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A Review on Weed Management in Soybean (*Glycine max*)

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A B S T R A C T

The present paper is review of various research findings on weeds and weed control in soybean. Soybean is the most important oil seed and grain legume crop in the world, in terms of total production and international trade. However, losses due to weeds have been one of the major limiting factors in soybean production. So, successful weed control is one of the most important practices for economical soybean production. Weeds that germinate at the same time as soybean, grow faster and maintain a canopy above and below the top of the soybean canopy and result in reduced quality. Common weeds in soybean are common cocklebur (*Xanthium pensylvanicum*), giant foxtail (*Setaria faberii*), sword grass (*Imperata cylindrica*), Johnson's grass (*Sorghum halepense*) and Couch grass (*Cynodon dactylon*). Different chemicals are used but a mixture of imazethapyr and quizalofop seems to perform best and when these chemicals are supplemented with mechanical or manual weeding it provides weed control throughout the growing period of the crop. Continuous cultivation of a single crop or crops having similar management practices allows certain weed species to become dominant in the system and, over time, these weed species become hard to control. An integral part of a weed program is to take care that weeds do not need to go to seed, harvesting equipment is not transporting weed seeds, and clean seeds are used for all crops in the rotation. Combining weed control method can help keep weed damage before economic threshold levels and shall be performed rather than a separate control method.

Introduction

Soybean (*Glycine max*) is an important rainy season crop of Central India which contributes to 25 % of the global edible oil. The crop has been sown on 105.76 lakh ha area and productivity near about 1.2 tha^{-1} which is too low (FAOSTAT, 2013). In India, weeds are one of the major biological constraints that limit crop productivity. Inadequate weed control is one of the main factors related to decrease in soybean production. The grain yield reduction due to the weed infestation in soybean may be up to 31-84 percent (Kachroo *et al.,* 2003). Weed control is essential to exploit the maximum yield potential and get the advantage of new high yielding varieties. A wide spectrum of weed flora is observed in India in soybean and their information is essential for effective weed control. Many ways are employed for weed control, generally hand weeding is usually carried out, but it is becoming expensive as it

requires more labor. Weed population is lower when sowing is done inline than broadcast. The application of mulches, broad bed cultivation and crop rotation are also effective for weed control. Chemical weed control by pre-sowing, pre-emergence and post-emergence application of herbicide is very effective method of control weed control. The intensity of weeds in early and later stage can be controlled by suitable combination of physical, chemical, cultural, mechanical, and possibly biological weed control techniques to achieve maximum yield. Development of integrated weed management that is economically viable as well as ecologically safe is of at most important to control the weed effectively and improve the productivity.

Common weeds found in Soybean

Grasses and sedges

Generally, perennial grasses are the most problematic weeds of soybeans. They cause significant damage and are difficult to control. Such weeds include common cocklebur (*Xanthium pensylvanicum*), giant foxtail (*Setaria faberii*), sword grass (Imperator cylindrica), Johnson's grass (*Sorghum halepense*) and Couch grass (*Cynodon dactylon*) (Daugovish *et al.*, 2003).

They form extensive underground vegetative system which make them hard to control. Sedges (*Cyperus rotundus*) and (*C. esculentus*) are also difficult to control, yet cause a lot of damage to soybeans. Apart from competition of moisture, carbondioxide, light and nutrient; they have allelopathic effects on soybeans (Drost and Doll, 1980). Perennial weeds usually have the ability for vegetative reproduction from underground parts.

These are also organs for growth after cutting and they are storage organs for food reserves. They therefore require deep cultivation which brings the underground propagules to the surface and expose them to desiccation by the sun and wind (Drost and Doll, 1980).

Broad leaved weeds

Broad-leaved weeds are not as detrimental as the grasses and sedge in soybean production. However, they cause some damage and should not be over looked. Some produce many seeds making them difficult to control e.g., lamb squatters (*Chenopodium album*). Other serious broad-leafed weeds common in soybean fields include spiny Amaranth (*Amaranthus spinosus*) and morning glory (*Convolvulus arvensis*). Annual weeds can be dealt with by repeated shallow cultivation.

