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RESEARCH ARTICLE

Efficacy of different post-emergence herbicides against complex weed flora in greengram

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ABSTRACT

A field experiment was conducted for three consecutive years (2021-23) at Agricultural Research Sub-Station, Nagaur, Agriculture University, Jodhpur during rainy season to evaluate the efficacy of different post-emergence herbicides for complex weed flora, growth and yield of greengram with twelve treatments laid out in randomized block design with three replications. The results revealed that post-emergence application of imazethapyr 50 g/ha significantly controlled grassy and broad-leaves weeds, but its efficacy was low against *Rhinchosia minima* and *Cyprus rotundus*. The significant lowest weed density (No./m^2) of different weeds like *Rhinchosia minima* (15.3), *Digera arvensis* (6.0), *Celosia argentea* (16.0), *Cyperus rotundus* (8.0), *Dactyloctenium aegyptium* (6.0), other broad-leaves and grassy weeds (5.3), total weed dry weight (27.0 g/m^2) and weed control efficiency (82.9 %) were recorded under fomesafen 11.1% w/w + fluazip-p-butyl 11.1% followed by sodium acifluorfen + clodinafop-propargyl 220 g/ha. Similar treatments resulted in significant improvement in number of seeds per pod (13.4), grain yield (1.22 t/ha), net returns (₹ 70,310/ha) and B-C ratio (2.1) and weed index (9.0%). The findings of this experiment endorse the application of either fomesafen 11.1%w/w + fluazip-p-butyl 11.1% (ready-mix) *or* sodium acifluorfen + clodinafop-propargyl 220 g/ha at 20-25 days after sowing to realized excellent control of complex weed flora in greengram consequently resulting in higher grain yields, net returns and B-C ratio.

Keywords: Economics, Fomesafen + fluazip-p-butyl, Sodium acifluorfen + clodinafop-propargyl, Weed density

INTRODUCTION

Greengram (*Vigna radiata* L.) alternatively known as green gram, green bean, moong bean, golden gram belongs to the Leguminaceae family. It is an important pulse crop and believed to be originated from India. It plays an important role as a food security crop because of its nutritional quality as well as ability to survive in harsh environmental conditions such as arid and semiarid lands. They are mainly grown for human food, flour while sprouts and immature pods as a vegetable. The grains contain approximately 25-28% protein, 3.5-4.5% fiber, 4.5-5.5% ash and 60- 65% carbohydrates on dry weight. The grains also contain vitamin-A (94 mg), Vitamin-C (8 mg), iron (7.3 mg), calcium (124 mg), magnesium (189 mg), phosphorus (367 mg) and foliate (549 mg) (Muchomba *et al*. 2023). Besides being a rich source of protein, green gram roots are important sources of soil nitrogen. The roots have the ability to develop nodules that help in fixing atmospheric nitrogen in the soil through rhizobium, the crop has the ability to add about 30-40 kg N/ha in a single season. The vegetative parts, stocks and husks are also useful sources of leguminous fodder for livestock. The crop also serves as an important cover and a rotation crop. India is the highest producer as well as consumer of pulses in the world. Greengram is the third most important pulse crop in India, with a contribution of 11.38% after chickpea (49.66%) and pigeonpea (15.67%) in total pulse production. Rajasthan is the state having highest area 23.25 lakh hectare, production 11.16 lakh tonnes and yield 480 kg/ha of greengram (Annon. 2021-22). The dominant contributors to greengram cultivation in terms of area and production are Rajasthan (70 % and 75%, respectively). The maximum area under greengram cultivation was covered in Nagaur (27%), followed by Jodhpur (13.57%) and Pali (12.18%) districts of Rajasthan. Nagaur, Jodhpur and Pali, together contribute more than 50% of the total area under greengram cultivation in Rajasthan (Sharma *et al*. 2017).

