International Archive of Applied Sciences and Technology
Int. Arch. App. Sci. Technol; Vol 11 [3] September 2020 : 120-131
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[ISO9001: 2008 Certified Organization]
www.soeagra.com/iaast.html

IAAST
ONLINE ISSN 2277- 1565
PRINT ISSN 0976 - 4828

CODEN: IAASCA ORIGINAL ARTICLE

DOI: .10.15515/iaast.0976-4828.11.3.120131

Efficacy of pre and post-emergence herbicides in black gram crop

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ABSTRACT

A field experiment was conducted at Birsa Agricultural University, Ranchi, Jharkhand during rainy & winter seasons of 2015-16 and 2016-17. The experiment was laid out in randomized block design with 12 treatments i.e. haloxyfop 81 g/ha, haloxyfop 108 g/ha, haloxyfop 135 g/ha, haloxyfop 270 g/ha, fenoxaprop-p-ethyl 61.9 g/ha, quizalofop-ethyl 43.8 g/ha, imazethapyr 100 g/ha each applied at 20 DAS, pendimethalin 1000 g/ha, oxyfluorfen 100 g/ha each applied at 3 DAS, two mechanical, two hand weeding each performed at 25 and 45 DAS and weedy check, replicated thrice. Black gram var. Birsa Urd-1 was sown at 30 cm using 30 kg seed/hafertilized with recommended level of nutrients N:P_2O_5:K_2O:Si.e. 25:50:25:25 kg/ha.Two hand weeding at 25 and 45 DAS followed by two mechanical weeding at 25 and 45 DAS recorded higher crop dry weight, LAI, CGR, RGR and NAR to the extent of 44.07, 22.70, 73.40, 48.31 and 38.36 per cent, respectively as compare to weedy check i.e. 212.17 g/m^2, 3.37, 0.83 g/m^2/day, 0.0046 g/g/day, 0.090 g/m^2/day, respectively.Among herbicides, application of haloxyfop 108 g/ha at 20 DAS recorded higher crop dry weight, LAI, CGR, RGR and NAR.

***Key word**: Blackgram, Dry weight, Growth, Weed control*

Received 06.06.2019 Revised 28.06.2019 Accepted 14.08.2019

CITATION OF THIS ARTICLE

S C Pankaj, R. R. Upasani, S Barla, P K Dewangan and V Kum.Efficacy of pre and post-emergence herbicides in black gram crop. Int. Arch. App. Sci. Technol; Vol 11 [3] September 2020: 120-131

INTRODUCTION

Pulses are a source of supplementary protein to daily diets based on cereals and starchy food for a predominantly vegetarian population and for those who cannot afford expensive animal protein. Pulses are therefore often regarded as poor man's meat. Pulses occupy a special place in human nutrition with protein (24%), carbohydrates (59.6%), fat (1.5%), minerals (3.2%) and it also contains 154 mg calcium, 9.1 mg iron and 38 mg beta-carotene per 100 g of black gram grain [7]. Globally pulse crops are grown in area of 76 m ha with a production of about 68 million tons. The average productivity at the global level is about 895 kg/ha. India is the largest producer, 25 per cent of world's production, and consumer of 27 per cent of total pulses of the world. The domestic production is often less than the estimated demand i.e. 2324 million tons. In India, the total pulse area is about 23.10 m ha with production of about 17.19 million tons and average productivity of 744 kg/ha [1].

Black gram (*Vigna mungo* L.) is one of the important pulse crops grown in India. It is also known as urdbean, mash and black maple etc. It being a short duration crop suits well in the cropping system, as it vacates field well in time giving the opportunity to many winter crops like mustard, lentil *etc* grown in limited irrigation and rainfed situation. Black gram is grown in about 3.62 million ha with productivity of 537 kg/ha in India (Anonymous,

2017b). In Jharkhand, it is grown in about 94.9 thousand ha with an average productivity of 760 kg/ha [3].

Weeds are controlled by various methods like cultural, manual, mechanical, biological and chemical methods. Manual and mechanical weeding is labor intensive and tedious. Many times laborers are not available during peak time of requirement for weeding. Even if they are available the escalating cost of laborers further limits its option. The cultural method of weed control like adoption of suitable crop rotation, stale seed bed method, reduced tillage and soil solarization *etc* are long term planning. With the identification of short-statured, compact and early-maturing varieties, the weed problem has become more acute. The most commonly employed method is weeding through physical methods which include both manual and mechanical operations. Manual weeding is also cumbersome and uneconomical to practice [19]. The chemical method of weed control is not only cost effective but also is efficient in minimizing weed infestation for longer period provided they are applied judiciously i.e. suitable herbicide, it's proper dose and appropriate time of application.

The functional leaves, dry matter production and leaf area index are the main growth factor which may directly reflect to grain yield. Growth analysis parameters like crop growth rate (CGR) are product of LAI. Relative growth rate (RGR) measures the increase in dry matter with a given amount of assimilatory material at a given point of time and net assimilation rate (NAR) is the net gain in total dry matter per unit leaf area per unit time.

