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Influence of Integrated Weed Management on Weed Control and Productivity of Soybean [*Glycine max* (L.) Merrill]

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Weed competition is one of the most important causes of yield loss in **kharif** soybean [*Glycine max* (L.) Merrill] and is estimated to be 30 to 80% (Yaduraju, 2002). Traditional methods of weed control could not be performed in time due to uncertainty of rains, unworkable soil conditions and higher cost. Non-availability of labour further accentuates the weed problem. Under these situations, use of herbicides in this crop can be a viable and effective method of weed control. Sole dependence on the herbicide use may not provide long lasting effective weed management. Therefore, the present investigation was undertaken to evaluate the performance of various integrated weed management approaches in soybean.

A field experiment was conducted during **kharif** 2003 at the Indian Agricultural Research Institute, New Delhi on deep sandy loam soil with pH 7.6, organic carbon 0.34%, medium in available phosphorus (34.5 kg P_2O_5 ha^{-1}) and potassium (267 kg K_2O ha^{-1}). Fourteen treatments (Table 1) were laid out in a three times replicated randomized block design. Fluchloralin @ 1 kg ha^{-1} in 500 litre water was sprayed and incorporated in the top soil layer by using *kasola* two days before sowing of the crop. Alachlor @ 2 kg ha^{-1} and pendimethalin @ 1 kg/ha in 500 litre water were sprayed using flat fan nozzle one day after sowing. There was heavy rainfall after 6 h of spraying alachlor and pendimethalin. Mulch of wheat and mustard straw @ 10 ha^{-1} was spread uniformly between the rows just after the emergence of crop. Quizalofop ethyl @ 50 g ha^{-1} in 600 litre water was sprayed uniformly on the crop and weeds canopy at 20 days after sowing. In the weed-free treatment field was kept weed-free for 60 days by doing three hand weedings at 15, 35 and 60 days after sowing. Soybean cv. 'Pusa-9702' was sown in rows 45 cm apart on July 8, 2003 and harvested on November 19, 2003. The data on weed flora and weed count were recorded at 60 DAS and weed dry weight at harvest by placing a quadrate of size 0.5 m x 0.5 m randomly at two spots in each plot. Weeds data were subjected to square root transformation using $\sqrt{x+0.5}$ notation.

Oil content (%) in soybean seeds was estimated by the pulsed Nuclear Magnetic Resonance (NMR). Oil content in seed sample of each treatment was multiplied by corresponding seed yield (kg ha^{-1}) to get the oil yield (kg ha^{-1}).

The experimental field was mainly infested with *Echinochloa colona* (58.0%), *Cyperus rotundus* (17.9%), *Trianthema portulacastrum* (4.8%) and *Digera arvensis* (17.3%). In addition to these, *Digitaria sanguinalis, Connnelina benghalensis, Dactyloctenium aegyptium* and *Phyllanthus niruri* were also recorded in small numbers. The predominance of these weeds in soybean under Delhi condition was also reported earlier by Kewat (1998). Weed control treatments caused significant variation in total weed population (Table 1). The highest weed population (224 m^{-2}) was recorded under weedy check, followed by alone application of pendimethalin (181.3 m^{-2}) and alachlor (164.0 m^{-2}). The poor efficacy of pendimethalin and alachlor in reducing the weed population may be due to leaching of these herbicides to deeper soil layers on account of heavy rainfall received after the herbicide application. However, the performance of pre-plant incorporation of fluchloralin at 1 kg ha^{-1} was better in controlling complex weed flora as it was mixed well before sowing, thereby resulting in lowest weed count (98 m^{-2}). Quizalofop ethyl at 50 g ha^{-1} caused the highest reduction in the population of *E. colona* and *C. rotundus*. Singh and Ali (2003) also found quizalofop ethyl effective against grassy weeds. Application of fluchloralin at 1 kg ha^{-1} followed by

Table 1. Weed density, weed dry weight, weed index, leaf area index, seed weight/plant, oil content, oil yield and benefit : cost ratio of soybean as influenced by weed control measures

