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Efficacy of sequential application of pre and post-emergent herbicides in *kharif* green gram (*Vigna radiata* L.)

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Abstract: A field experiment was conducted during *kharif*, 2013 to study the efficacy of sequential application of pre and post-emergent herbicides on weed control in green gram grown under rainfed condition. Results indicated that sequential treatments were found superior to individual application with respect to weed control. Among the sequential treatments, pre emergent application of pendimethalin @ 1.0 kg ha^{-1} followed by imazethapyr @ 75 g ha^{-1} at 20 days after sowing (DAS) significantly reduced weed growth and recorded higher seed yield (1110 kg ha^{-1}), net monetary returns (₹ 27345 ha^{-1}) and BC ratio (3.44:1) and was on par with other sequential treatments *viz.*, pendimethalin fb post-emergent application of fenoxyprop-p-ethyl or one hand weeding (HW) and one intercultivation (IC), pre-emergent application of alachlor fb post-emergent application of either imazethapyr or one HW and one IC, tank mix application of alachlor + pendimethalin as pre-emergence fb one HW and one IC and farmer's practice. Uncontrolled weed growth caused 57.4 per cent reduction in seed yield of green gram.

Key words: Greengram, Post-emergent, Pre-emergent, Sequential application

Introduction

In India green gram is the third most widely cultivated pulse crop after bengal gram and pigeonpea. India alone accounts for 65 per cent of the world's acreage and 54 per cent of the world's production. In India it is grown on an area of 3.55 m ha with a total production of 1.82 m t and with an average productivity of 500 kg ha^{-1}. In Karnataka, it is widely grown in *kharif* season and it covers an area of 2.84 lakh ha with a production of 0.69 lakh tonnes and productivity of only 258 kg ha^{-1} (Anon., 2013). The crop has very high yielding potentiality but its productivity in India and Karnataka is comparatively lower than the global level. Among many factors responsible for low productivity in green gram, the problem of weed infestation is considered to be prime one. Green gram grown in *kharif* season is severely infested by various grass, sedge and broad leaved weeds due to continuous rains during monsoon season. Several research results conducted elsewhere in India revealed that full season association of weeds with crop resulted in 30-50 per cent reduction in yield (Sheoran *et al.*, 2006). The critical period of crop-weed competition in case of kharif green gram is 20-40 days after sowing (Sheoran *et al.*, 2008). Therefore, control of weeds at appropriate time using a suitable method is essential to obtain high yields of green gram. Weeds could be controlled by hand weedings. However, hand weeding is laborious, time consuming, costly and tedious. Moreover, many times labour is not available at the critical period of weed removal. Furthermore, weather conditions do not permit timely hand weeding due to wet field conditions. Delayed removal of weeds is not as effective in controlling weeds and obtaining higher yields as against timely removal of weeds. Under these conditions, use of herbicides offers an alternative for possible effective control of weeds.

Usage of pre-emergent herbicides assumes greater importance in the view of their effectiveness from initial stages. But their efficacy may be last within 15 DAS and result in emergence of new flush of weeds and may pose problem in later crop growth period. Under such situation, post-emergent herbicides at about 20-30 DAS may help in avoiding the problem of weeds at later stages. Hence, in green gram managing weeds through sequential use of herbicides (pre-emergent followed by post-emergent) will be an ideal means of controlling the weeds for enhancing productivity of *kharif* green gram. Therefore, in the present studies, effect of sequential application of pre and post-emergent herbicides was compared with IWM practices, farmer's practice. Weed free and weedy check for evaluating weed control efficacy obtaining high yields of green gram grown during *kharif* season under rainfed condition.

Material and methods

The experiment was conducted during *kharif* season of 2013, at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad. The soil of experimental site was clay loam comprising of maximum clay content (53.01%) with bulk density and particle density of 1.15 g cc^{-1} and 2.65 g cc-1, respectively. The soil pH was 6.5 (neutral in reaction) and with low in available nitrogen and phosphorus and high in potassium. These fifteen treatments (Table 1) were laid out in complete randomized block design with three replications. Herbicides were sprayed using knapsack sprayer fitted with a flat fan nozzle using 750 liters of water per hectare. Pre-emergence herbicides were applied one day after sowing, whereas post-emergence herbicides were sprayed 25 days after sowing.

The green gram variety DGGV-2 was sown in 21st June 2013 with a spacing of 30 x 10 cm using a seed rate of 15 kg ha^{-1}. The crop was raised as per the package of practices for higher yields of UAS, Dharwad (Anon, 2012). Total weed density of different weed and total weed dry weight were recorded at various stages with the help of a quadrate and then converted to m^{-2} and the data on weed parameters were subjected to square root transformation before statistical analysis.

