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Bio-efficacy on tank-mixed propaquizafop and imazethapyr against weeds in soybean

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ABSTRACT

Intensive use of agro-chemicals coupled with congenial edaphic and weather conditions during *Kharif* season aggravate the weed menace, resulting into low yields of soybean. The experiment was conducted on the agricultural farm at Jawaharlal Nehru Krishi Vishwa Vidyalaya at Jabalpur in 2011-12. The rampant weed species identified in the experimental field was monocot weeds *Cyperus rotundus* (25.8 and 23.6%) followed by *Echinochloa colona* (23.1 and 23.3%) and *Commelina benghalensis* (15.6 and 17.8%). Beside these dicot weeds *Eclipta alba* (19.1 and 20.3%), and *Alternanthera philoxeroides* (16.4 and 14.9%) were also found in soybean ecosystem at 45 DAS and harvest stage, respectively. The weed menace was minimum under weed free treatment. Among the propaquizafop treatments, activity of propaquizafop at lowest dose 62.5 g/ha and highest dose 75 g/ha as post emergence was not well marked against most of weeds (broad-leaved) but imazethapyr applied at 50, 75, 100 g/ha controlled broad-leaved and grassy leaved weeds. Among herbicidal treatments, combined application of propaquizafop + imazethapyr as post-emergence 75 + 100 g/ha was most effective to reduced most of weed flora.

Key words: Bioefficacy, Chemical control, Propaquizafop, Soybean, Tank-mix, Weeds

Soybean is a crop of multiple qualities, as it is both a pulse and oilseed crop. It provides 40% protein and 20% edible oil, besides minerals and vitamins. In India, it is cultivated in 9.73 million hectares area with annual production of 9.96 million tonnes. In Madhya Pradesh, it is grown over an area of 5.35 million hectares with a production of 6.41 million tonnes. (Annonymous 2010). Although the ecological conditions of the state are congenial for soybean production, but the yield is substantially low (1007 kg/ha), despite of the best management practices. Being a rainy season crop, the environment is more conducive for excessive weed infestation in soybean. Severe weed competition is one of the major constraints for low productivity of soybean. Weeds in general, cause competition stress on soybean growth, especially during the first 40 days after sowing. Weeds alone are responsible for reduction in seed yield of soybean to the range of 25 to 70% depending upon the weed flora and intensity. Therefore, it is important to keep the soybean crop weed free as far as possible, so as to get higher seed yield (Kewat *et al*. 2000). Now a days pre-emergence herbicides are not very popular among the farmers due to short time span for sowing during *Kharif* season. Therefore, farmers are using post-emergence herbicides for control of weeds in soybean. Hand weeding is the most efficient mean to control weeds in soybean, but it is time consuming and difficult due to unavailability of laborers during peak period of demand. Hence, the use of suitable herbicide appears to be an alternative option to minimize the weed problem. But, each herbicide has its own spectrum of weed control. Secondly, the timing of herbicides application also has much concern on weed control efficiency. Therefore, in this study possibility of pre-emergent or post-emergent herbicides for effective weed control in soybean was explored.

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MATERIALS AND METHODS

A field experiment was conducted at Breeder Seed Production Unit, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Adhartal Jabalpur (M.P.). The rainfall received during the crop season was 1281.7 mm. Minimum and maximum mean temperature ranged from 20.7 ^{0}C to 31.1 ^{0}C, respectively. The soil was neutral in reaction (pH7.2), medium in organic carbon (0.60%), available N (372 kg/ha), available P (16.40 kg P_2O_5/ha) and high in available K (293 kg K_2O/ha). The field experiment was laid out in randomized block design with three replications. The experiment consisted of ten treatments. The herbicide spray solution was prepared by mixing the required quantity of both herbicide propaquizafop and imazethapyr or alone herbicide in water at 500 L/ha

for each plot. The sowing of seed was done manually on 22 July, 2012 at seed rate of 80 kg/ha. The sowing of seeds in each plots was done in rows 45 cm apart at the depth of 3-4 cm. Full dose of major plant nutrients (20 kg N + 60 kg P_2O_5 + 20 kg K_2O/ha) was applied as basal application through urea, single super phosphate and muriate of potash. Before sowing, the seeds were treated with carbendazim at 2.0 g/kg of seed followed by inoculation with *Rhizobium japonicum* culture at 5 g/kg of seed. The observations on weed density and dry weight were recorded at 45 DAS and harvest using quadrate of 0.25 square meter (0.5 m x 0.5 m) was randomly placed at four places in each plot. The data on weed count and weed biomass were subjected to square root transformation *i.e.*($\sqrt{x+0.5}$), before carrying out analysis of variance and comparisons were made on transformed values.