Crop weeds competition and influence on yield

The weeds spread and established easily and are not eradicated easily which compete with the crop and causes reduction in crop yield. The weeds are severe during rainy period, particularly at early stages (30 to 45 days after sowing) of the legume crop and early weed control is essential looking at critical period of growth phase stage. Pandey (2005) reported that major weed species (at 40 DAS and harvest) infesting soybean crop included *Trianthema portulacastrum* (28.4 and 0.0%), *Commelina benghalensis* (11.8 and 18.2%), *Parthenium hysterophorus* (8.4 and 20.1%), *Amaranthus spinosus* (5.4 and 6.8%), *Digera arvensis* (4.1 and 5.2%), *Echinochloa colonum* (25.5 and 32.5%), *Cynodon dactylon* (11.5 and 11.1%) and *Cyperus rotundus* (4.5 and 5.5%). Pandy *et al.*, (2007) reported that the 56% yield was reduced in soybean without weed management. Habimana *et al.*, (2013) reported that weed reduced the yield up to 80% against the best way of weed management. Tiwari and Kurchania (1990) at Jabalpur concluded that yield losses in soybean due to weeds vary from 20 to 70 % depending upon the type and intensity of infestation. Kurmawanshi *et al.*, (2015) concluded that soybean offers severe infestation of a large number of weeds, which reduce the yield to the extent of 18.83 to 42.37%. Mosier *et al.*, (1995) studied the effect of common cocklebur and morning-glory interference on soybean. Total LAI and LAI within the soybean canopy, crop growth rate and seed yield of soybean were decreased more

by cocklebur than by morning-glory. Interference from morning-glory, cocklebur or both species reduced soybean yields by 21, 57 and 64%, respectively with irrigation, whereas it was 12, 60 and 76 %, respectively without irrigation at Arkansas, USA.

Weed management strategies

Mechanical and manual weeding

From the experiment conducted by Algotar *et al.,* (2015) at Navsari (Gujarat), it is concluded that keeping the field weed free up to harvest 2 hand weeding and hoeing gives the highest grain and haulm yield. Chaudhari *et al.,* (2016) indicated that hand weeding at 20 and 30 DAS and hand hoeing at 20 and 30 DAS led to an enhancement of 3.4 %, 3.6 % yield of summer soybean over weedy check. Chhodavadia *et al.,* (2014) at Junagadh (Gujarat) found that hand weeding at 20, 30 and 40 DAS reduced weed infestation most efficiently throughout the growing period of the crop and as a consequence it produced the highest seed yield of summer soybean. Patel *et al.,* (2015) observed that at Anand (Gujarat) inter culturing followed by hand weeding carried out at 20 and 40 DAS was more effective in controlling weeds and gave more yield as compared to pendimethalin 500 gha^{-1} as PE fb IC + HW at 30DAS. Patil *et al.,* (2014) reported that at Akola, Maharashtra, hand weeding + 1 hoeing increased the grain yield by 68.9% over control. Patel *et al.,* (2015) at Navsari, Gujurat concluded that two hand weedings along with hoeing at 20 and 40 DAS or two hand weedings at 20 and 40 DAS are found most appropriate and profitable weed management practices.

Chemical control

As manual weeding is laborious and time consuming so farmers prefer chemical weed control. Poornima *et al.,* (2017) concluded that the combinations of Haloxyfop-p-methyl at 135 g ha^{-1} + Imazethapyr at g ha^{-1}, and Quizalofop ethyl at 50 g ha^{-1} + Imazethapyr at 75 g ha^{-1}applied at 12-15 days after sowing of soybean as an early post-emergence can be recommended for weed control in soybean in Southern Zone of Telangana for getting higher yield during kharif. Application of Vellore 32 (Pendimethalin 30 EC+ Imazethapyr 2 EC)@1.00 kg a.i. ha^{-1} was found most effective in reducing population and dry mass of weeds and producing maximum yield of soybean at Nadia, West Bengal (Tamang *et al.,* 2015). Singh *et al.,* (2016) conducted an experiment at Bihar and concluded that application of herbicide Pendimethalinat 1.0 kg ha^{-1} as preemergence was most effective and superior no application of herbicides for controlling of weeds and achieving maximum seed and stover yield of soybean. Ali *et al.,* (2011) in Sardarkrushinagar (Gujarat) concluded that under constraints of labour availability, maximum yield, net profit and effective weed control in soybean crop can be achieved with application of Imazethapyr or Quizalofop-p-ethyl 100 g ha^{-1} 15-20 days after sowing.

Integrated weed management

The conventional methods of weed control (hoeing or hand weeding) are labour intensive, expensive, insufficient and may cause damage to the crop. Chemical weed control is not common as the use of herbicides may be uneconomical due to low yield potential of soybean (Reddy, 2004). So, to avoid the ill effects of using a single method, use of integration of all possible methods can provide better yield and maximum benefit. Singh *et al.,* (2016) concluded that Pendimethalin (pre) 1000g a.i. ha^{-1} +1 hand weeding minimizes total weed density throughout the crop growth period and produces maximum yield. At Navsari; Raj *et al.,* (2012) conducted an experiment during 2005-2008 by comparing different methods of weed control and concluded that higher seed and haulm yields with higher weed control efficiency were obtained with two hoeing at20 and 40 DAS and was followed by pendimethalin as preemergence 0.75 kg ha^{-1} + one hand weeding at 40DAS.

