl	0.09	PE	
	Napropamide	1.125-1.406	PE	
	Isoproturon	1.00	PE or PoE	
	Quizalofop	0.04-0.05	PoE	
Sesame / niger	Butachlor	1.00-1.50	PE	Moorthy *et al.* (2004); Mathukia *et al.* (2015); Babu *et al.* (2016); Gupta and Kushwah (2016); Singh *et al.* (2018); Sahu *et al.* (2019); Mishra *et al.* (2021); Mishra and Choudhary (2022); Joshi *et al.* (2022)
	Oxadiazon	0.50-1.00	PE	
	Pendimethalin (30 and 38.7%)	0.50-0.75 & 0.678	PE	
	Isoproturon	1.00-1.50	PoE	
	Propaquizafop	0.10	PoE	
	Fluazifop	0.25	PoE	
Linseed	Pendimethalin	0.75-1.00	PPI and PE	Devendra *et al.* (2016); Dwivedi and Puhup (2019); Mishra *et al.* (2021); Mishra and Choudhary (2022)
	Butachlor	1.00-1.50	PE	
	Oxadiazon	0.50-1.00	PE	
	Propaquizafop	0.10	PoE	
	Isoproturon	1.00-1.50	PoE	
Sunflower	Pendimethalin	0.75-1.00	PPI and PE	Reddy *et al.* (2008); Sumathi *et al.* (2010); Nagmani *et al.* (2011); Baskaran and Kavimani (2014); Mohapatra *et al.* (2020); Mishra *et al.* (2021); Mishra and Choudhary (2022)
	Oxadiargyl	0.10	PE	
	Quizalofop	0.04-0.05	PoE	
Safflower	Pendimethalin (30% EC)	0.75-1.00	PPI and PE	Tewari *et al.* (2008); Mishra *et al.* (2021); Mishra and Choudhary (2022)
	Pyroxasulfone	0.1175	PE	
	Sulfentrazone	0.105	PE	
Castor	Metolachlor	1.0-1.5	PE	Kalaichelvi and Kumar (2016); Naik *et al.* (2016); Mishra *et al.* (2021); Mishra and Choudhary (2022)
	Pendimethalin	1.5-2.0	PE	
	Quizalofop-ethyl	0.05	PoE	
	Fenoxaprop-p-ethyl	0.05	PoE	

PPI- Pre-plant incorporation; PE- Pre-emergence; PoE- Post-emergence. The above herbicides should be integrated with hand weeding to remove the weeds that escaped/emerged after the application of herbicides climatic conditions and doses may be standardized as per crops and weeds.

Management of broomrape in Indian mustard and dodder in niger

Broomrape is a major weed of mustard. Seed coating of mustard seeds with 1.0 ppm of chlorsulfuron or triasulfuron provides 70-98% control of *Orobanche aegyptiaca* but the efficacy of seed treatment with sulfosulfuron was poor. Post-emergence application of glyphosate at 25 and 50 g/ha with 1% solution of $(NH_4)_2SO_4$ at 25 and 55 DAS showed promise with 63-100% control of this weed in large scale at farmers' fields (Poonia 2015; Singh *et al.* 2020). Glyphosate dose range is very limited. Over dosing of glyphosate, may leads to 15-35% toxicity to mustard in terms of marginal leaf chlorosis, slow leaf growth and bending of apical stems and stunting with a yield penalty. Bleaching of a few leaves of mustard may occurred with a 50 g/ha dose at 55 DAS, which can recovered within 20 days resulting in no loss in yield. Apart from these, based on irrigation availability crop rotation with wheat, barley and chickpea, delayed sowing (25 October -10 November) with higher seed rate, use of organic manures with increase N fertilizers and hand removal are also found effective in managing broomrape in mustard (Rao and Chauhan 2015). Dodder is an annual obligate stem parasite belonging to Cuscutaceae. Cuscuta is a major limitation for cultivation of niger [*Guizotia abyssinica* (L.f.) Cass.] in India. Application of pendimethalin 1.0 kg /ha as PE followed by hand removals were found to be effective in management of dodder.

Weed response to herbicides

Weed control percentages are intended as a guide for comparing alternatives. Percentages are estimated based on favourable conditions. The herbicides can be chosen based on efficacy of the herbicide. Some of the herbicides, their controlling ability, and choice patterns are given below in **Table 9**.

Biological method of weed management

Using living organisms such as competitive plants, insects, pathogens, and other animals for weed control is considered under the biological method. There are two popular methods (classical approach and the augmentative or bioherbicide approach) employed in the biological control of weeds. These methods are sustainable and risk-free. However, it takes a longer time to get optimum results and largely depends on population build-up and density. Parthenium emerging in oilseed crops can be controlled by the release of Mexican beetle (*Zygogramma bicolorata*) (Kumar 2009). Kaur *et al.* (2014) reported the rust fungi, *Puccinia abrupta* var. partheniicola and *Puccinia xanthii* var. parthenii-hysterophorae, can be used to control Parthenium. Likewise, *Bactra verutana* was another insect bioagent used against *Cyperus rotundus*.

