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RESEARCH ARTICLE

Chemical weed management in soybean with early post-emergence herbicides

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ABSTRACT

In soybean, weed control has proven to be particularly difficult during rainy (*Kharif*) season because of erratic precipitation, unusable soil on rainy days, and a shortage of labour. Under such conditions, using superior broad-spectrum herbicides is the only other viable way to suppress weeds. Thus, field experiments were conducted to study the effects of ready-mix early post emergence herbicides on soybean crop at research farm of Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal during the *Kharif* season of 2020 and 2021. Seven treatments consisted of three doses of early post-emergence ready-mix herbicide fluazifop-p-butyl 11.1% + fomesafen 11.1% SL at 250, 312.5 and 500 g/ha, other post emergence herbicide such as quizalofop-ethyl 5% EC (50 g/ha) and imazethapyr 10% SL (100 g/ha), and hand weeding at 20 and 40 DAS and weedy check control were laid out in randomized complete block design with three replications. Fluazifop-p-butyl 11.1% + fomesafen 11.1% SL (312.5 g/ha) found effectively to control all types of weed and dry weight and increased seed (2.41 t/ha) and stover (2.73 t/ha) yield significantly by improving growth and yield attributing characters which were at par with the twice hand weeding. The highest dose of fluazifop-p-butyl 11.1% + fomesafen 11.1% SL (500 g/ha) were found to be superior against weed flora but caused phytotoxicity on crop and reduced seed (1.58 t/ha) and stover yield (2.15 t/ha).

Keywords: Early post-emergence herbicides, Fluazifop-p-butyl + fomesafen, Hand weeding, Seed yield, Soybean

INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] is the important source of cheapest and richest vegetable protein and oil. About 18–20% oil and 40% protein are found in it (Ghosh and Pramanik 2020). Thus, compared to other oilseed and pulse crops grown during the *Kharif* season, soybean has emerged as a viable protein as well as oilseed crop across the world with greater adaptability and high production potential (Dhakad *et al.* 2022). During 2022-23, India recorded 13.98 mt soybean production from an area of 12.07 m ha with a productivity of 1158 kg/ha (IISR 2024) despite of its potential yield of 2500 kg/ha, as a result of severe weed competition (Sangeetha *et al.* 2013). As a rainy season crop, soybean is severely infested with grasses, *viz. Echinochloa colona*, *Echinochloa crusgalii*, *Cyperus* spp., *Cynodon dactylon* and broad leaf weeds like *Phyllanthus niruri*, *Euphorbia* spp., *Commelina benghalensis*, *Eclipta alba*, *Corchorus acutangulus etc.* (Sharma and Shrivastava 2002, Patidar *et al.* 2019). Further, due to the wide spacing which is necessary for the development of branches and the complete expansion of the canopy during the late growth stage, soybeans are susceptible to interference by weeds (Wax and Pendleton 1968, Yelverton and Coble 1991, Hock *et al.* 2006). Compared to other crops, soybeans have a late canopy closure that makes it easier for weeds to grow (Carey and Defelice 1991, Nelson and Renner 1998, Harder *et al.* 2007) which directly impact production during the *Kharif* season (Ghosh and Pramanik 2020).

Despite being very efficient, the conventional hand weeding approach is time-consuming, expensive, labour-intensive, and often impossible owing to a lack of manpower (Ghosh and Pramanik 2020, Dhakad *et al.* 2022, Patidar *et al.* 2023). Because of erratic rainfall, unusable soil on rainy seasons, and a shortage of labour in a timely manner, weed control in soybean has proven to be particularly difficult, especially during the *Kharif* season (Dhakad *et al.* 2022). Under such conditions, using superior broad-spectrum herbicides is the only alternate and viable way to suppress weeds. Although, farmers mainly use pendimethalin as a pre-emergence herbicide in soybean fields (Virk *et al.* 2018), but there is a limited window for using pre-emergence herbicides. Hence, in order to effectively manage weeds on soybean field, it is essential to use of post-emergence herbicides be investigated.