Results and discussion

The experimental field was dominated by natural infestation of broad leaved weeds (BLW) like *Digera arvensis* Forsk, *Amaranthus viridis* L., *Commelina benghalensis* L., *Cyanotis cucullata* L., *Phyllanthus niruri* L. and *Argemone mexicana*; grasses like *Brachiaria eruciformis* L., *Cynodon dactyl* L., *Digitaria sanguinalis* L. and *Dinebra retroflexa* L., and sedge *Cyperus rotundus* L.

All the weed control treatments significantly reduced the density of total weeds and total weed dry weight over unweeded check at all stages of observations (Table 1). Contrary to the weedy check, in the standard weed free check complete control of weeds at all the stages was maintained. Among the herbicide treatments, sequential application of pendimethalin as pre-emergent followed by (fb) imazethapyr as post-emergent recorded significantly lower total dry weight of weeds at 30, 60 DAS and harvest (1.50, 3.57 and 3.77 g m^{-2}, respectively) as compared to weedy check (23.53, 37.89 and 39.83 g m^{-2}, respectively). But, it was on par with either sequential or pre-emergent application of herbicide fb one HW or one IC treatments and farmer's practice *viz.*, T_5, T_9, T_7, T_4, T_{10} and T_{13} at 30 and 60 DAS (Table 1). This was mainly due to effective control of weeds by pre-emergent application of herbicides like pendimethalin or alachlor up to 20-25 DAS. While, late emerging weeds were effectively taken care by either post-emergent application of imazethapyr or fenoxyprop-p-ethyl or mechanical weed control *i.e*,. one HW and one IC at 30 DAS. These treatments recorded statistically on par control of weeds as that of farmer's practice. The results are in line with the findings of Rao *et al.* (2010) who reported that sand mix application of pendimethalin @ 1.0 kg ha^{-1} fb imazethapyr @ 50 g ha^{-1} at 20 DAS significantly reduced weed growth in green gram and it was on par with sequential application of alachlor @ 1.5 kg ha^{-1} fb imazethapyr @ 50 g ha^{-1} and also with two hand weedings at 15 and 30 DAS.

The crop yield is directly proportional to the weed control efficiency. The highest weed control efficiency at all the stages of observations (93.6, 90.6 and 90.0%, respectively at 30, 60 DAS and at harvest) was observed with pendimethalin @ 1.0 kg ha^{-1} fb imazethapyr @ 75 g ha^{-1} (T_8). It was on par with the treatments having either sequential or pre emergence application of herbicides as it was attributed to lower dry weight of weeds. The results are in conformity with Vijayalaxmi *et al.* (2012) and Jadhav (2013). Weedy check recorded lower weed control efficiency at all the stages due to higher weed dry weight.

The crop toxicity rating observed at 7 and 21 days after pre-emergent application of herbicides (Table 2) revealed that oxyfluorfen was found to cause toxicity to green gram (9.0) which led to death of seedlings. While, the toxicity came down at 21 days after spraying and crop recovered at later stages. Similar toxicity level with application of oxyfluorfen was also reported by Kandasamy (1999) in pigeonpea. Pre-emergent application of alachlor also caused moderate injury to green gram at early stage but plants recovered at later stages. Pre-emergent application of pendimethalin resulted in slight discoloration of plants at early stages but later they recovered.

Table 1. Weed density, dry weight and weed control efficiency at different growth stages of green gram as influenced by sequential application of pre and post-emergent herbicides