Greengram is recommended for cultivation mainly in *Kharif* season under arid conditions of Nagaur, Rajasthan. But weed infestation is one of the major constraints in greengram cultivation and causes 50 to 90% yield loss (Mishra *et al*. 2017). Weeds

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compete with crops for resources such as nutrients, water, light and space, thus reducing their yield. The presence of weeds not only reduces grain yield, but it also influences the quality of seed. The major weed flora of mung-bean is *Rhinchosia minima*, *Digera arvensis*, *Celosia argentea*, *Cyperus rotundus*, *Dactyloctenium aegyptium,* other broad leaved and grassy weeds. Weeds are present throughout the crop growth, yet there is a need to find out the exact time during which weeds cause the highest yield reductions. The critical period of weed competition is defined as the shortest period during crop growth in which weed management results in almost similar yield as that in weed free conditions throughout crop growth. The first period of 20-40 days after sowing is crucial for crop-weed competition in greengram (Pankaj *et al.* 2017). Mechanical practices such as hand weeding and inter–culturing is effective but unavailability of labour and incessant rains during the early crop season normally limit the weeding operations. Therefore, chemical weeding under such circumstances becomes indispensable and can be a cost-effective alternative.

Application of pendimethalin and imazethapyr during pre-emergence (PE) and post-emergence (PoE), respectively, have shown promising results in greengram Singh *et al.* (2015). However, narrow time window of application often makes the PE herbicides less preferred choice among the farmers. Also, application of a single herbicide is often ineffective in controlling diverse weed flora. On the contrary, either ready or tank mixes of compatible herbicides with varying modes of action may ensure effective control of diverse weed flora and check shifting of weed flora complex and herbicide resistance Banerjee *et al.* (2018). In general, there is paucity of information on the impact of new herbicide ready mixes available in Indian market on the performance of monsoon greengram. Under the above perspectives, the present study was formulated to evaluate the efficacy of different post-emergence herbicides for complex weed flora, growth, yield potential and economics of mung-bean.

MATERIALS AND METHODS

A field experiment was conducted during *Kharif* (rainy) seasons of 2021, 2022 and 2023 at the Research farm of Agricultural Research Sub-Station, Nagaur, Agriculture University, Jodhpur, Rajasthan situated at 27° 12' 7.24'' N latitude, 73° 44' 2.18 E longitude, at an altitude of 302 m above the mean sea level. This location falls within agro-climatic zone II A, characterized as arid and semi-arid transitional plain of inland drainage zone in Rajasthan. The climate of this region is distinctly arid and semi- arid marked by significant temperature fluctuations throughout the year. Average annual rainfall of 385 mm, about 80% of which falls during July–September from the southwest monsoon while the rest is more or less equally distributed during the rest of the year. The soil samples were drawn from top 15 cm soil depth. The soil in the experimental field is classified as loamy sand and slightly alkaline in reaction (pH 8.2) and with EC of 0.35 dS/m. The soil was low in organic carbon (0.15%), available N (219 kg/ha), available P (15 kg/ ha) and available K (217 kg/ha). Twelve treatments (imazethapyr 50 g/ha, imazethapyr 70 g/ha, Fomesafen 11.1% w/w + fluazip-p-butyl 11.1% 220 g/ha, fomesafen 11.1% w/w + fluazip-p-Butyl 11.1% 250 g/ha, sodium acifluorfen 16.5% + clodinafop-propargyl 8% EC ready-mix 220 g/ha, sodium acifluorfen 16.5% + clodinafop-propargyl 8% EC ready-mix 250 g/ha, imazethapyr 35% + imazamox 35% WG 40 g/ha, imazethapyr 35% + imazamox 35% WG 60 g/ha PoE, quizalofop-ethyl 7.5 % + imazethapyr 15 % EC 80 g/ha quizalofop-ethyl 7.5 % + imazethapyr 15 % EC 100 g/ha, along with weed free and weedy check laid out in randomized block design with three replications. Seeds of mung-bean variety "*MH-421*" were sown manually with 30 x 10 cm planting geometry in a plot size of 4m x 3m with seed rate of 15 kg/ha on 11 July, 08 July and 18 July 2021, 2022 and 2023, respectively. The crop was grown under totally rainfed conditions. Thinning and gap filling were done manually to maintain optimum plant population. A recommended dose of fertilizer (40:20 kg NP/ha) was applied as basal application through urea and diammonium phosphate (DAP) as per package of practices of crop for the area. Herbicides were applied as spray in an aqueous medium at the rate of 500 litre water/ha for post-emergence herbicides, using a knapsack sprayer with flat-fan nozzle. Data on weed count and weed biomass from an area enclosed in a quadrate of one m^2 at one places under different treatments were recorded at 45 days after sowing (DAS). The sampled weeds were then categorized into grasses, broad-leaved and sedges. Category-wise weed density was first determined by counting and then weed dry weight was measured after sun-drying for two days followed by oven-drying at 80 °C for 48 hours (h). Data on individual weed and total weed density and weed dry weight were subjected to square root transformation $(\sqrt{x+1})$. Weed control efficiency (WCE) was estimated at 45 DAS by using the formula:

