E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; SP-7(9): 252-255
Received: 23-06-2024
Accepted: 02-08-2024

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Effect of pre-emergence herbicides on weed dynamics and productivity of soybean [*Glycine max* (L.) Merill]

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DOI: https://doi.org/10.33545/2618060X.2024.v7.i9Sd.1483

Abstract
Experiment on "Effect of pre-emergence herbicides on weed dynamics and productivity of soybean [*Glycine max* (L.) Merrill]" was conducted during kharif, 2023 at Instructional cum research farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh. Soil of experimental field was clayey (vertisols), neutral (pH 7.40), contained 0.45% soil organic carbon, and had low nitrogen (216 kg ha^{-1}), low phosphorus (13.02) and high potassium (373 kg ha^{-1}). Experiment was laid out in Randomized block design with 3 replication and 8 treatments. The yield attributes *viz*, number of pod $plant^{-1}$, pod length, seed index, seed yield, stover yield and harvest index were found maximum under hand weeding twice (20 and 40 DAS) followed by PoE of imezathapyr (10%SL) @ 75 a.i. g ha^{-1}. Minimum values of above characters were recorded in weedy check. Experimental field was dominated with *Bracharia eruciformis, Cynodon dactylon, Echinochloa colona* and *Merremia emarginata*. In hand weeding twice (20 and 40 DAS) minimum total weed density and weed dry weight was recorded, it was followed by PoE of imezathapyr (10%SL) @ 75 a.i. g ha^{-1}**.** Highest Weed control efficiency was found in hand weeding twice (20 and 40 DAS) followed by PoE of imezathapyr (10%SL) @ 75 a.i. g $ha^{-1}$and lowest in weedy check.

Keywords: Pre emergence, herbicide, soybean, weed control efficiency, weed index, productivity

Introduction
India is ranked 5th in production and 4th in area among the nations that cultivate soybean. Madhya Pradesh, Maharashtra, Rajasthan, Karnataka, and Telangana are the principal soybean growing states. In Chhattisgarh soybean is grown on 75.12 thousand ha^{-1} of land in Chhattisgarh, with an average productivity of 1105 kg ha^{-1} where it produced 83.01 thousand tonnes annually. The districts that are significant for soybean cultivation include Kabirdham, Bemetara, Rajnandgaon, Mungeli and Raipur. The ecological conditions of the state are congenial for cultivation of soybean but the yield is substantially low. One of the major reasons for the poor performance of soybean yield is inadequate weed control. The crop is mainly cultivated under kharif conditions and is infested with various grassy, sedges and broad leaved weeds which emerge simultaneously with the crop plants and compete for essential nutrients, space and moisture causing substantial loss in yield (30-80%) depending upon the type of weed flora and weed density (Kewat *et al.,* 1998: Kuruchania *et al.,* 2000 and Yaduraju, 2002) [4, 7, 17]. Soybean is most vulnerable to weed interference during its early growth stages (Watts *et al.,* 1997) [15]. The critical period of crop-weed competition in soybean is reported to be first 30 days after sowing (Swarnakar, 2010) [14].

The competition between weeds and crop for the nutrients, water, light and space are responsible for poor yields of soybean. The weed stress is mainly due to presence of annual grassy weeds *viz*., *Echinochloa colona, Echinochloa crusgalli, Cyperus rotundus, Cynodon dactylon, Cyperus iria, Dinebra retroflexaand* dicot weeds like *Phyllanthus niruri, Euphorbia spp., Commelina benghalensis, Eclipta alba.* (Sharma and Shrivastava, 2002) [11]. The traditional method of weed control i.e. hand weeding is expensive, tedious and time consuming (Yadav *et al*., 2009) [16]. Moreover, hand-weeding and mechanical weeding are more often difficult due to continuous rainfall and less availability of labourers at the critical stage of crop-weed competition. Use of herbicides not only improves crop yield but also makes available labour for other productive activities (Kurchania *et al.,* 1989) [6].

Single pre emergence herbicides however, are not sufficient to obtain complete weed control because of their selective killing. Hence wide spectrum new herbicides are required to control majority of weed flora in soybean crop. Mostly the farmers use pre-plant incorporated and pre-emergence herbicides for weed control in soybean, but their efficacy are reduced by various climatic and edaphic factors. The only substitude 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. A number of broad spectrum pre plant incorporated (Trifluralin, Pendimethalin), pre emergence (Diclosulam, Metribuzin, Sulfentrazone, Clomazone) and post emergence herbicides (Imazethapyr) are available for use in soybean. These herbicides can be used in fields with low weed pressure with least risk of crop yield loss. These herbicides are quite effective in controlling annual weeds during critical period of crop-weed competition.

