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Efficacy of herbicides on weeds and yield of greengram

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ABSTRACT

The field experiments were conducted during *Kharif* 2016 and 2017 at Research Farm, College of Agriculture, RVSKVV, Gwalior (M.P.) to study the effective herbicide/combination of herbicides to control the problematic weeds in greengram (*Vigna radiata*). The experiments were laid out with ten treatments, *viz*. quizalofop-p-ethyl 50, 75 and 100 g/ha PoE, fenoxaprop-p-ethyl 100 g/ha PoE, pendimethalin 1000 g/ha pre-emergence (PE), pendimethalin + imazethapyr (RM) 750 and 1000 g/ha PE, imazethapyr + imazamox (RM) 80 g/ha PoE, two hand weeding at 20 and 40 DAS and weedy check in a randomized block design. The combination of imazethapyr + imazamox (RM) 80 g/ha applied as post-emergence was found to be very efficient in controlling the dominant grassy as well as broad-leaved weeds and produced maximum seed yield (993 kg/ha), and was at par with two hand weedings at 20 and 40 DAS (983 kg/ha) and combination of pendimethalin + imazethapyr 750 g/ha and 1000 g/ha PE (844 and 758 kg/ha, respectively). Application of imazethapyr + imazamox (RM) 80 g/ha PoE resulted in the highest B:C ratio (3.03), and net returns, *fb* pendimethalin + imazethapyr 750 g/ha PE and two hand weeding at 20 and 40 DAS.

INTRODUCTION

Greengram (*Vigna radiata* L.) is not very competitive against weeds. The loss of yield due to weeds ranges from 30 to 85% (Raman and Krishnamoorthy 2005, Dungarwal *et al*. 2003 and Mirjha *et al*. 2013). Therefore, proper weed management is essential to ensure good crop growth, especially in early stages. Among different methods of weed control, the chemical method is becoming popular among farmers because of increasing labour costs. The available pre- and post-emergence herbicides, *viz*. pendimethalin, oxyfluorfen, fenoxaprop-p-ethyl and quizalofop-ethyl are able to check the emergence and growth of annual grasses and broad-leaved weeds. Imazethapyr, a broad-spectrum herbicide, has soil and foliar activity that allows flexibility in its application timing and has low mammalian toxicity (Gupta *et al.* 2017, Tamang *et al.* 2015). Chhodavadia *et al.* (2013) reported that post-emergence application of imazethapyr 25 g/ha had no adverse effect on growth characters and resulted statistically similar grain yield to that of twice hand weeding (20 and 40 DAS). Pendimethalin is basically pre-emergence herbicide. In rain fed condition, if weeds have not yet germinated, this herbicide may be effective when applied after first shower.

The present study was taken to determine the efficacy of herbicides on problematic weeds and their impact on yield of greengram.

MATERIALS AND METHOD

Field experiments were conducted during *Kharif* 2016 and 2017 at Research Farm, College of Agriculture, Gwalior (M.P.) of 412 m altitude from sea level, 79^0 54'E longitude and 23^0 10'N latitude to find out the efficacy of herbicides on problematic weeds and their impact on yield of greengram. The soil was sandy clay loam in texture, low in available nitrogen (195 kg/ha), medium in phosphorus (13 kg/ha) and potassium (204 kg/ha) with pH 7.7 and EC 0.41 dS/m. The 10 treatments, *viz*. quizalofop-p-ethyl 50, 75 and 100 g/ha PoE, fenoxaprop-p-ethyl 100 g/ha PoE, pendimethalin 1000 g/ha PE, pendimethalin + imazethapyr (RM) 750 and 1000 g/ha pre-emergence (PE), imazethapyr + imazamox (RM) 80 g/ha PoE, two hand weeding at 20 and 40 DAS and weedy check were replicated thrice in a completely RBD. Greengram variety '*TJM-3*' was sown on 19th and 16th July with the seed rate of 18 kg/ha maintaining row to row spacing of 40 cm and harvested on 3rd and 5th October, in 2016 and 2017, respectively. The recommended dose of fertilizer 20:50:20 NPK kg/ha was applied during both the years. Pre-emergence

