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Weed Management in Oilseeds-A Holistic Perspective: A Review

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ABSTRACT

Weeds are the major biological constraint in oilseed crops. Yield loss in oilseeds vary from 20 to 77 per cent, depending on the crop, intensity of weed infestation, duration of crop competition, soil and climatic factors. Weed interference, not only reduces the seed yield, but also reduces the oil yield and quality. Critical period of weed control in oilseeds are generally from 15 to 45 DAS. Weed removal during the critical period is essential to reduce the yield loss. Hike in wage rate and phytotoxicity of herbicides calls for an integrated approach for weed management in oilseeds. Instead of relying on a single method, a holistic approach which involves the adoption of cultural/mechanical/biological/chemical methods is essential to keep the weeds below the threshold level for higher yield, productivity and net returns in oilseed crops.

Key words: Biological method, Chemical method, Cultural method, Mechanical method, Oilseed crops.

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India is the fourth largest oilseed producing country in the world after USA, China and Brazil and contributes about 10 per cent of the world oilseeds production (Sushilkumar and Mishra, 2018). Oilseeds are grown for the high valued oil contained in their seeds. They are not only rich in fatty acids but also rich in protein and adds nutritive value to diet.

In India, three major oilseed crops *viz.,* soybean, rapeseed-mustard and groundnut contribute 88 per cent of total oilseed production. Among these, the major one is soybean, with an annual production of 11. 6 MT, grown mainly in the states of Madhya Pradesh, Maharashtra and Rajasthan accounting for 95 per cent of the total production. The second important crop is rapeseed-mustard with an annual production of 7.1 MT, grown in the states of Rajasthan, Haryana, Uttar Pradesh, West Bengal and Gujarat accounting for 93 per cent of total production. Groundnut ranks third in production, (6.9 MT) cultivated mainly in the states of Gujarat andhra Pradesh and Tamil Nadu which constitutes 91 per cent of total production in the country (Jalandhra and Rana, 2018).

Among the various yield impeders weeds are crucial in causing qualitative and quantitative yield reduction in oilseeds. Weed competition is a major problem in agricultural system due to reduction in the value of agricultural lands. Weed infestation may differ with respect to crop, region and soil type. In India, reduction in crop yield due to weed infestation accounts for 22.7 per cent in winter and 36.5 per cent during summer and rainy seasons (Bhan and Sushilkumar, 1999). Yaduraju (2006) reported that weeds caused 37 per cent yield loss in India which was higher than that of yield loss due to insect damage and diseases.

Yield loss due to weed infestation in oil seeds

Oilseeds are mainly confined to rainfed/dryland areas, where weeds compete with the crop plants for nutrients and soil moisture; the most limiting factors for growth. Varaprasad and Shanti (1993) reported that yield loss due to weed infestation in oilseed crops varied from 16 to 68 per cent. However, Karim (1998) reported that, estimated yield loss due to weeds in oilseed crops was 40.86 per cent. Channappagoudar and Biradar (2007) reported that weed infestation during early stages was one of the major factors for yield loss in groundnut and soybean and resulted in the loss of approximately USD 347 ha^{-1} in groundnut and USD 117 ha^{-1} in soybean, respectively. Mruthul *et al*. (2015) reported a yield loss of 50-75 per cent in sesame due to crop-weed competition. The presence of weeds during the critical stages of soybean may cause 8-55 per cent reduction in yield (Datta *et al*., 2017). Apart from severe yield reduction within the range of 35 to 70 per cent, depletion in oil content and quality were also observed in mustard under rainfed and irrigated conditions (Shekhawat *et al*., 2017). In groundnut, the extent of yield loss due to weed infestation was reported to be 62 per cent, during the rainy season and 47 per cent, during the summer season (Gharde *et al*., 2018). Therefore, judicious weed management is essential to manage weed population below the threshold level to reduce the yield losses in oil seed crops. The yield losses in major oil seed crops are presented in Table 1.