Materials and Methods

The experiment was conducted at Instructional cum research farm, College of Agriculture, IGKV, Raipur, (C.G.) during *kharif* season, 2023. To study the relative performance of different herbicides on weed flora in soybean. The soil of the experimental field was characterized as clayey in texture, having neutral pH (7.40), moderate organic carbon status (0.45%), low nitrogen (216 kg ha^{-1}) low phosphorus (13.02) and high potassium (373 kg ha^{-1}). Soybean variety RSC 10-46 was sown on 10 July 2023 with spacing 45 × 10 cm and fertilizer use of 25:60:40 NPK kg/ha as basal and the crop was harvested on 2 November 2023. The total rainfall received during the crop growth period was 1236 mm. The experiment was laid out in Randomised block design (RBD) with three replications. The treatments comprised of eight weed management practices *viz.* T_1- Pre emergence application of pendimethalin (30%EC) @ 1000 a.i. g ha^{-1} T_2- Pre emergence application of diclosulam (84%WDG) @ 26 a.i. g ha^{-1} T_3- Pre emergence application of sulfentrazone(28%) + clomazone(30%)WP @ 350 g + 375 a.i. g ha^{-1} T_4- Pre emergence application of metribuzin (70%WP) @ 400 a.i. g ha^{-1} T_5- Post emergence application of imezathapyr (10%SL) @ 75 a.i. g ha^{-1} T_6- Pre emergence application of imezathapyr (10%SL) @ 75 a.i. g ha^{-1} T_7- Hand weeding twice (20 & 40 DAS) T_8- Weedy check. As per the treatments, pre emergence herbicides namely pendimethalin 30% EC, diclosulam 84% WDG, sulfentrazone 28% + clomazone 30% WP, metribuzin 70% WP, imezathapyr 10% SL were applied at 3 DAS. While imazethapyr 10% SL applied as post-emergence at 18 DAS. with the help of knap sack sprayer fitted with flat fan nozzle. All the pre-emergence herbicides were applied on the same day after sowing of crop seed and post emergence herbicides were applied at the 2-3 leaf stage (18 DAS). The data on weed density (no./m^2) and weed dry weight were assessed on the intensity and growth of weeds at 60 DAS and at harvest. The number of weeds in a quadrate of 0.25 m^2 were uprooted and cut close to the transition of root and shoot in each plot and collected for dry weight. The sample were first dried in the sun and kept in an oven at 70°C for 48 hours. The dried sample were weighed and expressed as dry weight (g/m^2). Square root transformation was done for weed density and weed dry weight by using the formula. Weed control efficiency (WCE) refers to the efficiency of treatment expressed in percent for controlling weeds in comparison to weedy check. Weed index refers to the reduction in the yield due to the presence of weeds in comparison with weedy free check.

Results and Discussion

Weed flora: The density of monocot weeds was much higher than that of dicot weeds throughout the crop growing season. Among monocot, the density of *Bracharia erusiformis, Cynodon dactylon, Echinochloa colona* and *Commelina benghalensis* and with respect to dicot *Merremia emarginata Parthenium hysterophorus, Phyllanthus niruri* and *Digeria arvensis* were predominant wees in the experimental plots. Similar finding were recorded in several previous studies reports by Shashidhar *et al*. (2020) [13] regarding weed flora existence in the experimental plots.

Weed density: Weed density at 60 DAS and 80 DAS was higher as compared to those recorded at 20 and 40 DAS irrespective of the species. The weed intensity of all species was significantly reduced by the application of herbicides either applied pre- or post-emergence at all stages (20, 40 and 60 DAS) of crop growth over the weedy check (Table 1). The results showed that hand weeding at 20 and 40 DAS was significantly better concerning control of different weed species. Imazethapyr was most effective in controlling the annual broadleaf weeds and some grasses. It was observed that the application of sulfentrazone 28% + clomazone 30% WP 0.725 kg/ha (RM) as pre emergence effectively controlled the sedge density. Herbicides initially inhibited the germination of weeds but later these dissipated and deactivated in the soil increasing the next flush of weeds subsequently. These results conformed with the findings of Mansoori *et al*. (2015) [8]. Many researchers (Krauz and Young 2003, Andhale and Kathmale 2019) [5, 1] have reported lower sedge densities in soybean with the use of herbicides like sulfentrazone 28% + clomazone 30% WP 0.725 kg/ha. Poornima *et al*. (2018) [10] reported that the application of diclosulam 84% WDG 0.026 kg/ha as pre-emergence effectively controlled both monocot and dicot weeds.