Tr. No.	Treatments	Total dry weight of weeds (g m^{-2})			Weed control efficiency (%)		
		30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
T_1	Oxyfluorfen @ 0.10 kg ha^{-1} (PRE) fb 1 HW and 1 IC	3.42 (1.98)^{f}	5.17 (2.37)$^{c-e}$	5.92 (2.53)^{bc}	85.5	86.5	85.0
T_2	Oxyfluorfen @ 0.10 kg ha^{-1} (PRE) fb imazethapyr @ 75 g ha^{-1} (POST)	2.30 (1.67)$^{b-d}$	5.24 (2.40)^{de}	5.80 (2.51)^{bc}	90.2	86.2	85.4
T_3	Oxyfluorfen @ 0.10 kg ha^{-1} (PRE) fb fenoxyprop-p-ethyl @ 75 g ha^{-1} (POST)	2.70 (1.79)$^{d-f}$	7.97 (2.90)^{f}	8.52 (2.99)^{cd}	88.5	79.1	78.7
T_4	Alachlor @ 1.5 kg ha^{-1} (PRE) fb 1 HW and 1 IC	3.28 (1.94)^{ef}	4.87 (2.31)$^{b-e}$	5.64 (2.48)^{bc}	86.0	87.2	85.8
T_5	Alachlor @ 1.5 kg ha^{-1} (PRE) fb imazethapyr @ 75 g ha^{-1} (POST)	1.81 (1.52)^{bc}	4.26 (2.18)$^{b-d}$	4.86 (2.32)^{b}	92.3	88.7	87.8
T_6	Alachlor @ 1.5 kg ha^{-1} (PRE) fb fenoxyprop-p-ethyl @ 75 g ha^{-1} (POST)	2.41(1.70)$^{c-e}$	6.09 (2.56)^{e}	6.63 (2.60)^{bc}	89.7	83.9	83.2
T_7	Pendimethalin @ 1.0 kg ha^{-1} (PRE) fb 1 HW and 1 IC	2.49 (1.73)$^{c-f}$	4.19 (2.15)$^{b-d}$	5.07 (2.35)^{b}	89.4	88.9	87.2
T_8	Pendimethalin @ 1.0 kg ha^{-1} (PRE) fb imazethapyr @ 75 g ha^{-1} (POST)	1.50 (1.41)^{b}	3.57 (2.02)$^{b-d}$	3.77 (2.06)^{b}	93.6	90.6	90.5
T_9	Pendimethalin @ 1.0 kg ha^{-1} (PRE) fb fenoxyprop-p-ethyl @ 75 g ha^{-1} (POST)	2.19 (1.64)$^{b-d}$	5.03 (2.35)$^{c-e}$	5.41 (2.43)^{bc}	90.7	86.7	86.3
T_{10}	Alachlor @ 1.0 kg ha^{-1} (PRE) + Pendimethalin @ 0.5 kg ha^{-1} (PRE) 1 HW and 1 IC	1.71 (1.48)^{bc}	3.48 (1.99)^{bc}	3.96 (2.11)^{b}	92.8	90.8	90.0
T_{11}	Imazethapyr @ 75 g ha^{-1} (POST)	4.57 (2.23)^{g}	10.49 (3.32)^{g}	11.20 (3.41)^{d}	80.7	72.3	72.0
T_{12}	Fenoxyprop-p-ethyl @ 75 g ha^{-1} (POST)	6.27 (2.60)^{h}	13.86 (3.78)^{h}	15.34 (3.97)^{e}	73.4	63.2	61.3
T_{13}	Farmer's practice (one HW and two IC at 20-25 and at 40 DAS)	2.38 (1.68)$^{c-e}$	3.36 (1.96)^{b}	4.84 (2.28)^{b}	89.9	91.2	87.9
T_{14}	Weedy check	23.53 (4.90)^{i}	37.89 (6.19)^{i}	39.83 (6.35)^{f}	0.0	0.0	0.0
T_{15}	Weed free	0.00 (0.71)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}	100.0	100.0	100.0
	S.Em.±	0.09	0.11	0.17	-	-	-
	C.D. (P=0.05)	0.25	0.33	0.50	-	-	-

DAS- Days after sowing, fb- followed by, HW- Hand weeding, IC- Intercultivation, Figures in parentheses indicate $\sqrt{x+0.5}$ transformed values, Means followed by same letters do not differ significantly

Table 2. Crop toxicity and growth parameters of green gram as influenced by sequential application of pre and post-emergent herbicides