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With its distinct selectivity and herbicidal action over broad-leaved weeds in soybeans, fomesafen is found to be a novel herbicide belonging to the diphenyl ether group that is used as an early post-emergence herbicide (Patidar *et al.* 2023) and also in beans (Soltani *et al.* 2017). A study conducted on soybeans by Singh *et al.* (2014) found that a pre-mix of fomesafen + fluazifop-p-butyl at 250+250 g/ha efficiently reduced both grasses and non-grassy weeds, resulting in less weeds compared to the untreated check. However, there is a dearth of research on their effectiveness in the soil of West Bengal's New Alluvial Zone under soybean cultivation. In order to better understand the effectiveness of ready-mix herbicides fluazifop-p-butyl 11.1% + fomesafen 11.1% SL in controlling weeds and enhancing soybean production, an experiment was conducted in West Bengal conditions.

MATERIALS AND METHODS

Field experiments were carried out to investigate the impact of ready-mix early post-emergence herbicides on soybean crop at Kalyani C-Unit Farm, Kalyani, Nadia under Bidhan Chandra Krishi Viswavidyalaya (BCKV), Mohanpur, Nadia, West Bengal during the *Kharif* season of 2020 and 2021. The farm is located 9.75 meters above mean sea level (MSL) in West Bengal's New Alluvial Zone (NAZ), which is located at latitude 22°98'N and longitude 88°42'E. The soil in this area was created by the recently formed Ganges River alluvium and is mostly rich, deep, and nearly neutral in response (7.34 pH) having 0.57% OC, medium N and P content with low K.

The present investigation was conducted in randomised block design with three replications. Seven treatments consist of different three levels of ready-mix fluazifop-p-butyl 11.1% + fomesafen 11.1% SL herbicide application at 250, 312.5 and 500 g/ha doses, quizalofop-ethyl 5% EC at 50 g/ha, imazethapyr 10% SL at 100 g/ha, two hand weeding at 20 and 40 DAS and weedy check control. Using a knapsack sprayer with a flat fan nozzle and a 500 L/ha spray volume, the formulated herbicide solution was uniformly sprayed on weeds at the 2-4 leaf stage (20 days after crop sowing). A simultaneous application of water was made to the weedy check and hand-weeded plots. In the hand weeding plots, weeds were physically pulled from each plot twice, at 20 and 40 DAS. Soybean seeds (var. *'Prabhakar'*) were planted with a spacing of 30cm ×10cm during second fortnight of June during both the years. The experimental plots were adhered to the recommended package of operations in all cases with the exception of weed control methods. 20 kg N, 60 kg P and 60 kg K/ha were applied basal at the time of sowing.

After applying herbicide, the population of dominating weeds species per square meter was observed individually at 45, 60 and 75 days after crop planting. The dry weight of the weeds (dried in an oven at 70°C) were computed. A 50 cm × 50 cm quadrate was positioned at four random locations per plot to record the population size as well as the dry weight of the weed flora. The results were presented on per square meter basis to assess the relative effectiveness of the test products. Statistical analysis was performed on the data related to weed count and dry weight where appropriate. Additionally, weed control efficiency was computed using the dry weight of the weeds. The following formula was used to calculate the weed index (WI) and weed control efficiency (WCE) (Lal *et al.* 2017, Singh *et al.* 2017):

$$WCE = \frac{DWC - DWT}{DWC} \times 100$$

Where, WCE: Weed control efficiency, DWC: Dry weight (g) of weeds in weedy check plots and DWT: Dry weight (g) of weeds in the treated plots.

$$WI = \frac{X - Y}{X} \times 100$$

Where, WI: Weed index, X: Seed yield of hand weeded plot and Y: Seed yield of the treated plot for which weed index is to be worked out.

From each replication of the treatment, five plants were chosen randomly and tagged. Replication-wise plant height (cm) at 75 DAS, number of branches/plant, number of pods/plant, number of seeds/pod, 100 seed weight (g) and also the seed and haulm yields (t/ha) were recorded for each treatment at harvest.

