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Weed management in blackgram [*Vigna mungo* (L.) Hepper] through sole and combined application of pre- and post-emergence herbicides

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ABSTRACT

Field experiments were conducted at the research farm of the Punjab Agricultural University, Ludhiana, Punjab, India during kharif 2011 and 2012 to study the effect of herbicides on weeds, growth, symbiotic traits and grain yield of blackgram (cv. Mash 338). The experiment was laid out in a randomized complete block design with three replications having fourteen treatments comprising of weedy check, different doses of pre-emergence and post-emergence herbicides, two hand weedings and weed free. Pre-emergence application of pendimethalin 30 EC + imazethapyr 2 EC (pre-mix) @ 0.75 kg ha^{-1} and 1.0 kg ha^{-1} significantly reduced the dry weight of weeds (84.9 and 85.3%, respectively) at harvest than weedy check and also provided highest weed control efficiency. However, application of post-emergence herbicides quizalofop ethyl 5 EC @ 37.5 kg ha^{-1} and fenoxaprop ethyl 10 EC @ 50 g ha^{-1} did not control the weeds effectively. Number and dry weight of nodules plant^{-1} were recorded lowest in post-emergence application of quizalofop ethyl 5 EC @ 37.5 g ha^{-1}. Amongst herbicide treatments, pre-emergence application of pendimethalin 30 EC + imazethapyr 2 EC (pre-mix) @ 1.0 and 0.75 kg ha^{-1} recorded the highest grain yield, gross returns, net returns and B:C ratio.

***Keywords* :** Blackgram, imazethapyr, nodulation, pendimethalin, weed control efficiency, yield

Weeds pose a major threat to the productivity of blackgram during *kharif* season. Weeds compete for nutrients, water, light and space with crop especially during early growth period. The crop is not a very good competitor against weeds (Choudhary *et al*., 2012) and therefore, weed control is essential to ensure proper crop growth, particularly in the early growth period. There is good negative correlation between dry matter of weeds and grain yield of the crop (Singh, 2007). Depending on the nature, density and period of occurrence, weeds can cause losses of grain yield of blackgram varying from 41.6 to 64.1per cent (Chand *et al*., 2004; Singh, 2011). Uncontrolled weeds not only reduce the grain yield of blackgram from 29 to 62 per cent (Aggarwal*et al*., 2014) but also remove a lot of nutrients from the soil (Kaur *et al*., 2010).

Since hand weeding and other weed control methods are laborious, time consuming, costly and difficult, use of herbicides is the cost effective method of weed control. For this many pre-emergence herbicides are being used by the farmers but very few post-emergence herbicides are available. Application of imazethapyr as post-emergence herbicide in blackgram (Aggarwal *et al*., 2014), mungbean (Singh *et al*., 2014a), soybean (Ram *et al*., 2013) and lentil (Singh *et al*., 2014b) showed promising results. Therefore, an experiment was conducted to study the effect of different herbicides on weeds, growth, symbiotic traits and grain yield of blackgram.

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MATERIALS AND METHODS

A field experiment was conducted during *kharif* 2011 and 2012 at the research farm of the Punjab Agricultural University, Ludhiana (30° 54' N, 75° 48' E, altitude 247m), Punjab. The soil of the experimental site was loamy sand, having pH 7.8, low in organic carbon (0.29%), medium in available P (11.5 kg ha^{-1})and available K (196 kg ha^{-1}). A total of 804.7 mm (34 rainy days) and 382.5 mm (26 rainy days) rainfall was received during the crop growing season in 2011 and 2012, respectively. Fourteen treatments, as listed in table 1, were arranged in a randomized complete block design with three replications. Quizalofop ethyl 5 EC, fenoxaprop ethyl 10 EC and imazethapyr 10 SL were sprayed at 23 and 25 days after sowing (DAS) during 2011 and 2012, respectively and pendimethalin 30 EC &pendimethalin 30 EC + imazethapyr 2 EC (pre-mix) as pre-emergence (within 24 hour of sowing) using 375 litres of water per hectare with a knapsack sprayer fitted with a flat fan nozzle. In the case of two hand weedings, weeds were removed manually with a *khurpa* at 20 and 40 DAS. In case of weedy check plots, weeds were allowed and in weed free plots, weeds were removed with a hand tool *khurpa* during the whole crop growing season.