herbicides were applied within 48 hours of sowing and post-emergence herbicides were applied on 20th day after sowing. Both the herbicides were applied with the help of flat fan nozzle and knapsack battery sprayer with a spray volume of 600 litre water/ha. Observations on weeds were recorded with the help of quadrate 1.0 m^2 placed randomly in each plot at 40 DAS and same were dried in the oven at the temperature 60-80 ^{0}C. Crop yield was recorded at harvest stage. Weed control efficiency and economics of different weed control treatments were also worked out.

The average rainfall of the state was 750 mm. Out of that, 590 mm was received during *Kharif* 2016 and 580 mm during *Kharif* 2017. Although the distribution of rainfall was erratic but good amount of rainfall was received during both the years. The temperature ranged from 13.5 ^{0}C to 44 ^{0}C during both the years.

RESULTS AND DISCUSSION

Effect on weeds

The major weed flora observed in an experimental site during *Kharif* 2016 and 2017 were *Cyperus rotundus* (55.45%), *Echinochloa crus-galli* (5.45%), *Setaria glauca* (1.97%), *Acrachne racemes* (12.78%), *Cynodon dactylon* (0.80%), and *Erragrostis* spp. (0.62%) as grasses. *Celosia argentia* (1.79%), *Phyllanthus niruri* (1.65%), *Commelina benghalensis* (5.9%) and *Digera arvensis* (13.58%), were observed as major broad-leaved weeds (BLWs). Among them, *Cyperus rotundus* was the most problematic weed and accounted for 55.45% of the total weed population during both the years (**Table 1**). At 40 DAS, weedy check recorded the highest weed density of *Cyperus rotundus* and *Digera arvensis* whereas hand weeding recorded the lowest number of weeds *fb* post-emergence herbicide of imazethapyr + imazamox (RM) 80 g/ha. Density and dry weight of weeds were significantly affected by weed management practices **(Table 1-3)**. Population of all weeds was significantly reduced under the influence of two hand weeding at 20 and 40 DAS.

During both the years, combination of post-emergence herbicides, imazethapyr+ imazamox (RM) 80 g/ha controlled the narrow and broad-leaved weeds more effectively as compare to the combination of pre-emergence with post-emergence herbicide pendimethalin + imazethapyr (RM) 750 g/ha PE and 1000 g/ha. Although the application of pendimethalin + imazethapyr (RM) 1000 g/ha was at par with 750 g/ha as PE to control the broad-leaved weeds *viz. Celosia argentia*, *Phyllenthus niruri* and *Commelina benghalensis*. Quizalofop-p-ethyl (50, 75 and 100 g/ha PoE) was found effective in controlling the *Cyperus rotundus* when applied at higher dose (100 g/ha).

The dry matter of weeds was the highest in weedy check and the lowest in two hand weeding, which was at par with application of post-emergence herbicide, imazethapyr + imazamox (RM) 80 g/ha in 2017 but higher in 2016 **(Table 2)**. Imazethapyr + imazamox have been reported to provide effective control of grassy weeds in green-gram (Singh *et al.* 2014) and (Singh *et al.* 2015).

