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Nodulation, weed flora and yield of greengram (*Vigna radiata*) influenced by use of herbicides

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ABSTRACT

A field experiment was conducted during *kharif* 2016 and 2017 at Research Farm, College of Agriculture, RVSKVV, Gwalior (MP) to determine the most effective herbicide/combination of herbicides to control the problematic weeds in greengram. The experiment was laid out with 10 treatments, *viz* quizalofop-p-ethyl 50, 75 & 100 g/ha PoE, fenoxaprop-p-ethyl 100 g/ha PoE, pendimethalin 1000 g/ha (PE), pendimethalin + imazethapyr (RM) 750 & 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 post-emergence herbicide imazethapyr + imazamox (RM) 80 g/ha was found to be very efficient in controlling the dominant grassy weeds as well as broad leaved weeds and gave maximum seed yield (993 kg/ha) followed by the cultural method of weed control where two hand weedings at 20 and 40 DAS have done (983 kg/ha). In respect of nodulation two hand weeding 20 and 40 DAS recorded maximum nodule number of 15.52/plant at 40 DAS followed by the application of imazethapyr + imazamox (RM) 80 g/ha PoE 14.45/plant. The application of imazethapyr + imazamox (RM) 80 g/ha PoE resulted in highest B:C ratio (3.03) and net returns followed by pendimethalin + imazethapyr 750 g/ha PE.

Key words: Greengram, Herbicides, Nodulation, Seed yield, Weed management

Greengram (*Vigna radiata* L.) is one of the most important and extensively cultivated pulse crop of arid and semi arid region of India. It is nutritionally important for our daily diet and contains about 25% protein, 1.3% fat, 3.5% mineral, 4.1 % fibre and 56.7 % carbohydrate. Green-gram occupies 40.70 lakh ha area in the country with a production of 19.01 lakh tonnes and productivity 467 kg/ha while, in Madhya Pradesh, it is grown in 2.97 lakh ha area with the production of 2.20 lakh tonnes and productivity 741 kg/ha (Anonymous 2018-19).

Greengram is not very competitive against weeds and, therefore, weed control is essential to ensure proper crop growth. Depending on weed type and crop weed competition it reduces crop yield up to 96.5 % (Verma *et al*. 2015). The low production of this crop is mainly due to crop-weed competition during the critical stages of crop growth, so weed is one of the most important factors responsible for low yield of greengram. The decrease in greengram productivity due to weed competition is 45.6% (Pandey and Mishra 2003). Whereas, the loss in yield of greengram due to weeds ranges from 65.4 to 79.0 % (Dungarwal *et al*, 2003).Weeds spread easily and their life cycle coincides with that of crop they invade, thus ensuring mixing of their seed with those of the crops (Mahroof *et al*. 2009). Growth stages of greengram such as emergence, flowering and pod setting are greatly hampered by weed. Moreover, besides low yield of crop, weeds increase production cost and decreasing quality of farm produce (Subramainian *et al*. 1993).In view of severe infestation of annual and perennial weeds in greengram, the available pre- and post-emergence herbicides, pendimethalin, oxyfluorfen, fenaxaprop-p-ethyl and quizalofop-ethyl are able to check the emergence and growth of weeds. Therefore, timely control of weeds is essential for getting high yield.

Therefore, keeping the above aspects in view and the known possible reasons, the present study was taken up to determine the herbicidal effects on weed flora, formation of nodules, yield and benefit cost ratio of greengram crop.

