Research Article

Comparative Efficacy of Herbicides for Weed Management in Soybean (*Glycine max* L.)

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Abstract

Field experiment was conducted at Agricultural Research Station, Borwat Farm, Banswara to evaluate the weed control efficiencies of different herbicides and their mixtures during *kharif* -2008 and 2009. Application of Pendimethalin (1.0 kg ha^{-1}) as pre emergence was effective against the grassy and broad leaf weed at initial stage. The herbicides Quizalofop ethyl (50 g ha^{-1}), Fenoxaprop-p-ethyl (70 g ha^{-1}) and Imazethapyr (75 g ha^{-1}) were effective against grassy weeds whereas Chlorimuron ethyl (10 g ha^{-1}) reduced the density and biomass of broad leaved weeds effectively. Tank mixtures of Chlorimuron ethyl + Imazethapyr @ (10 + 75 g ha^{-1}) and Chlorimuron ethyl + fenoxaprop-pethyl @ (10 + 70 g ha^{-1}) as post-emergence were found very effective control of both the categories of weeds and also resulted in highest seed yield (2187 and 2168 kg ha^{-1}) of soybean which was on par with weed free (2317 kg ha^{-1}) and proved significantly superior to sole application of these herbicides and weedy check.

The maximum net returns (Rs. 48438/- and 47908/-ha) and B: C ratio (2.20`and 2.18) were associated with post-emergence application of tank mixture of Chlorimuron ethyl (10 g ha^{-1}) + Imazethapyr (75 g ha^{-1}) POE Chlorimuron ethyl (10 g ha^{-1}) + Fenoxaprop-p-ethyl (70 g ha^{-1}) in the pooled analysis.

Keywords: Herbicides, soybean, weed control efficiency and harvest index

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Introduction

Soybean [*Glycine max* (L.) Merrill] is an important pulse as well as oilseed crop. Even though the area under soybean in India has shown an appreciable increase over past four decades, the productivity has remained only 1 t per ha as against world average of 2.2 t per ha. Among several factors responsible for lower productivity, the yield erosion on account of weeds is one of the important factors. Soybean is very sensitive to early weed competition. Weed infestation in soybean field may reduce yield up to 77 per cent depending upon the intensity, nature, and the duration of weed competition (Tiwari and Kurchania, 1990). To avoid competition during the early growth stages, soybean field should be kept free from weeds for the first 30-40 days after sowing. Chhokar *et al*. (1995) reported that weed free maintenance up to 45 days after sowing resulted in 96 per cent increase in grain yield of soybean. The crop smothers the weeds that emerge 30-40 days after sowing. Mechanical as well as chemical methods are adopted for control of weeds in soybean field. During rainy season, incessant rains and consequent wet condition does not permit inter-cultural operations or normal manual/mechanical weeding in the standing crop. Moreover, the scarcity of labour and high wages restricts their utilization in weeding. It is, therefore, necessary to evaluate alternative method for controlling weeds during critical growth period. Therefore, the present investigation was undertaken to find out the efficacy of the herbicides for weed management in soybean.

Material and Methods

An experiment was conducted during two consecutive years of *kharif* 2008 and 2009 at Agricultural Research Station, Borwat Farm, Banswara. The soil was clay loam (black cotton) in texture having pH 7.0 -7.8, organic carbon 0.58 per cent, medium in available nitrogen (267 and 262 kg ha^{-1}) and phosphorus (22.5 and 23.01 kg ha^{-1}) and high in available potash (320 and 324 kg ha^{-1}). The experiment was conducted in Randomized Block Design with three replications, comprising of ten weed management treatments viz. weedy check, weed free, pendimethalin@ 1.0 kg a.i. ha^{-1} (PE), chlorimuron ethyl @ 10 g a.i. ha^{-1} (POE), fenoxaprop-p-ethyl @ 70 g a.i. ha^{-1} (POE), quizalofop ethyl @ 50 g a.i. ha^{-1} (POE), Imazethapyr @ 75 g a.i. ha^{-1} (POE),chlorimuron ethyl + fenoxaprop-p-ethyl @ 10 + 70 g a.i.ha^{-1} as POE, chlorimuron ethyl + quizalofop ethyl @ 10 + 50 g a.i. ha^{-1} as POE and chlorimuron ethyl + Imazethapyr @ 10 + 75 g a.i. ha^{-1} POE at 10-25 days after sowing. The herbicides were sprayed by hand sprayer fitted with flat fan nozzle using 600 liters of water per hectare. Soybean seed (*var*. JS-335) was treated with thiram 75 per cent WP (2 g) + bavistine (1.0 g) per kg seed before inoculation with *Brady rhizobium japonicum*culture @ 7 g per kg seed. Recommended dose of fertilizer was applied as basal at the time of sowing. Thinning to maintain optimum plant population was completed within 15-20 DAS during both the years. All the production and protection measures were used as per package and practices of Humid Southern Plain Zone of Rajasthan. Weed control efficiency (WCE) was computed by using formula, WCE = (P -Q/P) x 100, where P and Q respectively, refer to oven dry weight of weeds at specific treatment for which value is computed. Necessary statistical analysis was carried out by method of Cochran and Cox (1959).