Weed dry weight: The dry weight of weeds (g/m^2) increased with the increasing weed density as well as the variation of weed species and their growth. The highest weed dry matter was achieved under weedy check at 60 and 80 DAS (Table 2) and the lowest weed dry weight was recorded in hand weeding at 20 and 40 DAS. Among herbicidal treatments, imazethapyr 10% SL 0.075 kg/ha as post-emergence resulted in maximum weed dry weight reduction of annual broadleaf weeds and some grasses. However, the application of sulfentrazone 28% + clomazone 30% WP 0.725 kg/ha (RM) as pre-emergence effectively reduced the dry weight of sedges. The effect of herbicides applied as pre-emergence was subdued at this belated stage, which might be on account of a longer period after application and restricted effective residual period. These results conform with Gupta *et al*. (2017) [3].

Weed indices: The highest weed control efficiency (%) and minimum weed index (%) were achieved under hand weeding at 20 and 40 DAS and the application of imazethapyr 10% SL 0.075 kg/ha as post-emergence which was followed by sulfentrazone 28% + clomazone 30% WP 0.725 kg/ ha (RM) (Table 3). Higher weed control efficiency and lower weed index in these treatments might be due to the lower dry weight of weeds and higher seed yield, respectively. Weed competition was significantly reduced by pre-emergence use of imazethapyr, which was significantly superior to the remaining treatments suggesting that imazethapyr offers greater reduction of grasses and broad-leaved weeds and there is a positive effect of herbicide application on crop yield.

Seed yield and stover yield: The seed yield was significantly influenced by various weed control treatments (Table 3). Hand weeding at 20 and 40 DAS produced the highest seed yield. Post emergence of imazethapyr 10% SL 0.075 kg/ha, sulfentrazone 28% + clomazone 30% WP 0.725 kg/ha, diclosulam 84% WDG 0.026 kg/ha were found to be significantly superior than pre emergence application of pendimethalin 30% EC 1 kg/ha, metribuzine 70% WP 0.4 kg/ha, and imazethapyr 10% SL 0.075 kg/ha. The lowest seed yield was recorded in the weedy check. The enhancement in the seed yield due to various weed control measures was because they helped to keep the field comparatively free from weeds. This consequently led to the production of more vigorous and healthy plants having more pod bearing capacity, more number of pod/plant, pod length and 100-seed weight. The cumulative effect of all these resulted in higher seed yield, making it amply clear that these weed control measures exerted a profound influence in curtailing the weed population and thereby reducing the weed dry weight at important growth stages of crop. The results corroborate the findings of Pandya *et al*. (2005) [9].

Table 1: Total and species wise weed density as influenced by different weed management practices