Table.1 Common weeds of soybean

Broad leaved-weeds	**Grassy weeds and sedges**	
Chenopodium album	**Perennial**	**Annuals** (continued)
Convolvulus avensis	*Cyperus rotundus*	*Echinochloa colona*
Abutilon theoprasti	*Cyperus esculentus*	*Eleusine indica*
Amaranthus spinosus	*Imperata cylindrica*	*Rottboela exaltata*
Amaranthus hybridus	*Xanthium pensylvanicum*	*Rottboella cochnichinesis*
A. tuberculatus	*Cynodon dactylon*	*Eleusine africana*
Protolactus oleracea	*Pennisetum clandestinum*	*Digitaria spp*
Solanum nigrum	**Annuals**	
Bidens pilosa	*Setaria virids*	
Baltimora recta	*Setaria faberii*	
Parthenium hysterophonus	*Setaria veticillata*	
Melampodium diranicatum	*Centhrus spp*	
Tridax procumbuens	*Sida spinosa*	

Table.2 Common herbicides for control of weeds in soybean and other oil crops

Crop	**Herbicide**	**Dose Kg a.i ha^{-1}**	**Treatment**	**Type of weed**
SOYBEAN	Trifluralin	1.0-1.5	PPL	Annual Weeds
	Pendimethalin	1.01-32	Pre	Annual grasses
	Metachlor	2.0-2.5	PPL	Annual Weeds & Sedges
	Vernolate	2.9-3.6	PPL	Annuals & Sedges
	EPTC	3.6-4.8	PPL	Broadleaved
	Linuron	0.5-1.0	Pre	Annual grasses
	Metropromuron	0.75-1.0	Post	Annual grasses
	Imazaquin	0.07-0.20	Pre/Post	Annual grasses
	Imazethpyr	0.70-0.10	Pre/Post	Broadleaved
GROUNDNUT & SESAME	Alachlor	2.0-3.0	Pre	Annual grass, broadleaved
	Pendimethalin	1.0-3.0	Pre	Annual grasses
RAPESEED	**Alachlor**	1.0-1.5	Pre	Annual grasses, broadleaved
	Metachlor	1.25-1.75	Pre	Annual &sedges
			Post	
SUNFLOWER	**Alachlor**	1.75-2.5	Pre	Annual grasses broadleaved
	Chloramben	2.0-3.0	Pre	Annual grasses broadleaved
	Butachlor	1.0-1.5	PPL	Annual grasses

Source: Joshi (2001)

Kundu *et al.,* (2009) from Nadia, West Bengal reported that integrated weed management practices with quizalofop-pethyl @ 50 g a.i. ha^{-1} at 21 DAE + hand weeding at 28 DAE produced the highest yield attributes, seed yield and benefit: cost ratio in mungbean cultivation compared with application of herbicide alone. Raman and Krishnamoorthy (2005) in Annamalai Nagar revealed that soybean produced highest yield with the application pendimethalin @ 1.0 kg ha^{-1} plus one hand weeding on 20 DAS. From the above stated reviews, it is revealed that weeds cause a great loss in crop production and they should be managed to an extent that there should no economic losses due to weeds. Due to shortage of labor and environment polluting effects of chemicals it is necessary to adopt integrated weed management for sustainable development and higher yield potential of soybean crop.

In an experiment conducted by Jhadhav and Kashid (2019)the highest plant height (75 cm), number of pods per plant (29), grain yield (3.73 t ha^{-1}) and straw yield (2.59 t ha^{-1}) were obtained in weed free treatment. It was at par with quizalofop-ethyl 0.05 kg ha^{-1} + chlorimuron-ethyl 0.009 kg ha^{-1} PoE at 15 DAS + HW at 30 DAS with the next highest grain yield (3.42 t ha^{-1}) and straw yield (2.44 t ha^{-1}).Various yield attributes of soybean were also affected by different treatments of weed control. Weed free check (two hand weeding at 20 and 40 DAS) recorded significantly higher number of pods per plant and seed yield $hectare^{-1}$ over all other treatments. Application of pendimethalin @ 1.0 kg a.i. ha^{-1} (PE) + one hand weeding at 40 DAS was at second place in respect of these yield attributes and found significantly superior over rest of the treatments excluding weedy check (Kalhapure *et al.,* 2011).

From the above review, it can be concluded that weed effectively compete with the crop up to 15-30 DAS and reduce grain yields ranging from 10 to 80 percent. Chemical weed control is getting importance in areas, where labour is scarce and costly. Some of the herbicides (quizalofop, pendimethalin and imazethapyr) either alone or their combinations at appropriate doses have been proved as economically viable alternative to hand weeding in management of weeds in soybean field. Since repeated use of chemicals is harmful for our ecosystem, integrated weed management should also be employed in soybean. Above stated herbicides, when integrated with mechanical and manual weeding gives season long weed control and also decreases herbicide residue and hence integrated weed management is advantageous for succeeding crops and soil microflora.

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