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Bio-Efficacy of Post Emergence Herbicides against Weed Control in Soybean

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A B S T R A C T

A field experiment was undertaken to assess the bio-efficacy of post emergence herbicides against weed control in soybean. The predominant weed species in experimental field were *Dinebra retroflexa, Echinocloa colona, Cyperus rotundus Lindernia ciliate and Mullogo pentaphylla.* The maximum suppression of all the weed density, weed biomass and highest weed control efficiency vis-à-vis crop yield were obtained where twice hand weeding done at 20 and 40 days after sowing and closely followed by the treatment with Imazethapyr+Propaquizafop 75.0+62.5 g/ha, Imazethapyr alone at 100 g/ha and Imazethapyr+Bentazone 75.0+75 g/ha. Whereas weedy check treatment produced lowest yield of soybean among all the treatment. Highest weed index occurred in weedy check plots where weeds were not controlled throughout the crop season, among all herbicidal treatment lowest weed index falls in combination of Imazethapyr + Propaquizafop 75+62.5 g/ha.

Introduction

Soybean (*Glycine max* L.) is one of the most important oil seed crop of the country, which contains 35-40% protein, 19% oil, 35% carbohydrate, 5% minerals and several other components including vitamins. In India it is grown under 11.65 million hectares area with the production of 8.0 million tonnes. In Madhya Pradesh it is cultivated under 5.9 million hectare area with production of 4.5 million tonnes (SOPA, 2016). In the state it grown as *Kharif* crop, but weed infestation is the major constraint in soybean produce in rainy season (Vollmann *et al.*, 2010), it is heavily infested with grasses, sedges and broad leaved weeds. During the initial period, the crop growth is very slow which resulted vigorous growth of weeds in *kharif* season. Thus intense weed competition for nutrients, sunlight, space and water, reduces the crop productivity. If weeds are not controlled at critical stage that is 20-40 DAS period of crop-weed competition, there may be identical reduction in the seed yield of soybean. The yield losses due to uncontrol weeds are ranging from 31 – 84 % as reported by Karchoo *et al.*, (2003). According to

Kundu *et al.,* (2011) the loss in yield of soybean due to weeds was 43% in control which indicates the necessity of controlling weed for exploiting the yield potential of soybean. There are so many herbicides reported to control weeds in soybean but they are less effective to control. The pre-emergence herbicides like alachlor and metalachlor have been recommended for weed control in soybean and are being used by the farmers since long period. Presently, Imazethapyr is being in use as a post-emergence herbicide for controlling weeds in soybean (Patel *et al.,* 2009). However, its efficacy has not been tested with Propaquizafop and Bentazone alone or in combination for wide spectrum weed control in soybean. At present, imazethapyr is being in use as a post-emergence herbicide for controlling weeds in soybean but some weeds had reported to uncontrol when imazethapyr was applied in alone (Patel *et al.,* 2009).

Materials and Methods

A field experiment was conducted at Research farm, Department of Agronomy, Jawaharlal Nehru Kirshi Vishwa Vidyalaya, Jabalpur (M.P.) during *kharif* 2016. The field selected for experimentation had having uniform topography and infested with location specific weeds representing to this area. The soil of the experimental field was clay loam in texture, neutral in reaction (7.1), medium in organic carbon (0.60 %), available nitrogen (367 kg/ha), available phosphorus (16.23 kg/ha) and available potassium (317.10 kg/ha) contents.

The climate of experiment field is typically sub humid, featured by hot dry summer and cool dry winter. Jabalpur is situated at 23^0 09' North latitude and 79^0 58' East longitudes with an altitude of 411.78 meters above the mean sea level. It is classified under "Kymore Plateau and Satpura Hills" agro- climatic zone as per norms of National Agriculture Research Project (NARP), New Delhi. The monsoon commenced in the first week of July and terminated in the 1st week of October. The total rainfall received during the crop season was 1187 mm, which was equally distributed in 52 rainy days from July to 2nd week of October. The maximum rainfall (263.20 mm) was received in the last week of August in 6 rainy days. The maximum temperature was ranged from 27.0°C (in 4th week of August) to 35.8°C (in the first week of July). However the minimum temperature was ranged from 15.4°C (in third week of October) to 24.9°C (in the first week of July). Similarly relative humidity ranged between 82 to 94 % in morning and 29 to 91 % in evening. The sunshine hours varied between 0.0 to 9.3 hours per day. Generally, relative humidity remains very low during summer (15 to 30%), moderate during winter (60 to 75%) and attains higher values (80 to 95%) during rainy season.

