International Journal of Agricultural Sciences
Volume **10** | Issue 1| January, 2014 | 42-48

RESEARCH PAPER

Bioefficacy of post emergence herbicides for weed control in soybean [*Glycine max* (L.) Merrill] under Chhattisgarh conditions

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Abstract : A field experiment was conducted at the Research cum Instructional Farm, Department of Agronomy, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.), during *Kharif* season of 2010, to find out the bioefficacy of post emergence herbicides for weed control in soybean [*Glycine max* (L.) Merrill] under Chhattisgarh conditions. All the weed management practices were found effective in controlling the weeds. The maximum total and species wise weed density of *Ecinocloa colonum*, *Cynodon dactylon*, *Bracharia ramose, Digitaria sanguinalis, Dinebra retroflexa*, *Cyperus rotandus*, *Alternanthra sessilis*, *Parthenium hysterophorus* and *Euphorbia geniculata* were observed under weedy check (T_{13}) and minimum were observed under treatment farmer's practice (hand weeding twice) at 20 DAS and 40 DAS (T_{12}). Highest weed control efficiency and seed yield was noted under treatment hand weeding twice at 20 DAS and 40 DAS (T_{12}) and lowest weed control efficiency was observed in weedy check (T_{13}). The economic returns in terms of net returns, additional return over weedy check and B:C ratio were maximum under hoeing twice (by wheel hoe) at 15 DAS and 35 DAS (T_{11}) followed by farmer's practice (hand weeding twice) at 20 DAS and 40 DAS (T_{12}), imazethapyr 10 SL @ 100 g ha^{-1} fb hoeing (by wheel hoe) at 35 DAS (T_{10}) and imazethapyr 10 SL @ 100 g ha^{-1} fb HW at 35 DAS (T_9).

Key Words : Herbicides, Weed control, Soybean

View Point Article : Toppo, Anuj Roshan, Dewangan, Devendra Kumar and Sahu, E. (2014). Bioefficacy of post emergence herbicides for weed control in soybean [*Glycine max* (L.) Merrill] under Chhattisgarh conditions. *Internat. J. agric. Sci.*, **10** (1): 42-48.

Article History : Received : 23.04.2013**; Revised :** 08.09.2013**; Accepted :** 06.10.2013

INTRODUCTION

The soybean grown in rainy season faces severe weed competition due to competition stress of grasses, sedges and broadleaf weeds and the yield reduction varying from 35 to 50 per cent (Tiwari and Kurchania, 1990) depending on type of weeds, intensity and duration of crop-weed competition during crop season. Most prominent weed species found in soybean are *Echinochloa crusgalli, Cynodon dactylon, Corchorus* spp., *Cyperus rotundus, Euphorbia* spp., *Commelina benghalensis, Parthenium hysterophorus, Setaria glauca, Eclipta alba, Phyllanthus niruri, Acalypha indica, Trianthema portulacastrum*, and *Alysicarpus rugosus* (Behera *et al.*, 2005). In soybean the weed flora as observed from the unweeded control plots consist of 58% sedges, 32% broad-leaved weeds and 10% grasses. Among the sedges, *Cyperus rotundus*, the broad-leaved weeds like *Trianthema portulacastrum, Digera arvensis, Amaranthus viridis* and *Phyllanthus niruri* and the grasses like *Acrachne racemosa, Dactyloctenium aegyptium, Digitaria sanguinalis, Eragrostis pilosa* and *Commelina benghalensis* were mostly found in soybean (Kumar and Das, 2008).

Weed competition in soybean at early stage of crop growth is critical. The critical period of crop-weed competition in soybean is reported to be first 45 days after sowing (Prabhakaran *et al.*, 1992). Mostly the farmers are using pre-plant incorporated and pre-emergence herbicides for weed control in soybean, but their efficacy are reduced by various climatic and edaphic factors. Hand weeding is a

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traditional and effective method of weed control, but untimely and continuous rains as well as unavailability of labour at peak time are main limitations of manual weeding. The only alternative that needs to be explored is the use of post-emergence herbicides. The screening of such herbicides in soybean reveals their efficiency against either monocotyledonous or dicotyledonous weeds. Hence, their mixtures may broaden the window of weed management by broad-spectrum weed control. Till now, no systematic work has been made in Chhattisgarh on post-emergence herbicides and their integration with cultural practices in soybean. In view of above facts, the present investigation was undertaken.