Results and Discussion

The predominant weeds encountered in the experimental plot were *Echinochloacolona*(25 %), *Eleusineindica*(10 %), *Brachiaria ramose* (6 %), *Digitariasanguinalis*(7 %),*Eragrostis japonica* (4 %) among the monocot weeds while *Celosia argentia*(32 %), *Lindernia ciliate* (6 %), *Eclipta alba* (5 %) and *Trianthemamonogyna*(5 %) were among the dicot weeds at crop growth stages of 45 DAS. Singh *et al*. (2004) also reported that soybean fields are infested predominantly with *Cyperusrotundus, Echinochloacolona,Commelinabenghalensis*and *Celosia argentea*.Other weeds infesting soybean crop foundwere *Cucumistrigosus, Eleusineindica, Cleomeviscosa, Dactylocteniumaegyptium, Digitariasanguinalis, Digeraarvensis, Partheniumhysterophorus, Trianthemamonogyna, Ecliptaalba*and *Brachiaria*spp. Their occurrence andintensity varied in different treatments.Intensity of weeds varied due to applicationof different herbicide and manual weeding plots at 45 DAS. The highestweed infestation was recorded in control(weedy check) plot.

Weed population

The total weed density wassignificantly reduced by the application ofevaluated herbicides, either applied as preorpost-emergence, at 45 DAS crop growth stages. Weed populations in all the herbicidal treatmentssignificantly reduced over weed check. Lowest weed population at 45 DASwas recorded with weed free plot (**Table 1**).Among the herbicides, tank mixture of chlorimuron ethyl + Imazethapyr @ 10 + 75 g a.i. ha^{-1} POE recorded lowest weed population of monocots and dicots (3.78 and 3.32 m^{-2}) being at parwith Chlorimuron ethyl + Fenoxaprop-p-ethyl @ 10 + 70 g a. i. ha^{-1} POE (5.80 and 4.28 m^{-2}) in the pooled analysis.Tiwari *et al.,* (2007) also reported that haloxyfop application in soybean as post-emergence gave effectivecontrol over the monocots weeds.

Table 1 Effect of weed management practices on weed population of monocots and dicots at 45 DAS

Treatments	**Weed population (m^{-2})**					
	Monocots			**Dicots**		
	2008	**2009**	**Pooled**	**2008**	**2009**	**Pooled**
Weedy check	51.45	44.95	48.20	40.85	41.87	41.36
Weed free	02.73	01.51	02.12	01.46	01.70	01.58
Pendimethalin 30EC @ 1.0 kg ha^{-1} PE	22.55	21.73	22.14	18.90	20.10	19.50
Chlorimuron ethyl @10 g a.i. ha^{-1} POE	37.20	34.96	36.08	28.56	29.50	29.03
Fenoxaprop-p-ethyl @ 70 g a. i. ha^{-1} POE	19.07	18.43	18.75	23.04	23.90	23.47
Quizalofop-ethyl @ 50 g a. i. ha^{-1} POE	15.78	14.70	15.24	19.74	19.98	19.86
Imazethapyr @ 75 g a. i. ha^{-1} POE	11.23	10.81	11.02	13.20	13.64	13.42
Chlorimuron ethyl + Fenoxaprop-p-ethyl @ 10 + 70 g a. i. ha^{-1} POE	05.80	05.09	05.44	04.07	04.49	04.28
Chlorimuron ethyl + Quizalofop-ethyl @ 10 + 50 g a.i. ha^{-1} POE	09.56	09.34	09.45	08.40	09.56	08.98
Chlorimuron ethyl + Imazethapyr @ 10 + 75 g a.i. ha^{-1} POE	04.01	03.55	03.78	03.23	03.41	03.32
SEm$\pm$	1.08	1.30	1.09	1.34	1.38	1.25
C. D. at 5%	3.25	3.90	3.28	4.03	4.20	3.76