The ten treatments comprising of different doses of imazethapyr + propaquizafop (75+62.5 g/ha), imazethapyr + bentazone (75+75 and 75+62.5 g/ha), propaquizafop +bentazone (75+75 and 62.5+75 g/ha), and alone application of imazethapyr (100 g/ha), propaquizafop (75 g/ha) and bentazone (150 g/ha) as post-emergence, hand weeding twice at 20 and 40 DAS including weedy check, were laid out in randomized block design with 3 replications.

Soybean, cv. JS 20-29 was sown manually on 11th July 2016 with the fertilizer dose (20 kg N + 60 kg P_2O_5 + 20 kg K_2O/ha) was applied as basal through urea, single super phosphate and muriate of potash. The whole quantity of all fertilizers was applied manually at the time of sowing as basal in the rows at about 2-3 cm below the seed. The seeds were sown @ 70 kg/ha manually in each experimental plot keeping a row to row distance of 30 cm at the

depth of 3-4 cm. The spray of herbicides was done with the help of knap-sack sprayer fitted with flat fan nozzle using 500 liters of water/ha. Other practices were adopted as per the recommendations. Species wise weed count, weed biomass, weed control efficiency were recorded after post emergence application. Finally the crop yield was measured at the time of harvest. The weed index (WI) was calculated by using formula: WI = [(Yield from weed free plot (i.e. hand weeding) - Yield from the treated plot)* 100/ Yield from weed free plot (i.e. hand weeding).

Results and Discussion

Weed flora

Five predominant weed species were observed in experimental field during the rainy (*kharif*) season of 2016 (Table 1). Among the monocot weeds *Dinebra retroflexa* was the most dominant weed have maximum relative density (26.77%) followed by *Echinocloa colona* (21.23%) and *Cyperus rotundus (14.46* %), Whereas dicot weeds contributed 37.54 % to relative density of weeds, However among the dicot weeds *Lindernia ciliate* marked its presence in more number (25.90 %) as compare to *Mullogo pentaphylla* (11.63%) in soybean. Similar observation was also reported by Singh and Rajkumar 2008.

Weed density

Species wise weed density in soybean field i.e. number of the weed m^{-2} particular weed species was recorded at BA, 15, 30, 45 DAA and at harvest after post emergence spray and differed significantly with the different weed management treatments (Table 2). Density of monocot (*Dinebra retroflexa, Echinocloa colona and Cyperus rotundus*) weeds were much higher than density of broad leaved weeds (*Lindernia ciliate and Mullogo pentaphylla*) at throughout the crop growing season, as because rainy season is highly favourable for monocot and dicot weeds population (Tiwari *et al.*, 2009)

The density of *Echinochloa colona* was significantly influenced by weed control treatment. Hand weeding at 20 DAS and 40 DAS had lowest weed density of *Echinochloa colona* (2.90 */m^2*) and it was further increased in different treatments. Data itself manifest that density of *Echinochloa colona* was maximum in weedy check plot (6.89 /m^2) at 45 DAA where weeds were not controlled by any means. Further it was reduced appreciably by adopting mechanical or chemical weed control. The application of Bentazone at 75 g/ha gave contradictally poor performance because Bentazone is narrow spectrum herbicide it's control only broad leaved weeds. Alone application of Imazethapyr and Propaquizafop at 100g/ha and 75 g/ha respectively caused significant reduction in the density. However, combined application of Imazethapyr+Propaquizafop 75.0+62.5 g/ha caused maximum reduction in *Echinochloa colona density (3.97*/m^2) followed by Imazethapyr 100 g/ha (4.38 /m^2). Among the different herbicidal treatment the maximum reduction in density of *Cyperus rotundus* was noticed with the combined application of Imazethapy+Propaquizfop 75.0+62.5 g/ha (4.84/m^2) in soybean. It was closely followed by the alone application of Imazethapyr 100 g/ha (5.21/ m^2) However, none of the herbicidal treatments surpassed the hand weeding in twice as the reduction in density of *Cyperus rotundus* as it recorded lowest density at all the above growth stages similar results observed by Sandil *et al.*, (2015). The density of *Dinebra retroflexa* was also significantly reduced due to different weed control treatments. Hand weeding at 20 DAS and 40 DAS had lowest weed density of *Dinebra retroflexa and it was further*