MATERIALS AND METHODS

A field experiment was conducted during rainy & winter seasons of 2015-16 and 2016-17 at Birsa Agricultural University, Ranchi, Jharkhand. Ranchi situated at 23°17'' N latitude, 85°10''E longitude and 625 m above mean sea level in the Chhotanagpur plateau range. The experimental soil was sandy-loam in texture with low organic carbon (0.33 %), moderately acidic (pH 5.5) in nature, low available nitrogen (185.30 kg/ha), medium phosphorus (21.32 kg/ha), medium potassium (161.28 kg/ha) and high sulphur (11.54 kg/ha) content. A total rainfall 521.4 mm (27 rainy day) during 2015-16 and 949.7 mm (35 rainy days) during 2016-17 was received at experimental site during crop period. The crop period (July to March) was characterized by 30.6 to 21.1 ^{0}C of mean monthly maximum temperature and 30.3 to 23.9 ^{0}C mean monthly minimum temperatures. The experiment was laid out in randomized block design with 12 treatments i.e. haloxyfop 81 g/ha, haloxyfop 108 g/ha, haloxyfop 135 g/ha, haloxyfop 270 g/ha, fenoxaprop-p-ethyl 61.9 g/ha, quizalofop-ethyl 43.8 g/ha, imazethapyr 100 g/ha each applied at 20 DAS, pendimethalin 1000 g/ha, oxyfluorfen 100 g/ha each applied at 3 DAS, two mechanical, two hand weeding each performed at 25 and 45 DAS and weedy check, replicated thrice. Black gram *var.* Birsa Urd-1 was sown at 30 cm using 30 kg seed/ha fertilized with recommended level of nutrients N:P_2O_5:K_2O:S i.e. 25:50:25:25 kg/ha. Prior to sowing black gram seeds were treated with bavistin and rhizobium culture. The crop was irrigated immediately after sowing to insure uniform germination. All the herbicides were applied at 20 days after sowing of the crop using Knapsack sprayer fitted with flat fan nozzle with 750 litre water/ha. Hand weeding and mechanical weeding was done as per the treatment schedule. For manual weeding treatment, two hand weeding were given at 25 and 45 DAS. Cultural practices recommended for black gram were adopted during the crop growth period. Statistical analysis was carried out by method of Gomez and Gomez [6]. Wherever statistical significance was observed, critical difference (CD) at 5 per cent level of probability was worked out for comparison. Periodic observations LAI and dry matter accumulation were recorded at 25, 45, 65 days after sowing and at maturity stage. Computations on the photosynthetic efficiency in terms of Crop growth rate (CGR),Relative growth rate (RGR) was calculated between 25-45, 45-65 DAS and 65 DAS-maturity stage and Net assimilation rate (NAR)between 25-45 and 45-65 DAS. For CGR, dry weight (W_1 and W_2) ofaerial parts of plants at beginning and end of time intervals ($t_1$and t_2) was calculated as per the procedure given by Radford [14].

$$\text{CGR } (g/m^2/day) = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{1}{A}$$

For RGR log values of the data were fitted in the formula

$$RGR\ (g/g/day) = \frac{LnW_2 - LnW_1}{t_2 - t_1}$$

NAR was calculated with the formula:

$$NAR\ (g/m^2/day) = \frac{(W_2 - W_1)(\ln L_2 - \ln L_1)}{(t_2 - t_1)(L_2 - L_1)}$$

Where, L_1 and L_2 are the areas of foliage at the beginning andend of time intervals, t_1 and t_2, respectively.

RESULT AND DISCUSSION

Effect on weed flora

Experimental field was naturally infested with all three categories of weeds i.e. grassy, broad-leaf and sedges covering seven families (Table 1). Altogether 14 weed species existed. Among grassy, *Eleusine indica* Gaerts, *Echinochloa crusgalli* (L.) P Beauv., *Digitaria sanguinalis* (L.), *Dactyloctenium aegyptium* (L.); among broad-leaf *Commelina benghalensis* (L.), *Commelina nodifolia* (L.), *Alternanthra sessilis* (L.), *Ageratum conyzoides* (L.), *Lactuca virosa* (L.), *Oldenlandia corymbosa* (L.); and among sedges, *Cyperus rotundus*(L.) and *Cyperus esculentus* (L.), were dominant. The relative composition of grassy, broad-leaf and sedges weeds accounted for 38.74, 34.58 and 37.11 per cent; 50.77, 54.38 and 52.66 per cent; 10.48, 10.04 and 10.23 per cent during 2015, 2016 and under pooled data, respectively.

The relative composition of major weed species accounted for *Eleusine indica* Gaerts - 16.43, 14.78 and 15.56 per cent; *Commelina benghalensis* (L.) - 14.28, 15.74 and 15.03; *Alternanthra sessilis* (L.) - 7.84, 8.03 and 7.94; *Cyperus rotundus* (L.) - 7.99,7.48 and 7.71; *Digitaria sanguinalis* (L.) - 7.84, 7.12 and 7.47; *Commelina nodifolia* (L.) - 6.74, 7.53 and 7.1 and *Echinochloa crusgalli* (L.) P Beauv. - 7.29, 6.80 and 7.04 per cent during 2015, 2016 and under pooled data, respectively.

Table-1: Weed flora observed in weedy check plot at maturity stage in black gram

Category	Common Name	Botanical Name	Family	Relative composition (%)		
				2015	2016	Pooled
Grassy	Goose grass	*Eleusine indica Gaerts.*	Poaceae	16.43	14.78	15.56
	Barnyard grass	*Echinocloa crusgalli* (L.) P. Beauv	Poaceae	7.29	6.80	7.04
	Crab grass	*Digitaria sanguinalis* (L.)	Poaceae	7.84	7.12	7.47
	Crow foot grass	*Dactyloctenium aegyptium* (L.)	Poaceae	7.19	6.89	7.04
Broad-leaf	Day flower	*Commelina bengalensis (*L.)	Commelianaceae	14.28	15.74	15.03
	Common day flower	*Commelina nodifolia* (L.)	Commelianaceae	6.74	7.53	7.14
	Wetland amaranth	*Alternanthra sessilis* (L.)	Amaranthaceae	7.84	8.03	7.94
	Bill goat weed	*Ageratum conyzoides* (L.)	Asteraceae	5.99	6.48	6.23
	Wild lettuce	*Lactuca virosa* (L.)	Asteraceae	5.49	6.80	6.18
	Diamond flower	*Oldenlandia corymbosa* (L.)	Rubiaceae	5.94	5.66	5.80
	Potato weed	*Galinsoga parviflora* (L.)	Asteraceae	3.49	2.74	3.09
	Scarlet pimpernel	*Anagallis arvensis*(L.)	Primulaceae	1.00	1.41	1.24
Sedges	Purple nut sedge	*Cyperus rotundus* (L.)	Cyperaceae	7.99	7.48	7.71
	Yellow nut sedge	*Cyperus esculentus* (L.)	Cyperaceae	2.50	2.55	2.52
Total				**100.00**	**100.00**	**100.00**

Mundra and *Echinochloa spp.* and *Cynodon dactylon, Digera arvensis* and *Elusine indica* among grasses, *Cyperu srotundus and Cyperus differmis* among sedges and *Parthenium hysterophorus*, *Amaranthus viridis*, *Triantherma portulacstrum* etc were among broad-leaved were dominant weed flora in black gram crop. Similar findings at different locations were also observed by Punia [13], Pankaj and Dewangan [11] and Upasani *et al.,* [18].

Crop dry weight

Crop dry weight at 25 DAS

Dry weight of black gram did not differ significantly by weed control methods at 25 DAS during 2015 (Table 1). However it was significantly influenced by different weed control methods during 2016 and under pooled data. Two hand weeding at 25 and 45 DAS being

similar to rest of the treatments except weedy check during 2016 and oxyfluorfen 100 g/ha at 3 DAS under pooled data recorded 19.88 and 19.30 per cent higher crop dry weight compared to weedy check i.e. 1.29 and 1.38 g/m^2 during 2016 and under pooled data, respectively.