Dry matter accumulation

In general, the dry matter accumulation of weeds at 45 DAS increased with increasing the weed density as well as variation of weed species and their growth. The highest weed dry matter was achieved under weedy check (**Table 2**) and the lowest was recorded in weed-free plot. Among the herbicidal treatments, application of, tank mixture Chlorimuron ethyl + Imazethapyr @ 10 + 75 g a.i. ha^{-1} POE gave lowest weed dry matter of monocots and dicots (8.99 and 8.04 g m^{-2}) at 45 DAS as compared to application of sole herbicides and mixture as PE or POE in soybean.

However, it was found at par with application of tank mixture Chlorimuron ethyl + Fenoxaprop-p-ethyl @ 10 + 70 g a. i. ha^{-1} POE (9.56 and 8.45 g m^{-2}) in the pooled analysis. The results are in line with the findings of Grichar *et al.* (2006), whoreported that application of diclosulamalone as pre-plant incorporation, or preemergenceor post-emergence controlled*Palmer amaranth* and pitted morninggloryg reater than 81 per cent, devil's-claw atleast 80 per cent, *Texas panicum*33 to 97per cent, and yellow nutsedge 48 to 88per cent four weeks after treatment.

Table 2 Effect of weed management practices on weed dry matter accumulation monocots and dicots at 45 DAS

Treatments	**Weed dry matter accumulation (g m^{-2})**					
	Monocots			**Dicots**		
	2008	**2009**	**Pooled**	**2008**	**2009**	**Pooled**
Weedy check	52.80	51.68	52.24	48.04	46.96	47.50
Weed free	3.95	3.65	3.80	2.60	2.48	2.54
Pendimethalin 30EC @ 1.0 kg ha^{-1} PE	28.74	27.28	28.01	24.10	23.10	23.60
Chlorimuron ethyl @10 g a.i. ha^{-1} POE	40.86	39.38	40.12	35.21	34.13	34.67
Fenoxaprop-p-ethyl @ 70 g a. i. ha^{-1} POE	23.20	22.58	22.89	30.76	28.84	29.80
Quizalofop-ethyl @ 50 g a. i. ha^{-1} POE	20.76	20.08	20.42	25.80	25.04	25.42
Imazethapyr @ 75 g a. i. ha^{-1} POE	14.98	14.22	14.60	18.30	17.72	18.01
Chlorimuron ethyl + Fenoxaprop-p-ethyl @ 10 + 70 g a. i. ha^{-1} POE	9.87	9.25	9.56	8.64	8.26	8.45
Chlorimuron ethyl + Quizalofop-ethyl @ 10 + 50 g a.i. ha^{-1} POE	13.42	12.98	13.20	13.05	12.73	12.89
Chlorimuron ethyl + Imazethapyr @ 10 + 75 g a.i. ha^{-1} POE	9.20	8.78	8.99	8.12	7.96	8.04
SEm±	1.06	1.05	0.97	1.37	1.35	1.25
C. D. at 5%	3.20	3.16	2.91	4.10	4.05	3.75

Weed control efficiency

The highest weed control efficiency (86 %) was achieved by weed-free plots followed byapplication of tank mixture, Chlorimuron ethyl + Imazethapyr @ 10 + 75 g a.i. ha^{-1} POE (80.06%) and Chlorimuron ethyl + Fenoxaprop-p-ethyl @ 10 + 70 g a. i. ha^{-1} POE (77.68%) as post-emergence. Amongthe herbicidal treatments, sole application of Pendimethalin 30EC @ 1.0 kg ha^{-1} PErecorded thelowest weed control efficiency (39.20%) in the pooled analysis (**Table 3**).