increased in different treatments. Application of Imazethapyr+Propaquizafop 75.0+62.5 g/ha caused maximum reduction in *Dinebra retroflexa density* (5.76 /m^2) followed by Imazethapyr 100 g/ha (5.87/m^2) and Propaquizafop 75 g/ha (6.01/m^2) being the maximum was recorded in weedy check (9.39 /m^2). Other herbicidal treatments did not caused significant reduction in density of *Dinebra retroflexa* (Kheriya *et al.,* 2016).

Among the broad leaved weeds *Lindernia ciliate* showed the highest population throughout the growing season followed by *Mullogo pentaphylla*. The activity of imazethapyr 100 g/ha was poor against *Mollugo pentaphylla* when it was applied alone but when it was applied in combination with Bentazone, it caused significant reduction in the density of *Mollugo pentaphylla*. Combination of Imazethapyr+ Bentazone 75.0+75 g/ha had maximum reduction (3.38/m^2) which was at par with Propaquizfop+ Bentazone 75+75 g/ha (3.97/m^2) both were found superior over other herbicidal treatments. However hand weeding at 20 and 40 DAS had lowest density (2.47/ m^2). The density of *Lindernia ciliate* was maximum (9.19 / m^2) under weedy check plots at 45 DAA. Alone application of Imazethapyr 100 g/ha was at par with Bentazone 150 g/ha. The combination of Imazethapyr+ Bentazone 75+75 g/ha (5.18/m^2) which was at par with Propaquizfop+ Bentazone 75+75 g/ha (5.87/m^2) was found to be superior over other herbicidal treatments (Chetan *et al.,* 2015)

Weed biomass

Dry matter accumulation by weeds per unit area is an indication of weed growth under particular treatment. The observation on dry weight of weeds was made at before application at 45 DAA and at harvest. The data taken at 45 DAA are given in Table 3. The dry weight of *Cyperus rotundus* was minimum under hand weeding twice at 20 and 40 DAS. The dry weight of *Cyperus rotundus* was maximum (10.82 *g/m^2*) under weedy check plot at 45 DAA where weeds were not controlled throughout the growing season whereas, its dry weight was reduced identically when control measures were adopted in different plots. *Combined application of* Imazethapyr+Propaquizafop 75+62.5 g/ha caused significantly higher reduction (5.49g/m^2) followed by alone application of Imazethapyr at 100 g/ha (5.83g/m^2). No one treatments was surpassed the weed control by two hand weeding at 20 and 40 DAS as it had lowest dry weight of *Cyperus rotundus* (3.08g/m^2*).* The biomass of different monocot weed flora (*Echinochloa colona and Dinebra retroflexa*) in soybean field at all the crop growth season reflect the same trend fallow as *Cyperus rotundus.*

Among the dicot weed the dry weight of *Mullogo pentaphylla* was maximum *(6.82g/*m^2). under weedy check plots due to uninterrupted growth during critical period of crop- weed competition. The activity of Propaquizafop at 75 g/ha was applied in alone was poor against the *Mullogo pentaphylla*. Combined application of Imazethapyr+ Bentazone 75.0+ 75.0 g/ha caused significantly higher reduction (3.06g/m^2). Than the alone application of Bentazone 150 g/ha (3.38g/ m^2) followed by combined application of Propaquizafop + Bentazone 75.0+75 g/ha (3.43 g/m^2).Whereas hand weeding at 20 and 40 DAS had lowest dry weight of *Mullogo pentaphylla* (2.27g/*m^2)* and proved superior to all chemical weed control treatments and weedy check (Sandil *et al.,* 2015). Similar trend fallow in case of *Lindernia ciliate.*

Weed control efficiency (WCE)

Weed control efficiency (WCE) was calculated on the basis of weed biomass obtained under weedy check plots and other

treatments. The data on WCE at 45 DAA are presented in Table 4. Among the different weed control treatments, the higher WCE (72.71%) was found in plots receiving combined application of Imazethapyr 75.0 g/ha + Propaquizafop 62.5 g/ha followed by alone application of Imazethapyr at 100 g/ha (70.76%). However WCE was further reduced with application of Bentazone in alone at 150 g/ha (42.35%) However, the WCE was maximum (90.23%) under hand weeding twice (20 and 40 DAS) in soybean (Thakre *et al.*, 2015).