RESULTS AND DISCUSSION

Among the monocot, *Cyperus rotundus (*25.8 and 23.6%) was the most dominant weed followed by *Echinocloa colona* (23.1 and 23.3%) and *Commelina benghalensis* (15.6 and 17.8%) at 45 DAS and harvest, respectively, whereas dicot weeds like *Eclipta alba* (19.1 and 20.3%), and *Alternanthera philoxeroides* (16.4 and 15.0%) were present in lesser number in soybean ecosystem at 45 DAS and harvest, respectively. The highest weed infestation were recorded in weedy check plot. Application of propaquizafop as post-emergence at highest dose 75 g/ha caused significantly reduction in weed density and dry weight of monocot weeds over weedy check, followed by propaquizafop 62.5 g/ha. Imazethapyr as at lowest dose (50 g/ha) caused significant reduction in the density of this weed over weedy check plots. However, the efficacy of imazethapyr was further improved with the corresponding increase in rates of application being the higher when it was applied between 75 and 100 g/ha. The effectiveness of propaquizafop was enhanced further when it was applied in combination with imazethapyr at highest doses (75 + 100 g/ha), followed by combined application of both the herbicide (propaquizafop + imazethapyr 62.5 + 75.0 and 50.0 + 50.0 g/ha). However, none of the herbicidal treatment surpassed hand weeding in reducing the dry weight at 45 DAS and harvest stage.

Among weed control treatments, higher weed control efficiency was noted in plots receiving combined application of propaquizafop + imazethapyr 75 + 100 g/ha at harvest, as compared to combined application of propaquizafop + imazethapyr at 62.5 + 75 g/ha followed by imazethapyr applied as post-emergence at 100 g/ha, propaquizafop at 75 g/ha and combined application of propaquizafop + imazethapyr

Table 1. Effect of different treatments on weed density at 45 DAS and harvest in soybean

Treatment	Density/m^2									
	C. rotundus		*E. colona*		*C. benghalensis*		*Eclipta alba*		*A. philoxeroides*	
	45 DAS	At harvest	45 DAS	At harvest	45 DAS	At harvest	45 DAS	At harvest	45 DAS	At harvest
Propaquizafop 62.5 g/ha	4.34 (18.3)	4.22 (17.3)	2.57 (6.08)	1.77 (2.63)	3.41 (11.1)	3.16 (9.50)	4.44 (19.2)	4.33 (18.2)	3.21 (9.83)	3.15 (9.43)
Propaquizafop 75 g/ha	4.33 (18.3)	4.06 (15.9)	2.36 (5.08)	1.74 (2.53)	3.24 (10.0)	3.00 (8.50)	4.41 (18.9)	4.32 (18.1)	3.15 (9.40)	3.08 (9.00)
Imazethapyr 50 g/ha	2.83 (7.5)	1.75 (2.57)	2.27 (4.65)	1.66 (2.25)	2.42 (5.37)	1.49 (1.72)	2.75 (7.04)	1.81 (2.77)	1.89 (3.06)	1.66 (2.27)
Imazethapyr 75 g/ha	2.79 (7.26)	1.73 (2.48)	2.22 (4.45)	1.60 (2.07)	2.23 (4.47)	1.46 (1.62)	2.63 (6.42)	1.68 (2.33)	1.80 (2.75)	1.55 (1.90)
Imazethapyr 100 g/ha	2.43 (5.40)	1.53 (1.83)	1.99 (3.47)	1.37 (1.37)	2.20 (4.34)	1.37 (1.38)	2.50 (5.73)	1.51 (1.77)	1.67 (2.30)	1.34 (1.30)
Propaquizafop + imazethapyr 50 + 50 g/ha	2.61 (6.30)	1.55 (1.90)	2.18 (4.24)	1.50 (1.75)	2.22 (4.44)	1.45 (1.60)	2.54 (5.93)	1.58 (2.00)	1.73 (2.50)	1.45 (1.61)
Propaquizafop + imazethapyr 62.5+75 g/ha	2.36 (5.06)	1.50 (1.76)	1.92 (3.17)	1.30 (1.20)	2.21 (4.40)	1.39 (1.42)	2.39 (5.19)	1.46 (1.63)	1.61 (2.09)	1.42 (1.53)
Propaquizafop + imazethapyr 75 + 100 g/ha	2.25 (4.57)	1.42 (1.53)	1.86 (2.95)	1.27 (1.12)	2.10 (3.93)	1.37 (1.37)	2.21 (4.40)	1.42 (1.53)	1.54 (1.87)	1.36 (1.35)
Hand weeding (20 and 40 DAS)	0.71 (0.00)	1.23 (1.02)	0.71 (0.00)	1.23 (1.01)	0.71 (0.00)	1.26 (1.09)	0.71 (0.00)	1.23 (91.0)	0.71 (0.00)	1.24 (1.05)
Weedy check (control)	6.07 (36.3)	6.32 (39.4)	5.74 (32.5)	6.27 (38.8)	4.73 (21.9)	5.46 (29.3)	5.23 (26.8)	5.87 (33.9)	4.85 (23.1)	5.05 (25.0)
LSD (P=0.05)	0.096	0.079	0.107	0.125	0.107	0.196	0.143	0.120	0.072	0.129