Major weed flora in oilseeds

Weed flora in oilseed crops changes with agro ecological conditions and crop management practices. All the three types of weeds *viz*., grasses, broad leaved weeds and sedges are found in association with oilseed crops. The major weed flora of Kharif grown oil seed crops are *Digitaria sanguinalis* (L.), *Portulaca oleracea* L., *Conyza aegyptiaca* (L.), *Xanthium strumarium* L., *Euphorbia geniculate* Ortega, *Amaranthus viridis* L., *Dinebra retroflexa* (Vahl) Panz, *Cyperus rotundus* L., *Cyperus iria* L., *Panicum repens* L., *Cynodon dactylon* (L.) Pers., *Trianthema monogyna* L., *Echinochloa colona* (L.), *Tribulus terrestris* L., *Cenchrus biflorus* Roxb. and *Setaria viridis* (L.) P. Beauv. The major weeds associated with Rabi grown oil seed crops are *Argemone mexicana* L., *Anagallis arvensis* L., *Chenopodium album* L., *Chenopodium murale* L., *Asphodelus tenuifolius* Cav., *Cirsium arvensis* (L.) Scop., *Cynodon dactylon*, *Cyperus spp*., *Euphorbia geniculata*, *Avena fatua.* L., *Boerhaavia* spp, *Brassica kaber* (DC) Wheeler, *Brassica sinensis* L., *Fumaria parviflora* Lam., *Lathyrus aphaca* L., *Medicago denticulata* Willd., *Melilotus alba* Medikus, *Melilotus indica* (L.), *Euphorbia hirta* L., *Melotropicum indicum*, *Parthenium hysterophorus* L., *Physalis minima* L., *Solanum nigrum* L., *Spergula arvensis* L. and *Vicia hirsuta* (L.) Gray (Jalandhar and Rana, 2018).

Berti and Zanin (1997) reported the frequent incidence of *Echinochloa crus-galli* (L.) P. Beauv, *Digitaria sanguinalis*, *Chenopodium album* (L.), *Amaranthus* spp. and *Sorghum halepense* (L.) Pers. in soybean. In addition to that, broad-leaved weeds *Trianthema portulcastrum* (L.), *Digera arvensis* Forssk., *Amarathus viridis* and *Commelina benghalensis* (L.) were also found in association with soybean during kharif season (Nirmala *et al*., 2018).

The major weed flora in sunflower were observed to be *Cyperus difformis* L. and *Cyperus rotundus* L. among sedges, *Euphorbia thymifolia* L., *Trichoderma indicum, Euphorbia hirta* L., *Phyllanthus niruri* L., *Digera arvensis* L., *Celosia argentea* L., *Commelina benghalensis* L. and *Boerhaavia erecta* L. among broad-leaved weeds and *Brachiaria reptans* L., *Cynodon dactylon* L. Pers., *Dactyloctenium aegyptium* L., *Echinochloa colona* L. Link., *Digitaria bicornis* L., *Digitaria sanguinalis* L. and *Chloris barbata* Sw., among grasses (Sankar and Subramanyam, 2011).

Melilotus indica, Trigonella polycerata, Chenopodium murale, Chenopodium album, Orobanche aegyptiaca (Pers.), *Cynodon dactylon, Convolvulus arvensis, Carthamus oxyacantha* M. Bieb. and *Avena ludoviciana* (Dur.) were found highly associated with mustard (Punia *et al*., 2010).

Onattukara tract is the major area under sesame and groundnut in Kerala. Sreepriya and Girija (2018) inferred that the major weeds associated with sesame grown in Onattukkara region were *Cleome viscosa* L, *Digitaria sanguinalis, Echinicloa colona and Melochia corchorifolia* L. Sarin (2020) reported that major broadleaved weeds associated with groundnut were *Portulaca oleracea Cleome rutidosperma DC*., *Melochia corchorifolia, Synedrella nodiflora* (L.) Gaertn., *Phyllanthus niruri* L. and *Heliotropium indicum* L. Moreover, the predominant grass weeds were *Cynodon dactylon* and *Eleusine indica* (L.) Gaertn. while *Cyperus rotundus* was the only one sedge found in the experimental field.