$$\text{Weed control Efficiency (\%)} = \frac{\text{Dry weight of weeds in control plot} - \text{Dry weight of weeds in treated plot}}{\text{Dry weight of weeds in control plot}} \times 100$$

Weed control efficiency was calculated on dry matter basis and yield recorded in kg per plot was standardized to 12-14 % moisture and then weight was converted into kg/ha. Weed index was calculated by using grain yield in treatment plots and control plots. The important growth parameters, yield attributes and yield were recorded as per standard procedures. In order to calculate the net returns for each treatment, total cost of cultivation was subtracted from the gross returns. Total cost of cultivation and gross returns were estimated as per the prices prevailing at the time of conduct of experiment and benefit-cost ratio was calculated from gross return to cost of cultivation. The experimental data were subjected to statistical analysis employing standard techniques of analysis of variance (ANOVA). Mean analysis of the data was conducted, adhering to the methodology outlined by Gomez and Gomez (1984). Furthermore, mean comparison was carried out based on critical differences at the 5% probability level.

RESULTS AND DISCUSSION

Weed flora and weed density

The different weed flora and density (No./m^2) observed at 45 DAS in control plots in greengram were *Rhynchosia minima* (36.3), *Digera arvensis* (66.8), *Celosia argentea* (29.7), *Cyperus rotundus* (26.7), *Dactyloctenium aegyptium* (14.3), other broad-leaves and grassy weeds (11.7). All the weed control treatments significantly reduced the weed density as compared to weedy check (**Table 1**). The efficacy of application of imazethapyr 50 g/ha and 70 g/ha controlled grassy and broad-leaved weeds but its efficacy was low against *Rhynchosia minima* and *Cyprus rotundus.* The significant lowest weed density (No./m^2) of different weeds like *Rhinchosia minima* (15.3), *Digera arvensis* (6.0), *Celosia argentea* (16.0), *Cyperus rotundus* (8.0), *Dactyloctenium aegyptium* (6.0), other broad-leaves & grassy weeds (5.3) were observed under fomesafen 11.1% w/w + fluazip-p-butyl 11.1% (Ready-mix) which was closely followed by sodium acifluorfen + clodinafop-propargyl 220 g/ha. However, it was statistically on par with fomesafen + fluazip-p-butyl and sodium acifluorfen + clodinafop-propargyl 250 g/ha. Efficacy of imazethapyr + imazamox 40 g/ha and quizalofop ethyl + imazethapyr 80 g/ha and higher dose were poor against broad-leaves weeds and *Cyprus rotundus.* These findings are confirmed with the findings of Singh and Singh (2020) and Singh *et al.* (2022).

Weed dry weight and weed control efficiency

Application of various herbicides had significant effect on dry weight and weed control efficiency at 45 DAS (**Table 1**). All the weed control treatments observed lower weed dry weight compared with untreated check. The efficacy of imazethapyr 50 g/ha had significant effect to reduce the dry weight of weeds (41 g/m^2) and weed control efficiency (70.7 %) but its efficacy was low against *Rhinchosia minima* and *sedges*. Application of fomesafen +

Table 1. Effect of different post emergence herbicides on the density, weed dry matter and weed control efficiency (WCE) at 45 DAS in greengram (mean data of three years)