Two mechanical weeding at 25 and 45 DAS being similar to rest of the treatments during 2015 and 2016; and recorded 1.42 per cent significantly higher crop dry weight compared to weedy check under pooled data.

Among herbicides, application of haloxyfop 108 g/ha at 20 DAS remained similar to rest of the treatments.

Crop dry weight at 45 DAS

Dry weight of black gram was significantly influenced by different weed control methods at 45 DAS during 2015, 2016 and under pooled data. Two hand weeding at 25 and 45 DAS being similar to rest of the treatments except fenoxaprop-p-ethyl 61.9 g/ha
at 20 DAS and oxyfluorfen 100 g/ha at 3 DAS recorded 27.84, 25.66 and 26.69 per cent higher crop dry weight compared to minimum observed under weedy check i.e. 113.75, 130.71 and 122.23 g/m^2 during 2015, 2016 and under pooled data, respectively.

Two mechanical weeding at 25 and 45 DAS being similar to rest of the treatments except oxyfluorfen 100 g/ha at 3 DAS recorded 23.66, 19.62 and 21.55 per cent higher crop dry weight compared to weedy check during 2015, 2016 and under pooled data, respectively.

Among herbicides application of haloxyfop 108 g/ha at 20 DAS being similar to rest of the treatments except oxyfluorfen 100 g/ha at 3 DAS recorded 26.75, 21.79 and 24.18 per cent higher crop dry weight compared to weedy check during 2015, 2016 and under pooled data, respectively.

Crop dry weight at 65 DAS

Dry weight of black gram was significantly influenced by different weed control methods at 65 DAS during 2015, 2016 and under pooled data. Two hand weeding at 25 and 45 DAS being similar to rest of the treatments except haloxyfop 108 g/ha, fenoxaprop-p-ethyl 61.9 g/ha, quizalofop-ethyl 43.8 g/ha each applied at 20 DAS, pendimethalin 1000 g/ha and oxyfluorfen 100 g/ha each applied at 3 DAS recorded 38.17, 38.28 and 38.23 per cent higher crop dry weight compared to minimum observed under weedy check i.e. 197.15, 194.51 and 195.83 g/m^2 during 2015, 2016 and under pooled data, respectively.

Two mechanical weeding at 25 and 45 DAS being similar to rest of the treatments except oxyfluorfen 100 g/ha at 3 DAS recorded 32.41, 29.80 and 31.14 per cent higher crop dry weight compared to weedy check during 2015, 2016 and under pooled data, respectively.

Among herbicides application of haloxyfop 108 g/ha at 20 DAS being similar to rest of the treatments except oxyfluorfen 100 g/ha at 3 DAS recorded 34.06, 61.73 and 32.93 per cent higher crop dry weight compared to weedy check during 2015, 2016 and under pooled data, respectively.

Crop dry weight at maturity stage

Dry weight of black gram was significantly influenced by different weed control methods at maturity stage during 2015, 2016 and under pooled data. Two hand weeding at 25 and 45 DAS being similar to haloxyfop 108 g/ha, haloxyfop 135 g/ha, imazethapyr 100 g/ha each applied at 20 DAS and two mechanical weeding at 25 and 45 DAS recorded 45.11, 43.01 and 44.07 per cent higher crop dry weight compared to minimum observed under weedy check i.e. 209.67, 214.67 and 212.17 g/m^2 during 2015, 2016 and under pooled data, respectively.

Two mechanical weeding at 25 and 45 DAS being similar to rest of the treatments except oxyfluorfen 100 g/ha at 3 DAS recorded 39.14, 32.56 and 35.98 per cent higher crop dry weight compared to weedy check during 2015, 2016 and under pooled data, respectively.

Among herbicides, application of haloxyfop 108 g/ha at 20 DAS being similar to rest of the treatments except oxyfluorfen 100 g/ha at 3 DAS recorded 37.39, 33.09 and 35.28 per cent higher crop dry weight compared to weedy check during 2015, 2016 and under pooled data, respectively.Similar findings were reported earlier by Balyan and Malik [4], Priya *et al.*, [12], Pankaj and Dewangan [11] and Upasani *et al.*, [18].

Leaf area index

Weed control methods significantly affected leaf area index of black gram at 25 DAS during 2015, 2016 and under pooled data (Table 2). Two hand weeding at 25 and 45 DAS being similar to rest of the treatments during 2015, 2016 and under pooled data recorded

significantly higher leaf area index to the tune of 22.7, 22.6 and 22.7 per cent, respectively compare to minimum observed under weedy check i.e. 1.70, 1.64 and 1.67, respectively. Two mechanical weeding at 25 and 45 DAS being significantly higher recorded 19.05, 19.32 and 19.32 per cent during 2016 compared to lower LAI observed under weedy check. Among herbicides, application of haloxyfop 108 g/ha at 20 DAS being similar to rest of herbicides recorded 15.42, 19.61 and 17.33 per cent higher leaf area compared to weedy check during 2015, 2016 and under pooled data, respectively.At 45 DAS two hand weeding at 25 and 45 DAS being similar to all treatments except fenoxaprop-p-ethyl 61.9 g/ha at 20 DAS during 2015; haloxyfop 81 g/ha, haloxyfop 270 g/ha, quizalofop-ethyl 43.8 g/ha each applied at 20 DAS, pendimethalin 1000 g/ha, oxyfluorfen 100 g/ha both at 3 DAS and weedy check during 2016 and haloxyfop 270 g/ha, fenoxaprop-p-ethyl 61.9 g/ha, quizalofop-ethyl 43.8 g/ha each applied at 20 DAS, pendimethalin 1000 g/ha, oxyfluorfen 100 g/ha both at 3 DAS and weedy check under pooled data recorded significantly higher leaf area index to the extent of 20.45, 19.11 and 19.81 per cent compared to minimum LAI observed under weedy check i.e. 2.20, 2.04 and 2.12 during 2015, 2016 and under pooled data, respectively. Two mechanical weeding at 25 and 45 DAS being similar to rest of treatments recorded significantly higher LAI to the extent of 17.60, 18.40 and 18.15 per cent compared to weedy check during 2015, 2016 and under pooled data, respectively.