Also, the soil samples from the individual experimental plots were collected from rhizosphere at a depth of 0-15 cm at different intervals, *viz.* pre-treatment, 15, 30 and 45 DAA and then requisite samples of each treatment were taken for soil microbial count such as total bacteria, total fungi and total actinomycetes. Specific media for plating, *viz.* Tronton's agar medium, Martin Rose Bengal Streptomycin in agar medium and Jensen's agar medium was also prepared for total bacteria, total fungi and total actinomycetes count, respectively. Then the plates were incubated at 28 ± 1 °C in BOD incubator and observations in terms of counting the total number of colonies per plate were taken at 2 days interval up to 7 days.

The data on density and dry weight of weeds were subjected to square root transformation $(\sqrt{x+1})$ to improve the homogeneity of the variance (ANOVA) separately for each year (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Associated weed flora

Density of grassy weeds *Digitaria sanguinalis*, *Echinochloa colona*, *Dactyloctenium aegyptium* and *Brachiaria* spp. were higher as compared to broad leaf weeds (BLW) *Cleome gynandra*, *Parthenium hysterophorus*, *Amaranthus spinosus*, *Senna tora*, *Phyllanthus niruri*, *Acalypha indica* and *Trianthema* sp. in weedy check plot at 60 DAS. Weedy check plot recorded 45.45% grassy weeds whereas, 35.27% BLW was observed at 60 DAS (**Table 1**). *Cyperus rotundus* (19.28%) was the only sedge weed found in the experimental field during the all three observations. Similar trend about the weed flora presence in soybean field was also reported by Lodha (2018) and Patidar *et al.* (2023).

Weed density and dry weight of weeds

All types of weeds (*i.e.*, grasses, BLW and sedges) were controlled efficiently by different weed control treatments (**Table 1**). Weedy check plots recorded the highest weed density and dry weight of weeds (**Table 2**) at 60 DAS because of continuous development throughout the crucial crop-weed competition phase (Patidar *et al.* 2023). 2 hand weedings at 20 and 40 DAS reduced the density and biomass of weeds to the maximum extent, when compared to herbicide-based treatments, as a result of all weed types being removed during manual weeding, as previously noted by Singh and Jolly (2004), Sharma *et al.* (2017) and Gidesa and Kebede (2018). Among the herbicide treatments, lowest number of weeds and their dry weight was recorded under the application of fluazifop-p-butyl 11.1% + fomesafen 11.1% SL at 500 g/ha followed by 312.5 g/ha during both the experimental seasons as a resultant of the two herbicides working together for successfully elimination of both grassy and non-grassy weeds in a broad-spectrum manner and significantly reduce the accumulation of dry weight of weeds over the weedy check (Deshmukh *et al.* 2023). According to Patidar *et al.* (2019), both lower as well as higher doses of the pre-mixture fomesafen + fluazifop-p-butyl (90+90 g/ha) applied early post-emergence resulted in a significant decrease in the dry weight of both dicot and monocot.

Weed control efficiency (WCE) and weed index

Highest weed control efficiency (WCE) was recorded under the hand weeding at 20 and 40 DAS at all the stages. Among the herbicidal treatments, application of fluazifop-p-butyl 11.1% + fomesafen 11.1% SL (500 g/ha) exhibited the highest WCE on all types of weed *i.e.*, grasses, BLW and sedges at all the observations, followed by fluazifop-p-butyl 11.1% + fomesafen 11.1% SL (312.5 g/ha). At 60 DAS, highest WCE on grasses (61.02%) and sedges (43.35%) was recorded under the application of fluazifop-p-butyl 11.1% + fomesafen 11.1% SL (500

Table 1. Population of dominant weeds/m^2 in soybean at 60 days after crop sowing (pooled data of 2 years)