Crop yield

Seed yield and haulm yield of soybean were observed at the time of harvest, and were varied significantly with the variation in weed management practices (Table 5). Hand weeding twice at 20 & 40 DAS produced the significantly highest seed yield of soybean and found to be superior to other weed management practices. The seed yield of weedy check plot was very poor (1104 kg/ha) due to maximum crop weed competition throughout the growing season. It increased markedly with the Bentazone 150 g/ha which gave the seed yield of 1323 kg/ha. This was at par with the alone application of Propaquizafop at 75 g/ha (1400 kg/ha). Alone application of Bentazone at 150 g/ha (1323 kg/ha) further increased the seed yield over Propaquizafop at 75 g/ha. But the difference between these treatments was not marked. It was noticed that alone application of Imazethapyr 100 g/ha markedly higher seed yield (1834 kg/ha) than alone application of Propaquizafop and Bentazone at 75 and 150 g/ha as well as the combined application of Propaquizafop+Bentazone 62.5+75 g/ha (1556 kg/ha) and Imazethapyr+Bentazone 75 +62.5 g/ha (1655 kg/ha). Among all the herbicidal treatments combined application Imazethapyr+Propaquizafop 75+62.5 g/ha registered maximum seed yield of 2100 kg/ha which was at par to hand weeding twice 2190 kg/ha. Similar work was also reported by Kulal *et al.*, (2017).

Table.1 Weed flora and relative density of weeds in weedy check plot at different stages

S.No.	Weed flora	Density / m^2					Relative density (%)
		15 DAA	30 DAA	45 DAA	Harvest	Mean	
A.	Monocot weeds						
1.	*Echinochloa colona*	64.67	67.67	69.00	67.00	67.08	21.23
2.	*Dinebra retroflexa*	81.00	84.67	87.67	85.00	84.58	26.77
3.	*Cyperus rotundus*	44.33	45.33	47.00	46.00	45.67	14.46
	Subtotal						62.46
B	Dicot weeds						
4.	*Mullogo pentaphylla*	34.67	36.67	38.33	37.33	36.75	11.63
5.	*Lindernia ciliate*	79.33	81.67	84.00	82.33	81.83	25.90
	Subtotal						37.54
	Total	304.00	316.01	326.00	317.66	315.41	100.00

Table.2 Density of weeds at 45 DAA as influenced by weed control treatments

Treatments	Dose g/ha	Density/ m^2				
		Cyperus rotundus	***Dinebra retroflexa***	***Echinochloa colona***	***Mullogo pentaphylla***	***Lindernia ciliate***
T_1-Imazethapyr	100	5.21 (26.67)	5.87 (34.00)	4.38 (18.67)	4.26 (17.67)	6.15 (37.33)
T_2-Propaquizafop	75	5.37 (28.33)	6.01 (35.67)	4.63 (21.00)	5.96 (35.00)	9.10 (82.33)
T_3-Bentazone	150	7.88 (61.67)	9.08 (82.00)	6.74 (45.00)	3.76 (13.67)	5.37 (28.33)
T_4-Imazethapyr+Propaquizafop	75+62.5	4.84 (23.00)	5.76 (32.67)	3.97 (15.33)	4.49 (19.67)	6.28 (39.00)
T_5-Imazethapyr+Bentazone	75+75	5.61 (31.00)	6.20 (38.00)	4.88 (23.33)	3.38 (11.00)	5.18 (26.33)
T_6-Propaquizafop+Bentazone	62.5+75	5.87 (34.00)	6.49 (41.67)	5.37 (28.33)	4.06 (16.00)	6.12 (37.00)
T_7-Imazethapyr+Bentazone	75+62.5	5.73 (32.33)	6.34 (39.67)	5.05 (25.00)	3.94 (15.00)	5.76 (32.67)
T_8-Propaquizafop+Bentazone	75+75	5.85 (33.67)	6.28 (40.00)	5.21 (26.67)	3.97 (15.33)	5.87 (34.00)
T_9-Hand weeding(20 and 40DAS)	-	2.67 (6.67)	3.42 (11.33)	2.90 (8.00)	2.47 (5.67)	3.80 (14.00)
T_{10}-Weedy-check (Control)	-	8.33 (69.00)	9.39 (87.67)	6.89 (47.00)	6.23 (38.33)	9.19 (84.00)
SEm±		0.10	0.11	0.13	0.12	0.07
CD at 5%		0.28	0.31	0.37	0.35	0.21