Among herbicides, application of haloxyfop 108 g/ha at 20 DAS being similar to rest of herbicides recorded 20.45, 19.12 and 19.81 per cent higher leaf area compared to weedy check during 2015, 2016 and under pooled data, respectively.

Weed control methods did not significantly affected leaf area index of black gram at 65 DAS during 2015 and 2016. However, under pooled data two hand weeding at 25 and 45 DAS being similar to rest of the treatments recorded 18.10 per cent higher LAI compared to weedy check i.e. 3.37. Mechanical weeding as well as herbicides application did not differ significantly with weedy check during 2015, 2016 and under pooled data.These views were confirmed by Mundra and Maliwal [9], Choudhary *et al.*,[5] and Sangeetha *et al.*, [15].

Crop growth rate (CGR)

Crop growth rate of black gram gradually increased with crop age and reached to its peak during 45-65 days of crop age and thereafter it declined sharply as the crop proceeded towards maturity. In general crop growth rate was faster during early phases than the later (Table 3).

Crop growth rate between 25-45 DAS

Crop growth rate of black gram was significantly influenced by different weed control methods between 25-45 DAS during 2015, 2016 and under pooled data. Two hand weeding at 25 and 45 DAS being similar to rest of the treatments except oxyfluorfen 100 g/ha at 3 DAS during 2015; and also fenoxaprop-p-ethyl 61.9 g/ha at 20 DAS during 2016 and under pooled data recorded 27.98, 25.72 and 26.79 per cent higher crop growth rate compared to minimum observed under weedy check i.e. 5.61, 6.47 and 6.04 g/m^2/day during 2015, 2016 and under pooled data, respectively.

Two mechanical weeding at 25 and 45 DAS being similar to rest of the treatments except oxyfluorfen 100 g/ha at 3 DAS recorded 23.78, 19.63 and 21.66 per cent higher crop growth rate compared to weedy check during 2015, 2016 and under pooled data, respectively.

Among herbicides, application of haloxyfop 108 g/ha at 20 DAS being similar to rest of the treatments except oxyfluorfen 100 g/ha at 3 DAS recorded 26.86, 21.86 and 24.22 per cent higher crop growth rate compared to weedy check during 2015, 2016 and under pooled data, respectively.

Crop growth rate between 45-65 DAS

Crop growth rate of black gram was significantly influenced by different weed control methods between 45-65 DAS during 2015, 2016 and under pooled data. Two hand weeding at 25 and 45 DAS being similar to rest of the treatments except fenoxaprop-p-ethyl 61.9 g/ha at 20 DAS, pendimethalin 1000 g/ha and oxyfluorfen 100 g/ha each applied at 3 DAS during 2015; and similar to haloxyfop 108 g/ha at 20 DAS and two mechanical weeding at 25 and 45 DAS during 2016 and under pooled data similar to recorded 40.38, 51.74 and 45.76 per cent higher crop growth rate compared to minimum observed under weedy check i.e. 4.34, 3.19 and 3.77 g/m^2/day during 2015, 2016 and under pooled data, respectively.

Two mechanical weeding at 25 and 45 DAS being similar to rest of the treatments except fenoxaprop-p-ethyl 61.9 g/ha at 20 DAS and oxyfluorfen 100 g/ha at 3 DAS during 2015; haloxyfop 81 g/ha, fenoxaprop-p-ethyl 61.9 g/ha, quizalofop-ethyl 43.8 g/ha each applied at 20 DAS and oxyfluorfen 100 g/ha at 3 DAS during 2016; haloxyfop 81 g/ha, haloxyfop 270 g/ha, fenoxaprop-p-ethyl 61.9 g/ha, quizalofop-ethyl 43.8 g/ha each applied at 20 DAS and oxyfluorfen 100 g/ha at 3 DAS under pooled data recorded 39.13, 44.23 and 41.37 per cent higher crop growth rate compared to weedy check during 2015, 2016 and under pooled data, respectively.

Among herbicides, application of haloxyfop 108 g/ha at 20 DAS being similar to rest of the treatments except fenoxaprop-p-ethyl 61.9 g/ha at 20 DAS and oxyfluorfen 100 g/ha at 3 DAS during 2015; haloxyfop 81 g/ha, haloxyfop 135 g/ha, haloxyfop 270 g/ha, fenoxaprop-p-ethyl 61.9 g/ha, quizalofop-ethyl 43.8 g/ha each applied at 20 DAS and oxyfluorfen 100 g/ha at 3 DAS during 2016 and significantly higher over rest of the herbicides under pooled data recorded 39.55, 45.84 and 42.35 per cent higher crop growth rate compared to weedy check during 2015, 2016 and under pooled data, respectively.

Crop growth rate between 65 DAS-maturity stage of crop

Crop growth rate of black gram was significantly influenced by different weed control methods between 65 DAS- at maturity stage of crop during 2015, 2016 and under pooled data. Two hand weeding at 25 and 45 DAS followed by two mechanical weeding at 25 and 45 DAS recorded 81.65, 64.82 & 73.40 and 78.03, 47.57 & 64.68 per cent higher crop growth rate compared to minimum observed under weedy check i.e. 0.58, 1.08 and 0.83 g/m^2/day during 2015, 2016 and under pooled data, respectively.

Among herbicides, application of haloxyfop 135 g/ha at 20 DAS being similar to rest of the treatments except haloxyfop 81 g/ha, haloxyfop 108 g/ha, haloxyfop 270 g/ha and oxyfluorfen 100 g/ha at 3 DAS during 2015; oxyfluorfen 100 g/ha at 3 DAS during 2016; haloxyfop 270 g/ha and oxyfluorfen 100 g/ha at 3 DAS under pooled data recorded 73.27, 43.16 and 59.31 per cent higher crop growth rate compared to weedy check during 2015, 2016 and under pooled data, respectively.These results are in agreement with the findings of Thakare *et al.* [17], Nirala and Dewangan [10] and Punia, [13].

Relative growth rate

Relative growth rate of black gram increased with crop age and attained its peak between 45-65 DAS and thereafter declined gradually during both the year of investigation (Table 4).

Relative growth rate between 25-45 DAS

Relative growth rate of black gram did not differ significantly by weed control methods between 25-45 DAS, during 2015, 2016 and under pooled data.

