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Broad spectrum post emergence herbicide combinations for weed control in soybean (*Glycine max* L. Merrill)

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Abstract
A field investigation to study the performance of newly released broad spectrum post emergence herbicide combinations in soybean (*Glycine max* (L.) Merrill)" was conducted during *kharif* 2021-22 at experimental farm, Department of Agronomy, College of Agriculture, VNMKV, Parbhani (M.S) to study the effect of different weed management practices on growth and yield of soybean. The experiment was laid out in Randomized Block Design. The experiment was carried out with seven weed management practices replicated thrice. Treatment comprised of T_1-PoE- Fluazifop-p-butyl 11.1% + Fomesafen 11.1% W/W SL @ 250 g a.i ha^{-1}, T_2- PoE- Imazethapyr 35% + Imazamox 35% WG @ 70 g a.i ha^{-1}, T_3- PoE- Sodium acifluorfen 16.5% + clodinafop propargyl 8% EC @ 80 +165 g a.i ha^{-1}, T_4- PoE- Propaquizafop 2.5% + Imazethapyr 3.75% W/W @ 50 + 75 g a.i ha^{-1}, T_5- PoE- Fomesafen 12% + Quizalofop ethyl 3% SC @ 180 +45 g a.i ha^{-1}, T_6- Weed free and T_7- Weedy check. Result of study revealed that among the herbicide combinations in soybean the lowest weed dry matter for both monocot and dicot weed and highest seed yield was recorded with PoE-Fomesafen 12% + Quizalofop ethyl 3% SC @ 180 +45 g a.i ha^{-1} (T_5), PoE-Fluazifop-p-butyl 11.1% + Fomesafen 11.1% W/W SL@ 250 g a.i ha^{-1} (T_1) and PoE-Sodium acifluorfen 16.5% + clodinafop propargyl 8% EC @ 80 +165 g a.i ha^{-1} (T_3) and these treatments were found most effective in controlling dry weed weight and as well as recorded highest seed yield, biological yield, straw yield and yield attributing character. The treatments were comparable to weed free (T_6) and found to be significantly superior over rest of treatments.

Keywords: Soybean, weed management, herbicide combinations, post emergence, *kharif*

Introduction
Among the annual agricultural losses in India, weeds cause 10 to 80% crop yield losses besides deteriorating quality of products and causing health and environmental hazards they use the available moisture, soil fertility, nutrients and compete for space & sunlight with the crops plants which result in yield reduction. Weeds provide shelter and acts as an alternate host for pests. Weeds in India diminish crop yields by 32 to 80%, according to (Rao *et al.* 2014), because soybean is a rainy season crop, it is infested with a wide variety of weed flora in various flushes that compete with the crop plants for nutrients, light, and moisture, in addition to their allelopathic effects. The weed flora in soybean included *Trianthema monogyna* L, *Amaranthus viridis* L., *Phyllanthus niruri* L, *Digera arvensis* Forsk, *Cynodon dactylon* (L) Pers, *Echinochloa colonum* (L) Link. Therefore, for sustaining food grain production to feed ever-increasing population and ensuring food security, effective weed management is very essential.

Herbicides now on the market are either pre-emergence or pre-plant integrated and have a limited weed control scope. Furthermore, if farmers fail to apply these pre- emergence or pre-incorporated herbicides for one reason or another, they will need to use alternate post-emergence herbicides to control weeds. As a result, new pre- and post-emergence herbicides with a larger spectrum of activity are required. Some new pre- and post-emergence herbicides combination for weed management in soybeans have recently been released in India, and they must be examined before being used in the field and their efficacy to control dominant weeds at different locations and their evaluation for field use.

Materials and Methods
Field experiment entitled "Efficacy of broad spectrum post emergence herbicide combinations in soybean (*Glycine max* (L.) Merrill)" was carried out on black soil during the *Kharif* season of 2021-22 at Experimental Farm, Department of Agronomy, College of Agriculture,

VNMKV, Parbhani. The topography of the experimental plot was well uniform and levelled. The soil was black in colour, deep and fairly well drained. The experiment was laid out in Randomized Block Design. The experiment was carried out with seven weed management treatments each treatment was replicated thrice. Treatment were T_1-PoE- Fluazifop-p-butyl 11.1% + Fomesafen 11.1% W/W SL @ 250 g a.i ha^{-1}, T_2-PoE- Imazethapyr 35% + Imazamox 35% WG @ 70 g a.i ha^{-1}, T_3- PoE- Sodium acifluorfen 16.5% + clodinafop propargyl 8% EC @ 80 +165 g a.i ha^{-1}, T_4- PoE- Propaquizafop 2.5% + Imazethapyr 3.75% W/W @ 50 + 75 g a.i ha^{-1}, T_5- PoE- Fomesafen 12% + Quizalofop ethyl 3% SC @ 180 +45 g a.i ha^{-1}, T_6- Weed free and T_7- Weedy check. The gross and net plot size of each experimental unit was 5.4 m x 4.5 m and 4.5m x 4.2m, respectively and variety of soybean used for experimental study was MAUS-158. Sowing was done on 27th August 2021. Different observations were recorded *viz*., weed dry weight, yield attributes, seed yield, biological yield and straw yield of soybean.