*figure in parenthesis are the original value

Table.3 Weed biomass of weeds as influenced by weed control treatments at 45 DAA

Treatments	Dose g/ha	Dry weight g/m^2				
		Cyperus rotundus	***Dinebra retroflexa***	***Echinochloa colona***	***Mullogo pentaphylla***	***Lindernia ciliate***
T_1-Imazethapyr	100	5.88 (34.09)	5.55 (30.29)	5.12 (25.94)	3.73 (13.43)	3.92 (14.06)
T_2-Propaquizafop	75	6.06 (36.16)	5.68 (31.76)	5.48 (29.18)	5.23 (26.59)	5.70 (31.92)
T_3-Bentazone	150	8.90 (78.80)	8.62 (73.04)	8.00 (62.58)	3.38 (10.91)	3.38 (10.64)
T_4-Imazethapyr+Propaquizafop	75+62.5	5.49 (29.40)	5.49 (29.10)	4.72 (21.30)	3.93 (14.96)	3.98 (15.20)
T_5-Imazethapyr+Bentazone	75+75	6.31 (39.60)	5.85 (33.85)	5.72 (32.40)	3.06 (8.37)	3.13 (9.50)
T_6-Propaquizafop+Bentazone	62.5+75	6.65 (43.45)	6.17 (37.11)	6.34 (39.38)	3.60 (12.17)	3.85 (14.06)
T_7-Imazethapyr+Bentazone	75+62.5	6.45 (41.31)	5.98 (35.33)	5.95 (34.74)	3.48 (11.40)	3.67 (12.92)
T_8-Propaquizafop+Bentazone	75+75	6.61 (43.01)	5.99 (35.62)	6.15 (37.04)	3.43 (11.66)	3.62 (12.54)
T_9-Hand weeding(20 and 40DAS)	-	3.08 (8.50)	3.25 (10.12)	3.48 (11.13)	2.27 (4.30)	2.54 (5.32)
T_{10}-Weedy-check (Control)	-	10.82 (116.71)	10.64 (112.82)	9.47 (89.26)	6.82 (46.02)	6.21 (38.09)
SEm±		0.10	0.09	0.06	0.10	0.10
CD at 5%		0.28	0.27	0.16	0.28	0.29

*figure in parenthesis are the original value

Table.4 WCE (%) of narrow leaf and broad leaf weeds as influenced by weed control treatments at 45 DAA