Relative growth rate between 45-65 DAS

Relative growth rate of black gram was significantly influenced by different weed control methods between 45-65 DAS during 2015, 2016 and under pooled data. Two hand weeding at 25 and 45 DAS being similar to rest of the treatments except oxyfluorfen 100 g/ha at 3 DAS during 2015; haloxyfop 135 g/ha, quizalofop-ethyl 43.8 g/ha each applied at 20 DAS and oxyfluorfen 100 g/ha at 3 DAS during 2016 and similar to haloxyfop 108 g/ha at 20 DAS, pendimethalin 1000 g/ha at 3 DAS and two mechanical weeding at 25 and 45 DAS under pooled data recorded 27.03, 31.03 and 30.30 per cent higher relative growth rate compared to minimum observed under weedy check i.e. 0.027, 0.020 and 0.023 g/g/day during 2015, 2016 and under pooled data, respectively.

Two mechanical weeding at 25 and 45 DAS being similar to rest of the treatments oxyfluorfen 100 g/ha at 3 DAS during 2016 and under pooled data recorded 20.59, 25.93 and 23.33 per cent higher relative growth rate compared to minimum observed under weedy check during 2015, 2016 and under pooled data, respectively.

Among herbicides, application of haloxyfop 108 g/ha at 20 DAS being similar to rest of the treatments except weedy check during 2015; oxyfluorfen 100 g/ha at 3 DAS during 2016 and under pooled data recorded 18.18, 23.08 and 20.69 per cent higher relative growth rate compared to weedy check during 2015, 2016 and under pooled data, respectively.

Relative growth rate between 65 DAS-maturity stage of crop

Relative growth rate of black gram was significantly influenced by different weed control methods between 65 DAS-maturity stage of crop during 2015, 2016 and under pooled data. Two hand weeding at 25 and 45 DAS followed by pendimethalin 1000 g/ha at 3 DAS during 2015; haloxyfop 81 g/ha and quizalofop-ethyl 43.8 g/ha each applied at 20 DAS during

2016 recorded 57.30, 39.77 and 48.31 per cent higher relative growth rate compared to minimum observed under weedy check i.e. 0.0038, 0.0053 and 0.0046 g/g/day during 2015, 2016 and under pooled data, respectively.

Two mechanical weeding at 25 and 45 DAS being similar to rest of the treatments except haloxyfop 108 g/ha, haloxyfop 270 g/ha, imazethapyr 100 g/ha each applied at 20 DAS and oxyfluorfen 100 g/ha at 3 DAS during 2015 and under pooled data; oxyfluorfen 100 g/ha at 3 DAS during 2016 recorded 54.22, 24.29 and 40.26 per cent higher relative growth rate compared to minimum observed under weedy check during 2015, 2016 and under pooled data, respectively.

Among herbicides, application of pendimethalin 1000 g/ha at 3 DAS being similar to rest of the treatments except haloxyfop 108 g/ha, haloxyfop 270 g/ha each applied at 20 DAS and oxyfluorfen 100 g/ha at 3 DAS during 2015. While, application of quizalofop-ethyl 43.8 g/ha at 20 DAS being similar to rest of the treatments except imazethapyr 100 g/ha at 20 DAS and oxyfluorfen 100 g/ha at 3 DAS during 2016; haloxyfop 108 g/ha, haloxyfop 270 g/ha, imazethapyr 100 g/ha each applied at 20 DAS and oxyfluorfen 100 g/ha at 3 DAS under pooled data recorded 50.00, 34.57 and 39.47 per cent higher relative growth rate compared to minimum observed under weedy check during 2015, 2016 and under pooled data, respectively.The efficacy of these herbicides was also corroborated by Kushwah and Vyas [8], Nirala and Dewangan [10] and Punia, [13].

Net assimilation rate

Net assimilation rate of black gram increased with crop age and attained its peak between 45-65 DAS and thereafter declined gradually during both the year of investigation (Table 5).

Net assimilation rate between 25-45 DAS

Net assimilation rate of black gram was significantly influenced by different weed control methods between 25-45 DAS during 2015, 2016 and under pooled data. Two hand weeding at 25 and 45 DAS being similar two mechanical weeding at 25 and 45 DAS during 2016 and under pooled data and also similar to haloxyfop 81 g/ha, haloxyfop 108 g/ha, haloxyfop 135 g/ha each applied at 20 DAS and two mechanical weeding at 25 and 45 DAS during 2015 recorded 39.45, 44.74 and 42.34 per cent higher net assimilation rate compared to minimum observed under weedy check i.e. 0.066, 0.063 and 0.064 g/m^2/day during 2015, 2016 and under pooled data, respectively.

Two mechanical weeding at 25 and 45 DAS being similar to rest of the treatments except fenoxaprop-p-ethyl 61.9 g/ha, quizalofop-ethyl 43.8 g/ha each applied at 20 DAS, pendimethalin 1000 g/ha and oxyfluorfen 100 g/ha each applied at 3 DAS during 2015; imazethapyr 100 g/ha at 20 DAS and oxyfluorfen 100 g/ha at 3 DAS during 2016; haloxyfop 270 g/ha, fenoxaprop-p-ethyl 61.9 g/ha, quizalofop-ethyl 43.8 g/ha each applied at 20 DAS, pendimethalin 1000 g/ha and oxyfluorfen 100 g/ha each applied at 3 DAS under pooled data recorded 34.00, 35.05 and 34.69 per cent net assimilation rate compared to weedy check during 2015, 2016 and under pooled data, respectively.

Among herbicides, application of haloxyfop 108 g/ha at 20 DAS being similar to rest of the treatments except haloxyfop 270 g/ha, fenoxaprop-p-ethyl 61.9 g/ha, quizalofop-ethyl 43.8 g/ha each applied at 20 DAS, pendimethalin 1000 g/ha and oxyfluorfen 100 g/ha each applied at 3 DAS during 2015; weedy check during 2016; haloxyfop 270 g/ha, quizalofop-ethyl 43.8 g/ha each applied at 20 DAS, pendimethalin 1000 g/ha and oxyfluorfen 100 g/ha each applied at 3 DAS under pooled data recorded 38.89, 24.10 and 33.33 per cent higher net assimilation rate compared to minimum observed under weedy check during 2015, 2016 and under pooled data, respectively.

