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Effect of Imazethapyr as Early Post-Emergence Herbicide on Weed Dynamics and Yield of Greengram (*Vigna radiata* L.)

Girdhari Lal[1], S.M. Hiremath[2] and Bheiru Singh[3*]

[1]Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi-221005, India
[2]Department of Agronomy, ARS, Gadag, UAS, Dharwad-580 005 (Karnatka), India
[3]Krishi Vigyan Kendra, Hanumangarh-II 335523 (Rajasthan), India

**Corresponding author*

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A B S T R A C T

A field experiment was conducted during *kharif* of 2014-15 at Main Agricultural Research Station, Dharwad to study the effect of early post-emergence herbicide Imazethapyr on weed dynamics and yield of greengram. Results revealed that weed free check (T_{10}) recorded significantly lower total weed population, total weed dry weight of weeds, higher weed control efficiency (WCE), higher grain yield (833 kg ha^{-1}), haulm yield (2685 kg ha^{-1}), number of pods plant^{-1} (15.49), grain weight plant^{-1} (4.32 g) and gross return (Rs 40,707 ha^{-1}), However, treatments T_8 (Standard check 2 IC + 2 HW at 20 and 40 DAS) and T_6 (Imazethapyr 10% SL @ 75 g a.i. ha^{-1} + adjuvant @ 2.0 ml litre^{-1} of water) found to be at par with T_{10}. Among the herbicide treatments, T_6 recorded significantly higher grain yield (783 kg ha^{-1}), haulm yield (2528 kg ha^{-1}), number of pods plant^{-1} (15.06), grain weight plant^{-1} (4.08 g), gross return (Rs 38,269 ha^{-1}), net return (Rs 19,090 ha^{-1}) and B: C ratio (2.00). It also recorded lower total number of grassy weeds, broad leaved weeds, sedge, total weed dry weight and higher WCE at 40 (86.49 %), 60 DAS (82.93 %) and at harvest (82.30 %).

Introduction

Greengram (*Vigna radiata* L.) is the third most important pulse crop of India, after chickpea and pigeonpea. It contains about 24.5 per cent protein. The protein is comparatively rich in lysine which is deficient in cereal grains. In India it covers an area of 3.55 million hectares with total production of 1.61 million tonnes and an average productivity of 619 kg ha^{-1} (Anon., 2013). The low yields of greengram in India as compared to the world productivity is growing of pulses under marginal and less fertile soil with low inputs and without weed, pest and disease management. Among several factors responsible for lower productivity and grain yield of greengram, weed infestation is one of the major factors. The crop mainly cultivated during *kharif* season and is infested with various grassy weeds, sedge and broad leaved weeds which emerge simultaneously with the crop plants and rob essential nutrients, space, moisture and sunlight causing substantial loss

in yield. The weeds, if not controlled during critical period of crop-weed competition, there may be reduction in the yield of greengram depending upon type of weeds and weed intensity. The critical period of crop-weed competition is 45 days (Singh *et al.,* 1996). To avoid the competition during early growth stages, greengram field should kept free from weeds for the first 30-45 days after sowing, after that the crop able to cover the land and takes care of late emerging weeds.

Weed control through hand weeding is tedious, time and labour consuming. So, there is need to evaluate the new post emergence herbicide for weed control in greengram. The herbicide presently available for greengram are narrow spectrum and control only one type of weeds either grassy or broad leaved weeds. Imazethapyr is a broad spectrum herbicide used as early post-emergence in pulses, oilseeds and leguminous crops. The information on use of imazethapyr as a early post-emergence is meager & hence study was carried out.