Critical period of crop weed competition

The critical period of crop weed competition (CPCWC) is the most sensitive interval in the crop growth cycle at which weeds should be controlled to avert inadmissible yield loss. It is referred to as the optimum time in the life cycle of the crop during which the crop must be free of the adverse effect of weeds (Juraimi *et al*., 2009). Most of the annual crops are susceptible to weed competition during the early stage of growth and it is usually between the first one third to one half of the crop life cycle (Mercado, 1979). However, it depends on crop cultivar, weed flora, weed intensity, climatic and edaphic factors. Knowledge of CPCWC is essential for integrated weed management programme and for planning precise weed control strategy through rational use of herbicides and other weed control measures. (Rana and Rana, 2016). Critical period of crop weed competition in oilseeds are presented in Table 2.

Integrated weed management (IWM)

Integrated weed management (IWM) is an approach that aims at bringing down the weed intensity to a level that do not pose any significant danger to crops and humans. Being a comprehensive method, it controls and mitigates weed infestation in fields incorporating diverse techniques. Multiple strategies which are economically and environmentally sound are advocated in IWM to manage weeds (Nazarko *et al*., 2005). It has been proved to be more effective than any single method in alleviating the buildup of weeds in a crop land (Lamichhane *et al.,* 2017). It is a system approach to maintain the weed population below the economic threshold

Table 1: Average yield reduction in oilseed crops due to weed infestation.

Crop	Average yield reduction (%)	References
Soybean	20-77	Kurchania *et al.* (2001)
Groundnut	24-51	Gharde *et al.* (2018)
Sunflower	54.6	Wanjari *et al.* (2001)
Castor	73.6	Dungarwal *et al.* (2002)
Sesame	14-33	Gharde *et al.* (2018)
Rapeseed-mustard	9.6-38	Gharde *et al.* (2018)
Linseed	36	Singh *et al.* (1992)

Table 2: Critical period of crop weed competition in oilseeds.

Crop	Critical period (Days)
Groundnut	40-60
Sesame	15-45
Sunflower	30-45
Soybean	20-45
Safflower	15-45
Castor	30-50
Rapeseed-mustard	15-40
Linseed	20-45

level by employing all available means of weed control in coordination (Pooniya *et al*., 2017). IWM is an inevitable strategy that involves the combination of cultural, mechanical, chemical and/or biological practices of weed management in a systematic manner.

Cultural weed management

Cultural methods are essential for improving crop health and competitiveness of crop against weeds thus enabling the crop to overcome the existing weed pressure. It includes non-chemical and ecologically sound practices.

Selection of suitable planting method helps to eliminate weed flora. Jha and Soni (2013) reported that in soybean, flat bed method of sowing recorded higher density of monocot (43.2 no. m^{-2}) and dicot weeds (34.4 no. m^{-2}) whereas, broad bed furrow method recorded the lowest density of monocots and dicots (25.1 and 18.7 no. m^{-2}). Jangir *et al*. (2018) revealed that weed dry weight in mustard at 20 and 40 DAS was the lowest (9.53 and 20.99 g m^{-2} respectively) in normal planting with narrow row spacing of 30 cm × 10 cm compared to paired row planting and normal planting with wider row spacing of 45 cm. The decrease in weed dry weight in narrow row spacing was attributed to higher plant population per unit area which limits availability of resources essential for weed emergence, germination and growth. Thus narrow inter-row spacing, increased the competitiveness of mustard against weeds.

Optimization of sowing time is essential, as it influences the crop yield and other agronomic traits. Weed density and biomass can be significantly reduced by adopting optimum time of sowing. Marangoni *et al*. (2013) revealed that compared to planting in December, November planted soybean cultivars recorded the lowest dry weight of monocot weeds and total weed dry weight at 26 days after emergence and harvest. The optimum time of sowing favoured better crop development and enhanced the competitive potential of soybean cultivars against weeds. Sesame seed yield declined as the planting date was delayed from May to late June (Ahmed *et al*., 2009). Rahman *et al*. (1994) and Sarkar *et al*. (2007) also obtained highest seed yield for early sown sesame compared to the late sown crop.