Net assimilation rate between 45-65 DAS

Net assimilation rate of black gram was significantly influenced by different weed control methods at 45-65 DAS during 2015, 2016 and under pooled data. Two hand weeding at 25 and 45 DAS being similar to rest of the treatments except haloxyfop 270 g/ha, fenoxaprop-p-ethyl 61.9 g/ha each applied at 20 DAS and oxyfluorfen 100 g/ha at 3 DAS during 2015; haloxyfop 81 g/ha, haloxyfop 135 g/ha, haloxyfop 270 g/ha, fenoxaprop-p-ethyl 61.9 g/ha, quizalofop-ethyl 43.8 g/ha each applied at 20 DAS, pendimethalin 1000 g/ha and oxyfluorfen 100 g/ha each applied at 3 DAS during 2016 and under pooled data recorded 33.33, 44.53 and 38.36 per cent higher net assimilation rate compared to minimum observed under weedy check i.e. 0.104, 0.076 and 0.090 g/m^2/day during 2015, 2016 and under pooled data, respectively.

Two mechanical weeding at 25 and 45 DAS being similar to rest of the treatments except fenoxaprop-p-ethyl 61.9 g/ha, quizalofop-ethyl 43.8 g/ha each applied at 20 DAS and oxyfluorfen 100 g/ha at 3 DAS during 2015; haloxyfop 81 g/ha, haloxyfop 270 g/ha, fenoxaprop-p-ethyl 61.9 g/ha, quizalofop-ethyl 43.8 g/ha each applied at 20 DAS, and oxyfluorfen 100 g/ha at 3 DAS during 2016 and under pooled data recorded 32.47, 39.68 and 35.71 per cent net assimilation rate compared to weedy check during 2015, 2016 and under pooled data, respectively.

Among herbicides, application of haloxyfop 108 g/ha at 20 DAS being similar to rest of the treatments except fenoxaprop-p-ethyl 61.9 g/ha, quizalofop-ethyl 43.8 g/ha each applied at 20 DAS and oxyfluorfen 100 g/ha at 3 DAS during 2015; haloxyfop 81 g/ha, haloxyfop 270 g/ha, fenoxaprop-p-ethyl 61.9 g/ha, quizalofop-ethyl 43.8 g/ha each applied at 20 DAS, and oxyfluorfen 100 g/ha at 3 DAS during 2016 and under pooled data recorded 31.13, 42.86 and 36.62 per cent net assimilation rate compared to weedy check during 2015, 2016 and under pooled data, respectively. The efficacy of these herbicides was also corroborated by Kushwah and Vyas [8], Nirala and Dewangan [10] and Punia, [13].

Table 1.Crop dry weight of black gram as influenced by weed control methods at different stages

Tr. No.	Treatments	Crop dry weight (g/m²)											
		25 DAS			45 DAS			65 DAS			At maturity stage		
		2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1	Haloxyfop 10.8% EC @ 81 g/ha at 20 DAS	1.72	1.55	1.63	136.20	154.53	145.37	258.28	247.46	252.87	294.10	284.32	289.21
T_2	Haloxyfop 10.8% EC @ 108 g/ha at 20 DAS	1.81	1.57	1.69	155.30	167.13	161.22	298.99	284.93	291.96	334.86	320.82	327.84
T_3	Haloxyfop 10.8% EC @ 135 g/ha at 20 DAS	1.73	1.55	1.64	146.37	161.83	154.10	272.28	259.15	265.72	315.59	297.14	306.36
T_4	Haloxyfop1 0.8% EC @ 270 g/ha at 20 DAS	1.65	1.49	1.57	138.96	153.65	146.31	258.85	250.43	254.64	290.86	286.52	288.69
T_5	Fenoxapro p-p-ethyl 9.3% EC @ 61.9 g/ha at 20 DAS	1.53	1.40	1.47	129.77	142.21	135.99	243.80	235.93	239.86	280.90	269.46	275.18
T_6	Quizalofop-ethyl 5% EC @ 43.8 g/ha at 20 DAS	1.61	1.46	1.53	133.80	153.37	143.58	255.96	243.85	249.90	293.95	284.04	289.00
T_7	Imazethapyr 10% SL@ 100 g/ha at 20 DAS	1.76	1.53	1.64	148.98	158.68	153.83	273.28	258.30	265.79	310.77	296.66	303.72

T_8	Pendimethalin 30 EC @ 1000 g/ha at 3 DAS	1.68	1.42	1.55	138.59	151.19	144.89	257.56	252.95	255.25	298.92	291.18	295.05
T_9	Oxyfluorfen 23.5% EC @ 100 g/ha at 3 DAS	1.51	1.31	1.41	114.68	132.78	123.73	204.62	202.17	203.40	219.32	221.90	220.61
T_{10}	Two mechanical weeding at 25 and 45 DAS	1.80	1.55	1.68	149.00	162.61	155.80	291.67	277.08	284.37	344.53	318.29	331.41
T_{11}	Two hand weeding at 25 and 45 DAS	1.82	1.61	1.71	157.63	175.82	166.73	318.87	315.17	317.02	382.00	376.67	379.33
T_{12}	Weedy check	1.48	1.29	1.38	113.75	130.71	122.23	197.15	194.51	195.83	209.67	214.67	212.17
SEm (±)		0.12	0.10	0.09	9.06	10.07	8.59	20.59	20.17	18.26	23.83	23.67	20.90
CD (P=0.05)		NS	0.31	0.27	26.57	29.54	25.20	60.40	59.16	53.55	69.88	69.42	61.28
CV (%)		12.56	12.31	10.28	11.33	11.35	10.18	13.67	13.87	12.34	13.85	14.21	12.34

Table 2. Periodic leaf area index of black gram as influenced by weed control methods