Materials and Methods

A field experiment was undertaken at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad (Karnataka) during *kharif* season of 2014-15. The experiment was laid out in a randomized complete block design (RCBD) with three replications and ten treatments comprising, Imazethapyr 10% SL @ 50 g a.i. ha^{-1} (T_1), Imazethapyr 10% SL @ 62.5 g a.i. ha^{-1} (T_2), Imazethapyr 10% SL @ 75 g a.i. ha^{-1} (T_3), Imazethapyr 10% SL @ 50 g a.i. ha^{-1} + adjuvant @ 2.0 ml $litre^{-1}$ of water (T_4), Imazethapyr 10% SL @ 62.5 g a.i. ha^{-1} + adjuvant @ 2.0 ml $litre^{-1}$ of water (T_5), Imazethapyr 10% SL @ 75 g a.i. ha^{-1} + adjuvant @ 2.0 ml $litre^{-1}$ of water (T_6), Quizalofop-ethyl 5% EC @ 1000 ml $litre^{-1}$ of water (T_7), standard check (2 Inter-cultivation + 2 Hand Weeding at 20 and 40 DAS)(T_8), weedy check (T_9) and weed free check (T_{10}). The experimental soil was black clayey soil (Vertisol) with the pH 7.4, organic carbon (8 g kg^{-1}), available N (248 kg ha^{-1}), available P_2O_5 (25.55 kg ha^{-1}) and available K_2O (396 kg ha^{-1}). Greengram variety 'Nirmal Gold (NVL-1)' was sown on 14th July 2014 at 30 x 10 cm spacing using seed rate of 12 kg ha^{-1}. The recommended fertilizers i.e. 25:50 kg ha^{-1} N and P_2O_5 were applied at the time of sowing. The total rainfall received during crop growth period was 604.2 mm and was well distributed. Spraying of chloropyriphos @ 2 ml $litre^{-1}$ and bavistin @ 2 g $litre^{-1}$ of water was done for control of sucking insects, pod borers and disease. The early post-emergence herbicide Imazethapyr was sprayed at 23 DAS and other herbicide such as Quizalofop-ethyl was sprayed at the same time. The herbicides were sprayed with knapsack sprayer using 750 litres of spray solution per hectare. Weed population and weed dry weight m^{-2} were recorded at 20, 40, 60 DAS and at harvest based on which WCE was calculated. The quadrate of 0.25 square meter was used to count the weeds in each plot. The data collected on weeds were transformed through the square root transformation $\sqrt{X+0.5}$ for statistical analysis. The various yield parameters such as number of pods $plant^{-1}$, grain weight $plant^{-1}$, grain yield and haulm yield were recorded at harvest stage of greengram.

Results and Discussion

The important grassy weeds were *Cynodon dactylon* and *Dinebra retroflexa,* and while among the broad-leaved weeds *Ageratum conyzoides, Corchorus trilocularis, Digera arvensis* and *Parthenium hysterophorus* were found and among sedge *Cyperus rotundus* was found in the experimental area. Among the different weed *Cyperus rotundus* and *Cynodon dactylon* were dominant.

Table.1 Total number of grassy weeds, broad leaved weeds and sedge (m^{-2}) at different growth stages in soybean as influenced by application of early post-emergence herbicides