*Figure in parentheses are original values

50+ 50 g/ha. However, the highest WCE was noted under weed free treatment (100 and 98.6%), which was proved superior over all the herbicidal treatments at harvest.

Crop biomass and leaf area index

Crop biomass was differed significantly under different weed control treatments (Table 3) biomass increased with application of propaquizafop (62.5 and 75 g/ha) and further increased with application of imazethapyr between 50.0 to 100.0 g/ha being higher when propaquizafop applied in combination with imazethapyr as post-emergence (62.5 + 75 and 75 + 100 g/ha). But combined application of propaquizafop + imazethapyr (50 + 50 g/ha) was less as compared to application of imazethapyr 100 g/ha while crop biomass was minimum under weedy check. However, the highest crop biomass was recorded under hand weeding treatments. Application of propaquizafop as post-emergence at 62.5 and 75 g/ha slightly increased the LAI. The LAI of imazethapyr at dose 100 g/ha was better than combined application of propaquizafop + imazethapyr at dose (50 + 50 g/ ha) being the higher when applied propaquizafop + imazethapyr at doses (75 + 100 and 62.5 + 75 g/ha) and proved equally good to that of hand weeding twice at 60 DAS.

Yield attributes and yield

Yield attributes, *viz.* pods per plant, number of seeds per pod, seed yield and stover yield (Table 3) were recorded significantly higher under two hand weeding at 20 and 40 DAS followed by combined application of propaquizafop + imazethapyr at (75 + 100 g/ha and 62.5+75 g/ha) over weedy check plots. Excellent growth and development of soybean plants under weed free environment during critical period of crop growth might have resulted in superior yield attributes under hand weeding treatment. Almost similar results were obtained by Raghuwanshi *et al.* (2005) and Shete *et al*. (2008). Application of imazethpyr at 75 and 100.0 g/ha as post-emergence produced better yield attributing characters (pods per plant and seeds per pod) but combined application with both herbicides (75.0 + 100 g/ha) was superior as compared to other herbicidal treatments. However, seeds per pod were superior but numerical higher over weedy check plots. Among treatments, the minimum seed index (6.92) was recorded in weedy check plot which was significantly increased when weed control measures were adopted. The application of imazethapyr at dos 100 g/ha produced higher seed index as compared to combined application of propaquizafop + imazethapyr at dose

Table 2. Effect of different treatments on weed dry weight (g/m^2) at 45 DAS and harvest in soybean