Tr. No.	Treatments	Crop toxicity ratings				Dry matter production (g/m^2)		Leaf area index	
		Pre-emergent application		Post-emergent application					
		7 DAS	21 DAS	7 DAS	21 DAS	60 DAS	At harvest	30 DAS	60 DAS
T_1	Oxyfluorfen @ 0.10 kg ha^{-1} (PRE) fb 1 HW and 1 IC	9.0	3.7	0.0	0.0	15.03^{cd}	14.14^{cd}	1.12^{d-g}	3.48^{bc}
T_2	Oxyfluorfen @ 0.10 kg ha^{-1} (PRE) fb imazethapyr @ 75 g ha^{-1} (POST)	9.0	4.3	1.5	0.0	14.82^{cd}	13.87^{d}	1.08^{e-g}	3.46^{bc}
T_3	Oxyfluorfen @ 0.10 kg ha^{-1} (PRE) fb fenoxyprop-p-ethyl @ 75 g ha^{-1} (POST)	9.0	4.3	0.0	0.0	14.30^{d}	13.84^{d}	0.99^{g}	3.36^{c}
T_4	Alachlor @ 1.5 kg ha^{-1} (PRE) fb 1 HW and 1 IC	4.0	0.0	0.0	0.0	16.28^{a-d}	15.31^{a-d}	1.49^{b-e}	3.59^{a-c}
T_5	Alachlor @ 1.5 kg ha^{-1} (PRE) fb imazethapyr @ 75 g ha^{-1} (POST)	4.0	0.0	1.2	0.0	16.70^{a-c}	15.58^{a-d}	1.57^{a-d}	3.70^{a-c}
T_6	Alachlor @ 1.5 kg ha^{-1} (PRE) fb fenoxyprop-p-ethyl @ 75 g ha^{-1} (POST)	4.0	0.0	0.0	0.0	16.13^{b-d}	15.03^{b-d}	1.46^{c-f}	3.47^{bc}
T_7	Pendimethalin @ 1.0 kg ha^{-1} (PRE) fb 1 HW and 1 IC	2.3	0.0	0.0	0.0	17.49^{ab}	16.57^{a-c}	1.70^{a-c}	4.00^{a-c}
T_8	Pendimethalin @ 1.0 kg ha^{-1} (PRE) fb imazethapyr @ 75 g ha^{-1} (POST)	2.3	0.0	1.0	0.0	18.09^{ab}	16.84^{ab}	1.95^{ab}	4.16^{ab}
T_9	Pendimethalin @ 1.0 kg ha^{-1} (PRE) fb fenoxyprop-p-ethyl @ 75 g ha^{-1} (POST)	2.0	0.0	0.0	0.0	17.16^{a-c}	16.10^{a-d}	1.66^{a-c}	3.86^{a-c}
T_{10}	Alachlor @ 1.0 kg ha^{-1} (PRE) + Pendimethalin @ 0.5 kg ha^{-1} (PRE) 1 HW and 1 IC	3.3	0.7	0.0	0.0	17.16^{a-c}	15.41^{a-d}	1.52^{b-e}	3.95^{a-c}
T_{11}	Imazethapyr @ 75 g ha^{-1} (POST)	0.0	0.0	1.2	0.0	11.57^{e}	11.57^{e}	1.03^{fg}	2.60^{d}
T_{12}	Fenoxyprop-p-ethyl @ 75 g ha^{-1} (POST)	0.0	0.0	0.5	0.0	10.33^{e}	10.33^{e}	0.85^{g}	2.32^{d}
T_{13}	Farmer's practice (one HW and two IC at 20-25 and at 40 DAS)	0.0	0.0	0.0	0.0	17.43^{ab}	16.42^{a-c}	1.84^{a-c}	3.98^{a-c}
T_{14}	Weedy check	0.0	0.0	0.0	0.0	6.94^{f}	6.94^{f}	0.39^{h}	1.56^{e}
T_{15}	Weed free	0.0	0.0	0.0	0.0	18.65^{a}	17.79^{a}	2.00^{a}	4.26^{a}
	S.Em.±	-	-	-	-	0.72	0.75	0.14	0.22
	C.D. (P=0.05)	-	-	-	-	2.08	2.17	0.40	0.63

DAS- Days after sowing, fb- followed by, HW- Hand weeding, IC- Intercultivation, Means followed by same letters do not differ significantly

Post-emergent application of either imazethapyr or fenoxyprop-p-ethyl did not show any phytotoxic effect on green gram at 7 and 21 days after spraying as indicated by crop toxicity rating except slight injury to the crop in fenoxyprop-p-ethyl applied plots.