Results and Discussion

Weed dry matter (g)

Data on dry weed weight of monocot and dicot weeds in g m^{-2} at 15, 30 and 45 DAS as influenced by different treatments are presented in Table 1.

Weed dry weight for monocot and dicot weeds were significantly influenced at 30 and 45 DAS except at 15 DAS. The lowest weed dry weight were recorded at weed free (T_6) treatments and which are statistically at par with PoE- Fomesafen 12% + Quizalofop ethyl 3% SC @ 180 + 45 g a.i/ha (T_5), PoE-Fluazifop-p-butyl 11.1% + Fomesafen 11.1% w/w SL @ 250 g a.i/ha (T_1) and PoE- Sodium acifluorfen 16.5% + Clodinofop propargyl 8% EC @ 80 + 165 g a.i/ha (T_3). Whereas, highest dry weight for monocot weeds was observed with treatment weedy check (T_7). It might be due to better weed control of both monocot and dicot weeds, under weeding treatments and use of post-emergence herbicide combinations which resulted in reduced weed dry weight due to effect on weeds over extended period. Similar findings were also reported by Shaikh *et al.* (2010) [11], Das *et al.* (2021) [3] and Kadam *et al*. (2018) [6].

Yield attributes of soybean

Perusal data presented in Table 2. Different weed management practices significantly influenced yield attributes of soybean. The highest seed yield plant^{-1} (4.45 g) was recorded in weed free (T_6) treatments it was significantly superior over rest of treatments statistically at par with PoE- Fomesafen 12% + Quizalofop ethyl 3% SC @ 180 + 45 g a.i/ha (T_5), PoE-Fluazifop-p-butyl 11.1% + Fomesafen 11.1% w/w SL @ 250 g a.i/ha (T_1) and PoE- Sodium acifluorfen 16.5% + Clodinofop propargyl 8% EC @ 80 + 165 g a.i/ha (T_3). Lowest seed yield was observed in treatments weedy check (T_7). Similar trend was observed in number of pods plant^{-1}, and number. of Seeds pod^{-1}

The treatment weed free recorded significantly higher number of seed yield plant^{-1}, indicating least competition offered by weeds for nutrients and moisture at crucial growth stages under treatment which altimately improved all yield attributes. Singh *et al*. (2014) [12], Kadam *et al*. (2018) [6] and Jha *et al*. (2014) [5] reported similar findings was observed in seed yield of soybean as influenced by weed management treatments.

Yield attributes and soybean yield (kg ha^{-1})

Data on yield attributes and soybean yield (kg ha^{-1}) was significantly influenced by different weed management practices as presented in Table 2.

Yield attributes and Seed yield (kg ha^{-1})

The treatment weed free recorded highest values for yield attributes like number of pods per plant, seed yield per plant and seed yield (1720 kg ha^{-1}), however, it was at par with PoE- Fomesafen 12% + Quizalofop ethyl 3% SC @ 180 + 45 g a.i/ha (T_5), PoE-Fluazifop-p-butyl 11.1% + Fomesafen 11.1% w/w SL @ 250 g a.i/ha (T_1) and PoE- Sodium acifluorfen 16.5% + Clodinofop propargyl 8% EC @ 80 + 165 g a.i/ha (T_3) and significantly superior over rest of treatments. The lowest seed yield (895 kg ha^{-1}) was recorded in weedy check (T_7) as compared to all other treatments.

These might be due to increased rate of nutrient absorption cumulative helped the crop plant to produce more surface area for photosynthetic rate as well as maximum translocation of photosynthesis from source to sink, subsequently resulted in improvement in seed yield due to lowered competition from weeds. Similar results were observed by Bharat *et al*. (2020) [20], Ghosh *et al*. (2020) [4] and Panda *et al*. (2015) [8] who reported effective weed management in soybean with PoE- Fomesafen 12% + Quizalofop ethyl 3% SC @ 180 + 45 g a.i/ha as compared with other treatents.

Straw yield (kg ha^{-1})

Data revealed that the weed free, recorded highest straw yield over all other treatments except it was at par with PoE- Fomesafen 12% + Quizalofop ethyl 3% SC @ 180 + 45 g a.i/ha (T_5), PoE-Fluazifop-p-butyl 11.1% + Fomesafen 11.1% w/w SL @ 250 g a.i/ha (T_1) and PoE- Sodium acifluorfen 16.5% + Clodinofop propargyl 8% EC @ 80 + 165 g a.i/ha (T_3). Significantly lowest straw yield was recorded with (T_7) weedy check as compared to all other treatments. This might be due to straw yield was an augmenting effect of increased vegetative growth through plant height, number of branches and number of leaves plant^{-1}. Profound effect on seed and straw yield was noted due to different weed management practices. Biological yield for soybean also found the similar trend.