Soil solarisation, a method of hydrothermal disinfestation of soil offers weed control through built up of lethally high temperature in surface soil where most of the viable and dormant seeds dry and promote suicidal germination (Soumya *et al*., 2004). Incorporation of organic residue or amendments to the seedbed before soil solarization, will enhance the effect of solarization by providing food for the microbes and enhance the soil temperature. Annual weeds are better controlled by soil solarization than perennials (D' Addabbo *et al*., 2009). Creeping perennials (nut sedge) and weeds having hard seed coat (morning glory) are resilient to soil solarisation (Birthisel *et al*., 2018). Singh (2006) reported that soil solarization, using transparent or black polyethylene film for 30 days before sowing of soybean, decreased the weed growth. Besides, soil solarization using transparent polyethylene for 30 days increased the soybean yield by 90 per cent.

Covering the soil surface with suitable mulch can reduce weed seed germination. Mulches control weed density by acting as a physical barrier, altering the microclimate, pH, C: N ratio, immobilization of nutrients, release of allelopathic chemicals and restricting the amount of light reaching the soil surface. Natural materials (straw, crop residues *etc*.) as well as polyethene films can be used as mulch for weed management. Cover crop residues that remained as natural mulches over soil surface had greater potential to suppress weeds by reducing light availability, increasing the soil temperature and production of allelochemicals (Teasdale and Mohler, 1993). Subrahmaniyan *et al*. (2002) reported that among the various weed control practices, mulching with polyethylene film recorded the lowest weed dry weight at harvest and the highest weed control efficiency. Bio-mulches have greater scope for effective weed management as the bio-mulches are eco-friendly, sustainable, locally available and economical. Vidyashree *et al*. (2019) revealed that mulching with eucalyptus leaves @7 t ha^{-1} in sunflower, registered weed control efficiency of 66.5 per cent by effectively supressing the weed emergence and weed growth. This was attributed to the release of allelochemicals like p-coumaric acid and caffeic acid upon decomposition which are detrimental to the weeds.

Stale seedbed technique works by killing the shallow "germinable" weeds that would develop normally and compete with the crop after being planted/sown. The shallow weed seeds emerge prior to crop planting or during the early stages of the crop establishment, while germinable weed seeds at deeper depths remain unaffected (Cerruti *et al*., 2014). Stale seed bed prepared 30 days before sowing sesame, significantly reduced the density of grasses, broad-leaved weeds and sedges compared to conventional seed bed preparation (Venkatakrishnan, 1997). The success of stale seed bed is assured, when the seeds of non-dormant weeds are present in the top 6 cm soil profile (Sanbagavalli *et al*., 2016). Arora and Tomar (2012) opined that the stale seedbed recorded the lowest dry weight of weeds, the highest WCE (53.91 %) and the highest pod yield in groundnut.

Crop rotation is considered to be a vital tool for weed management. Crop rotation with different production practices decreased the weed density by reducing the build-up of crop associated weeds. Kumar *et al*. (2016) opined that crop rotation breaks the weed seed cycle and prevents the development of diverse weed population. Mustard/Gobhi sarson sown after rice during winter season reduced *Phalaris minor* infestation to a great extent in north-western wheat belt of India (Singh and Singh, 2006). Kumar *et al*. (2016) reported that growing sesame in rainy season significantly reduced the population of *Cyperus* in winter pulses. Rotation with non-host crops is usually suggested for parasitic weed control. Acharya *et al*. (2002) observed that *Orobanche aegyptiaca* seed bank was reduced by 33.35 per cent by a local cultivar of *Brassica campestris* as a catch crop. Sesame as a trap crop decreased broomrape biomass by 86 per cent when included in rotation at infested fields. (Sirwan *et al*., 2010).

Inclusion of oilseed crops in the cropping system significantly reduced the weeds. Singh *et al*. (2005) reported that maize + soybean in 1:1 or 1:2 ratio effectively reduced the weeds in maize. Mishra (2014) pointed out that maize + toria in 1:2 ratio or maize + linseed in 1:2 ratio or maize + mustard in 1:1 ratio significantly reduced the weeds in winter maize over sole maize. Inclusion of sunflower before rice in rice-wheat rotation provided a satisfactory weed control in the succeeding rice crop. Similarly, replacement of sorghum by summer sunflower would also help to control summer as well as winter weeds (Rawat *et al*., 2017). In rice-yellow mustard- green gram cropping system, conservation tillage with recommended herbicides + one handing in all the three crops resulted in effective control of weeds and higher seed yield in yellow mustard (Teja and Duary, 2018).