Treatment	Total number of weeds (m^{-2})			Total number of grassy weeds (m^{-2})			Total number of broad leaved weeds (m^{-2})			Total number of sedge (m^{-2})		
	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS
T_1- Imazethapyr 10% SL 50 g a.i ha^{-1} (EPOE)	11.94* (144.00)	10.05* (101.00)	12.45* (154.67)	5.14* (26.00)	4.91* (23.67)	5.74* (32.67)	5.74* (32.67)	7.24* (52.00)	9.16* (84.00)	9.12* (85.33)	5.97* (35.33)	6.19* (38.00)
T_2 - Imazethapyr 10% SL 62.5 g a.i ha^{-1} (EPOE)	11.65 (135.33)	9.99 (100.00)	11.96 (142.67)	4.92 (24.00)	4.71 (22.00)	5.37 (28.67)	6.40 (40.67)	7.64 (58.00)	8.93 (79.33)	8.43 (70.67)	5.33 (28.00)	5.92 (34.67)
T_3 - Imazethapyr 10% SL 75 g a.i ha^{-1} (EPOE)	11.63 (136.00)	8.68 (75.33)	10.82 (116.67)	4.29 (18.00)	4.58 (20.67)	5.14 (26.00)	7.01 (48.67)	6.15 (37.33)	8.10 (65.33)	8.27 (69.33)	4.78 (22.67)	5.05 (25.33)
T_4 - Imazethapyr 10% SL 50 g a.i ha^{-1} + Adjuvant @ 2.0 ml $litre^{-1}$ of water (EPOE)	10.30 (106.67)	9.39 (88.67)	10.96 (120.00)	4.52 (20.00)	4.88 (23.33)	5.58 (30.67)	5.90 (34.67)	6.75 (45.33)	7.82 (61.67)	7.12 (52.00)	5.02 (25.33)	5.35 (28.67)
T_5 -Imazethapyr 10% SL 62.5g a.i ha^{-1} + Adjuvant @ 2.0 ml $litre^{-1}$ of water (EPOE)	11.48 (131.33)	8.67 (75.33)	10.38 (107.33)	5.03 (25.33)	4.67 (21.33)	5.05 (25.33)	6.62 (43.33)	6.25 (38.67)	7.37 (54.00)	7.90 (62.67)	4.46 (20.00)	5.30 (28.00)
T_6 - Imazethapyr 10% SL 75 g a.i ha^{-1} + Adjuvant @ 2.0 ml $litre^{-1}$ of water (EPOE)	10.66 (114.00)	6.46 (41.33)	8.03 (64.00)	4.36 (18.67)	3.81 (14.00)	4.14 (16.67)	5.76 (32.67)	4.74 (22.00)	5.91 (34.67)	7.87 (62.67)	2.90 (8.00)	3.61 (12.67)
T_7 - Quizalofop-ethyl 5% EC @ 1000 ml ha^{-1} (EPOE)	11.26 (126.67)	10.88 (118.00)	11.90 (141.33)	4.99 (24.67)	3.42 (11.33)	3.88 (14.67)	5.81 (33.33)	9.55 (90.67)	10.22 (104.00)	8.26 (68.67)	4.61 (21.33)	4.74 (22.67)
T_8 - Standard check (2 IC + 2 HW at 20 and 40 DAS)	11.55 (134.00)	5.21 (26.67)	6.74 (45.00)	4.81 (22.67)	3.12 (9.33)	3.53 (12.00)	5.17 (26.67)	3.80 (14.00)	4.75 (22.33)	9.12 (84.67)	2.21 (4.67)	3.32 (10.67)
T_9 - Weedy check	11.33 (130.00)	17.49 (306.00)	19.45 (380.00)	4.66 (22.00)	10.09 (101.33)	11.09 (122.67)	6.03 (36.00)	12.20 (148.67)	13.22 (174.67)	8.37 (72.00)	8.72 (76.00)	8.97 (82.67)
T_{10} - Weed free	3.44 (11.33)	2.76 (7.33)	3.00 (8.67)	1.76 (2.67)	1.47 (2.00)	1.65 (2.67)	2.90 (8.00)	2.08 (4.00)	2.23 (4.67)	1.00 (0.67)	1.29 (1.33)	1.29 (1.33)
S.Em±	0.44	0.27	0.36	0.34	0.19	0.25	0.28	0.24	0.31	0.50	0.25	0.32
CD (5%)	1.31	0.81	1.08	1.01	0.57	0.74	0.85	0.74	0.94	1.49	0.74	0.96

Note: EPOE- Early post-emergence (23 DAS), IC - Inter-cultivation (20 & 40 DAS), HW- Hand weeding (20 &40 DAS), DAS- Days after sowing
* Transformed values [$\sqrt{(x + 0.5)}$], Figures in the parenthesis indicate original values.

Table.2 Total weed dry weight (g m^{-2}) and weed control efficiency (%) at different growth stages in greengram and weed index (%) as influenced by application of early post-emergence herbicides

Treatment	Total weed dry weight (g m^{-2})				WCE (%)			Weed index
	20 DAS	40 DAS	60 DAS	At harvest	40 DAS	60 DAS	At harvest	(%)
T_1- Imazethapyr 10% SL 50 g a.i ha^{-1} (EPOE)	4.56* (20.57)	5.83* (33.67)	7.88* (61.73)	7.92* (62.35)	67.18	58.52	58.02	29.78
T_2 - Imazethapyr 10% SL 62.5 g a.i ha^{-1} (EPOE)	4.45 (19.33)	5.80 (33.33)	7.56 (56.80)	7.60 (57.37)	67.54	61.87	61.17	29.49
T_3 - Imazethapyr 10% SL 75 g a.i ha^{-1} (EPOE)	4.45 (19.43)	5.05 (25.11)	6.85 (46.53)	6.88 (47.00)	75.50	68.56	68.34	23.94
T_4 - Imazethapyr 10% SL 50 g a.i ha^{-1} + Adjuvant @ 2.0 ml $litre^{-1}$ of water (EPOE)	3.95 (15.24)	5.45 (29.56)	6.96 (48.00)	6.99 (48.48)	71.28	68.16	68.10	25.91
T_5 -Imazethapyr 10% SL 62.5g a.i ha^{-1} + Adjuvant @ 2.0 ml $litre^{-1}$ of water (EPOE)	4.39 (18.76)	5.04 (25.11)	6.63 (43.47)	6.66 (43.90)	75.55	71.42	71.10	20.07
T_6 - Imazethapyr 10% SL 75 g a.i ha^{-1} + Adjuvant @ 2.0 ml $litre^{-1}$ of water (EPOE)	4.08 (16.29)	3.77 (13.78)	5.05 (25.07)	5.08 (25.32)	86.49	82.93	82.30	6.00
T_7 - Quizalofop-ethyl 5% EC @ 1000 ml ha^{-1} (EPOE)	4.31 (18.10)	6.31 (39.33)	7.55 (56.67)	7.59 (57.23)	61.32	62.17	62.06	28.46
T_8 - Standard check (2 IC + 2 HW at 20 and 40 DAS)	4.41 (19.14)	3.06 (8.89)	4.36 (18.53)	4.38 (18.72)	91.28	87.76	87.44	2.64
T_9 - Weedy check	4.33 (18.57)	10.11 (102.00)	12.31 (151.87)	12.37 (153.39)	-	-	-	41.79
T_{10} - Weed free	1.45 (1.62)	1.70 (2.44)	1.95 (3.33)	2.03 (3.63)	97.59	97.74	97.58	-
S.Em±	0.16	0.15	0.26	0.27	1.39	1.84	2.90	4.61
CD (5%)	0.49	0.46	0.79	0.82	4.17	5.52	8.70	13.69