Treatment	Doses (g/ha)	Grasses				Broad-leaf weeds							Sedges
		Digitaria spp.	*E. colona*	*Dactyloctenium* spp.	*Brachiaria* spp.	*Cleome gynandra*	*Parthenium* sp.	*Amaranthus* spp.	*Cassia* sp.	*Phyllanthus* sp.	*Acalypha indica*	*Trianthema* sp.	*Cyperus rotundus*
Fluazifop-p-butyl 11.1% + fomesafen 11.1% SL	250	2.12 (3.50)	3.26 (9.60)	1.82 (2.30)	2.05 (3.20)	2.43 (4.90)	2.39 (4.70)	1.52 (1.30)	1.73 (2.00)	1.87 (2.50)	1.70 (1.90)	1.87 (2.50)	3.49 (11.20)
Fluazifop-p-butyl 11.1% + fomesafen 11.1% SL	312.5	1.84 (2.40)	2.61 (5.80)	1.61 (1.60)	1.82 (2.30)	2.05 (3.20)	2.00 (3.00)	1.41 (1.00)	1.58 (1.50)	1.73 (2.00)	1.48 (1.20)	1.67 (1.80)	3.00 (8.00)
Fluazifop-p-butyl 11.1% + fomesafen 11.1% SL	500	1.76 (2.10)	2.39 (4.70)	1.52 (1.30)	1.73 (2.00)	2.00 (3.00)	1.90 (2.60)	1.41 (1.00)	1.52 (1.30)	1.64 (1.70)	1.45 (1.10)	1.58 (1.50)	2.86 (7.20)
Quizalofop-ethyl 5% EC	50	1.90 (2.60)	2.86 (7.20)	1.73 (2.00)	2.00 (3.00)	2.26 (4.10)	2.32 (4.40)	1.55 (1.40)	1.73 (2.00)	2.02 (3.10)	1.64 (1.70)	2.02 (3.10)	3.81 (13.50)
Imazethapyr 10% SL	100	2.02 (3.10)	3.00 (8.00)	1.67 (1.80)	2.07 (3.30)	2.12 (3.50)	2.24 (4.00)	1.41 (1.00)	1.61 (1.60)	1.90 (2.60)	1.48 (1.20)	1.84 (2.40)	3.29 (9.80)
Hand weeding at 20 & 40 DAS	-	1.45 (1.10)	1.76 (2.10)	1.41 (1.00)	1.00 (0.00)	1.41 (1.00)	1.58 (1.50)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.76 (2.10)
Weedy check control	-	2.97 (7.80)	6.15 (36.80)	2.19 (3.80)	2.83 (7.00)	3.51 (11.30)	3.29 (9.80)	1.95 (2.80)	2.26 (4.10)	2.41 (4.80)	2.30 (4.30)	2.63 (5.90)	4.95 (23.50)
LSD (p=0.05)		0.05	0.12	0.06	0.15	0.08	0.20	0.10	0.12	0.16	0.11	0.14	0.27

Data are subjected to square root transformation $(\sqrt{x+1})$ and original data presented in parentheses g/ha) next to the hand weeded plots. It might have been caused by using a ready-mix combination of two herbicides, which successfully inhibited or controlled weed development in a wide manner and decreased the dry mass of weeds relative to the control, increasing the efficacy of weed control (Deshmukh *et al.* 2023). Better plant leaf development at a later stage of the crop inhibits weed growth in addition to having an efficient herbicidal impact. Findings are in agreement with Singh *et al.* (2014), Yadav *et al.* (2022) and Patidar *et al.* (2023).

Highest weed index (%) was recorded in weedy check plots during both the years due to maximum yield reduction as well as heavy infestation of weeds and higher competition between weeds and crop plants (**Table 3**). Lowest weed index was observed with the application of fluazifop-p-butyl 11.1% + fomesafen 11.1% SL at 312.5 g/ha (3.22%) followed by quizalofop ethyl 5% EC at 50 g/ha (8.45%) and imazethapyr 10% SL at 100 g/ha (11.67%). In comparison to all other ready-mix herbicide treatments, the said treatment having greater WCE, resulted in higher yields. Singh *et al.* (2014) and Patidar *et al.* (2023) also recorded the lowest weed index with the application of fluazifop-p-butyl + fomesafen.