Table 1. Population of narrow-leaved weeds/m^2 as influenced by weed management practices at 40 DAS

Treatment	*Cyperus rotundus*			*Echinochloa crus-galli*			*Setaria glauca*			*Acrachne racemosa*	*Cynodon dactylon*	*Eragrostis* spp.
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2017	2017	2016
Quizalofop-p-ethyl 50 g/ha PoE	10.96 (119.7)	10.62 (112.3)	10.79 (116.0)	1.86 (3.00)	3.08 (9.00)	2.47 (6.0)	1.22 (1.00)	1.00 (0.67)	1.11 (0.83)	1.76 (2.67)	1.17 (1.00)	1.58 (2.00)
Quizalofop-p-ethyl 75 g/ha PoE	10.21 (107.0)	11.00 (123.3)	10.61 (115.7)	1.34 (1.33)	4.39 (20.33)	2.87 (10.8)	1.05 (0.67)	1.68 (2.33)	1.36 (1.50)	2.85 (7.67)	1.17 (1.00)	1.46 (1.67)
Quizalofop-p-ethyl 100 g/ha PoE	9.03 (83.7)	10.99 (153.3)	10.01 (118.5)	1.34 (1.33)	4.56 (20.67)	2.95 (11.0)	1.05 (0.67)	1.95 (3.33)	1.50 (2.00)	4.30 (18.00)	1.56 (2.00)	1.58 (2.00)
Fenoxaprop-p-ethyl 100 g/ha PoE	8.18 (71.7)	13.73 (190.3)	10.96 (131.0)	2.11 (4.00)	5.92 (34.67)	4.02 (19.3)	1.22 (1.00)	3.03 (8.67)	2.13 (4.83)	5.08 (25.33)	1.58 (2.00)	1.68 (2.33)
Pendimethalin 1000 g/ha PE	9.29 (86.7)	8.83 (79.3)	9.06 (83.0)	2.12 (4.00)	2.03 (3.67)	2.08 (3.8)	1.34 (1.33)	0.71 (0)	1.03 (0.67)	1.00 (0.67)	1.05 (0.67)	1.68 (2.33)
Pendimethalin + imazethapyr (RM) 750 g/ha PE	9.09 (82.7)	6.17 (39.3)	7.63 (61.0)	1.17 (1.00)	0.71 (0)	0.94 (0.5)	1.05 (0.67)	0.71 (0)	0.88 (0.33)	0.71 (0)	0.71 (0)	1.34 (1.33)
Pendimethalin + imazethapyr (RM) 1000 g/ha PE	7.36 (55.7)	8.64 (74.7)	8.00 (65.2)	1.05 (0.67)	0.71 (0)	0.88 (0.3)	1.05 (0.67)	0.71 (0)	0.88 (0.33)	0.71 (0)	0.71 (0)	1.17 (1.00)
Imazethapyr + imazamox (RM) 80 g/haPoE	6.30 (39.3)	4.83 (23.3)	5.56 (31.3)	1.05 (0.67)	0.71 (0)	0.88 (0.3)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.88 (0.33)
2 HW at 20 and 40 DAS	5.62 (31.3)	0.71 (0)	3.16 (15.7)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)
Weedy check	12.28 (150.3)	16.16 (262.0)	14.22 (206.7)	2.27 (4.67)	6.12 (37.00)	6.94 (20.8)	1.87 (3.00)	3.49 (11.67)	2.68 (7.33)	1.69 (47.67)	1.87 (3.00)	1.68 (2.33)
LSD (p=0.05)	2.58	4.12	4.86	0.42	0.97	0.37	0.34	0.32	0.47	0.37	0.37	0.377

Original data were subjected to square root $\sqrt{x+0.5}$ transformation and presented in parentheses

Two hand weeding recorded the highest weed control efficiency (94.61%) *fb* imazethapyr + imazamox (RM) 80 g/ha (86.86%), pendimethalin + imazethapyr (RM) 750 g/ha (77.28%) and 1000 g/ha PE (75.64%) respectively due to lower dry matter of weeds.

Effect on crop

Weed control treatments significantly influenced the yield of green-gram (**Table 4**). On the basis of pooled analysis the yield of green-gram was superior in the case of imazethapyr + imazamox (RM) 80 g/ha and it was at par with two hand weeding *fb* pendimethalin+ imazethapyr (RM) 750 g/ha and pendimethalin + imazethapyr (RM) 1000 g/ha treatment. Similarly imazethapyr + imazamox (RM) 80 g/ha *fb* two hand weeding registered the highest biological yield which was significantly higher than other treatments as pooled analysis. (**Table 5**).