Note: EPOE- Early post-emergence (23 DAS), IC - Inter-cultivation (20 & 40 DAS), HW- Hand weeding (20 &40 DAS), DAS- Days after sowing
* Transformed values [√(x + 0.5)], Figures in the parenthesis indicate original values.

Table.3 Yield, yield attributes and economics of greengram as influenced by application of early post emergence herbicide

Treatment	At harvest							
	Number of pods plant^{-1}	Grain weight (g plant^{-1})	Test weight (g / 1000 grains)	Grain yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Harvest index (%)	Net return (Rs ha^{-1})	B:C Ratio
T_1- Imazethapyr 10% SL 50 g a.i ha^{-1} (EPOE)	10.51	2.94	48.82	586	2065	22.06	10604	1.58
T_2 - Imazethapyr 10% SL 62.5 g a.i ha^{-1} (EPOE)	10.66	2.98	48.96	588	2070	22.16	10463	1.57
T_3 - Imazethapyr 10% SL 75 g a.i ha^{-1} (EPOE)	11.65	3.41	49.02	635	2217	22.25	12472	1.66
T_4 - Imazethapyr 10% SL 50 g a.i ha^{-1} + Adjuvant @ 2.0 ml litre^{-1} of water (EPOE)	11.13	3.22	48.86	618	2175	22.15	11876	1.64
T_5 - Imazethapyr 10% SL 62.5 g a.i ha^{-1} + Adjuvant @ 2.0 ml litre^{-1} of water (EPOE)	12.99	3.45	50.46	664	2342	22.36	13865	1.74
T_6 - Imazethapyr 10% SL 75 g a.i ha^{-1} + Adjuvant @ 2.0 ml litre^{-1} of water (EPOE)	15.06	4.08	51.14	783	2528	23.92	19090	2.00
T_7 - Quizalofop-ethyl 5% EC @ 1000 ml ha^{-1} (EPOE)	11.33	3.12	48.72	596	2110	22.15	10554	1.56
T_8 - Standard check (2 IC + 2 HW at 20 and 40 DAS)	15.43	4.23	51.18	811	2638	23.71	16520	1.71
T_9 - Weedy check	9.09	2.35	48.66	485	1817	21.12	7038	1.41
T_{10} - Weed free	15.49	4.32	51.78	833	2685	23.83	13952	1.52
S.Em±	0.72	0.21	1.26	39.72	113.78	1.69	1650	0.08
CD (5%)	2.15	0.63	NS	118	338	NS	4904	0.26

Note: EPOE- Early post-emergence (23 DAS), IC - Inter-cultivation (20 & 40 DAS), HW- Hand weeding (20 &40 DAS), DAS- Days after sowing