MATERIAL AND METHODS

The present experiment was carried out at Research cum Instructional Farm, Department of Agronomy, IGKV, Raipur (C.G.) during *Kharif* season of 2010. The experiment was conducted in Randomized Block Design (RBD). Soybean variety 'JS-335' (Jawahar Soybean-335) was grown as a test crop. The crop was fertilized with 20:60:30 kg $N:P_2O_5:K_2O$ ha^{-1}, respectively, was applied through urea, single super phosphate (SSP) and muriate of potash (MOP) as basal in rows uniformly to each plot. The treatment comprised of thirteen integrated weed management practices, *viz*., T_1- quizalofop ethyl 10 EC @ 37.5 g ha^{-1}, T_2- chlorimuron ethyl 25 WP @ 9 g ha^{-1}, T_3- chlorimuron ethyl 25 WP @ 9 g ha^{-1} + surfactant @ 0.2%, T_4- quizalofop ethyl 10 EC @ 37.5 g ha^{-1} + chlorimuron ethyl 25 WP @ 9 g ha^{-1}, T_5- quizalofop ethyl 10 EC @ 37.5 g ha^{-1} + chlorimuron ethyl 25 WP @ 9 g ha^{-1} + surfactant @ 0.2%, T_6- quizalofop ethyl 10 EC @ 37.5 g ha^{-1} + chlorimuron ethyl 25 WP @ 9 g ha^{-1} + surfactant @ 0.2% fb HW at 35 DAS, T_7- imazethapyr 10 SL @ 100 g ha^{-1}, T_8- imazethapyr 10 SL @ 100 g ha^{-1} + chlorimuron ethyl 25 WP @ 9 g ha^{-1}, T_9- imazethapyr 10 SL @ 100 g ha^{-1} fb HW at 35 DAS, T_{10}- imazethapyr 10 SL @ 100 g ha^{-1} fb hoeing (by wheel hoe) at 35 DAS, T_{11}- hoeing twice (by wheel hoe) at 15 DAS and 35 DAS, T_{12}- farmer's practice (hand weeding twice) at 20 DAS and 40 DAS, T_{13}- control (weedy check). Soybean variety 'JS-335' was sown as a test crop on July 06^{th}, 2010. Sowing was done with a seed-rate of 75 kg ha^{-1} at a spacing of 30 x 10 cm. the crop was harvested on October 27^{th}, 2010. Most prominent weed species found in soybean are *Echinochloa crusgalli, Cynodon dactylon, Corchorus* spp., *Cyperus rotundus, Euphorbia* spp., *Commelina benghalensis, Parthenium hysterophorus, Setaria glauca, Eclipta alba, Phyllanthus niruri, Acalypha indica, Trianthema portulacastrum,* and *Alysicarpus rugosus* (Behera *et al.*, 2005).

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Effect on weeds:

Weedy check (T_{13}) resulted significantly maximum density of weed species namely *Ecinocloa colonum*, *Cynodon dactylon*, *Bracharia ramose*, *Digitaria sanguinalis*, *Dinebra retroflexa* and *Cyperus rotandus* at 45 DAS, however, it was at par with treatment chlorimuron ethyl 25 WP @ 9 g ha^{-1} (T_2) and chlorimuron ethyl 25 WP @ 9 g ha^{-1} + surfactant @ 0.2% (T_3) but, the weed species namely *Alternanthra sessilis*, *Parthenium hysterophorus* and *Euphorbia geniculata* were observed significantly maximum density under weedy check (T_{13}), however, it was at par with treatment quizalofop ethyl 10 EC @ 37.5 g ha^{-1} (T_1). Significantly minimum densities of all the species were observed under treatment farmer's practice (hand weeding twice) at 20 DAS and 40 DAS (T_{12}), throughout the period of investigation. The data on species wise weed density are presented in Table 2. Density of total weeds was significantly maximum under the weedy check and significantly minimum density observed under treatment farmer's practice (two hand weeding) at 20 DAS and 40 DAS, throughout the period of investigation. This was because no any weed management practices was applied to control weeds which freely proliferated and compete with the crop for available nutrient, moisture and sunlight resulting in reduction of crop yield. Similar results were observed by Prabhakaran *et al.* (1992) and Chavan *et al.* (1990)