Economics

Application of imazethapyr + imazamox (RM) 80 g/ha PoE was proved to be economically the best weed management treatment with the maximum net returns ` 43,401/ha *fb* two hand weeding (` 38,906/ ha) and pendimethalin + imazethapyr 750 g/ha PE (` 34,512/ha). However, the maximum B:C ratio of 3.03 was found in imazethapyr + imazamox (RM) 80 g/ha PoE *fb* pendimethalin + imazethapyr 750 g/ha PE (2.56) and two hand weeding (2.48). The minimum net returns (` 4,917/ha) was recorded under weedy check with B:C ratio of 1.25 **(Table 5)**.

Weed persistence and herbicide efficiency indices

Weed persistence index (WPI) and herbicide efficiency index (HEI) express the tolerance of weeds to different herbicidal treatments as well as their efficacy to eradicate the weeds **(Table 3**). Among different pre- and post-emergence herbicides,

Table 2. Population of broad-leaved weeds /m^2 as influenced by weed management practices at 40 DAS

Treatment	*Celosia argentia*			*Phyllenthus niruri*			*Commelina benghalensis*			*Digera arvensis*		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Quizalofop-p-ethyl 50 g/ha PoE	2.12 (4.00)	2.41 (5.33)	2.27 (4.67)	1.58 (2.00	2.34 (5.00	1.96 (3.50	2.73 (7.00	4.41 (19.00	3.57 (13.00)	3.18 (9.67)	6.28 (39.00)	4.73 (24.33)
Quizalofop-p-ethyl 75 g/ha PoE	1.77 (2.67)	2.73 (7.00)	2.25 (4.83)	1.34 (1.33)	2.68 (6.67)	2.01 (4.00)	2.60 (6.33)	4.95 (24.00)	3.78 (15.17)	3.08 (9.00)	6.84 (46.33)	4.96 (27.67)
Quizalofop-p-ethyl 100 g/ha PoE	1.56 (2.00)	3.13 (9.33)	2.35 (5.67)	1.34 (1.33)	2.85 (7.67)	2.10 (4.50)	2.54 (6.00)	4.98 (24.33)	3.76 (15.17)	2.34 (5.00)	7.78 (61.00)	5.06 (33.00)
Fenoxaprop-p-ethyl 100 g/ha PoE	1.34 (1.33)	2.86 (7.67)	2.10 (4.50)	1.34 (1.33)	2.97 (8.33)	2.16 (4.83)	1.95 (3.33)	5.66 (31.67)	3.81 (17.50)	2.34 (5.00)	8.01 (63.67)	5.17 (34.33)
Pendimethalin 1000 g/ha PE	1.34 (1.33)	1.64 (2.67)	1.49 (2.00)	1.22 (1.00)	1.76 (2.67)	1.49 (1.83)	1.86 (3.00)	4.34 (18.33)	3.10 (10.67)	1.86 (3.00)	4.37 (18.67)	3.11 (10.83)
Pendimethalin + imazethapyr (RM) 750 g/ha PE	1.05 (0.67)	1.17 (1.00)	1.11 (0.83)	0.88 (0.33)	1.39 (1.67)	1.13 (1.00)	1.64 (2.33)	3.44 (11.33)	2.54 (6.83)	1.68 (2.33)	3.29 (10.33)	2.48 (6.33)
Pendimethalin + imazethapyr (RM) 1000 g/ha PE	0.88 (0.33)	1.27 (1.33)	1.07 (0.83)	0.71 (0)	1.58 (2.00)	1.14 (1.00)	1.46 (1.67)	4.10 (16.33)	2.78 (9.00)	1.17 (1.00)	3.81 (14.00)	2.49 (7.50)
Imazethapyr + imazamox (RM) 80 g/haPoE	0.71 (0)	1.05 (0.67)	0.88 (0.33)	0.71 (0)	1.34 (1.33)	1.03 (0.67)	1.05 (0.67)	3.29 (10.33)	2.17 (5.50)	0.71 (0)	2.91 (8.00)	1.81 (4.00)
2 HW at 20 and 40 DAS	0.71 (0)	1.05 (0.67)	0.88 (0.33)	0.71 (0)	1.05 (0.67)	0.88 (0.33)	0.71 (0)	1.34 (1.33)	1.03 (0.67)	0.71 (0)	1.34 (1.33)	1.03 (0.67)
Weedy check	2.27 (4.67)	3.03 (8.67)	2.65 (6.67)	1.68 (2.33)	3.24 (10.0)	2.46 (6.17)	3.19 (9.67)	5.90 (34.33)	4.54 (22.00)	3.48 (11.67)	9.40 (88.00)	6.44 (49.83)
LSD (p=0.05)	0.347	0.622	0.712	0.275	0.447	0.525	0.391	0.386	0.549	0.387	0.765	0.858