Tr. No.	Treatments	Leaf area index (LAI)								
		25 DAS			45 DAS			65 DAS		
		2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1	Haloxyfop 10.8% EC @ 81 g/ha at 20 DAS	1.95	1.89	1.92	2.45	2.27	2.36	3.76	3.45	3.60
T_2	Haloxyfop 10.8% EC @ 108 g/ha at 20 DAS	2.01	2.04	2.02	2.65	2.43	2.54	3.95	3.63	3.79
T_3	Haloxyfop 10.8% EC @ 135 g/ha at 20 DAS	1.98	1.93	1.96	2.60	2.42	2.51	3.91	3.61	3.76
T_4	Haloxyfop10.8% EC @ 270 g/ha at 20 DAS	1.93	1.87	1.90	2.39	2.26	2.33	3.68	3.46	3.57
T_5	Fenoxaprop-p-ethyl 9.3% EC @ 61.9 g/ha at 20 DAS	1.88	1.81	1.84	2.34	2.33	2.34	3.67	3.53	3.60
T_6	Quizalofop-ethyl 5% EC @ 43.8 g/ha at 20 DAS	1.95	1.88	1.92	2.41	2.27	2.34	3.73	3.47	3.60
T_7	Imazethapyr 10% SL @ 100 g/ha at 20 DAS	2.04	2.04	2.04	2.61	2.37	2.49	3.93	3.56	3.75
T_8	Pendimethalin 30 EC @ 1000 g/ha at 3 DAS	1.94	1.86	1.90	2.39	2.27	2.33	3.72	3.79	3.76
T_9	Oxyfluorfen 23.5% EC @ 100 g/ha at 3 DAS	1.93	1.86	1.89	2.41	2.25	2.33	3.72	3.44	3.58
T_{10}	Two mechanical weeding at 25 and 45 DAS	2.10	2.04	2.07	2.67	2.50	2.59	3.97	3.70	3.83
T_{11}	Two hand weeding at 25 and 45 DAS	2.20	2.12	2.16	2.80	2.66	2.73	4.09	3.87	3.98
T_{12}	Weedy check	1.70	1.64	1.67	2.20	2.04	2.12	3.51	3.23	3.37
SEm (±)		0.14	0.11	0.12	0.14	0.12	0.13	0.29	0.24	0.20
CD (P=0.05)		0.41	0.33	0.36	0.41	0.36	0.38	NS	NS	0.58
CV (%)		12.24	10.26	10.98	9.82	9.21	9.26	13.18	11.70	9.33

Table 3.Crop growth rate of black gram as influenced by weed control methods at different interval

Tr. No.	Treatments	Crop growth rate (g/m²/day)								
		25-45 DAS			45-65 DAS			65 DAS-Maturity stage		
		2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1	Haloxyfop 10.8% EC @ 81 g/ha at 20 DAS	6.72	7.65	7.19	6.10	4.65	5.37	1.79	1.84	1.82
T_2	Haloxyfop 10.8% EC @ 108 g/ha at 20 DAS	7.67	8.28	7.97	7.18	5.89	6.54	1.79	1.79	1.79
T_3	Haloxyfop 10.8% EC @ 135 g/ha at 20 DAS	7.23	8.01	7.62	6.29	4.87	5.58	2.17	1.90	2.04
T_4	Haloxyfop10.8% EC @ 270 g/ha at 20 DAS	6.87	7.61	7.24	5.99	4.85	5.42	1.60	1.80	1.70
T_5	Fenoxaprop-p-ethyl 9.3% EC @ 61.9 g/ha at 20 DAS	6.41	7.04	6.73	5.70	4.69	5.20	1.86	1.68	1.77
T_6	Quizalofop-ethyl 5% EC @ 43.8 g/ha at 20 DAS	6.61	7.60	7.10	6.11	4.52	5.31	1.90	2.01	1.96
T_7	Imazethapyr 10% SL @ 100 g/ha at 20 DAS	7.36	7.86	7.61	6.21	4.98	5.60	1.87	1.92	1.90
T_8	Pendimethalin 30 EC @ 1000 g/ha at 3 DAS	6.85	7.49	7.17	5.95	5.09	5.52	2.07	1.91	1.99
T_9	Oxyfluorfen 23.5% EC @ 100 g/ha at 3 DAS	5.66	6.57	6.12	4.50	3.47	3.99	0.74	0.99	0.87
T_{10}	Two mechanical weeding at 25 and 45 DAS	7.36	8.05	7.71	7.13	5.72	6.43	2.64	2.06	2.35
T_{11}	Two hand weeding at 25 and 45 DAS	7.79	8.71	8.25	7.28	6.61	6.95	3.16	3.07	3.12
T_{12}	Weedy check	5.61	6.47	6.04	4.34	3.19	3.77	0.58	1.08	0.83
SEm (±)		0.50	0.56	0.48	0.44	0.34	0.31	0.13	0.13	0.10
CD (P=0.05)		1.46	1.65	1.40	1.30	1.00	0.91	0.37	0.39	0.29
CV (%)		12.59	12.81	11.42	12.67	12.12	9.82	11.73	12.55	9.17

Table 4.Relative growth rate of black gram as influenced by weed control methods at different interval

Tr. No.	Treatments	Relative growth rate (g/g/day)								
		25-45 DAS			45-65 DAS			65 DAS- Maturity stage		
		2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1	Haloxyfop 10.8% EC @ 81 g/ha at 20 DAS	0.218	0.223	0.221	0.032	0.024	0.028	0.0069	0.0073	0.0071
T_2	Haloxyfop 10.8% EC @ 108 g/ha at 20 DAS	0.223	0.234	0.228	0.033	0.026	0.029	0.0051	0.0063	0.0057
T_3	Haloxyfop 10.8% EC @ 135 g/ha at 20 DAS	0.222	0.232	0.227	0.031	0.023	0.027	0.0068	0.0066	0.0067
T_4	Haloxyfop10.8% EC @ 270 g/ha at 20 DAS	0.222	0.231	0.227	0.031	0.024	0.028	0.0058	0.0070	0.0064
T_5	Fenoxaprop-p-ethyl 9.3% EC @ 61.9 g/ha at 20 DAS	0.219	0.225	0.222	0.031	0.025	0.028	0.0069	0.0066	0.0068
T_6	Quizalofop-ethyl 5% EC @ 43.8 g/ha at 20 DAS	0.221	0.233	0.227	0.032	0.023	0.027	0.0071	0.0081	0.0076
T_7	Imazethapyr 10% SL @ 100 g/ha at 20 DAS	0.219	0.228	0.224	0.031	0.024	0.027	0.0063	0.0065	0.0064
T_8	Pendimethalin 30 EC @ 1000 g/ha at 3 DAS	0.221	0.233	0.227	0.032	0.026	0.029	0.0076	0.0072	0.0074
T_9	Oxyfluorfen 23.5% EC @ 100 g/ha at 3 DAS	0.217	0.228	0.222	0.027	0.020	0.024	0.0049	0.0054	0.0052
T_{10}	Two mechanical weeding at 25 and 45 DAS	0.220	0.233	0.227	0.034	0.027	0.030	0.0083	0.0070	0.0077
T_{11}	Two hand weeding at 25 and 45 DAS	0.223	0.234	0.228	0.037	0.029	0.033	0.0089	0.0088	0.0089
T_{12}	Weedy check	0.217	0.228	0.222	0.027	0.020	0.023	0.0038	0.0053	0.0046
SEm (±)		0.016	0.018	0.013	0.002	0.002	0.001	0.0005	0.0005	0.0003
CD (P=0.05)		NS	NS	NS	0.007	0.005	0.004	0.0015	0.0015	0.0010
CV (%)		12.68	13.28	10.02	13.60	12.81	9.14	13.22	13.13	8.47