As far as dry matter production by total species and other weed species is concerned, the significantly maximum weed dry matter observed under weedy check (T_{13}) and significantly minimum production of dry matter under treatment farmer's practice (hand weeding twice) at 20 DAS and 40 DAS (T_{12}), throughout the period of investigation (Patra, 1987, Mandloi *et al.*, 2000).

Weed species namely *Ecinocloa colonum*, *Cynodon dactylon*, *Bracharia ramose*, *Digitaria sanguinalis*, *Dinebra retroflexa* and *Cyperus rotandus* produced significantly maximum dry matter under weedy check (T_{13}), however it was at par with treatment chlorimuron ethyl 25 WP @ 9 g ha^{-1} and chlorimuron ethyl 25 WP @ 9 g ha^{-1} + surfactant @ 0.2% but, the weed species namely *Alternanthra sessilis*, *Parthenium hysterophorus* and *Euphorbia geniculata* were observed significantly maximum production of dry matter under weedy check (T_{13}) however, it was at par with treatment quizalofop ethyl 10 EC @ 37.5 g ha^{-1} (T_1). Significantly minimum production of dry matter by all the species were observed under treatment farmer's practice (hand weeding twice) at 20 DAS and 40 DAS, throughout the period of investigation.

Weed control efficiency based on weed biomass numerically highest under treatment farmer's practice (hand weeding twice) at 20 DAS and 40 DAS (T_{12}) followed by imazethapyr 10 SL @ 100 g ha^{-1} fb HW at 35 DAS (T_9) and quizalofop ethyl 10 EC @ 37.5 g ha^{-1} + chlorimuron ethyl 25% WP @ 9 g ha^{-1} + surfactant @ 0.2% fb HW at 35 DAS (T_6). Lowest weed control efficiency was observed in weedy check (T_{13}) throughout the crop growth period. These results might be due to owing to less weed density and production of dry matter by weeds in the treated plots. Similar results were observed by Pramila *et al.* (2004) and Rajput and Kushwah (2004).

Effect on crop:

Lower weed population and higher weed control efficiency also resulted in higher grain yield. The maximum seed yield was produced by farmer's practice (hand weeding twice) at 20 DAS and 40 DAS (T_{12}), which was found comparable with treatment hoeing twice (by wheel hoe) at 15 DAS and 35 DAS (T_{11}), imazethapyr 10 SL @ 100 g ha^{-1} fb hoeing (by wheel hoe) at 35 DAS (T_{10}) and imazethapyr 10 SL @ 100 g ha^{-1} fb HW at 35 DAS (T_9), whereas significantly minimum seed yield observed under weedy check (T_{13}). Similar findings were also reported by Kumar *et al.* (2001), Dubey *et al.* (2000) and Mandloi *et al.* (2000) (Table 1).

The significantly higher harvest index was observed under treatment farmer's practice (hand weeding twice) at 20 DAS and 40 DAS (T_{12}) which was found comparable with treatments hoeing twice (by wheel hoe) at 15 DAS and 35 DAS (T_{11}), imazethapyr 10 SL @ 100 g ha^{-1} fb hoeing (by wheel hoe) at 35 DAS (T_{10}), imazethapyr 10 SL @ 100 g ha^{-1} fb HW at 35 DAS (T_9), imazethapyr 10 SL @ 100 g ha^{-1} + chlorimuron ethyl 25 WP @ 9 g ha^{-1}, imazethapyr 10 SL @ 100 g ha^{-1}, quizalofop ethyl 10 EC @ 37.5 g ha^{-1} + chlorimuron ethyl 25 WP @ 9 g ha^{-1} + surfactant @ 0.2% fb HW at 35 DAS (T_6) whereas, significantly lower harvest index was observed under weedy check (T_{13}), due to higher economic yield because of low crop-weed competition. The