Original data were subjected to square root $\sqrt{x+0.5}$ transformation and presented in parentheses

Table 3. Dry weight of weeds and weed control efficiency as influenced by weed management practices at 40 DAS

Treatment	Dry weight of weeds (g/m^2)			WCE (%)
	2016	2017	Pooled	
Quizalofop-p-ethyl 50 g/haPoE	70.33	63.73	67.03	52.89
Quizalofop-p-ethyl 75 g/haPoE	67.33	81.07	74.20	47.86
Quizalofop-p-ethyl 100 g/haPoE	47.33	101.47	74.40	47.72
Fenoxaprop-p-ethyl 100 g/haPoE	59.33	119.60	89.47	37.13
Pendimethalin 1000 g/ha PE	59.33	58.13	58.73	58.73
Pendimethalin + imazethapyr (RM) 750 g/haPE	47.33	17.33	32.33	77.28
Pendimethalin + imazethapyr (RM) 1000 g/ha PE	46.33	23.00	34.67	75.64
Imazethapyr + imazamox (RM) 80 g/haPoE	27.67	9.73	18.70	86.86
2 HW at 20 and 40 DAS	12.67	2.67	7.67	94.61
Weedy check	97.00	187.60	142.30	-
LSD (p=0.05)	6.684	9.578	11.680	-

Table 4. Biological yield, grain yield, herbicide efficiency index (HEI) and weed persistence index (WPI) of greengram as influenced by weed management practices

Treatment	Biological yield (t/ha)			Grain yield (t/ha)			Herbicide efficiency index			Weed persistence index		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Quizalofop-p-ethyl 50 g/ha PoE	1.75	1.21	5.24	0.57	0.44	0.50	0.53	0.22	0.33	0.76	0.40	0.52
Quizalofop-p-ethyl 75 g/ha PoE	1.89	1.36	5.69	0.68	0.49	0.59	0.95	0.28	0.50	0.75	0.49	0.58
Quizalofop-p-ethyl 100 g/ha PoE	1.70	1.27	5.10	0.54	0.46	0.50	0.63	0.17	0.29	0.56	0.59	0.59
Fenoxaprop-p-ethyl 100 g/ha PoE	1.91	1.35	5.74	0.64	0.49	0.56	0.92	0.18	0.37	0.73	0.66	0.69
Pendimethalin 1000 g/ha PE	1.99	1.84	5.98	0.70	0.67	0.69	1.19	0.84	0.95	0.71	0.41	0.51
Pendimethalin + imazethapyr (RM) 750 g/ha PE	2.41	2.38	7.24	0.82	0.86	0.84	2.13	4.54	2.62	0.60	0.14	0.31
Pendimethalin + imazethapyr (RM) 1000 g/ha PE	2.18	2.12	6.55	0.75	0.77	0.76	1.76	2.79	1.99	0.62	0.17	0.32
Imazethapyr + imazamox (RM) 80 g/ha PoE	2.81	2.79	8.44	0.97	1.01	0.99	4.96	10.41	5.98	0.40	0.09	0.20
2 HW at 20 and 40 DAS	2.64	2.94	7.94	0.90	1.07	0.98	9.39	41.15	14.36	0.20	0.07	0.13
Weedy check	1.16	0.90	3.47	0.42	0.35	0.38	-	-	-	-	-	-
LSD (p=0.05)	0.65	0.71	0.97	0.17	0.19	0.25	-	-	-	-	-	-