Table 3 Effect of weed management practices on weed control efficiency at 45 DAS

Treatments	**Weed control efficiency (%)**		
	2008	**2009**	**Pooled**
Weedy check	0.0	0.0	0.0
Weed free	86.95	85.05	86.00
Pendimethalin 30EC @ 1.0 kg ha^{-1} PE	40.03	38.37	39.20
Chlorimuron ethyl @10 g a.i. ha^{-1} POE	52.80	51.66	52.23
Fenoxaprop-p-ethyl @ 70 g a. i. ha^{-1} POE	56.97	55.96	56.47
Quizalofop-ethyl @ 50 g a. i. ha^{-1} POE	58.23	57.85	58.04
Imazethapyr @ 75 g a. i. ha^{-1} POE	61.50	61.10	61.30
Chlorimuron ethyl + Fenoxaprop-p-ethyl @ 10 + 70 g a. i. ha^{-1} POE	78.08	77.28	77.68
Chlorimuron ethyl + Quizalofop-ethyl @ 10 + 50 g a.i. ha^{-1} POE	66.13	65.37	65.75
Chlorimuron ethyl + Imazethapyr @ 10 + 75 g a.i. ha^{-1} POE	81.45	78.67	80.06
SEm±	3.37	3.39	3.11
C. D. at 5%	10.08	10.16	9.35

Yield

Application of tank mixture of chemicals produced more seed yield obviously due to favourable environment result of effective management of both mono- and di-cot weeds. Herbicidal treatments have better effect on yield over weedy check (**Table 4**). Among the herbicides, application of Chlorimuron ethyl + Imazethapyr @ 10 + 75 g a.i. ha^{-1} POE gave significantly higher seed yield (2187 kg ha^{-1}), stover yield (2690 kg ha^{-1}) and harvest index (44.84 %) over weedy check, application of Pendimethalin 30EC @ 1.0 kg ha^{-1} PE, Chlorimuron ethyl @10 g a.i. ha^{-1} POE, Fenoxaprop-p-ethyl @ 70 g a. i. ha^{-1} POE, Quizalofop-ethyl @ 50 g a. i. ha^{-1} POE, Imazethapyr @ 75 g a. i. ha^{-1} POE and Chlorimuron ethyl + Quizalofop-ethyl @ 10 + 50 g a.i. ha^{-1} POE, respectively. However, it was found at per with application of tank mixture, Chlorimuron ethyl + Fenoxaprop-p-ethyl @ 10 + 70 g a. i. ha^{-1} POE and weed free plot (2168 and 2317 kg ha^{-1}), (2696 and 2460 kg ha^{-1}) and (44.57 and 48.49 %) in the pooled analysis.These results are in close conformity with Tiwari and Mathew (2002), Joshi *et al*. (1998) and Vyas *et al*. (2004) also reported similar findings.

Table 4 Effect of weed management practices on yield and harvest index of soybean

Treatments	Seed yield (kg ha^{-1})			Stover yield (kg ha^{-1})			Harvest Index (%)		
	2008	2009	Pooled	2008	2009	Pooled	2008	2009	Pooled
Weedy check	1178	1026	1102	2405	2341	2373	32.88	30.47	31.71
Weed free	2405	2229	2317	2532	2388	2460	48.71	48.27	48.49
Pendimethalin 30EC @ 1.0 kg ha^{-1} PE	1529	1399	1464	2414	2232	2323	38.78	38.53	38.66
Chlorimuron ethyl @10 g a.i. ha^{-1} POE	1687	1473	1580	2505	2287	2396	40.24	39.18	39.74
Fenoxaprop-p-ethyl @ 70 g a. i. ha^{-1} POE	1602	1442	1522	2480	2240	2360	39.25	39.16	39.21
Quizalofop-ethyl @ 50 g a. i. ha^{-1} POE	1635	1455	1545	2454	2242	2384	39.99	39.36	39.32
Imazethapyr @ 75 g a. i. ha^{-1} POE	1708	1502	1605	2458	2323	2391	40.39	37.27	38.83
Chlorimuron ethyl + Fenoxaprop-p-ethyl @ 10 + 70 g a. i. ha^{-1} POE	2229	2107	2168	2780	2612	2696	44.50	44.65	44.57
Chlorimuron ethyl + Quizalofop-ethyl @ 10 + 50 g a.i. ha^{-1} POE	1906	1722	1814	2723	2637	2680	41.18	39.50	40.36
Chlorimuron ethyl + Imazethapyr @ 10 + 75 g a.i. ha^{-1} POE	2301	2073	2187	2778	2602	2690	45.30	44.34	44.84
SEm$\pm$	95	102	91	65	71	63	1.06	1.17	1.02
C. D. at 5%	280	298	272	201	217	188	3.12	3.45	3.07