Intercropping suppressed weeds better than sole cropping and provided condition favourable for the crop to utilize resources in a sustained manner (Rao and Shetty, 1976). Liebman and Dyck (1993) suggested that intercropping provides better weed control over sole cropping by imparting competition with weeds and also by converting resources to harvest material efficiently than sole crops. Intercropping of *Brassica carinata* and *Brassica juncea* significantly reduced the weed population and weed dry matter accumulation compared to sole stand (Rana, 2006). Kour *et al*. (2013) reported that intercropping of chickpea + mustard recorded the lowest weed density and weed dry weight compared to sole cropping of chickpea as a result of lesser space available to the weeds due to intercrops and lesser availability of resources to the weeds. Kumar *et al*. (2020) revealed that intercropping of cotton with sesame and sunflower, lowered the weed density and total weed biomass compared to mono cropping of cotton. The reduction in weed density and biomass observed in intercropping treatments was due to the smothering effect of intercrops on the weeds that prevented seed germination. Lower weed density and biomass in the intercropping system may also be due to the release of allelopathic compounds from sesame and sunflower by volatilization and root exudation.

Seed priming is a pre-sowing strategy of controlled hydration of seeds by modulating pre-germination metabolic activity of seeds prior to emergence of the radicle. This technique hastens the rate of germination and ensures better plant performance. Dias *et al*. (2011) reported that soybean plants developed from high vigour seeds had higher competitive ability against weeds than those developed from low vigour seeds. Hydropriming of sesame seeds followed by pre and post emergence of herbicides effectively controlled the weeds and produced seed yield comparable with that of weed free situation (Vafaei *et al*., 2013). Sreepriya and Girija (2018) revealed that seed priming improved weed competitiveness in sesame. The seeds soaked in 0.3 per cent $MnSO_4$ solution for 8 hours increased the competitive ability of sesame and supressed the weed growth in sesame.

Selection of suitable competitive cultivars significantly reduced the weed growth. Priya *et al.* (2015) revealed that groundnut cultivars significantly influenced the dry weight and density of weeds associated with the crop. The lowest density and dry weight of all the categories of weeds were observed in groundnut cultivar ‘Kadiri-6’ due to its better ground coverage. Soybean cultivars showed significant effect on weed dry weight and the lowest weed dry weight observed in Giza 111 cultivar was due to its higher vegetative growth which in turn exerted greater competition against weeds compared to other cultivars (El-Metwally *et al*., 2017).

Mechanical weed management

Mechanical method of weed management involves the removal of weeds mechanically with the help of various tools and implements. Hand operated/power operated/ animal drawn harrows/ cultivator and manual or power operated weeders are the commonly used ones.

Tillage and hoeing come under mechanical method of weed control. The distance between the rows is a critical factor and proper inter row space should be maintained so that inter-row hoeing can be carried out with minimum damage to the crop. Rotary hoes and cultivators are commonly used for weed control in soybean. About 70 per cent weed control could be achieved by rotary hoeing up to 1-3 leaf stage. In addition, harrowing before planting can also help to reduce the weeds in soybean (Joshi, 2001). Wheel hoeing twice at 20 and 40 DAS recorded the highest seed yield (9.07 q ha^{-1}) in mustard (Gogoi and Kalita, 1995). Ali and Kumar (2000) found that deep tillage practices before sowing of mustard seed, controlled annual weeds (*Anagallis arvensis* and *Medicago denticulta*) and perennial weed (*Convolvolus arvensis*).