After pre-sowing irrigation, at optimum soil moisture, the field was ploughed twice followed by planking. The sowing of blackgram variety 'Mash 338' was done in rows 30 cm apart using a seed rate of 20 kg ha^{-1} on 19 July, 2011 and 11 July, 2012. Each plot measured

6.0 m × 2.70 m in 2011 and 5.50 × 2.10 m in 2012. The crop was harvested on 12 October, 2011 and 3 October, 2012.

Data on weed species count were recorded at 38 DAS from a randomly selected area measuring 50 × 50 cm from each plot and then converted to weed species count per m^2 area. At harvest, all weed species were dried together plot-wise and the data converted to dry matter of weeds in kg ha^{-1}. Weed control efficiency (WCE) and weed index (WI), at harvest, were calculated as per the following formula (Prachand *et al.*, 2014):

$$\text{WCE (\%)} = \frac{X-Y}{X} \times 100$$

Where,

X= Dry weight of weeds (kg ha^{-1}) in weedy check

Y= Dry weight of weeds (kg ha^{-1}) in the treated plot

$$\text{WI (\%)} = \frac{X-Y}{X} \times 100$$

Where,

X = Grain yield (kg ha^{-1}) in treatment which has highest yield

Y = Grain yield (kg ha^{-1}) in treatment for which weed index is to be calculated

Data on number and dry weight of nodules were recorded at 40 DAS. Five plants per plot were randomly selected for number and dry weight of nodules, and then average worked out. Observations on phytotoxic effects of herbicides were observed visually periodically after their application. At maturity, data on plant height, branches $plant^{-1}$ and pods $plant^{-1}$ were recorded from randomly selected five plants from each plot, and seeds pod^{-1} from randomly selected 20 pods. Biological yield and grain yield were recorded on the basis of whole plot area and converted into kg ha^{-1}. From the produce of each plot 100 seeds were taken for 100-seed weight data. Harvest index (HI) was also calculated. Gross returns, net returns as well as benefit:cost (B:C) ratio were also worked out using prevailing prices of inputs and output.

Statistical assessment of this experiment was performed by the analysis of variance (ANOVA) for randomised block design (RBD) based on the guidelines given by Gomez and Gomez (1984). The standard error of mean (SEm ±) and the value of CD were indicated in the tables to compare the difference between the mean values.

RESULTS AND DISCUSSION

Effect on weeds

The major weed flora in experimental field was *Cyperusrotundus* (Nut grass), *Eleucineaegyptiacum* (Crow foot grass) and *Commelinabenghalensis*(Day flower). Weedy check recorded the highest population of different weed species (Table 1). Among the herbicide treatments, quizalofop ethyl @ 37.5 g ha^{-1} and fenoxaprop ethyl @ 50 g ha^{-1} recorded high population of *Cyperusrotundus*. However, application of pendimethalin + imazethapyr (pre-mix) @ 0.75 and 1.0 kg ha^{-1} effectively controlled the weeds at 38 DAS. Pre-emergence application of pendimethalin + imazethapyr (pre-mix) @ 1.0 kg ha^{-1} recorded the lowest dry weight of weeds (Table 1). Pre-emergence application of pendimethalin + imazethapyr (pre-mix) @ 0.75 and 1.0 kg ha^{-1} caused significant reduction in dry weight of weeds (84.9 and 85.3%, respectively) at harvest than weedy check. However, application of post-emergence herbicides quizalofop ethyl @ 37.5 g ha^{-1} and fenoxaprop ethyl @ 50 g ha^{-1} did not control the weeds effectively. However, among the post-emergence herbicides, imazethapyr at all the doses significantly reduced the dry weight of weeds at harvest than quizalofop ethyl and fenoxaprop ethyl. Similarly, significant reduction in total weed density and biomass were observed in two hand weedings (20 and 40 DAS) and imazethaypr 40 and 25 g ha^{-1} at 20 DAS than weedy check (Gupta *et al.*, 2014). Pre-emergence application of pendimethalin + imazethapyr (pre-mix) @ 0.75 kg ha^{-1} and 1.0 kg ha^{-1} recorded the highest weed control efficiency (Table 1) followed by two hand weedings, pendimethalin @ 0.45 kg ha^{-1} + HW 25-30 DAS and pendimethalin @0.75 kg ha^{-1}. This could be due to effective weed control with the application of pendimethalin + imazethapyr (pre-mix) @ 0.75 kg ha^{-1} and 1.0 kg ha^{-1}. Rao *et al.* (2010) also reported that application of pre-mix of pendimethalin + imazethapyr effectively controlled the weeds. Singh *et al.* (2016b) reported maximum WCE of pre-mix of imazethapyr + pendimethalin at 1000 g ha^{-1} over alone application of herbicides applied as pre- or post-emergence. Post-emergence application of quizalofop ethyl @ 37.5 g ha^{-1} and fenoxaprop ethyl @ 50 g ha^{-1} recorded low weed control efficiency, as these treatments did not control weeds effectively (Table 1). Two hand weedings recorded the lowest weed index followed by pre-emergence application of pendimethalin + imazethapyr (pre-mix) @ 1.0 kg ha^{-1}, pendimethalin 0.45 kg ha^{-1} + HW 25-30 DAS and pendimethalin + imazethapyr @ 0.75 kg ha^{-1}, due to effective weed control.