Table 5. Net assimilation rate of black gram as influenced by weed control methods at different interval

Tr. No.	Treatments	Net assimilation rate (g/m²/day)					
		25-45 DAS			45-65 DAS		
		2015	2016	Pooled	2015	2016	Pooled
T_1	Haloxyfop 10.8% EC @ 81 g/ha at 20 DAS	0.089	0.081	0.085	0.133	0.096	0.114
T_2	Haloxyfop 10.8% EC @ 108 g/ha at 20 DAS	0.108	0.083	0.096	0.151	0.133	0.142
T_3	Haloxyfop 10.8% EC @ 135 g/ha at 20 DAS	0.098	0.083	0.091	0.132	0.113	0.123
T_4	Haloxyfop10.8% EC @ 270 g/ha at 20 DAS	0.080	0.078	0.079	0.118	0.100	0.109
T_5	Fenoxaprop-p-ethyl 9.3% EC @ 61.9 g/ha at 20 DAS	0.077	0.088	0.083	0.110	0.098	0.104
T_6	Quizalofop-ethyl 5% EC @ 43.8 g/ha at 20 DAS	0.078	0.080	0.079	0.139	0.105	0.122
T_7	Imazethapyr 10% SL @ 100 g/ha at 20 DAS	0.104	0.077	0.091	0.140	0.123	0.132
T_8	Pendimethalin 30 EC @ 1000 g/ha at 3 DAS	0.078	0.081	0.079	0.134	0.114	0.124
T_9	Oxyfluorfen 23.5% EC @ 100 g/ha at 3 DAS	0.067	0.069	0.068	0.107	0.076	0.091
T_{10}	Two mechanical weeding at 25 and 45 DAS	0.100	0.097	0.098	0.154	0.126	0.140
T_{11}	Two hand weeding at 25 and 45 DAS	0.109	0.114	0.111	0.156	0.137	0.146
T_{12}	Weedy check	0.066	0.063	0.064	0.104	0.076	0.090
SEm (±)		0.007	0.006	0.004	0.010	0.008	0.006
CD (P=0.05)		0.020	0.019	0.013	0.030	0.022	0.018
CV (%)		13.20	13.29	8.81	13.36	12.15	8.86

ACKNOWLEDGEMENT

The authors acknowledge Dow Agro Sciences India Pvt. Ltd., for funding the project.

REFERENCES

1. Anonymous. (2017a). *Pulses in India: Retrospect and Prospects*. Publication: DPD/Pub.1/ Vol.2/2016. Published by Director, Govt. of India, Ministry of Agri. & Farmers Welfare, Directorate of Pulses Development, Vindhyachal Bhavan, Bhopal, Madhya Pradesh.
2. Anonymous. (2017b). Economics Survey of India, Directorate of Economics and Statistics, Government of India.
3. Anonymous. (2017c). Directorate of Agriculture, Jharkhand, *Annual Report.*
4. Balyan RS. and Malik RK. (1989). Control of horse purslane (*Trianthema portulacastrum*) and *E. crusgalli* in mung bean. *Weed Science* **37**:695–699.
5. Choudhary VK, Kumar SP and Bhagawati R. (2012). Integrated weed management in black gram (*Vigna mungo* L.) under mid hills of Arunachal Pradesh. *Indian Journal of Agronomy* **57**(4):382–385.
6. Gomez KA and Gomez AA. 2008. *Statistical procedures for agricultural Research*. A Willey-Interscience Publication, John Willey and Sons, New York.
7. Kumar S. (2014). Evaluation of herbicides in black gram and their residual effect on succeeding mustard crop. *M.Sc. (Ag) Thesis* (Agronomy) College of Agriculture, Chaudhary Charan Singh Haryana Agricultural University, Hisar.
8. Kushwah SS and Vyas MD. 2005. Herbicidal weed control in soybean. *Indian Journal of Agronomy***50**(3):225–227.
9. Mundra SL and Maliwal PL (2012). Influence of quizalofop-ethyl on narrow-leaved weeds in black gram and its residual effect on succeeding crops. *Indian Journal of Weed Science* **44**(4):231–234.
10. Nirala H and Dewangan DK. (2012). Effect of weed management on weeds, growth and yield of *kharif* black gram (*Vigna mungo* L.). *Journal of Interacademicia* **16**(4):835–844.
11. Pankaj SCand Dewangan PK. 2017. Weed management in black gram (*Vigna mungo* L.) and residual effect of herbicides on succeeding mustard (*Brassica juncea* L.) crop. *International Journal of Current Microbiology and Applied Sciences* **6**(11):865–881.
12. Priya RS, Chinnusamy C, Janaki P and Arthanari PM. (2017). Persistence and carryover effect of oxyfluorfen residues in red sandy clay loam soil. *Journal of Pharmacognosy and Phytochemistry***6**(3):527–532.
13. Punia R. (2014). Evaluation of some herbicides in green gram (*Vigna radiata* L.) and their residual effect on succeeding mustard crop. *M.Sc. (Ag) Thesis* (Agronomy) College of Agriculture, Chaudhary Charan Singh Haryana Agricultural University, Hisar.

14. Radford PJ. (1967). Growth analysis formula-their use and abuse. *Crop Science***7**:171–175.
15. Sangeetha C, Chinnusamy C and Prabhakaran NK. 2012. Efficacy of imazethapyr on productivity of soybean and its residual effect on succeeding crops. *Indian Journal of Weed Science* **44**(2):135–138.
16. Singh R and Chaudhary GR. (1992). Effect of weed control and phosphorus on yield attributes of green gram (*Phaseolus radiatus). Indian Journal of Agron*omy **37**(2):373-374.
17. Thakare PD, Patil, BM, Kakade SU and Dangore ST. (2002). Studies on chemical weed control in soybean [*Glycine max* (L.) Merrill]. *Crop Research* **24**(1):11–14.
18. Upasani RR, BarlaS, Hassan D and Puran AN. (2017). Weed management in black gram and its residual effect on succeeding mustard crop. *Indian Journal of Weed Science***49**(4): 346–349.
19. Sasikala K, Boopathi SNM, Ramachandra and Ashok P. (2014). Evaluation of methods of sowing and post-emergence herbicides for efficient weed control in zero till sown rice fallow black gram (*Vigna mungo* L). *International Journal of Farm Sciences* **4**(1): 81–91.