Growth parameters

All the early post emergence herbicidal treatments produced significantly superior growth parameters of soybean crop as compared to weedy check (**Table 4**) since they controlled the weed population and growth. Pooled data clearly depicted that the highest plant height (71.9 cm) and number of branches per plant (6.33) was recorded under the hand weeding twice which was at par with the herbicide fluazifop-p-butyl 11.1% + fomesafen 11.1% SL (312.5 g/ha) application. Fluazifop-p-butyl 11.1% + fomesafen 11.1% SL application recorded significantly higher plant height and number of branches per plant than other herbicidal treatments. This could be the result of wide spectrum post-emergence herbicidal combination of fluazifop-p-butyl 11.1% + fomesafen 11.1% SL controlling weeds more effectively than other herbicides and reducing the competition of weeds with crop for resources, such as light, nutrients, and moisture. Similar findings were also reported by Dhakad *et al.* (2022).

Yield attributes and yield

Weed control treatments significantly improved the number of pods/plant, number of seeds/pod, 100 seed weight (g), seed and stover yield in comparison to weedy check. Among the yield attributes, pods/plant (116) and seeds/pod (3.0) were significantly higher under the 2-hand weeding at 20 and 40 DAS (**Table 4**). The lowest yield attributes were observed under weedy check during both the years which were significantly lower than all other treatments applied

Table 2. Effects of weed control measures on weed dry weight (g/m^2) in soybean at 60 days after crop sowing (pooled data of 2 years)

Treatment	Doses (g/ha)	Grasses	Broad-leaf weeds	Sedges
Fluazifop-p-butyl 11.1% + fomesafen 11.1% SL	250	3.53(11.43)	2.20(3.85)	2.61(5.82)
Fluazifop-p-butyl 11.1% + fomesafen 11.1% SL	312.5	2.90(7.4)	1.93(2.72)	2.44(4.94)
Fluazifop-p-butyl 11.1% + fomesafen 11.1% SL	500	2.73 (6.48)	1.84(2.39)	2.18(3.75)
Quizalofop-ethyl 5% EC	50	3.19(9.15)	2.25(4.06)	2.71(6.35)
Imazethapyr 10% SL	100	3.31(9.97)	2.07(3.29)	2.49 (5.2)
Hand weeding at 20 and 40 DAS	-	1.91(2.64)	1.20(0.45)	1.64(1.68)
Weedy check control	-	7.02(48.22)	3.86(13.88)	3.85(13.8)
LSD (p=0.05)		0.35	0.15	0.22

Data are subjected to square root transformation ($\sqrt{x+1}$) and original data presented in parentheses

Table 3. Effects of weed control measures on weed control efficiency (%) and weed index (%) in soybean at 60 days after crop sowing (pooled data of 2 years)

Treatment	Doses (g/ha)	WCE (%)			Weed index (%)		
		Grasses	Broad-leaf weeds	Sedges	2020	2021	Pooled
Fluazifop-p-butyl 11.1% + fomesafen 11.1% SL	250	49.75	42.90	32.12	24.89	25.66	25.35
Fluazifop-p-butyl 11.1% + fomesafen 11.1% SL	312.5	58.69	49.99	36.65	1.72	4.53	3.22
Fluazifop-p-butyl 11.1% + fomesafen 11.1% SL	500	61.02	52.26	43.35	37.77	35.47	36.42
Quizalofop-ethyl 5% EC	50	54.59	41.68	29.53	0.86	15.09	8.45
Imazethapyr 10% SL	100	52.79	46.30	35.27	11.59	11.70	11.67
Hand weeding at 20 and 40 DAS	-	72.81	68.78	57.45	-	-	-
Weedy check control	-	-	-	-	76.39	74.72	75.45

for weed control. Among the herbicides treated plots, fluazifop-p-butyl 11.1% + fomesafen 11.1% SL (312.5 g/ha) registered highest number of pods/plant (111) and number of seeds/pod (2.95) which was at par with the 2-hand weeding treatment. However, no such significant effect was observed in 100 seed weight.