Treatment	Dose ($kg\ ha^{-1}$)	Application stage/DAS	Weed density ($No.\ m^{-2}$) 60 DAS	Weed dry weight at harvest ($g\ m^{-2}$)	Weed index (%)	Leaf area index	Seed weight/ plant (g)	Oil content (%)	Oil yield ($kg\ ha^{-1}$)	Benefit : cost ratio
Weedy check	-	-	15.0 (224)	4.3 (17.8)	79.3	1.86	3.2	19.71	72	0.54
Hand weeding	-	20 & 40	6.3 (39)	3.0 (8.5)	14.7'	5.24	9.4	20.23	307	1.75
Hoeing	-	20 & 40	7.3 (52)	3.2 (9.4)	9.3	5.15	9.6	20.21	317	1.79
Alachlor	2.0	PE	12.8 (16)	3.2 (17.2)	65.0	3.55	4.0	20.00	124	0.75
Quizalofop ethyl	0.05	20, POE	9.9 (97)	4.5 (20.1)	70.7	3.45	3.4	19.67	106	0.65
Fluchloralin	1.0	PPI	9.9 (98)	4.2 (17.5)	39.0	4.14	6.6	19.17	207	1.32
Pendimethalin	1.0	PE	13.5 (181)	4.2 (17.6)	67.3	2.44	3.7	19.87	116	0.71
Fluchloralin+Hand weeding	1.0	PPI+30	8.0 (63)	2.9 (8.2)	14.0	4.96	9.0	18.91	289	1.68
Pendimethalin+Hand weeding	1.0	PE+30	8.6 (74)	4.2 (17.8)	47.0	3.12	5.6	19.49	184	1.04
Mulching	10^4	Just after crop emergence	8.1 (64)	3.4 (11.2)	20.0	4.68	8.1	19.31	273	1.59
Pendimethalin+ Mulching	1 10^4	PE+Just after crop emergence	8.1 (64)	3.5 (12.1)	21.3	4.93	8.3	20.01	279	1.36
Reduced spacing (30 cm)+Pendimethalin	- +1	- + PE	11.5 (132)	4.0 (15.9)	43.3	4.67	6.2	19.96	220	1.21
Reduced spacing (30 cm)+ Hand weeding	- + -	- + 30	8.6 (75)	3.6 (12.9)	26.3	3.57	7.6	19.46	255	1.51
Weed-free upto 60 days	-	15, 35 & 60	0.7 (0)	1.7 (2.5)	0.0	5.47	9.8	20.30	362	1.82
C. D. (P=0.05)			1.40	0.51	10.3	1.13	2.7	0.22	33	-

PE–Pre-emergence, POE–Post-emergence, PPI–Pre-plant incorporation, DAS–Days after sowing.

one hand weeding at 30 days after sowing (DAS) was found more effective in reducing weeds, which may be ascribed to their cumulative effect. Lowest weed intensity was recorded with 2 HW (39.2 m^{-2}) or two hoeings (52.7 m^{-2}) at 20 and 40 DAS which may be ascribed to effectiveness of these methods to control all sorts of weeds during the critical period of crop-weed competition.

At harvest, maximum weed dry matter (20.9 g m^{-2} was recorded with quizalofop ethyl rather than weedy check (17.85 g m^{-2}). This may be ascribed to late emergence of dicot weeds after the killing of monocot weeds, which continued their growth upto maturity of soybean, while in weedy check most of weeds matured earlier and part of weed biomass became part of soil organic matter before harvest of crop. Lowest dry matter at harvest was recorded with 2 HW or hoeing at 20 and 40 DAS closely followed by integrated application of fluchloralin + 1 HW at 30 DAS (Table 1). The lowest weed index was recorded with two hoeings at 20 and 40 DAS (9.3), closely followed by integrated use of fluchloralin+one HW at 30 DAS (14.0), 2 HW at 20 and 40 DAS (14.7), while the highest value was recorded under weedy check (79.3). This trend of weed index is the result of variable seed yield of soybean under different treatments (Table 1).

The highest values of LAI and seed yield/plant were recorded under weed free upto 60 DAS closely followed by two hand weedings or hoeing at 20 and 40 DAS and integrated control with fluchloralin+1 HW at 30 DAS (Table 1). Weedy check recorded the lowest values of these parameters closely followed by alone application of alachlor, pendimethalin and quizalofop ethyl. These variations in growth and yield attributes due to weed control treatments may be attributed to variable weed control under different treatments as evidenced by observation on weed count and weed dry weight (Table 1). Improvement in yield attributes due to effective weed management has also been reported by Kewat (1998), Ravi *et al.* (2001) and Patil *et al.* (2002). Two hoeings at 20 and 40 DAS, 2 HW at 20 and 40 DAS and integrated application of fluchloralin+1 HW at 30 DAS recorded statistical identical oil yield which may be ascribed to effective weed control due to these treatments that favoured improvement in growth and yield attributes. These treatments, respectively, recorded 329, 346 and 304% increase in oil yield over weedy check. Mulching alone and in combination with pendimethalin recorded oil yield at par with integrated application of fluchloralin+1 HW at 30 DAS. This may be attributed to long term effect of mulches in suppressing the germination and emergence of weeds and enhancing availability of moisture to the crop during post-monsoon period. These findings are in agreement with those reported by Kewat (1998), Ravi *et al.* (2001) and Sankaranarayanan *et al.* (2002).

The highest benefit : cost ratio (1.82) was obtained with weed-free upto 60 DAS closely followed by two HW or two hoeings at 20 and 40 DAS, integrated application of fluchloralin+1 HW at 30 DAS and mulching 10 t ha^{-1} (Table 1). On the contrary, the lowest benefit : cost ratio was recorded under weedy check followed by treatments of alone application of herbicides except fluchloralin. This type of behaviour of benefit : cost ratio under different treatments could be ascribed to variation in economic yield and marginal cost.

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