Treatments	Dose g/ha	*Cyperus rotundus*	*Dinebra retroflexa*	*Echinochloa colona*	*Mullogo pentaphylla*	*Lindernia ciliate*	Weed total	WCE %
T_1-Imazethapyr	100	5.88 (34.09)	5.55 (30.29)	5.12 (25.94)	3.73 (13.43)	3.92 (14.06)	117.81	70.76
T_2-Propaquizafop	75	6.06 (36.16)	5.68 (31.76)	5.48 (29.18)	5.23 (26.59)	5.70 (31.92)	155.61	61.38
T_3-Bentazone	150	8.90 (78.80)	8.62 (73.04)	8.00 (62.58)	3.06 (8.37)	3.13 (9.50)	232.28	42.35
T_4-Imazethapyr+Propaquizafop	75+62.5	5.49 (29.40)	5.49 (29.10)	4.72 (21.30)	3.93 (14.96)	3.98 (15.20)	109.96	72.71
T_5-Imazethapyr+Bentazone	75+75	6.31 (39.60)	5.85 (33.85)	5.72 (32.40)	3.38 (10.91)	3.38 (10.64)	127.40	68.38
T_6-Propaquizafop+Bentazone	62.5+75	6.65 (43.45)	6.17 (37.11)	6.34 (39.38)	3.60 (12.17)	3.85 (14.06)	146.16	63.72
T_7-Imazethapyr+Bentazone	75+62.5	6.45 (41.31)	5.98 (35.33)	5.95 (34.74)	3.48 (11.40)	3.62 (12.92)	135.70	66.32
T_8-Propaquizafop+Bentazone	75+75	6.61 (43.01)	5.99 (35.62)	6.15 (37.04)	3.43 (11.66)	3.67 (12.54)	139.87	65.28
T_9-Hand weeding(20 and 40DAS)		3.08 (8.50)	3.25 (10.12)	3.48 (11.13)	2.27 (4.30)	2.54 (5.32)	39.37	90.23
T_{10}-Weedy-check (Control)		10.82 (116.71)	10.64 (112.82)	9.47 (89.26)	6.82 (46.02)	6.21 (38.09)	402.91	0.00
SEm±		0.10	0.09	0.06	0.10	0.10		
CD at 5%		0.28	0.27	0.16	0.28	0.29		

*figure in parenthesis are the original value

Table.5 Influence of herbicidal treatments on seed yield, haulm yield, harvest index and weed index of soybean

Treatments	Dose g/ha	Seed yield (kg/ha)	Haulm yield (kg/ha)	Harvest index (%)	Weed index (%)
T_1-Imazethapyr	100	1834	3788	32.62	16.26
T_2-Propaquizafop	75	1400	3927	26.28	36.07
T_3-Bentazone	150	1323	2911	25.69	39.59
T_4-Imazethapyr+Propaquizafop	75+62.5	2100	3900	35.00	4.11
T_5-Imazethapyr+Bentazone	75+75	1903	3779	33.49	13.11
T_6-Propaquizafop+Bentazone	62.5+75	1556	3892	28.56	28.95
T_7-Imazethapyr+Bentazone	75+62.5	1655	3679	31.03	24.43
T_8-Propaquizafop+Bentazone	75+75	1626	3812	29.90	25.75
T_9-Hand weeding(20 and 40DAS)		2190	4176	34.41	0.00
T_{10}-Weedy-check (Control)		1104	3556	23.69	49.59
SEm±		31.42	37.20	-	-
CD at 5%		94.56	110.60	-	-

All the treated plots produced significantly higher haulm yield over weedy check (3556 kg/ha). Haulm yield was increased in Imazethapyr+Bentazone 75+62.5 g/ha (3679 kg/ha) and was increased with the alone application of Propaquizafop and Bentazone at 75g/ha and 150 g/ha combined application of Imazethapyr+Bentazone 75.0+75 g/ha (3779 kg/ha) or combination of Propaquizafop+Bentazone 62.5+75.0 g/ha (3893 kg/ha) respectively.

Haulm yield curbed higher at large extent with the application of Imazethapyr alone at 100 g/ha (3788 kg/ha) while the more pronounced increase in the yield was obtained with the combined application of Imazethapyr+Propaquizafop 75.0+62.5 g/ha (3900 kg/ha) which was at par to the obtained under hand weeding twice at 20 and 40 DAS (4176 kg/ha).

Weed index

Weed index measures the reduction in crop yield due to weed competition as against weed free treatment and is expressed in percentage. Data pertaining to weed index are presented in Table 5. The data revealed that maximum reduction in yield (49.59%) occurred in weedy check plots where weeds were not controlled throughout the crop season.

Application of Bentazone, Propaquizafop, Imazethapyr, at 150, 75, 100 g/ha respactivily alone and combined application of Propaquizafop + Bentazone or Imazethapyr + Bentazone as post emergence at 62.5+75.0 or 75+62.5 g/ha respectively. Curbed the weed menace to the tune of 39.59%, 36.07%, 16.26%, 28.95%, 24.43% respectively. But a turning point was there when weed index falls at 4.11 % in combination of Imazethapyr + Propaquizafop 75+62.5 g/ha (Prachand *et al.*, 2014).

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