Table 1 : Total weed density (m^{-1}), Total weed dry matter production (g m^{-1}), WCE (%), seed yield (q ha^{-1}) and harvest index (%) at different intervals

	Integrated weed management practices	Dose (a.i.ha^{-1})	Time of application	Total weed density		Total weed dry matter production		Weed control efficiency (%)		Seed yield (q ha^{-1})	Harvest index (%)
				45 DAS	At harvest	45 DAS	At harvest	45 DAS	At harvest		
T_1	Quizalofop ethyl 10 EC	37.5g	15 DAS	12.87 (165.09)	12.46 (154.74)	8.69 (75.00)	18.31 (335.46)	57.67	33.76	14.40	40.42
T_2	Chlorimuron ethyl 25 WP	9g	15 DAS	15.21 (230.87)	14.63 (213.66)	11.90 (141.30)	18.24 (332.66)	20.25	34.31	10.30	37.40
T_3	Chlorimuron ethyl 25 WP + Surfactant	9g + 0.2%	15 DAS	15.13 (228.85)	14.55 (211.52)	11.77 (138.21)	17.91 (320.48)	21.99	36.72	10.53	37.39
T_4	Quizalofop ethyl 10 EC + Chlorimuron ethyl 25 WP	37.5g + 9g	15 DAS	10.62 (112.39)	10.00 (99.48)	6.77 (45.40)	13.53 (182.51)	74.38	63.96	15.25	40.91
T_5	Quizalofop ethyl 10 EC + Chlorimuron ethyl 25 WP + Surfactant	37.5g + 9g+ 0.2%	15 DAS	10.66 (113.32)	10.32 (106.11)	6.76 (45.22)	13.43 (180.13)	74.48	64.43	15.42	40.84
T_6	Quizalofop ethyl 10 EC + Chlorimuron ethyl 25 WP + Surfactant fb HW	37.5g + 9g+ 0.2%	15 DAS fb 35 DAS	6.09 (36.97)	6.46 (41.74)	3.78 (13.85)	8.60 (73.58)	92.18	85.47	17.66	42.72
T_7	Imazethapyr 10 SL	100g	15 DAS	10.32 (106.15)	10.02 (100.00)	6.29 (39.06)	13.04 (169.83)	77.95	66.46	16.56	42.86
T_8	Imazethapyr 10 SL + Chlorimuron ethyl 25 WP	100g + 9g	15 DAS	9.91 (97.66)	9.80 (95.51)	5.99 (35.49)	12.86 (164.90)	79.97	67.44	16.76	42.33
T_9	Imazethapyr 10 SL fb HW	100g	15 DAS fb 35 DAS	6.15 (37.92)	6.48 (41.94)	3.67 (13.02)	8.68 (74.97)	92.65	85.20	19.88	43.11
T_{10}	Imazethapyr 10 SL fb Hoeing (by wheel hoe)	100g	15 DAS fb 35 DAS	9.20 (84.55)	8.98 (80.92)	5.54 (30.19)	12.17 (148.32)	82.96	70.71	19.56	43.16
T_{11}	Hoeing (by wheel hoe)	-	15 DAS and 35DAS	9.78 (95.95)	9.45 (89.01)	6.18 (37.68)	12.06 (145.23)	78.73	71.32	20.81	44.57
T_{12}	Farmer's practice (hand weeding twice)	-	20 DAS and 40DAS	5.58 (31.09)	6.03 (36.12)	3.14 (9.38)	7.85 (61.32)	94.71	87.89	21.13	44.90
T_{13}	Control (Weedy check)	-	-	17.28	16.66 (277.25)	13.32 (177.18)	22.51 (506.42)	0.00	0.00	9.15	34.45
S.E.±				0.44	0.36	0.19	0.38	-	-	1.28	-
C.D. (P=0.05)				1.29	1.06	0.55	1.12	-	-	3.74	-