MATERIALS AND METHODS

A field experiment was conducted during *kharif* 2016 and 2017 at Research Farm, College of Agriculture, Gwalior which was geographically located at gird zone in the central part of MP at 23^0 10' N latitude, 79^0 54' E longitude and at an altitude of 411.98 m above mean sea level. The total rainfall during the season was 590 mm with 11 rainy days in 2016 and 580 mm with 16 rainy days in 2017. The soil was sandy clay loam in texture, low in available nitrogen (195 kg/ha), medium in phosphorus (13 kg/ha) and potash (204 kg/ha) with pH 7.7 and EC 0.41 dS/m. The 10 treatments replicated thrice in a completely RBD with quizalofop-

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p-ethyl 50, 75 & 100 g/ha PoE, fenoxaprop-p-ethyl 100 g/ha PoE, pendimethalin 1000 g/ha PE, pendimethalin + imazethapyr (RM) 750 & 1000 g/ha PE, imazethapyr + imazamox (RM) 80 g/ha PoE, two hand weedings at 20 and 40 DAS and weedy check. The greengram variety TJM-3 was sown on 19 and 16 July and got harvested on 3 and 5 October, in 2016 and 2017, respectively with the seed rate of 18 kg/ha maintaining row to row spacing of 40 cm. The recommended dose of fertilizer 20: 50: 20 NPK kg/ha was applied during both the years.

Pre-emergence herbicides pendimethalin and pendimethalin + imazethapyr were applied on the next day of sowing and post- emergence herbicides quizalofop-p-ethyl, fenoxaprop-p-ethyl and imazethapyr + imazamox were applied at 25 DAS (3-4 leaves stage) as per the treatments with knapsack sprayer. The data on total weed density was recorded at 40 DAS by using quadrate of 0.25m^2 at two random selected spots in each plot subjected to square root transformation to normalize their distribution (Gomez *et al.* 1984) and then the samples were kept in oven at 70^{0}C till constant weight for taking dry weight of weeds in g/m^2. Weed control efficiency was computed on the basis of dry weight of weeds. Number of root nodules at 40 DAS was recorded from five plants selected at random from outside the net plot area of each plot. The selected plants were carefully pull out and removed from the soil under running water without any loss of roots and nodules were counted and then fresh weight of nodules were taken. Dry weight of nodules was also recorded after drying for one day in oven at 40^{0}C.Yield and economics of greengram was recorded at crop harvest.

RESULTS AND DISCUSSION

Weed flora

The major weed flora in the experimental plots were *Cyperus rotundus*, *Echinochloa crus-galli, Setaria glauca, Acrachne racemes, Cynodon dactylon, Erragrostis* spp., *Celosia argentia, Phyllanthus niruri, Commelina benghalensis* and *Digera arvensis*.

Effect on weeds

The population of weed flora observed in the experimental field was *Cyperus rotundus* (55.45%), *Echinochloa crusgalli* (5.45%), *Setaria glauca* (1.97%), *Acrachne racemes* (12.78%), *Cynodon dactylon* (0.80%), and *Erragrostis* spp. (0.62%) recorded as grasses and *Celosia argentia* (1.79%), *Phyllanthus niruri* (1.65%), *Commelina benghalensis* (5.9%) and *Digera arvensis* (13.58%), were observed as major broad-leaved weeds (BLW's). Among all the weeds *Cyperus rotundus* was the most problematic weed accounted 55.45% population of total weeds during both the years. Similar result was found (Sasode *et al.* 2020) and Rajib *et al*. (2014). At 40 DAS, weedy check recorded

Table 1 Effect of different weed management practices on weed density/m^2, wed control efficiency and nodulation of plant at 40 DAS