Weed management practices	Weed density species wise (m^{-2})											
	Echinochloa colona		*Bracharia eruciformis*		*Merremia emarginata*		*Cynodon dactylon*		Other		Total	
	60 DAS	80 DAS	60 DAS	80 DAS	60 DAS	80 DAS	60 DAS	80 DAS	60 DAS	80 DAS	60 DAS	80 DAS
T_1- Pre emergence application of pendimethalin (30%EC) @ 1000 a.i. g ha^{-1}	7.84 (61.00)	5.21 (26.67)	5.49 (29.67)	5.46 (29.33)	2.48 (5.67)	2.48 (5.67)	2.27 (4.67)	2.41 (5.33)	4.22 (17.33)	5.02 (24.67)	10.90 (118.33)	9.60 (91.67)
T_2- Pre emergence application of diclosulam (84%WDG) @ 26 a.i. g ha^{-1}	6.10 (36.67)	4.66 (21.33)	4.74 (22.00)	4.60 (20.67)	2.11 (4.00)	2.03 (3.67)	1.94 (3.33)	2.12 (4.00)	4.18 (17.00)	4.71 (21.67)	9.14 (83.00)	8.47 (71.33)
T_3- Pre emergence application of sulfentrazone(28%)+clomazone(30%)WP @ 350 g + 375 a.i. g ha^{-1}	6.31 (39.00)	4.71 (21.67)	4.64 (21.00)	4.49 (19.67)	2.04 (3.67)	1.86 (3.00)	2.03 (3.67)	1.87 (3.00)	4.26 (17.67)	4.56 (20.33)	9.26 (85.33)	8.25 (67.67)
T_4- Pre emergence application of metribuzin (70%WP) @ 400 a.i. g ha^{-1}	5.37 (28.33)	4.81 (22.67)	5.31 (27.67)	4.87 (23.33)	2.54 (6.00)	2.54 (6.00)	2.20 (4.33)	2.41 (5.33)	4.34 (18.33)	5.18 (26.33)	9.22 (84.67)	9.17 (83.67)
T_5- Post emergence application of imezathapyr (10%SL) @ 75 a.i. g ha^{-1}	3.44 (11.33)	3.13 (9.33)	4.22 (17.33)	4.10 (16.33)	1.68 (2.33)	1.77 (2.67)	1.77 (2.67)	1.78 (2.67)	3.53 (12.00)	3.71 (13.33)	6.79 (45.67)	6.69 (44.33)
T_6- Pre emergence application of imezathapyr (10%SL) @ 75 a.i. g ha^{-1}	7.76 (59.67)	5.64 (31.33)	5.28 (27.33)	5.11 (25.67)	2.35 (5.00)	2.68 (6.67)	2.35 (5.00)	2.48 (5.67)	4.85 (23.00)	5.37 (28.33)	10.98 (120.00)	9.90 (97.67)
T_7- Hand weeding twice (20 & 40 DAS)	2.85 (7.67)	2.20 (4.33)	2.04 (3.67)	1.46 (1.67)	1.34 (1.33)	1.46 (1.67)	1.34 (1.33)	1.08 (0.67)	2.48 (5.67)	2.54 (6.00)	4.49 (19.67)	3.85 (14.33)
T_8- Weedy check	8.09 (65.00)	5.90 (34.33)	5.96 (35.00)	5.87 (34.00)	2.68 (6.67)	2.74 (7.00)	2.45 (5.67)	2.55 (6.00)	5.76 (32.67)	5.46 (29.33)	12.06 (145.00)	10.54 (110.67)
S.Em±	0.08	0.12	0.06	0.14	0.11	0.11	0.15	0.11	0.07	0.10	0.09	0.09
CD (P=0.05)	0.24	0.36	0.17	0.41	0.33	0.33	0.46	0.33	0.23	0.31	0.28	0.28

*Data subjected to $\sqrt{x+0.5}$ transformation and figure in parentheses are the original value.

Table 2: Total and species wise weed dry weight as influenced by different weed management practices