Treatment	Density* of the different weeds (no./m^2)						Total Weed dry matter at 45 DAS (g/m^2)	WCE (%)
	Rhynchosia minima	*Digera arvensis*	*Celosia argentea*	*Cyperus rotundus*	*Dactyloctenium aegyptium*	Other BLW& grassy weeds		
Imazethapyr 50 g/ha	(5.3) 27.7	(3.1) 9.3	(4.4) 19.0	(3.1) 9.3	(2.7) 7.0	(2.5) 6.0	41	70.7
Imazethapyr 70 g/ha	(4.9) 23.7	(2.8) 7.3	(4.3) 17.7	(2.7) 6.7	(2.5) 5.7	(2.5) 5.7	32	77.1
Fomesafen + fluazifop-p-butyl 220 g/ha	(4.0) 15.3	(2.5) 6.0	(4.1) 16.0	(2.9) 8.0	(2.5) 6.0	(2.4) 5.3	27	82.9
Fomesafen + fluazifop-p-butyl 250 g/ha	(3.0) 8.3	(2.4) 5.3	(4.1) 16.0	(2.5) 6.0	(2.5) 5.7	(2.5) 6.0	24	82.8
Sodium acifluorfen + clodinafop-propargyl 220 g/ha	(3.4) 11.0	(2.5) 5.7	(4.2) 17.3	(2.7) 6.7	(2.6) 6.3	(2.5) 5.7	26	81.0
Sodium acifluorfen + clodinafop-propargyl 250 g/ha	(3.0) 8.3	(2.3) 5.0	(4.0) 15.7	(2.9) 7.7	(2.7) 7.0	(2.6) 6.3	25	82.0
Imazethapyr + imazamox 40 g/ha	(5.0) 24.7	(2.5) 6.0	(5.1) 25.3	(2.9) 7.7	(2.6) 6.3	(2.5) 6.0	98	30.0
Imazethapyr + imazamox 60 g/ha	(5.1) 25.7	(2.5) 6.0	(4.9) 24.0	(3.2) 9.7	(2.7) 6.7	(2.5) 6.0	92	34.3
Quizalofop-ethyl + imazethapyr 80 g/ha	(4.2) 17.0	(2.7) 6.7	(4.9) 24.0	(2.9) 7.7	(2.5) 5.7	(2.5) 5.7	98	30.0
Quizalofop-ethyl + imazethapyr 100 g/ha	(3.8) 14.3	(2.4) 5.3	(4.8) 23.0	(2.9) 8.0	(2.5) 6.0	(2.3) 5.0	95	32.1
Weed free	(2.5) 6.0	(2.1) 4.0	(3.1) 9.0	(0.7) 0.0	(2.1) 4.0	(2.1) 4.0	0.0	100.0
Weedy check	(6.1) 36.3	(8.2)66.8	(5.5)29.7	(5.2)26.7	(3.8) 14.3	(3.5) 11.7	140	0.0
LSD (p=0.05)	11.1	8.8	12.2	6.3	4.5	3.9	7.0	-

*Original figures in parentheses were subjected to square root transformation ($\sqrt{x+1}$)

Table 2. Effect of different post emergence herbicides on yield attributes, yield, harvest index, economics and weed index in greengram (mean data of three years)

Treatment	No. of seeds/ pods	1000 grain weight (gm)	Grain yield (t/ha) 2021	2022	2023	Mean	Straw yield (t/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B: C Ratio	Harvest index (%)	Weed index (%)
Imazethapyr 50 g/ha	13.2	43.2	1.04	0.82	1.20	1.02	1.89	86868	52868	1.6	34.9	24.2
Imazethapyr 70 g/ha	13.1	43.6	1.15	0.89	1.24	1.09	1.99	92853	58853	1.7	35.3	19.0
Fomesafen + fluazifop-p-butyl 220 g/ha	13.9	44.8	1.26	1.02	1.43	1.24	2.20	106362	72362	2.1	36.1	7.2
Fomesafen + fluazifop-p-butyl 250 g/ha	13.4	44.4	1.25	1.01	1.41	1.22	2.17	104310	70310	2.1	36.0	9.0
Sodium acifluorfen + clodinafop-propargyl 220 g/ha	13.3	44.1	1.24	1.02	1.38	1.21	2.10	102173	68173	2.0	36.3	10.8
Sodium acifluorfen + clodinafop-propargyl 250 g/ha	13.4	44.6	1.20	1.04	1.40	1.21	2.18	103370	69370	2.0	35.6	9.8
Imazethapyr + imazamox 40 g/ha	12.8	42.1	1.08	0.82	1.07	0.99	1.71	76523	42523	1.3	34.4	33.2
Imazethapyr + imazamox 60 g/ha	12.6	42	1.02	0.78	1.04	0.95	1.77	81567	47567	1.4	35.0	28.8
Quizalofop-ethyl + imazethapyr 80 g/ha	12.8	43.1	1.04	0.88	1.06	0.99	1.86	84816	50816	1.5	34.8	26.0
Quizalofop-ethyl + imazethapyr100 g/ha	12.4	43.6	1.08	0.93	1.11	1.04	1.98	88835	54835	1.6	34.4	22.5
Weed free	14.3	45.1	1.31	1.20	1.51	1.34	2.38	114570	74570	1.9	36.0	0.0
Weedy check	11.6	41.4	0.54	0.44	0.64	0.54	1.32	45828	17828	0.6	28.9	60.0
LSD (p=0.05)	0.6	1.0	0.108	0.074	0.099	0.094	0.16	5124	3466	-	-	-