Effect on symbiotic traits

Weedy check recorded the lowest number and dry weight of nodules (Table 2). Among different post-emergence herbicides, quizalofop ethyl, fenoxaprop ethyl and lowest dose of imazethapyr recorded a slight reduction in number and dry weight of nodules. Ahemad and Khan (2010) also reported the negative effects of

Table 1: Population of different weed species, dry weight, weed control efficiency and weed index as influenced by different weed control treatments in blackgram (pooled)

Treatments	At 38 DAS Weed count (No. m^{-2})			At harvest		
	C. rotundus	***E. aegyptiacum***	***C. benghalensis***	**Dry weight of weeds (kg ha^{-1})**	**Weed control efficiency (%)**	**Weed index (%)**
Weedy check	7.6 (57.2)*	5.6 (32.0)	2.6 (6.6)	58.8 (3463)	0.0	55.5
Hand weeding (20 and 40 DAS)	3.3 (10.4)	1.8 (2.6)	1.2 (1.5)	11.4 (129)	96.6	6.2
Pendimethalin @ 0.45 kg ha^{-1}pre-emergence + HW 25-30 DAS	3.9 (14.0)	1.5 (1.3)	2.6 (6.7)	17.6 (313)	91.6	12.6
Pendimethalin @ 0.75 kg ha^{-1} pre-emergence	4.3 (18.0)	2.3 (4.7)	2.3 (5.3)	18.5 (341)	90.9	22.7
Pendimethalin @ 1.0 kg ha^{-1} pre-emergence	4.7 (22.6)	1.9 (3.2)	2.3 (5.3)	22.5 (539)	85.6	20.7
Quizalofop ethyl @ 37.5 g ha^{-1}	6.8 (46.0)	4.8 (22.6)	2.9 (8.7)	35.9 (1306)	65.0	41.7
Fenoxaprop ethyl @ 50 g ha^{-1}	6.2 (38.0)	3.9 (15.9)	2.6 (8.6)	40.6 (1661)	55.5	45.8
Pendimethalin + imazethapyr @ 0.75 kg ha^{-1}	1.9 (3.4)	1.7 (1.9)	1.3 (0.6)	8.9 (106)	97.2	14.8
Pendimethalin + imazethapyr @ 1.0 kg ha^{-1}	1.9 (3.4)	1.4 (1.1)	1.2 (0.5)	8.6 (96)	97.4	12.4
Imazethapyr@ 25 g ha^{-1}	3.8 (14.7)	4.6 (20.6)	2.8 (7.2)	27.4 (753)	79.8	41.5
Imazethapyr@ 40 g ha^{-1}	3.5 (11.2)	3.9 (14.6)	2.4 (5.9)	25.6 (655)	82.4	38.7
Imazethapyr@ 60 g ha^{-1}	2.3 (6.0)	3.9 (14.6)	2.7 (6.6)	23.1 (534)	85.7	43.8
Imazethapyr@ 75 g ha^{-1}	2.9 (8.0)	3.7 (14.6)	1.8 (2.6)	23.4 (553)	85.2	43.1
Weed free	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	100.0	0
SEm (±)	**0.79**	**0.63**	**0.42**	**2.3**	**3.1**	**9.5**
LSD (0.05)	**2.4**	**1.9**	**1.3**	**7.2**	**9.3**	**28.5**