Table 4 : Herbicidal phytotoxicity effects on soybean at 3 and 9 DAHT as influenced by integrated weed management practices

	Integrated weed management practices	Dose (a.i. ha^{-1})	Time of application	Yellowing		Epinasty		Hyponasty		Necrosis		Scorching		Others	
				3 DAHT	9 DAHT	3 DAHT	9 DAHT	3 DAHT	9 DAHT	3 DAHT	9 DAHT	3 DAHT	9 DAHT	3 DAHT	9 DAHT
T_1	Quizalofop ethyl 10 EC	37.5g	15 DAS	0	0	0	0	0	0	0	0	0	0	0	0
T_2	Chlorimuron ethyl 25 WP	9g	15 DAS	0	0	0	0	0	0	0	0	0	0	0	0
T_3	Chlorimuron ethyl 25 WP + Surfactant	9g + 0.2%	15 DAS	0	0	0	0	0	0	0	0	0	0	0	0
T_4	Quizalofop ethyl 10 EC + Chlorimuron ethyl 25 WP	37.5g + 9g	15 DAS	0	0	0	0	0	0	0	0	0	0	0	0
T_5	Quizalofop ethyl 10 EC + Chlorimuron ethyl 25 WP + Surfactant	37.5g + 9g + 0.2%	15 DAS	0	0	0	0	0	0	0	0	0	0	0	0
T_6	Quizalofop ethyl 10 EC + Chlorimuron ethyl 25 WP + Surfactant fb HW	37.5g + 9g + 0.2%	15 DAS fb 35DAS	0	0	0	0	0	0	0	0	0	0	0	0
T_7	Imazethapyr 10 SL	100g	15 DAS	0	0	0	0	0	0	0	0	0	0	0	0
T_8	Imazethapyr 10SL + Chlorimuron ethyl 25 WP	100g + 9g	15 DAS	0	0	0	0	0	0	0	0	0	0	0	0
T_9	Imazethapyr 10 SL fb HW	100g	15 DAS fb 35DAS	0	0	0	0	0	0	0	0	0	0	0	0
T_{10}	Imazethapyr 10 SL fb Hoeing (by wheel hoe)	100g	15 DAS fb 35DAS	0	0	0	0	0	0	0	0	0	0	0	0
T_{11}	Hoeing (by wheel hoe)	-	15 DAS and 35DAS	0	0	0	0	0	0	0	0	0	0	0	0
T_{12}	Farmer's practice (hand weeding twice)	-	20 DAS and 40 DAS	0	0	0	0	0	0	0	0	0	0	0	0
T_{13}	Control (Weedy check)	-	-	0	0	0	0	0	0	0	0	0	0	0	0

Table 5: Economics of soybean as affected by integrated weed management practices

	Integrated weed management practices	Dose (a.i. ha^{-1})	Cost of cultivation (Rs ha^{-1})			Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	Benefit : Cost ratio
			Fixed cost	Treatment cost	Total cost			
T_1	Quizalofop ethyl 10 EC	37.5g	13048	1390	14438	21072	6634	0.46
T_2	Chlorimuron 25 WP	9g	13048	706	13754	15175	1421	0.10
T_3	Chlorimuron 25 WP + Surfactant	9g + 0.2%	13048	986	14034	15515	1481	0.11
T_4	Quizalofop ethyl 10 EC + Chlorimuron 25 WP	37.5g + 9g	13048	1846	14894	22293	7399	0.50
T_5	Quizalofop ethyl 10 EC + Chlorimuron 25 WP + Surfactant	37.5g+9g+0.2%	13048	2126	15174	22547	7373	0.49
T_6	Quizalofop ethyl 10 EC+Chlorimuron 25 WP+Surfactant fb HW at 35 DAS	37.5g+9g+0.2%	13048	4001	17049	25729	8680	0.51
T_7	Imazethapyr 10 SL	100g	13048	2030	15078	24121	9043	0.60
T_8	Imazethapyr 10 SL + Chlorimuron 25 WP	100g + 9g	13048	2486	15534	24408	8874	0.57
T_9	Imazethapyr 10 SL fb HW at 35 DAS	100g	13048	3905	16953	28875	11922	0.70
T_{10}	Imazethapyr 10 SL fb Hoeing (by wheel hoe) at 35 DAS	100g	13048	3580	16628	28449	11821	0.71
T_{11}	Hoeing (by wheel hoe) at 15 DAS and 35DAS	-	13048	3100	16148	30189	14041	0.87
T_{12}	Farmer's practice (hand weeding twice) at 20 DAS and 40 DAS	-	13048	3750	16798	30637	13839	0.82
T_{13}	Control (Weedy check)	-	13048	-	13048	13566	518	0.04