fluazip-p-butyl 220 g/ha observed the lowest total dry weight of weeds (27 g/m^2) and weed control efficiency (82.9 %) which was closely followed by sodium acifluorfen + clodinafop-propargyl 220 g/ha over the weedy check (140 g/m^2). The better performance of combination of herbicides was due to its synergistic effect in controlling population as well as dry matter accumulation of different weed flora complex. These results are in tune with the findings of Katoch *et al.* (2023) Poornima *et al.* (2018) and Singh *et al.* (2015).

Yield attributes, yield and weed index

Yield and yield attributing characters in treated plots were found significantly superior to weedy check (**Table 2**). Among the different weed control treatments, application of imazethapyr 50 g/ha resulted in higher number of seeds/pods (13.2), test weight (43.2 g), grain yield (1.02 t/ha), straw yield (1.89 t/ha), harvest index (34.9%), and weed index (24.2) over the weedy check conditions. The efficacy of fomesafen + fluazip-p-butyl 220 g/ha registered the highest number of seeds/pods (13.4), test weight (44.4 g), grain yield (1.22 t/ha), straw yield (2.17 t/ha), harvest index (36.0%), and weed index (9.0) which was at par with weed free conditions and sodium acifluorfen + clodinafop-propargyl 220 g/ha. Notably, application of fomesafen + fluazip-p-Butyl and sodium acifluorfen + clodinafop-propargyl exhibited a considerable increase of 20% and 17.6% in greengram seed yield compared to application of imazethapyr 50 g/ha. The higher yield attributes and seed yield under these treatments might be due to least competition from weeds for nutrients, light, space and other above-and below-ground resources, which in turn led to effective weed control, reduced crop weed competition and provided almost weed-free environment. The results were in agreement with findings of Katoch *et al.* (2023), Poornima *et al.* (2018) and Singh *et al.* (2022).

Economics

Weed free treatments were found significantly superior in gross returns (₹ 1,14,570/ha) net returns (₹ 74,570/ha) and BC ratio (1.9) as compared to weedy control treatments (**Table 2**), and the lowest value of gross returns (₹ 45,828/ha) net returns (₹ 17,828/ha) and BC ratio (0.6) in weedy check. Among different weed control techniques, the highest gross returns (₹ 1,04,310/ha) net returns (₹ 70,310/ ha) and BC ratio (2.1) was recorded in post–emergence application of fomesafen + fluazip-P-butyl closely followed by sodium acifluorfen + clodinafop-propargyl 220 g/ha. However, it was statistically at par with 250 g/ha of fomesafen + fluazip-p-butyl and sodium acifluorfen + clodinafop-propargyl. Notably, application of fomesafen + fluazip-p-butyl and sodium acifluorfen + clodinafop-propargyl exhibited a statistically at par with weed free treatment. The findings are similar with Poornima *et al.* (2018).

Conclusion

It was concluded that weeds can be effectively controlled by suitable herbicidal combinations as either application of fomesafen 11.1% w/w + fluazip-p-butyl 11.1% (ready-mix) or Sodium acifluorfen 16.5% + clodinafop-propargyl 8% EC (ready-mix) 220 g/ha at 20-25 DAS were the best herbicidal combination at 45 DAS for effective control of complex weed flora in greengram with improved yields, net returns and B-C ratio.

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