Effect of imazethapyr as early post emergence on weed dynamics

Among the herbicide treated plots application of Imazethapyr @ 75 g a.i ha^{-1} + adjuvant @ 2.0 ml $litre^{-1}$ of water was recorded lower total number of weeds, broad leaved weeds, and sedge at all the growth stages of crop and was on par with standard check (2IC + 2HW at 20 and 40 DAS). Quizalofop-ethyl @ 1000 ml ha^{-1} recorded significantly lower number of grassy weeds at all stages of crop growth which on par with Imazethapyr @ 75 g a.i ha^{-1} + adjuvant @ 2.0 ml $litre^{-1}$ and standard check (2IC + 2HW at 20 and 40 DAS) (Table 1). These results are in conformity with the findings of Venkatesha *et al.,* (2008). The standard check (2IC + 2HW at 20 and 40 DAS) has recorded lesser dry weight of weeds, higher WCE and lower weed index. Among the herbicide treatments application of Imazethapyr @ 75 g a.i ha^{-1} + Adjuvant @ 2.0 ml $litre^{-1}$ of water has recorded lesser dry weight of weeds, higher WCE and lower weed index compared to all other herbicidal treatments (Table 2). These results are in conformity with Venkatesha *et al.,* (2008) and Devi *et al.,* (2012). The higher total weed population, weed dry weight, weed index and lower weed control efficiency was recorded in weedy check (Table 1 and 2). Goud *et al.,* (2013) and Lhungdim *et al.,* (2013) quoted similar findings.

Effect of Imazethapyr as early post emergence on yield and yield attributes

All the herbicide treatments produced significantly higher grain and haulm yields compared to weedy check (Table 3). Weed free check recorded significantly higher grain and haulm yields (833 kg ha^{-1} and 2685 kg ha^{-1}), but on par with standard check (2IC + 2HW at 20 and 40 DAS) (811 kg ha^{-1} and 2638 kg ha^{-1}) and Imazethapyr @ 75 g a.i. ha^{-1} + adjuvant @ 2.0 ml $litre^{-1}$ of water (783 kg ha^{-1} and 2528 kg ha^{-1}). Similarly weed free check recorded significantly higher number of pods and grain weight (15.49 $plant^{-1}$ and 4.32 g $plant^{-1}$), which was on par with standard check (2IC + 2HW at 20 and 40 DAS) (15.43 $plant^{-1}$ and 4.23 g $plant^{-1}$) and Imazethapyr @ 75 g a.i. ha^{-1} + adjuvant @ 2.0 ml $litre^{-1}$ of water (15.06 $plant^{-1}$ and 4.08 g $plant^{-1}$) (Table 3). This may be attributed to excellent control of broad leaved weeds, sedge and grassy weeds at critical stage of crop growth. These results were in conformity with Venkatesha *et al.,* (2008), Devi *et al.,* (2012) and Ram *et al.,* (2013). There was no significant difference in thousand grain weight (Table 3). Significantly lower grain yield and yield attributes were recorded in weedy check. This may be attributed to severe crop weed competition stress right from crop establishment to the end of critical period of crop growth.

Effect of Imazethapyr as early post emergence on economics

Economics of various weed control treatments indicated that significantly higher gross return (Rs 40,707 ha^{-1}) was recorded with weed free check but on par with standard check (2IC + 2HW at 20 and 40 DAS) (Rs 39,661 ha^{-1}) and Imazethapyr @ 75 g a.i. ha^{-1} + adjuvant @ 2.0 ml $litre^{-1}$ of water (Rs 38,269 ha^{-1}). Net return was significantly higher in Imazethapyr @ 75 g a.i. ha^{-1} + adjuvant @ 2.0 ml $litre^{-1}$ of water (Rs 19,090 ha^{-1}) but on par with standard check (2IC + 2HW at 20 and 40 DAS) (Rs 16,520 ha^{-1}) (Table 3). Significant differences were observed in B: C ratio due to different weed control treatments. Imazethapyr @ 75 g a.i. ha^{-1} + adjuvant @ 2.0 ml $litre^{-1}$ of water recorded significantly higher B:C ratio (2.00) compared to all other treatments and was followed by Imazethapyr @ 62.5 g a.i. ha^{-1} + adjuvant @ 2.0 ml $litre^{-1}$ of water (1.74) (Table 3). The higher net return in Imazethapyr @ 75 g a.i. ha^{-1} + adjuvant @ 2.0 ml $litre^{-1}$ of water could be attributed to

higher grain yield and lower cost of cultivation and higher gross return. The variations in B: C ratio could be attributed to cost of cultivation and gross return. On the contrary, the lower net return and B:C ratio were recorded in weedy check (1.41) due to lower gross return which in turn due to significantly the lower grain yield of greengram. Similar finding was reported by Venkatesha *et al.,* (2008).

Based on results of the field experimentation, it seems quite logical to conclude that profitable, potential and effective weed control in greengram can be achieved by application of Imazethapyr @ 75 g a.i. ha^{-1} + adjuvant @ 2 ml $litre^{-1}$ of water, another alternative is standard check (2IC + 2HW at

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