*Note: *Values after square root transformation. Figures in parentheses are means of original values*

quizalofop-p-ethyl on the symbiosis in greengram plants and the effects enhanced gradually with the increase in dose of the herbicide. Pendimethalin and pendimethalin + imazethapyr (pre-mix) were safe from the view point of symbiotic parameters. Plant height was significantly influenced by different weed control treatments (Table 2). Weed free treatment recorded the highest plant height. Weedy check recorded the lowest plant height and it was significantly lower than weed free, pre-emergence application of pendimethalin at all doses, two hand weedings and application of pendimethalin + imazethapyr (pre-mix) @ 0.75 and 1.00 kg ha^{-1}. Branches $plant^{-1}$, pods $plant^{-1}$, seeds pod^{-1} and 100-seed weight were non-significantly affected by different treatments of weed control (Table 2). However, weed free recorded the highest number of pods $plant^{-1}$. The weedy check recorded the lowest number of pods $plant^{-1}$ due to competition between weeds and the crop plants for various inputs.

Table 2: Influence of different weed control treatments on the symbiotic traits, growth characters and yield attributes of black gram (pooled)

Treatments	No. of nodules plant^{-1}	Dry wt. of nodules plant^{-1} (mg)	Plant height (cm)	Branches Plant^{-1}	Pods plant^{-1}	Seeds pod^{-1}	100-seed weight (g)
Weedy check	11.6	19.5	63.8	6.4	28.7	4.4	2.88
Hand weeding (20 and 40 DAS)	18.2	27.1	70.5	6.9	45.7	4.8	3.01
Pendimethalin @ 0.45 kg ha^{-1} pre-emergence + HW 25-30 DAS	17.1	25.8	71.6	6.7	36.5	4.5	2.76
Pendimethalin @ 0.75 kg ha^{-1} pre-emergence	16.4	24.0	74.2	6.7	39.2	4.6	2.93
Pendimethalin @ 1.0 kg ha^{-1} pre-emergence	17.2	25.1	70.2	6.5	39.5	4.6	3.00
Quizalofop ethyl @ 37.5 g ha^{-1}	14.3	21.3	67.1	6.2	30.2	4.8	2.85
Fenoxaprop ethyl @ 50 g ha^{-1}	14.6	21.6	68.1	6.3	30.6	4.5	2.86
Pendimethalin + imazethapyr @ 0.75 kg ha^{-1}	18.0	25.5	70.0	6.9	45.2	4.4	2.85
Pendimethalin + imazethapyr @ 1.0 kg ha^{-1}	17.0	25.7	69.2	7.0	46.9	4.6	3.04
Imazethapyr @ 25 g ha^{-1}	13.0	20.8	65.8	6.6	39.0	4.7	2.93
Imazethapyr @ 40 g ha^{-1}	15.6	21.9	68.4	6.4	39.4	4.6	2.91
Imazethapyr @ 60 g ha^{-1}	15.5	22.5	67.9	6.1	39.2	4.6	2.88
Imazethapyr @ 75 g ha^{-1}	16.5	22.0	67.8	6.2	38.4	4.7	2.80
Weed free	20.3	30.1	73.1	7.1	48.0	4.9	3.05
SEm (±)	**0.92**	**1.16**	**1.65**	**0.22**	**3.95**	**0.16**	**0.08**
LSD (0.05)	**2.8**	**3.5**	**5.0**	**NS**	**NS**	**NS**	**NS**

Table 3: Influence of different weed control treatments on biological yield, grain yield, harvest index and economics of black gram (pooled)