Conventional tillage practices recorded the lowest weed density and the highest grain yield in sesame whereas, the no-till planting system resulted in the highest weed density (Ozturk, 2019). Tarwariya and Rajput (2019) revealed that conventional tillage practices recorded the lowest weed population and the highest weed control efficiency and grain yield in mustard. This was due to the fact that tillage provided a favourable condition for the effective absorption and utilization of nutrients and moisture by the plants which resulted in higher photosynthetic rate and accumulation of dry matter.

Chemical method of weed management

Use of effective and reliable chemical herbicides is a predominant method adopted for weed management in many parts of the world. Herbicides are the only alternatives left under such circumstances of unavailability of labours, high cost of labours and unfavourable environment. Presently a wide variety of old and new generation herbicides are available and are being recommended for usage. The efficiency of the herbicide is governed by factors like weed species, soil conditions (type, moisture, organic matter, clay content and pH), dose of herbicide, method of application, spray volume and physiological stage of the crop.

Pre-plant incorporation of fluchloralin at 1.0 kg ha^{-1} supplemented with one hand weeding at 40 days after sowing (Degra *et al*., 2006) showed significant reduction in weed density in mustard. Pre-emergence application of isoproturon at 0.5 kg ha^{-1} + one inter cultivation at 30 DAS brought significant reduction in weed density and biomass in rapeseed and mustard in India (Singh *et al*., 2009). Nainwal *et al*. (2010) opined that the application of diclosulam in soybean, controlled both monocot and dicot weeds whereas post-emergence application of haloxyfop was found effective for control of grasses. The improved seed yield obtained with diclosulam application showed its higher efficacy to control the broad spectrum of weeds. Mishra (2020) revealed that application of oxyfluorfen 23.5 EC @ 0.2kg ha^{-1} at 2 DAS and imazethapyr 10 per cent SL @ 100 g ha^{-1} at 15 DAS were the practically convenient and economically feasible weed management practice for groundnut considering the extent of weed control, scarcity and high cost of labours and B:C ratio. Sarin (2020) reported that imazethapyr @ 70 g ha^{-1} as post emergence application recorded the lowest weed dry weight in groundnut. The better suppression of weeds also resulted in higher kernel yield compared to other treatments. Commonly used herbicides for weed control according to the time of application are presented in Table 3.

Weed population in ground nut was effectively managed by pre-emergence application of pendimethalin @ 1.0 kg ha^{-1} + post emergence application of quizalofop-p- ethyl @ 50 g ha^{-1} at 20 DAS + one hand weeding at 45 DAS. Pre emergence application of pendimethalin @ 1.0 kg ha^{-1} + post emergence application of imazethapyr @ 75 g ha^{-1} at 20 DAS + one hand weeding @ 45 DAS was proved to be best weed control in ground nut (AICRPG, 2009). Weed management strategy that recorded best results in soybean were pre emergence application of pendimethalin @ 677.25 g ha^{-1} + one hand weeding at 30 DAS or pre emergence application of mertribuzin @ 525 g ha^{-1} + one hand weeding at 30 DAS or pre emergence application of mertribuzin @ 525 g ha^{-1} followed by post emergence application of imazethapyr + propaquizafop-ethyl @ (80+60) g ha^{-1} (Patel *et al*., 2018).

Biological weed management

Biological management of weeds are the use of a biotic agents to suppress or reduce the population of a pest. The two major types of biological weed control are classical (inoculative) and inundative approach (Watson, 1991). Classical approach involves the selection and introduction of an agent, that upon release, self-perpetuates and establishes itself and provides long term control of the weed population. The inundative strategy of biological control entails the mass production and application of a host specific agent at high inoculum levels over a localized area infected with the target weed.

Pseudomonas syringae pv. *tagetis* is used as a bioherbicide for the control of Canada thistle *Cirsium arvense*) in soybean. Watson (1991) observed that application of the bacteria during spring reduced the number of Canada thistle (no m^{-2}) by 78 per cent compared to the control, with no disease incidence in soybean crop. *Puccinia canaliculata* registered as DR BIOSEDGE is used for controlling *Cyperus rotundus* in all cropping systems. Phatak *et al*. (1983) reported that application of *Puccinia canaliculata* completely inhibited flowering and reduced yellow nutsedge stand and tuber formation by 46 and 66 per cent, respectively. The fungus *Colletotricum gleosporoides* f. sp *aeschnomene* (CGA) was effective against northern joint vetch (*Aeschynomene virginica*) in soybean. Biological method of weed control was reported in the management of parthenium, an invasive alien weed found in soybean growing areas. Sushilkumar (2008) reported that *Zygogramma bicolorata* was the only successful insect bioagent against parthenium.