Similar trend was observed by Rupareliya *et al*. (2020) [9] Thakare *et al* (2015) [13] and Kadam *et al*. (2018) [6] who reported that PoE-Fluazifop-p-butyl 11.1% + Fomesafen 11.1% w/w SL @ 250 g a.i/ha (T_1) and PoE- Sodium acifluorfen 16.5% + Clodinofop propargyl 8% EC @ 80 + 165 g a.i/ha and hand weeding recorded highest straw yield than weedy check (T_7).

Table 1: Mean weed dry matter for monocot and dicot weeds of soybean (g m^{-2}) as influenced by different treatments at 15, 30 and 45 DAS.

Tr. No	Treatments	15 DAS		30 DAS		45 DAS	
		Monocot	Dicot	Monocot	Dicot	Monocot	Dicot
T_1	PoE- Fluazifop-p-butyl 11.1% + Fomesafen 11.1 W/W SL@ 250 g a.i/ha	10.87*(3.44)	7.71 (2.95)	2.23 (1.79)	1.36 (1.53)	3.14 (2.03)	2.46 (1.86)
T_2	PoE- Imazethapyr 35% + Imazamox 35% WG @ 70 g a.i/ha.	11.32 (3.50)	7.87 (2.97)	6.84 (2.80)	6.87 (2.80)	9.65 (3.26)	8.46 (3.07)
T_3	PoE- Sodium acifluorfen 16.5% + clodinafop propargyl 8% EC @ 80 +165 g a.i/ha.	11.02 (3.46)	7.85 (2.97)	2.39 (1.84)	1.44 (1.56)	3.30 (2.07)	2.54 (1.88)
T_3	PoE- Propaquizafop 2.5% + Imazethapyr 3.75% W/W @ 50 + 75 g a.i/ha.	11.46 (3.52)	8.01 (3.01)	7.49 (2.91)	8.02 (3.00)	10.37 (3.37)	9.51 (3.24)
T_5	PoE- Fomesafen 12% + Quizalofop ethyl 3% SC @ 180 +45 g a.i/ha	10.77 (3.43)	7.65 (2.94)	2.07 (1.75)	1.26 (1.50)	2.71 (1.92)	2.25 (1.80)
T_6	Weed free	10.78 (3.43)	7.58 (2.92)	1.07 (1.43)	0.53 (1.23)	1.72 (1.65)	1.42 (1.55)
T_7	Weedy check	11.74 (3.57)	8.35 (2.92)	17.78 (4.33)	16.43 (4.17)	29.48 (5.52)	34.42 (5.95)
S.E.±		0.41	0.43	0.52	0.29	0.30	0.38
C.D. at 5%		NS	NS	1.60	0.90	0.94	1.17
General mean		9.72	6.84	5.98	5.47	8.62	8.72

*The value in parenthesis are transformed by $\sqrt{x} + 1$

Table 2: Yield attributes and yield of soybean as influenced by different treatments.

Tr. No	Treatments	Seed yield plant^{-1} (g)	No. of Seeds pod^{-1}	No. of pods plant^{-1}	Seed yield Kg ha^{-1}	Straw yield Kg ha^{-1}	Biological yield kg ha^{-1}
T_1	PoE- Fluazifop-p-butyl 11.1% + Fomesafen 11.1 W/W SL@ 250 g a.i/ha	4.03	2.24	26.01	1587	2434	4021
T_2	PoE- Imazethapyr 35% + Imazamox 35% WG @ 70 g a.i/ha.	3.21	2.18	22.64	1376	2264	3641
T_3	PoE- Sodium acifluorfen 16.5% + clodinafop propargyl 8% EC @ 80 +165 g a.i/ha.	3.83	2.24	25.54	1492	2317	3800
T_3	PoE- Propaquizafop 2.5% + Imazethapyr 3.75% W/W @ 50 + 75 g a.i/ha.	3.10	2.07	21.16	1259	2230	3489
T_5	PoE- Fomesafen 12% + Quizalofop ethyl 3% SC @ 180 +45 g a.i/ha	4.20	2.27	26.46	1671	2497	4168
T_6	Weed free	4.45	2.31	27.17	1720	2565	4286
T_7	Weedy check	2.24	2.04	17.14	895	1631	2526
S.E.±		0.22	0.42	1.03	75.08	92.57	161.72
C.D. at 5%		0.67	NS	3.17	231.34	285.21	498.29
General mean		3.58	2.19	23.73	1427.64	2277.24	3702.52

Conclusion

Among the different broad spectrum post emergence herbicide combinations post emergence application of Fomesafen 12% + Quizalofop ethyl 3% @ 180 + 45 g a.i ha^{-1}, post emergence application of Fluazifop-p-butyl 11.1% + Fomesafen 11.1% @ 250 g a.i ha^{-1} and post emergence application of Sodium acifluorfen 16.5% + Clodinofop propargyl 8% @ 80 + 165 g a.i ha^{-1} were found highly effective in controlling monocot and dicot weed in soybean compared to rest of treatment as well as highly productive, profitable and also it was comparable to weed free.

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