Pooled data depicted that seed and stover yield were recorded as minimum (0.61 and 0.78 t/ha, respectively) in the weedy check plot receiving no weed control measure throughout the growing season (**Table 5**). The weedy check decreased the grain yield by 75.5% as compared to 2 hands weeding due to increased crop weed competition as a result of unchecked weed development. Highest seed (2.49 t/ha) and stover (2.81 t/ha) yield were observed under the hand weeding at 20 and 40 DAS, followed by fluazifop-p-butyl 11.1% + fomesafen 11.1% SL at 312.5 g/ha (2.41 and 2.73 t/ha) which were at par with the hand weeded plot. Further increase in doses of fluazifop-p-butyl 11.1% + fomesafen 11.1% SL herbicides mixture to 500 g/ha reduced the yield due to lowering the yield attributing characters as a little phytotoxicity generated by the maximum dosage of fomesafen + fluazifop-p-butyl (500 g/ha) on crop plants. This led to inferior yield parameters (Patidar *et al.* 2023). Similarly, when fomesafen + fluazifop-p-butyl was given at a greater dosage (250+250 g/ha), Singh *et al.* (2014) recorded phytotoxicity on soybean and got a lower seed yield than lower doses (125+125 g/ha).

Soil microbial population

After application of the post emergence herbicides at 2-4 leaf stage of weeds (20 days after crop sowing) the microbial population was drastically reduced as compared to the initial soil samples collected from the treated plots. The pooled data of bacteria, fungi and actinomycetes count at the 15 and 30 days after application (DAA) clearly depicted that the microbial population significantly reduced due to the toxic effects of herbicides as compared to hand weeded and weedy check plots (**Table 6**). However, with the advancement of time on the later stages (45 DAA) of the crop herbicidal effect on the microbial population was minimized and there was no significant effect of herbicides on soil total microbial count *viz.* bacteria, fungi and actinomycetes. Total bacterial count under the application of fluazifop-p-butyl 11.1% + fomesafen 11.1% SL (312.5 g/ha) was 24.92 $\times 10^6$ and 44.21$\times 10^6$ CFU/g soil, respectively at 15 and 45 DAA, whereas weedy check plots recorded 31.26 $\times 10^6$ and 46.18 $\times 10^6$ CFU /g soil, respectively which coincides with the findings of

Table 4. Effects of weed control measures on growth and yield attributes of soybean

Treatment	Doses (g/ha)	Plant height (cm) at 75 DAS			No. of branches/plant			No. of pods/ plant			No. of seeds/ pod			100 seed wt. (g)		
		2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
Fluazifop-p-butyl 11.1% + fomesafen 11.1% SL	250	67.1	68.9	68.0	4.91	5.31	5.11	71	73	72	2.45	2.65	2.55	10.90	10.80	10.85
Fluazifop-p-butyl 11.1% + fomesafen 11.1% SL	312.5	68.4	72.2	70.3	5.73	6.01	5.87	109	113	111	2.90	3.00	2.95	10.95	11.15	11.05
Fluazifop-p-butyl 11.1% + fomesafen 11.1% SL	500	66.2	69.2	67.7	4.29	4.49	4.39	60	54	57	2.70	2.40	2.55	10.75	10.65	10.70
Quizalofop-ethyl 5% EC	50	60.3	65.3	62.8	4.27	4.43	4.35	99	109	104	2.85	2.75	2.80	10.70	10.80	10.75
Imazethapyr 10% SL	100	59.8	63.6	61.7	5.35	5.67	5.51	94	98	96	2.55	2.85	2.70	10.85	10.95	10.90
Hand weeding at 20 and 40 DAS	-	70.1	73.7	71.9	6.08	6.58	6.33	114	118	116	2.85	3.15	3.00	11.10	11.30	11.20
Weedy check control	-	52.2	56.8	54.5	1.83	2.27	2.05	29	35	32	2.00	2.30	2.15	10.60	10.60	10.60
LSD (p=0.05)	--	5.96	7.26	6.16	0.46	0.68	0.491	6.51	5.89	5.91	0.19	0.17	0.17	NS*	NS	NS