Biotechnological method of weed management

Herbicide-resistant crops can be used in weed management as biotechnological approach. Use of herbicides with a similar mode of action for an extended period can develop resistance in many weeds. ICAR-DWR (2017-18) has already reported that *Commelina communis* and *Echinochloa colona* are not being controlled by imazethapyr (an ALS-inhibiting herbicide) in soybean fields of Madhya Pradesh. Similarly, many more complaints have been received from farmer's fields that imazethapyr is unable to control certain weeds of greengram and blackgram crops, which were killed earlier. Several biotechnological techniques have been adopted for developing herbicide-resistance in crop plants. Plant transformation by transfer of cloned genes in susceptible plants through an engineered vector technique is a common method (Chacko *et al.* 2021).

Integrated weed management in oilseed crops

Dependence on herbicides alone for weed management is not encouraged due to the problems in the environment and resistance development in weeds. Therefore, a system that combines two or

Table 9. Response of herbicide on % weed control

Grade	% control	Extent of control	Choice of herbicide
E= Excellent	90-95%	Usually over 90% seldom 100%	Best choice for weed
G=Good	80-90%	Sometimes under 80% seldom over 90%	Usually satisfactory
F=Fair	65-80%	Sometimes under 65% seldom over 80%	Sometimes unsatisfactory Moderate infestation
M=Marginal	40-65%	Seldom over 65% and Erratic	Seldom satisfactory Light infestation only
P=Poor	-	Usually under 40 or no control	Not recommended

more weed control measures and other good crop husbandry practices should be practiced to increase effectiveness and efficiency Chakraborthy (2020). opined that integrated weed management is a cost-effective, sound, reliable practice that can be easily and effectively adopted by a farmer as a part of any sound management practice (Rao and Nagamani 2010; Chakraborthy 2020). Buhler (1992) revealed that combining rotary hoeing followed by cultivation with herbicide gives better weed control and higher soybean yield over non-combined herbicides. Application of PE provides broad-spectrum weed control of initial flush, but later some weeds get emerged and offer severe competition with crops for resources, thus they need to be managed by adopting other management practices suitable for the crop. Care must be taken that weeds do not need to go to seed, that harvesting equipment is not transporting weed seeds, and that clean seed is used for all crops in the rotation; is an integral part of a weed program.

Based on the research carried out in India, some of the important integrated weed management practices have been compiled that provides excellent weed control, higher crop yield, more returns, and no injury to the crop. However, herbicides must be selected based on the existing weed flora, as some of the herbicides are good on some weeds but not effective against some other weeds.

Soybean and groundnut

Application of pendimethalin 0.678 kg/ha or imazethapyr + pendimethalin 1.00 kg/ha or diclosulam 0.02 kg/ha or oxyfluorfen 0.18 kg/ha (PE) followed by premix of imazethapyr + imazamox 0.07 kg/ha or fluazifop-p-butyl + fomesafen 0.25 kg/ha or propaquizafop + imazethapyr 0.125 kg/ha or sodium-acifluorfen + clodinafop-propargyl 0.245 kg/ha or haloxyfop-p-ethyl 0.135 kg/ha (PoE) along with need-based hand weeding provides broad-spectrum weed control, higher seed yield and net returns in soybean and groundnut.

Sesame and niger

Application of pendimethalin at 0.75 kg/ha or oxadiazon 0.50 kg/ha (PE) followed by propaquizafop 0.10 kg/ha or fluazifop 0.25 kg/ha (PoE) and need-based hand weeding was effective for weed management in sesame and niger.

Sunflower

Application of pendimethalin at 1.0 kg/ha or oxadiargyl 0.125 kg/ha (PE) followed by propaquizafop 0.062 kg/ha at 15-20 DAS (PoE) and need-based hand weeding was effective for weed management in sunflower.

Linseed

In irrigated linseed crops, sequential application of pendimethalin 1.0 kg/ha (PE) followed by metsulfuron-methyl 0.004 kg/ha (PoE) or clodinafop + metsulfuron-methyl at 0.06 + 0.004 kg/ha at 2-3 leaf stage of weed and need-based hand weeding for higher weed control efficiency, linseed yield and economic returns.

Mustard

Application of pendimethalin 1.0 kg/ha or oxadiargyl 0.09 kg/ha (PE) followed by quizalofop 0.05 kg/ha at 15-20 DAS (early PoE) or fluazifop-p-butyl 0.125 kg/ha at 25-30 DAS (PoE) provided broad-spectrum weed control, increased mustard seed yield and higher net returns.

Castor

Application of pendimethalin 1.0 kg/ha or metolachlor 0.5-1.0 kg/ha (PE) followed by hand weeding provided broad-spectrum weed control, increased castor seed yield and higher net returns.

Conclusion

Weed interference causes substantial yield reduction in oilseed crops. Although, severity largely depends on the density of weeds, duration of the competition, types of weed flora, *etc*. Thus, it is important to keep the weed density below the threshold level to minimize yield loss. Similarly, to avert economic loss, weed control should be followed to minimize weed density during the first four weeks of growth period. Relying on a single method may lead to various problems such as shift in weed flora, development of herbicide-resistance, emergence of perennial weeds, establishment of tough-to-kill weeds, *etc*. Under the circumstances, the adoption of integrated weed management considering 'little hammers' such as cultural, mechanical, chemical, biological and biotechnological interventions judiciously without any adverse effect on the environment together effectively managing the weeds that do not pose serious yield penalty. Integrated weed management should also minimize weed seed recruitment and deplete the weed seed bank. Accordingly, integrated weed management can be considered to be effective, efficient, and sustainable for oilseed crops.

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