Weed management practices	Dry weight of weeds (g m^{-2})											
	Echinochloa colona		*Bracharia eruciformis*		*Merremia emarginata*		*Cynodon dactylon*		Other		Total	
	60 DAS	80 DAS	60 DAS	80 DAS	60 DAS	80 DAS	60 DAS	80 DAS	60 DAS	80 DAS	60 DAS	80 DAS
T_1- Pre emergence application of pendimethalin (30%EC) @ 1000 a.i. g ha^{-1}	4.02 (15.67)	5.01 (24.63)	3.57 (12.26)	3.71 (13.30)	2.38 (5.18)	2.76 (7.15)	1.84 (2.88)	1.99 (3.49)	5.29 (27.49)	5.82 (33.35)	8.00 (63.48)	9.08 (81.92)
T_2- Pre emergence application of diclosulam (84%WDG) @ 26 a.i. g ha^{-1}	4.18 (16.97)	4.04 (15.81)	3.44 (11.33)	3.58 (12.37)	2.20 (4.36)	2.59 (6.30)	1.82 (2.81)	1.76 (2.61)	4.68 (21.44)	6.21 (38.05)	7.58 (56.91)	8.70 (75.13)
T_3- Pre emergence application of sulfentrazone(28%)+clomazone(30%)WP @ 350 g + 375 a.i. g ha^{-1}	3.71 (13.31)	4.00 (15.50)	3.34 (10.67)	3.43 (11.27)	2.35 (5.09)	2.41 (5.32)	1.70 (2.45)	1.73 (2.53)	4.76 (22.24)	5.72 (32.23)	7.37 (53.25)	8.21 (66.85)
T_4- Pre emergence application of metribuzin (70%WP) @ 400 a.i. g ha^{-1}	3.68 (13.03)	4.56 (20.32)	3.73 (13.43)	3.79 (13.90)	2.53 (5.89)	2.37 (5.18)	1.79 (2.78)	2.05 (3.74)	5.09 (25.42)	6.17 (37.55)	7.81 (60.55)	9.01 (80.69)
T_5- Post emergence application of imezathapyr (10%SL) @ 75 a.i. g ha^{-1}	3.65 (12.83)	3.58 (12.39)	3.29 (10.30)	3.64 (12.77)	1.90 (3.19)	2.19 (4.32)	1.66 (2.25)	1.60 (2.06)	4.44 (19.20)	5.73 (32.36)	6.95 (47.77)	8.02 (63.90)
T_6- Pre emergence application of imezathapyr (10%SL) @ 75 a.i. g ha^{-1}	4.34 (18.37)	5.21 (26.61)	3.58 (12.30)	3.99 (15.43)	2.19 (4.37)	2.40 (5.33)	1.84 (2.90)	2.01 (3.59)	5.28 (27.36)	5.76 (32.71)	8.11 (65.30)	9.17 (83.67)
T_7- Hand weeding twice (20 & 40 DAS)	2.01 (3.53)	1.61 (2.14)	1.73 (2.50)	1.86 (3.07)	1.26 (1.08)	2.07 (3.78)	1.58 (2.03)	1.60 (2.06)	1.89 (3.23)	2.94 (8.19)	3.59 (12.37)	4.44 (19.24)
T_8- Weedy check	5.54 (30.18)	8.43 (70.56)	5.14 (26.13)	5.48 (29.53)	5.04 (24.89)	3.04 (8.79)	5.05 (25.08)	2.23 (4.55)	6.74 (44.91)	8.48 (71.48)	12.30 (150.86)	13.58 (183.91)
S.Em±	0.07	0.12	0.11	0.12	0.12	0.14	0.15	0.10	0.13	0.09	0.12	0.13
CD (P=0.05)	0.21	0.37	0.35	0.37	0.36	0.42	0.46	0.31	0.38	0.27	0.36	0.40

*Data subjected to $\sqrt{x+0.5}$ transformation and figure in parentheses are the original value.

Table 3: Weed control efficiency, weed index, yield attributes, yield and harvest index of soybean as influenced by different weed management practices

Weed management practices	Weed index (%)	Weed control efficiency (%)		Yield attributes			Yield (kg ha^{-1})		Harvest index (%)
		60 DAS	80 DAS	Pods plant^{-1} (No.)	Pod length (cm)	100 seed weight (g)	Seed yield	Stover yield	
T_1- Pre emergence application of pendimethalin (30%EC) @ 1000 a.i. g ha^{-1}	34.16	57.92	55.45	68.55	2.94	9.91	1112	2469	41.97
T_2- Pre emergence application of diclosulam (84%WDG) @ 26 a.i. g ha^{-1}	21.90	62.27	59.14	74.66	3.04	10.90	1319	2680	43.45
T_3- Pre emergence application of sulfentrazone(28%)+clomazone(30%)WP @ 350 g + 375 a.i. g ha^{-1}	20.01	64.36	63.65	75.52	3.23	11.29	1351	2863	43.64
T_4- Pre emergence application of metribuzin (70%WP) @ 400 a.i. g ha^{-1}	28.29	59.86	56.12	71.33	2.98	10.29	1214	2405	42.33
T_5- Post emergence application of imezathapyr (10%SL) @ 75 a.i. g ha^{-1}	13.20	68.33	65.25	77.22	3.40	11.43	1466	3103	43.91
T_6- Pre emergence application of imezathapyr (10%SL) @ 75 a.i. g ha^{-1}	46.29	56.71	54.50	62.70	2.83	9.56	907	2023	40.59
T_7- Hand weeding twice (20 & 40 DAS)	-	91.80	89.53	83.73	3.79	11.68	1689	3220	45.49
T_8- Weedy check	58.08	-	-	57.10	2.61	9.33	708	1539	38.81
S.Em±				2.26	0.09	0.31	64	49	2.19
CD (P=0.05)				6.87	0.28	0.94	193	148	(NS)

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