Treatments	Biological yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Harvest index (%)	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio
Weedy check	3711	683	18.3	34150	18470	1.18
Hand weeding (20 and 40 DAS)	5628	1406	25.4	70300	50620	2.57
Pendimethalin @ 0.45 kg ha^{-1}pre-emergence + HW 25-30 DAS	5662	1301	23.1	65050	44807	2.21
Pendimethalin @ 0.75 kg ha^{-1} pre-emergence	5236	1133	21.9	56650	38119	2.06
Pendimethalin @ 1.0 kg ha^{-1} pre-emergence	5192	1171	22.9	58575	39669	2.09
Quizalofop ethyl @ 37.5 g ha^{-1}	5073	877	17.5	43850	25280	1.36
Fenoxaprop ethyl @ 50 g ha^{-1}	5218	801	15.4	40050	21194	1.12
Pendimethalin + imazethapyr @ 0.75 kg ha^{-1}	5822	1280	22.0	64025	44400	2.26
Pendimethalin + imazethapyr @ 1.0 kg ha^{-1}	5242	1318	26.1	65900	45494	2.23
Imazethapyr @ 25 g ha^{-1}	4824	923	20.0	46125	28219	1.57
Imazethapyr @ 40 g ha^{-1}	5070	950	19.1	47500	29219	1.60
Imazethapyr @ 60 g ha^{-1}	5039	872	17.7	43575	24794	1.32
Imazethapyr @ 75 g ha^{-1}	5054	863	17.3	43150	23994	1.25
Weed free	5753	1509	27.1	75425	51745	2.18
SEm (±)	**218**	**105**	**2.35**	**5272**	**5272**	**0.28**
LSD (0.05)	**668**	**322**	**NS**	**16111**	**16111**	**0.88**

Effect on crop growth and yield

The biological yield was recorded significantly lower in weedy check than all the other treatments (Table 3). Weed free recorded the highest grain yield followed by two hand weedings and pendimethalin + imazethapyr (pre-mix) @ 1.0 kg ha^{-1}. Post-emergence application of fenoxaprop ethyl @ 50 g ha^{-1} and quizalofop ethyl @ 37.5 g ha^{-1} recorded the lowest grain yield after weedy check, which might be due to high dry weight of weeds (Table 1).

Treatments of weed free, two hand weedings, pre-emergence application of pendimethalin + imazethapyr (pre-mix) @ 1.0 and 0.75 kg ha^{-1}, pendimethalin @ 0.45 kg ha^{-1} + HW 25-30 DAS and pendimethalin @ 0.75 and 1.00 kg ha^{-1} recorded significantly higher grain yield than the other treatments. The higher grain yield in these treatments might be owing to better weed control (Table 1) which ultimately increased the yield attributes (Table 2). Different treatments of weed control did not affect the harvest index significantly. Singh *et al.* (2016b) reported that the pre-emergence application of imazethapyr + pendimethalin (pre-mix) @ 1.0 kg ha^{-1} to be effective in improving grain yield of blackgram. Integrated use of pendimethalin @ 0.45 kg ha^{-1} and hand weeding provided higher grain yield than the sole application of pendimethalin even at higher rates (Table 3). Integrated use of pendimethalin and hand weeding is known to provide higher grain yield than herbicide alone (Singh *et al*., 2010; Singh and Sekhon, 2013; Singh *et al*., 2015; Singh *et al*., 2016a) as the weeds which are not controlled by the herbicide are effectively controlled by hand weeding.

Economics

Gross returns, net returns and B:C ratio were significantly influenced by different tretaments (Table 3). Weed free recorded the highest gross and net returns followed by two hand weedings. Treatments of weed free, two hand weedings, pre-emergence application of pendimethalin + imazethapyr (pre-mix) @ 1.0 and 0.75 kg ha^{-1} recorded significantly higher gross returns than the other treatments of weed control. Treatments of weed free, two hand weedings, pre-emergence application of pendimethalin + imazethapyr (pre-mix) @ 1.0 and 0.75 kg ha^{-1}, pendimethalin @ 0.45 kg ha^{-1} + HW 25-30 DAS and pendimethalin @ 0.75 and 1.00 kg ha^{-1} recorded significantly higher net returns than the other treatments of weed control. Two hand weedings recorded the highest B:C ratio (2.57). Among different herbicide treatments, pendimethalin + imazethapyr@ 0.75 and 1.00 kg ha^{-1} recorded significantly higher B:C ratio than other herbicides. Higher gross returns, net returns and B:C ratio in these treatments could be due to higher grain yield and low cost of cultivation.

It can be concluded that pre-emergence application of pendimethalin + imazethapyr (pre-mix) @ 1.0 and 0.75 kg ha^{-1} improves the grain yield of blackgram by effectively controlling the weeds and provides highest gross returns, net returns and B:C ratio.

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REFERENCES

Aggarwal, N., Singh, G., Ram, H. and Khanna, V. 2014.Effect of post-emergence application of imazethapyr on symbiotic activities, growth and yield of blackgram (*Vignamungo*) cultivars and its efficacy against weeds. *Indian J. Agron.*, **59**: 421-26.