*NS: Non-significant

Table 5. Effects of weed control measures on seed and stover yield of soybean

Treatment	Doses (g/ha)	Seed yield (t/ha)			Stover yield (t/ha)		
		2020	2021	Pooled	2020	2021	Pooled
Fluazifop-p-butyl 11.1% + fomesafen 11.1% SL	250	1.75	1.97	1.86	2.15	2.39	2.27
Fluazifop-p-butyl 11.1% + fomesafen 11.1% SL	312.5	2.29	2.53	2.41	2.59	2.87	2.73
Fluazifop-p-butyl 11.1% + fomesafen 11.1% SL	500	1.45	1.71	1.58	1.95	2.35	2.15
Quizalofop-ethyl 5% EC	50	2.31	2.25	2.28	2.82	2.52	2.67
Imazethapyr 10% SL	100	2.06	2.34	2.20	2.48	2.74	2.61
Hand weeding at 20 and 40 DAS	-	2.33	2.65	2.49	2.66	2.96	2.81
Weedy check control	-	0.55	0.67	0.61	0.65	0.91	0.78
LSD (p=0.05)	--	0.15	0.10	0.11	0.07	0.14	0.09

Table 6. Effects of weed control measures on soil microbial properties in soybean (pooled data of 2 years)

Treatment	Doses (g/ha)	Bacteria (CFU 1 x 10^6/g soil)				Fungi (CFU 1 x 10^4/g soil)				Actinomycetes (CFU 1 x 10^5/g soil)			
		Initial	15 DAA	30 DAA	45 DAA	Initial	15 DAA	30 DAA	45 DAA	Initial	15 DAA	30 DAA	45 DAA
Fluazifop-p-butyl 11.1% + fomesafen 11.1% SL	250	27.29	23.46	33.77	42.63	41.72	24.57	38.71	53.14	35.46	24.72	32.69	47.82
Fluazifop-p-butyl 11.1% + fomesafen 11.1% SL	312.5	28.72	24.92	32.19	44.21	43.25	26.42	37.68	55.21	36.23	23.65	33.24	48.36
Fluazifop-p-butyl 11.1% + fomesafen 11.1% SL	500	29.25	21.84	30.58	41.25	42.65	24.61	34.45	52.63	33.54	21.55	33.87	43.87
Quizalofop ethyl 5% EC	50	27.14	21.86	31.54	43.82	44.16	22.54	34.47	54.74	35.26	25.34	34.93	45.83
Imazethapyr 10% SL	100	28.43	23.17	33.27	40.93	43.79	23.78	32.76	51.93	36.12	26.32	33.72	47.25
Hand weeding at 20 and 40 DAS	-	31.15	30.85	46.95	48.24	42.58	45.73	51.45	55.47	34.36	39.18	47.75	52.18
Weedy check control	-	27.64	31.26	43.86	46.18	43.17	47.47	52.28	56.62	36.43	42.82	45.28	53.26
LSD (p=0.05)	--	NS*	3.09	3.76	NS	NS	2.56	2.94	NS	NS	1.47	2.14	NS

*NS: Non-significant

Latha and Gopal (2010). Similarly, total fungi and actinomycetes count were increased 26.42×10^4 to 55.21×10^4 CFU /g soil and 36.65×10^5 to 48.36×10^5 CFU /g soil, respectively under the fluazifop-p-butyl 11.1% + fomesafen 11.1% SL (312.5 g/ha) treatment. It might be due to these bacteria engaged in the process of herbicide breakdown, which released carbon-rich substrates that boost the number of microorganisms in the soil. On the other hand, it might be because the herbicides have some harmful effects immediately after application (Ramalakshmi *et al.* 2017).

It can be concluded that all post-emergence ready mix herbicide treatments resulted in broad spectrum weed control in soybean thus reducing the crop-weed competition which leads to enhance the crop productivity with respect to weedy check. It is proved that hand weeding twice *i.e.,* 20 and 40 DAS effectively controlled weed population and increased all the growth and yield attributes significantly, but it was quite costly and time and labour consuming control method compared to chemical control. The application of fluazifop-p-butyl 11.1% + fomesafen 11.1% SL (312.5 g/ha) produced the comparable seed and stover yield of soybean with the 2-hand weeding at 20 and 40 DAS. So, early post emergence ready-mix herbicide fluazifop-p-butyl 11.1% + fomesafen 11.1% SL at 312.5 g/ha may be recommended as an effective weed control measure in soybean field.

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