All the herbicide treatments produced significantly higher seed yield (714-1110 kg ha^{-1}) as compared to weedy check (500 kg ha^{-1}). Unweeded check registered 57.4 per cent reduction in seed yield as compared to weed free check owing to sever competition offered by uncontrolled weeds for nutrients, soil moisture, space and light. Among the weed control treatments, significantly higher seed yield (1175 kg ha^{-1}) was obtained with season long weed free check (T_{15}) as compared to weedy check and treatments consisting of only post-emergent herbicides (T_{11} and T_{12}) (Table 2). However, it was on par with all herbicide treatments involving sequential and pre-emergent herbicides application fb cultural practices *viz.*, pendimethalin fb post-emergent application of either imazethapyr (T_8-1110 kg ha^{-1}) or fenoxyprop-p-ethyl (T_9-1060 kg ha^{-1}) or one HW and one IC (T_7-1103 kg ha^{-1}), pre-emergent application of alachlor fb post-emergent application of either imazethapyr (T_5- 1026 kg ha^{-1}) or one HW and one IC (T_4-1012 kg ha^{-1}), tank mix application of alachlor + pendimethalin as pre-emergent fb one HW and one IC (T_{10}- 1019 kg ha^{-1}) and farmer's practice (T_{13}-1084 kg ha^{-1}). The extent of yield increase in herbicide application treatments (T_8, T_9, T_7, T_5, T_4 and T_{10}) was to the tune of 122, 112, 121, 106, 102 and 104 per cent, respectively over weedy check. The superior performance of these treatments was mainly due to effective control of weeds since from the sowing to maximum vegetative stage which created conditions similar to weed free environment due to sequential application of herbicides and pre-mergent application of herbicides fb cultural practices which resulted in increased yield attributing parameters *viz.*, number of pods per plant, number of seeds per pod, pod length and 100-seed weight. These increased yield parameters were mainly due to increased crop growth in terms of total dry matter production and leaf area index (Table 2). Weed index was the lowest in treatments consisting of pendimethalin fb either imazethapyr (T_8-5.6%) or fb one HW and one IC (T_7-6.2%). While, the highest weed index was noticed in weedy check (57.4%) followed by post-emergent application of treatments only (T_{11}-32.5%) or (T_{12}-39.2%) due to lower seed yield in these treatments. The results are akin to those reported by Vijayalaxmi *et al.* (2012), Dwivedi *et al.* (2012) and Younesabadi *et al.* (2013).

Sequential application of pendimethalin fb imazethapyr (T_8) recorded significantly higher gross returns (₹ 58032 ha^{-1}) and it was on par with pre-emergent and sequential application of herbicide treatments involving alachlor (T_4, T_5, T_6), pendimethalin (T_7 and T_9), tank mix application of alachlor + pendimethalin (₹ 53461 ha^{-1}) and farmer's practice (₹ 56653 ha^{-1}) (Table 3). The highest return obtained in above treatments was due to higher seed yield and lesser weed. While, weed free check recorded significantly higher gross returns (₹ 61311ha^{-1}) and the lowest gross return was obtained with weedy check (₹ 26871 ha^{-1}). Higher net return was obtained with weed free check (₹ 41570 ha^{-1}) and it was on par with all pre-

Table 3. Yield components and grain yield of green gram as influenced by sequential application of pre and post-emergent herbicides