Ahemad, M. and Khan, M. S. 2010. Phosphate-solubilizing and plant growth promoting *Pseudomonas aeruginosa* PS 1 improves greengram performance in quizalofop-p-ethyl and clodinafop amended soil. *Archives Environ. Contamin.Toxicol.*, **58**: 361-72.

Chand, R., Singh, N. P. and Singh, V. K. 2004. Effect of weed control treatments on weeds and grain yield of late planted urdbean during *kharif*season. *Indian J. Pulses Res.*, **16**: 163-64.

Choudhary, V. K., Kumar, S. P. and Bhagawati, R. 2012. Integrated weed management in blackgram (*Vigna mungo*) under mid hills of Arunachal Pradesh. *Indian J. Agron.*, **57**:382-85.

Gomez, K. A. and Gomez, A. A. 1984. *Statistical Procedures for Agricultural Research*. 2nd Edition, John Wiley & Sons. Inc., New York, pp. 704.

Gupta, V., Singh, M., Kumar, A., Sharma, B. C. and Kher, D. 2014.Effect of different weed management practices in urdbean [*Vigna mungo* (L.) Hepper] under sub-tropical rainfed conditions of Jammu, India. *Legume Res.*, **37**: 424-29.

Kaur, G., Brar, H. S. and Singh, G. 2010. Effect of weed management on weeds, nutrient uptake, nodulation, growth and yield of summer mungbean (*Vigna radiata*). *Indian J. Weed Sci.*, **42**: 114-19.

Prachand, S., Kubde, K. J. and Bankar, S. 2014. Effect of chemical weed control on weed parameters, growth, yield attributes, yield and economics in soybean (*Glycine max*).*American-Eurasian J. Agric. Env. Sci.*, **14**: 698-701.

Ram, H., Singh, G., Aggarwal, N., Buttar, G. S. and Singh, O. 2013.Standardization of rate and time of application of imazethapyr weedicide in soybean.*Indian J. Pl. Protect.*,**41**: 33-37.

Rao, A. S., Rao, G. S. and Ratnam, M. 2010. Bio-efficacy of sand mix application of pre-emergence herbicides alone and in sequence with imazethapyr on weed control in relay crop of blackgram. *Pakistan J. Weed Sci. Res.,* **16**:279-85.

Singh, G. 2007. Integrated weed management in soybean (*Glycine max*). *Indian J. Agric. Sci.*,**77**: 675-76.

Singh, G. 2011. Weed management in summer and *kharif* season blackgram [*Vigna mungo* (L.) Hepper]. *Indian J. Weed Sci.,* **43**: 77-80.

Singh, G. and Sekhon, H. S. 2013. Integrated weed management in pigeonpea [*Cajanus cajan* (L.) Millsp.].*World J. Agric. Sci.,* **9**: 86-91.

Singh, G., Aggarwal, N. and Ram, H. 2014a. Efficacy of post-emergence herbicide imazethapyr for weed management in different mungbean (*Vigna radiata*) cultivars. *Indian J. Agric. Sci*., **84**: 540-43.

Singh, G., Kaur, H. and Khanna, V. 2014b. Weed management in lentil with post-emergence herbicides. *Indian J. Weed Sci.,* **46**: 187-89.

Singh, G., Kaur, H. and Khanna, V. 2016a. Integration of pre- and post-emergence herbicides for weed management in pigeonpea. *Indian J. Weed Sci.,* **48**: 336-38.

Singh, G., Kaur, H., Aggarwal, N. and Sharma, P. 2015. Effect of herbicides on weeds growth and yield of greengram. *Indian J. Weed Sci.,* **47**: 38-42.

Singh, G., Ram, H., Sekhon, H. S., Aggarwal, N., Buttar, G. S., Singh, K., Kaur, H. and Khanna, V. 2010. Bio-efficacy of pendimethalin for the control of weeds in pigeonpea [*Cajanus cajan* (L.) Millsp.]. *J. Res. Punjab Agric. Univ.,* **47**: 121-26.

Singh, T. P., Singh, S. P., Kumar, A., Satyawali, K., Banga, A., Bisht, N. and Singh, R. P. 2016b. Weed management in blackgram with pre-mix herbicides. *Indian J. Weed Sci.,* **48**: 178-81.