Marketable price: Seed = Rs 13900 t^{-1} and Stover yield = Rs 500 t^{-1}

lower harvest index was obtained in weedy check (T_{13}) due to lower seed yield and more crop-weed competition.

The effect of herbicidal phytotoxicity like yellowing, epinesty, hyponasty, necrosis and scorching etc. on soybean was observed at 3 and 9 days after herbicidal treatment (DAHT) and data are presented in Table 4. Data reveal that the crop was not affected by herbicidal phytotoxicity due to integrated weed management practices on soybean at initial stage of herbicide application *i.e.* 3 and 9 days after herbicide application. These results are in agreement with the findings of Bhattacharya *et al*. (1998), Foloni and Chitoffoleti (1998), Raskar and Bhoi (2002) and Singh *et al.* (2004). This result might be due to optimal and timely application of herbicides like, quizalofop-ethyl, chlorimuron-ethyl and imazethapyr individual and combined with cultural and mechanical control.

Economics:

The data on cost of cultivation, gross return, net return and benefit cost ratio from soybean as affected by integrated weed management practices are presented in Table 5. The maximum cost of cultivation was recorded under treatment quizalofop ethyl 10 EC @ 37.5 g ha^{-1} + chlorimuron ethyl 25 WP @ 9 g ha^{-1} + surfactant @ 0.2% fb HW at 35 DAS (T_6) and minimum was noted under weedy check (T_{13}). The highest gross return was obtained under treatment farmer's practice (hand weeding twice) at 20 DAS and 40 DAS (T_{12}). It was followed by hoeing twice (by wheel hoe) at 15 DAS and 35 DAS (T_{11}), imazethapyr 10 SL @ 100 g ha^{-1} fb hoeing (by wheel hoe) at 35 DAS (T_{10}), imazethapyr 10 SL @ 100 g ha^{-1} fb HW at 35 DAS (T_9) and quizalofop ethyl 10 EC @ 37.5 g ha^{-1} + chlorimuron ethyl 25 WP @ 9 g ha^{-1} + surfactant @ 0.2% fb HW at 35 DAS (T_6). The lowest values were recorded under weedy check (T_{13}). The highest, net return and benefit cost of ratio were obtained under treatment hoeing twice (by wheel hoe) at 15 DAS and 35 DAS (T_{11}). It was followed by farmer's practice (hand weeding twice) at 20 DAS and 40 DAS (T_{12}), imazethapyr 10 SL @ 100 g ha^{-1} fb hoeing (by wheel hoe) at 35 DAS (T_{10}) and imazethapyr 10 SL @ 100 g ha^{-1} fb HW at 35 DAS (T_9). The lowest values were recorded under weedy check (T_{13}). Total dry matter production of a plant often reflects its potentiality for its biomass production. Whereas, mobilization forwards the seed development is an important factor for realization of economic yield and serves as the yardstick resulting in maximum grass return in for farmer's practice (hand weeding twice) at 20 DAS and 40 DAS, whereas hoeing twice (by wheel hoe) at 15 DAS and 35 DAS gave maximum net return and benefit cost ratio. This was due to lower cost of cultivation associated with higher seed yield than other herbicidal treatments. It is in conformity with the findings of Dhane *et al.* (2009) and Yadav *et al.* (2009).

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