Treatment	Weed density (no./m^2)*				Nodulation study/plant			WCE (%)
	NLW	BLW	Sedges	Total	No. of nodules	Fresh wt. (mg)	Dry wt. (mg)	
Quizalofop-p-ethyl 50 g/haPoE	3.13 (9.67)	6.55 (45.50)	10.79 (116.00)	13.07 (171.17)	10.56	51.44	21.87	52.89
Quizalofop-p-ethyl 75 g/haPoE	3.80 (17.50)	6.82 (51.67)	10.61 (115.17)	13.37 (184.33)	11.30	52.78	22.63	47.86
Quizalofop-p-ethyl 100 g/haPoE	4.39 (24.00)	6.98 (58.33)	10.01 (118.50)	13.45 (200.83)	10.65	50.56	21.30	47.72
Fenoxaprop-p-ethyl 100 g/haPoE	5.61 (39.00)	6.98 (61.17)	10.96 (131.00)	14.29 (231.17)	10.88	50.56	22.37	37.13
Pendimethalin 1000 g/ha PE	2.59 (6.33)	4.75 (25.33)	9.06 (83.00)	10.68 (114.67)	11.09	51.23	22.23	58.73
Pendimethalin + imazethapyr (RM) 750 g/haPE	1.28 (1.50)	3.73 (15.00)	7.63 (61.00)	8.75 (77.50)	11.78	51.85	23.90	77.28
Pendimethalin + imazethapyr (RM) 1000 g/ha PE	1.18 (1.17)	3.86 (18.33)	8.00 (65.17)	9.07 (84.67)	11.59	52.60	24.30	75.64
Imazethapyr + imazamox (RM) 80 g/haPoE	0.97 (0.50)	2.81 (10.50)	5.56 (31.33)	6.52 (42.33)	14.45	58.23	25.37	86.86
2 HW at 20 and 40 DAS	0.71 (0.00)	1.40 (2.00)	3.16 (15.67)	3.85 (17.67)	15.52	60.76	27.13	94.61
Weedy check	6.62 (54.67)	8.63 (84.67)	14.22 (206.17)	18.08 (345.50)	9.45	48.89	20.30	-
SEm (±)	0.281	0.253	1.662	1.235	0.798	3.301	1.154	-
LSD (P=0.05)	0.824	0.741	4.865	3.614	2.337	9.662	3.379	-

*Square root transformed value; actual values are given in parentheses

the highest weed density of *Cyperus rotundus* and *Digera arvensis,* whereas two hand weedings reduced the population of weeds followed by the application of post-emergence herbicide imazethapyr + imazamox (RM) 80 g/ha.

The density of broad and grassy weeds at 40 DAS was significantly reduced by all weed control treatments compared to weedy check (Table 1). However two hand weeding resulted minimum density and biomass of weeds compared to rest of the weed control treatments. Among all the herbicides post-emergence application of imazethapyr + imazamox (RM) 80 g/ha proved best and most effective in reducing the density of both broad and grassy weeds and biomass of weeds followed by the pre-emergence application of pendimethalin + imazethapyr (RM) 1000 g/ha and its lower dose 750 g/ha. Whereas the maximum weed density and their biomass was observed with post-emergence application of fenoxaprop-p-ethyl 100 g/ha which proved very poor to control the weeds.

Imazethapyr + imazamox has been controlled the grassy weeds in greengram (Singh *et al.* 2015) and (Gupta *et al.* 2017). This is a selective herbicide and is used as a post-emergence to control the late emerging weeds.

Effect on crop

Under all the weed management practices, two hand weeding had efficiently controlled weeds which directly led to better values of growth and yield parameters as is evident from a significant increase in plant height, number of branches/plant, number of pods/plant, number of seeds/pod, test weight (g) and was followed by the combine application of post-emergence herbicide imazethapyr + imazamox (RM) 80g/ha (Table 2).

Application of two hand weedings at 20 and 40 DAS resulted in the significantly highest values of growth parameters compared among all weed management practices and it was at par with the post-emergence application of imazethapyr + imazamox 80 g/ha. The lowest values of growth and yield attributes of greengram were recorded with weedy check. Grain and stover yield of greengram was significantly influenced due to different weed management practices tried in this experiment. Post-emergence application of imazethapyr + imazamox 80g/ha established its superiority by recording significantly higher grain and stover yield **(**Table 2**)** and noted the increment by 159 and 167% of seed and stover yield as compared to weedy check and 1 and 0.6% higher seed and stover yield compared to two hand weeding at 20 and 40 DAS respectively. This increase in yield might be due to effective control of weeds at ground growth stage, which smothered weed growth and gave higher yield attributes of greengram and ultimately

Table 2 Effect of different weed management practices on growth parameters, yield attributes, yield, economics, weed persistence and herbicide efficiency indices of greengram at harvest stage (pooled 2016 and 2017)