Tr No.	Treatments	No. of pods per plant	No. of seeds per plant	Pod length (cm)	100-seed weight (g)	Seed yield (kg/ha)	Weed index (%)	Gross returns (₹/ha)	Net returns (₹/ha)	BC ratio
T_1	Oxyfluorfen @ 0.10 kg ha^{-1} (PRE) fb one HW and one IC	26.19^{b-e}	5.43^{b}	5.57^{d}	5.09^{ab}	897^{c-e}	23.7	47029	29959	2.76
T_2	Oxyfluorfen @ 0.10 kg ha^{-1} (PRE) fb imazethapyr @ 75 g ha^{-1} (POST)	25.70^{c-e}	5.27^{b}	5.81^{cd}	5.37^{ab}	874^{d-f}	25.7	45847	29761	2.85
T_3	Oxyfluorfen @ 0.10 kg ha^{-1} (PRE) fb fenoxyprop-p-ethyl @ 75 g ha^{-1} (POST)	25.50^{c-e}	5.40^{b}	5.67^{d}	5.11^{ab}	849^{d-f}	27.7	44581	28772	2.82
T_4	Alachlor @ 1.5 kg ha^{-1} (PRE) fb one HW and one IC	28.72^{a-c}	6.90^{a}	6.50^{a-d}	6.01^{a}	1012^{a-d}	13.9	53147	35433	3.00
T_5	Alachlor @ 1.5 kg ha^{-1} (PRE) fb imazethapyr @ 75 g ha^{-1} (POST)	29.51^{a-c}	6.83^{a}	6.65^{a-c}	6.19^{a}	1028^{a-d}	12.5	53910	37180	3.22
T_6	Alachlor @ 1.5 kg ha^{-1} (PRE) fb fenoxyprop-p-ethyl @ 75 g ha^{-1} (POST)	28.14^{a-d}	6.67^{a}	6.41^{a-d}	6.19^{a}	988^{b-d}	15.9	51922	35468	3.16
T_7	Pendimethalin @ 1.0 kg ha^{-1} (PRE) fb one HW and one IC	30.66^{a-c}	7.07^{a}	6.91^{ab}	6.18^{a}	1103^{ab}	6.2	57651	39791	3.23
T_8	Pendimethalin @ 1.0 kg ha^{-1} (PRE) fb imazethapyr @ 75 g ha^{-1} (POST)	31.24^{ab}	7.23^{a}	7.00^{ab}	6.33^{a}	1110^{ab}	5.6	58032	41156	3.44
T_9	Pendimethalin @ 1.0 kg ha^{-1} (PRE) fb fenoxyprop-p-ethyl @ 75 g ha^{-1} (POST)	30.02^{a-c}	6.97^{a}	6.68^{a-c}	6.07^{a}	1060^{a-c}	9.8	55506	38906	3.34
T_{10}	Alachlor @ 1.0 kg ha^{-1} (PRE) + Pendimethalin @ 0.5 kg ha^{-1} (PRE) fb one HW and one IC	29.26^{a-c}	5.33^{b}	6.36^{b-d}	6.30^{a}	1019^{a-d}	13.3	53461	36588	3.17
T_{11}	Imazethapyr @ 75 g ha^{-1} (POST)	23.42^{de}	6.90^{a}	4.60^{e}	4.60^{b}	794^{ef}	32.5	42126	27345	2.85
T_{12}	Fenoxyprop-p-ethyl @ 75 g ha^{-1} (POST)	22.36^{e}	6.73^{a}	3.93^{e}	4.43^{b}	714^{f}	39.2	37970	22913	2.52
T_{13}	Farmer's practice (one HW and two IC at 20-25 and at 40 DAS)	31.20^{ab}	5.77^{b}	7.13^{ab}	5.33^{ab}	1084^{ab}	7.8	56653	39996	3.40
T_{14}	Weedy check	21.34^{e}	2.20^{c}	3.03^{f}	3.23^{c}	500^{g}	57.4	26817	13640	2.04
T_{15}	Weed free	32.78^{a}	7.43^{a}	7.38^{a}	6.37^{a}	1175^{a}	0.0	61311	41570	3.11
	S.Em.±	1.61	0.30	0.30	0.40	55	-			
	C.D. (P=0.05)	4.66	0.87	0.86	1.15	160	-			

fb- followed by, HW- Hand weeding, IC- Intercultivation, Means followed by same letters do not differ significantly

emergent and sequential application of treatments except treatments consisting of application of oxyfluorfen (T_1 - ₹ 29959 ha^{-1}) or (T_2 - ₹ 29761 ha^{-1}) or (T_3 - ₹ 28722 ha^{-1}) and post-emergent application of either imazethapyr (T_{11} -₹ 27345 ha^{-1}) or fenoxyprop-p-ethyl (T_{12} - ₹ 22913 ha^{-1}). Higher net returns in these treatments could be attributed to higher seed yield and lower cost of cultivation. While, the lowest net return was obtained with weedy check (₹ 13640 ha^{-1}).

BC ratio was significantly higher with sequential application of herbicide pendimethalin fb imazethapyr (3.44), but it was on par with either pre-emergent or sequential application of herbicide treatments and farmer's practice (T_{10}). While, the lowest BC ratio was obtained with weedy check (2.04) (Table 3). The variations in BC ratio could be attributed to cost of cultivation and gross returns. Similar findings were reported by Choudhary *et al*. (2012), Rao *et al*. (2010); Khot *et al*. (2012) who revealed that integrated weed management with pre-emergent application of pendimethalin and one HW at 25 DAS or imazethapyr application were found economically viable with higher net returns and B C ratio in black gram.

Sequential application of pendimethalin @ 1.0 kg ha^{-1} as pre-emergent fb imazethapyr @ 75 g ha^{-1} as post-emergent at 25 DAS was found economically viable and it can be used as substitute to farmer's practice in green gram grown in northern transitional zone. For the farmer's convenience and practical feasibility pre-emergent application of pendimethalin @ 1.0 kg ha^{-1} fb one HW and one IC can also be used as an alternative practice which was on par with sequential herbicide treatments with respect to higher seed yield (1103 kg ha^{-1}), net returns (₹ 39791 ha^{-1}) and BC ratio (3.23). These weed management methods were found promising to control weeds in green gram crop grown under rainfed condition and would play an important role in areas where labours are too expensive and timely weeding is required.

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