Table 5. Economics of green-gram as influenced by weed management practices

Treatment	Total cost of cultivation (x10^3 `/ha)			Gross returns (x10^3 `/ha			Net returns (x10^3 `/ha)			B:C Ratio		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Quizalofop-p-ethyl 50 g/haPoE	19.77	23.60	21.68	36.50	29.48	32.99	16.73	5.88	11.30	1.85	1.25	1.52
Quizalofop-p-ethyl 75 g/haPoE	20.57	24.68	22.62	43.00	33.07	38.04	22.43	8.39	15.41	2.09	1.34	1.68
Quizalofop-p-ethyl 100 g/haPoE	21.37	25.64	23.50	34.55	30.84	32.69	13.18	5.20	9.19	1.62	1.20	1.39
Fenoxaprop-p-ethyl 100 g/haPoE	19.67	23.60	21.63	40.78	32.76	36.77	21.11	9.16	15.13	2.07	1.39	1.70
Pendimethalin 1000 g/ha PE	18.93	22.70	20.81	44.82	44.58	44.70	25.89	21.88	23.88	2.37	1.96	2.15
Pendimethalin + imazethapyr (RM) 750 g/ha PE	18.78	22.50	20.64	52.62	57.68	55.15	33.84	35.18	34.51	2.80	2.56	2.67
Pendimethalin + imazethapyr (RM) 1000 g/ha PE	18.98	22.77	20.87	47.69	51.62	49.65	28.71	28.85	28.78	2.51	2.27	2.38
Imazethapyr + imazamox (RM) 80 g/ha PoE	19.52	23.30	21.41	62.01	67.61	64.81	42.49	44.31	43.40	3.18	2.90	3.03
2 HW at 20 and 40 DAS	22.06	28.78	25.42	57.37	71.28	64.33	35.31	42.50	38.91	2.60	2.48	2.53
Weedy check	18.17	21.80	19.99	26.50	23.31	24.90	8.33	1.50	4.92	1.46	1.07	1.25

application of post-emergence herbicide imazethapyr + imazamox 80 g/ha was recorded the lowest WPI (0.20%) *fb* pendimethalin + imazethapyr applied 750 g/ha and it was at par with its higher dose of 1000 g/ha. Among all treatments, the highest WPI was recorded with fenoxaprop-p-ethyl 100 g/ha PoE *fb* post-emergence application of quizalofop-p-ethyl 100 g/ha, which was at par with its lower dose of 75 g/ha. Regarding HEI, application of post- emergence herbicide of imazethapyr + imazamox 80 g/ha produced higher HEI (5.98%) than all other herbicidal treatments *fb* pendimethalin + imazethapyr applied 750 g/ha. However, twice hand weeding (20 and 40 DAS) proved to be superior to all the herbicidal treatments.

On the basis of pooled data, it was concluded that post-emergence application of imazethapyr + imazamox (RM) 80 g/ha produced maximum seed yield (993 kg/ha) *fb* two hand weeding at 20 and 40 DAS (983 kg/ha) and pre-emergence application of pendimethalin + imazethapyr 750 g/ha (844 kg/ha).

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