Treatment	Growth parameters and yield attributes at harvest stage					Yield and economics of crop				Weed persistence and herbicide efficiency indices	
	Plant height (cm)	No. of branches/ plant	No. of pods/ plant	No. of seeds/ pod	Test weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)	Net returns (₹/ha)	B:C ratio	WPI	HEI
Quizalofop-p-ethyl 50 g/ haPoE	57.77	4.02	27.14	11.99	30.75	505	975	11304	1.52	0.65	0.33
Quizalofop-p-ethyl 75 g/ haPoE	59.29	4.35	28.23	12.21	31.32	586	1045	15412	1.68	0.71	0.50
Quizalofop-p-ethyl 100 g/ haPoE	58.13	4.22	25.32	11.77	30.18	500	986	9190	1.39	0.70	0.29
Fenoxaprop-p-ethyl 100 g/ haPoE	58.45	4.28	26.31	11.66	29.91	564	1068	15135	1.70	0.80	0.37
Pendimethalin 1000 g/ ha PE	59.01	4.42	28.48	11.99	30.75	686	1229	23886	2.15	0.70	0.95
Pendimethalin + imazethapyr (RM) 750 g/haPE	60.07	4.95	29.83	12.43	31.89	844	1551	34513	2.67	0.47	2.62
Pendimethalin + imazethapyr (RM) 1000 g/ha PE	59.44	4.68	29.13	12.10	31.04	758	1394	28780	2.38	0.49	1.99
Imazethapyr + imazamox (RM) 80 g/ha PoE	62.48	5.08	31.50	12.88	33.04	993	1819	43401	3.03	0.36	5.98
2 HW at 20 and 40 DAS	63.64	5.95	32.31	12.66	32.46	983	1808	38907	2.53	-	-
Weedy check	52.85	3.95	23.19	10.82	14.88	383	676	4917	1.25	-	-
SEm (±)	1.960	0.496	2.109	0.489	1.251	86.9	288.9	-	-	-	-
LSD (P=0.05)	5.736	1.453	6.174	1.430	3.661	254.5	845.6	-	-	-	-

resulted to higher yields. This data was in conformity with the findings of Gupta *et al*. (2019) and Shivran *et al*. (2017).

Effect on nodulation

The data pertaining in the Table-1 clearly indicated the effect of different herbicides on the nodulation efficiency of the crop. Maximum nodules/plant was recorded through the application of two HW at 20 and 40 DAS (15.52) which was at par with the combination of imazethapyr + imazamox (RM) 80g/ha PoE (14.45). However, application of the combination of herbicides pendimethalin + imazethapyr (RM) 1000g/ha PE (11.59) and 750g/ha PE (11.78) and alone application of pendimethalin 1000g/ha PE (11.09) and quizalofop-p-ethyl 75g/ha PoE (11.30) were produced statistically at par nodules/plant but they were significantly lower than the combination of post-emergence application imazethapyr + imazamox (RM) 80g/ha PoE. The minimum nodules/plant (9.45) was recorded under weedy check. Similarly the fresh and dry weight of nodules was also affected significantly by the application of different herbicides in greengram crop. The maximum fresh weight and dry weight of nodules mg/plant was recorded under two hand weeding at 20 and 40 DAS which was at par with the application of imazethapyr + imazamox (RM) 80g/ha PoE.

Weed persistence index (WPI) and herbicide efficiency index (HEI)

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

Economics

Among different weed management practices post-emergence application of imazethapyr + imazamox 80g/ha PoE increased the gross returns by 160% and B C ratio by 142%, compared to weedy check and it was at par with two hand weeding at 20 and 40 DAS. The net monetary returns (₹ 4917/ha) and benefit cost ratio (1.25) were lowest in weedy check plots.

Based on two years experimentation it was concluded that the population of narrow and broad leaved weeds continues to be less under two hand weeding application during both the years. The post-emergence application of imazethapyr + imazamox (RM) 80g/ha resulted in provided the maximum grain yield, gross and net returns among different weed management practices. Therefore, the post-emergence application of imazethapyr + imazamox (RM) 80g/ha was proved to be economically best weed management treatment to decrease narrow and broad leaved weeds and higher productivity and profitability of greengram.

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