Treatment	*C. rotundus*		*E. colona*		*C. benghalensis*		*E. alba*		*A. philoxeroides*	
	45 DAS	At harvest	45 DAS	At harvest	45 DAS	At harvest	45 DAS	At harvest	45 DAS	At harvest
Propaquizafop 62.5 g/ha	2.96 (8.25)	2.85 (7.61)	2.54 (5.93)	1.58 (1.99)	3.30 (10.4)	2.98 (8.38)	2.99 (8.47)	2.64 (6.47)	2.96 (8.27)	2.71 (6.87)
Propaquizafop 75.0 g/ha	2.94 (8.14)	2.79 (7.29)	2.39 (5.19)	1.57 (1.95)	3.15 (9.41)	2.81 (7.38)	2.74 (7.03)	2.35 (5.03)	2.95 (8.18)	2.71 (6.83)
Imazethapyr 50.0 g/ha	1.99 (3.47)	1.61 (2.09)	2.30 (4.77)	1.52 (1.81)	2.73 (6.97)	1.24 (1.05)	2.17 (4.22)	1.50 (1.76)	2.35 (5.04)	1.29 (1.16)
Imazethapyr 75.0 g/ha	1.99 (3.46)	1.60 (2.06)	2.28 (4.71)	1.51 (1.77)	2.71 (6.85)	1.23 (1.02)	2.14 (4.07)	1.47 (1.66)	2.34 (4.98)	1.28 (1.13)
Imazethapyr 100.0 g/ha	1.95 (3.32)	1.57 (1.97)	2.14 (4.06)	1.36 (1.35)	2.67 (6.62)	1.19 (0.92)	2.08 (3.83)	1.37 (1.38)	2.17 (4.20)	1.24 (1.05)
Propaquizafop + imazethapyr 50.0 + 50.0 g/ha	1.98 (3.44)	1.59 (2.02)	2.20 (4.36)	1.43 (1.55)	2.68 (6.70)	1.14 (0.79)	2.11 (3.95)	1.40 (1.47)	2.21 (4.37)	1.26 (1.10)
Propaquizafop + imazethapyr 62.5 + 75.0 g/ha	1.95 (3.29)	1.49 (1.73)	1.94 (3.27)	1.31 (1.22)	2.42 (5.34)	1.08 (0.66)	2.01 (3.56)	1.34 (1.29)	2.11 (3.94)	1.20 (0.95)
Propaquizafop + imazethapyr 75.0 + 100 g/ha	1.91 (3.14)	1.45 (1.60)	1.91 (3.16)	1.16 (0.84)	2.37 (5.12)	1.03 (0.57)	1.89 (3.06)	1.26 (1.09)	2.08 (3.84)	1.20 (0.93)
Hand Weeding (20 and 40 DAS)	0.71 (0.00)	0.89 (0.290	0.71 (0.00)	1.00 (0.500	0.71 (0.00)	0.87 (0.25)	0.71 (0.00)	0.98 (0.46)	0.71 (0.00)	1.02 (0.54)
Weedy Check (control)	5.56 (30.4)	5.66 (31.5)	4.55 (20.2)	5.79 (33.0)	4.22 (17.3)	5.49 (29.6)	4.46 (19.4)	5.37 (28.3)	4.66 (21.2)	5.01 (24.63)
LSD(P=0.05)	0.095	0.112	0.113	0.141	0.089	0.244	0.141	0.230	0.087	0.131

*Figure in parentheses are original values.

50 + 50 g/ha. Among the combined application of herbicidal treatments propaquizafop + imazethapyr at doses 75 + 100 (7.72) produced higher seed index as compared to other herbicidal treatments. However, super value (7.74) was recorded in plots receiving hand weeding twice (20 and 40 DAS).

The seed yield was lowest in the plots under weedy check due to severe competition stress right from crop establishment up to the end of critical period of crop growth, leading to poor growth parameters and yield attributing traits and finally the seed yield. All the treated plots receiving either manual weeding or herbicidal treatments produced higher yield over weedy check plots. Weed free treatment produced the maximum seed yield and proved its superiority over all the treatments. Sharma and Shrivastava (2002), Vyas and Jain (2003) and Halvankar *et al.* (2005) also reported that, hand weeding as an effective method of weed control for achieving the maximum yield of soybean. Among the herbicidal treatments, application of propaquizafop at 62.5 g/ha gave lower seed yields but increase correspondingly with the increase in application rate and imazethpyr at 50 g/ha gave lower seed yield but increased correspondingly with the increase in application rate being higher when imazethpyr was applied 75, 100 g/ha. However, seed yield was further increase in plot receiving combined application of propaquizafop + imazethapyr at (75 + 100 g/ha) being at par to hand weeding twice. Excellent weed free conditions, provided congenial environment for better growth and development of growth parameters, yield attributes and in turn the seed yield. The data revealed that maximum reduction in yield (41.83%) occurred in weedy check plots where weeds were not controlled throughout the crop season. Application of propaquizafop, imazethapyr alone and combined application of propaquizafop + imazethapyr as post-emergence at highest doses 75, 100 and 75 + 100 g/ ha, respectively curbed the weed menace to 20.1, 17.4 and 12.0%, respectively. Among weed control treatments, the minimum harvest index was recorded in weedy check plots (30.6) which was increased when the application of propaquizafop (62.5, 75 g/ha) and imazethapyr (50, 75, 100 g/ha) being highest (34.8) under combined application of propaquizafop + imazethapyr at 75 + 100 g/ha and hand weeded plots (35.8) and proved superior over rest of the treatments.