Economics

Application of tank mixture of chemicals gave higher monetary return obviously due to favourable environment as a result of effective management of both mono- and di-cot weeds. Herbicidal treatments have better effect on monetary return over weedy check (**Table 5**). Among the herbicides, application of Chlorimuron ethyl + Imazethapyr @ 10 + 75 g a.i. ha^{-1} POE gave significantly higher net return (Rs. 48438/-) and B:C ratio (2.20) over weedy check, application of Pendimethalin 30EC @ 1.0 kg ha^{-1} PE, Chlorimuron ethyl @10 g a.i. ha^{-1} POE, Fenoxaprop-p-ethyl @ 70 g a. i. ha^{-1} POE, Quizalofop-ethyl @ 50 g a. i. ha^{-1} POE, Imazethapyr @ 75 g a. i. ha^{-1} POE and Chlorimuron ethyl + Quizalofop-ethyl @ 10 + 50 g a.i. ha^{-1} POE, respectively. However, it was found at per with application of tank mixture, Chlorimuron ethyl + Fenoxaprop-p-ethyl @ 10 + 70 g a. i. ha^{-1} POE and weed free plot (Rs. 47908 and 50259/- ha^{-1}) and (2.18 and 2.09)in the pooled analysis.Theseresults are in close conformity with Tiwariand Mathew (2002).Joshi *et al*. (1998) and Vyas *et al*. (2004) also reported similar findings.

Table 5 Effect of weed management practices on economics of soybean

Treatments	Net return (Rs. ha^{-1})			B:C ratio		
	2008	2009	Pooled	2008	2009	Pooled
Weedy check	18745	16290	17518	0.99	0.86	0.92
Weed free	50682	49835	50259	2.11	2.08	2.09
Pendimethalin 30EC @ 1.0 kg ha^{-1} PE	27144	25972	26558	1.28	1.23	1.26
Chlorimuron ethyl @10 g a.i. ha^{-1} POE	32115	28537	30326	1.53	1.36	1.44
Fenoxaprop-p-ethyl @ 70 g a. i. ha^{-1} POE	29440	27396	28418	1.40	1.30	1.35
Quizalofop-ethyl @ 50 g a. i. ha^{-1} POE	30404	27814	29109	1.44	1.32	1.38
Imazethapyr @ 75 g a. i. ha^{-1} POE	32598	29403	31001	1.54	1.39	1.47
Chlorimuron ethyl + Fenoxaprop-p-ethyl @ 10 + 70 g a. i. ha^{-1} POE	47650	48167	47908	2.17	2.19	2.18
Chlorimuron ethyl + Quizalofop-ethyl @ 10 + 50 g a.i. ha^{-1} POE	37803	35773	36788	1.71	1.62	1.66
Chlorimuron ethyl + Imazethapyr @ 10 + 75 g a.i. ha^{-1} POE	49808	47068	48438	2.26	2.14	2.20
SEm$\pm$	2621	2835	2510	0.14	0.15	0.13
C. D. at 5%	7850	8500	7529	0.39	0.45	0.40

Conclusion

On the basis of pooled results oftwo years, it may be concluded thatbroad and narrow leaved weeds wereeffectively controlled and higher soybeanyield and monetary returns could beobtained by post-emergence applicationof Chlorimuron ethyl + Imazethapyr @ 10 + 75 g a.i. ha^{-1} POE mixtur

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