Allelopathic weed management

Allelopathy infers to any direct or indirect interaction of one plant on other through the release of chemical substances.

Table 3: Herbicides used for weed control in oilseeds according to the time of application.

Herbicides	Dose (kg ha^{-1})	Crops	Weeds controlled
		Pre plant herbicides	
Fluchloralin	0.75-1.0	All oilseeds	BLW and sedges
Trichloralin	0.75-1.0	All oilseeds	BLW and sedges
		Pre emergence herbicides	
Pendimethalin	1.0	All oilseeds	BLW and grasses
Oxyfluorfen	0.10-0.20	Soybean, linseed, groundnut	BLW and grasses
Oxadiazon	0.75-1.0	Soybean, groundnut, mustard, sunflower	BLW and grasses
Diclosulam	0.037	Soybean	BLW, grasses, sedges
Metribuzin	0.50-0.75	Soybean	BLW and grasses
		Post emergence herbicides	
Chlorimuron ethyl	0.008-0.012	Soybean	BLW
Fluazifop-butyl	0.25-0.50	Soybean	Grasses
Imazethapyr	0.10-0.15	Soybean, groundnut	BLW and grasses
Metsulfuron methyl	0.004-0.006	Soybean	BLW
Quizalofop-p-ethyl	0.050	All oil seed crops	Grasses

Mahmoodzadeh and Mahmoodzadeh (2013) revealed that soybean leaf extracts significantly decreased the germination and growth of *Sorghum halepense*. Besides, growth of *Abutilon theophrasti* (velvet leaf) and *Setaria italica* (foxtail millet) were retarded when watered with soybean root exudates.

Aqueous extracts of sunflower inflorescence, stem, leaves and roots inhibited the germination and seedling growth of red root pig weed (*Amaranthus retroflexus*), crab grass (*D. sanguinalis*) and Japanese brome (*Bromus japonicus*) (Naseem *et al*., 2009). Hussain *et al*. (2017) reported that the shoot length and dry weight of *Cyperus rotundus* decreased with the graded concentrations (50% and 100%, respectively) of sesame leaf leachate. Allelochemicals present in sesame leaf leachate inhibited the expression and elongation of bud cells and caused cessation of cell division resulting in reduced dry weight.

Herbicide resistant crops (HRCs)

Herbicide resistance is the inherited ability of a plant to survive and reproduce following exposure to a dose of herbicide normally lethal to the wild type. Herbicide-resistant crops were initially produced by methods of traditional breeding, whereas at present the major HRCs have been produced by genetic engineering. Among the HRC's, glyphosate-resistant crops (Roundup Ready) occupy more than 80 per cent of area under transgenic crops (Duke *et al*., 2001). Gusta *et al*. (2011) reported that herbicide-tolerant canola generated USD 1.06-1.19 billion annual net direct and indirect benefits for farmers and offered a new weed control option.

CONCLUSION

Weed interference cause significant reduction in yield in oilseed crops. Yield reduction depends on the duration of weeds in the field and severity of weed infestation. To reduce losses in oilseed crops, weed control should be carried out at the early stages of crop growth. Hand hoeing is commonly practiced by the farmers, but non availability of labour for weeding and hike in wage rate forced the farmer to skip weeding during the critical period of weed control and resulted in heavy yield loss. Phytotoxicity also restricts the use of herbicides in oil seed crops. Non availability of selective post emergence herbicides for the control of broad leaf weeds leads to severe infestation of broad leaf weeds in oilseed crops. Hence, a holistic approach involving a judicious and rationalized blend of cultural/mechanical/ chemical and /or biological methods is essential to obtain a satisfactory and successful weed control for higher yield and net returns in oil seed crops.

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