Economics

Among the herbicidal treatments, combined application of propaquizafop + imazethapyr (75 + 100 g/ha) fetched the highest GMR and NMR. The GMR was followed by imazethapyr at 100 g/ha but NMR closely followed by imazethapyr at (62.5 + 75 g/ha)

Table 3. Effect of different weed control treatments on yield, WCE and economics of soybean

Treatment	Pods/ plant	Seeds /pod	LAI (at 60 DAS)	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index	Weed index	Weed control efficiency (%)	Net monetary returns (x10^3 `/ha)	B:C Ratio
Propaquizafop 62.5 g/ha	49.0	2.07	6.34	2.06	4.35	32.2	27.9	78.7	25.4	2.04
Propaquizafop 75 g/ha	51.8	2.10	6.56	2.29	4.62	33.1	20.1	80.6	30.6	2.25
Imazethapyr 50 g/ha	58.6	2.12	6.88	2.32	4.65	33.3	19.1	94.6	31.3	2.28
Imazethapyr 75 g/ha	58.8	2.14	7.19	2.35	4.66	33.5	18.1	94.8	31.8	2.30
Imazethapyr 100 g/ha	63.1	2.18	7.84	2.37	4.67	33.6	17.4	95.5	32.3	2.31
Propaquizafop + imazethapyr 50 + 50 g/ha	62.9	2.15	7.67	2.35	4.66	33.6	17.8	95.2	31.7	2.27
Propaquizafop + imazethapyr 62.5 +75 g/ha	66.1	2.20	8.22	2.42	4.70	33.9	15.6	96.0	33.1	2.33
Propaquizafop + imazethapyr 75 + 100 g/ha	66.2	2.23	8.83	2.52	4.75	34.8	12.1	96.5	35.3	2.41
Hand weeding (20 and 40 DAS)	67.3	2.27	9.11	2.67	4.78	35.8	0.00	98.6	30.2	1.91
Weedy check (control)	45.6	1.98	5.66	1.67	3.77	30.6	41.83	0.00	16.4	1.68
LSD (P=0.05)	0.74	NS	0.09	0.34	0.14	-	-	-		

and imazethapyr at highest dose 100 g/ha as post-emergence. The B-C ratio was maximum under propaquizafop + imazethapyr (75. +100 g/ha) (2.41) followed by propaquizafop + imazethapyr (62.5+75.0 g/ha) (2.33), imazethapyr 100 g/ha (2.31), imazethapyr 75 g/ha (2.30), imazethapyr 50 g/ha (2.28), propaquizafop + imazethapyr (50 +50 g/ha) (2.27), propaquizafop 75 g/ha (2.25), propaquizafop 62.5 g/ha (2.04), hand weeding 20 and 40 DAS (1.91) and minimum in weedy check (1.68).

Major dominant weeds infesting the soybean crop were *Cyperus rotundus, Echinochloa colona, Commelina benghalensis, Eclipta alba,* and *Alternanthera philoxeroides.* Combined application of propaquizafop + imazethapyr herbicides as post-emergence was more effective at (75 + 100 g/ha) against mixed weed flora in soybean. Growth parameters, yield attributes and seeds yield were superior under combined application of propaquizafop + imazethapyr at (75 + 100 g/ha) as post-emergence without any phytoxicity on soybean plants. Application of propaquizafop + imazethapyr at (75 + 100 g/ha) as post-emergence was found more remunerative in terms of NMR (` 35,298).

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