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Effect of weed management on growth, nodule, protein and yield responses of black gram (*Vigna mungo* L.) crop

Sooraj Chandra Pankaj, RR Upasani and Pradeep Kumar Dewangan

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/ha fertilized with recommended level of nutrients N:P_2O_5:K_2O:S i.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 plant population, nodule dry weight, seed yield and protein yield to the extent of 13.22, 10.00, 104.09 and 52.30 per cent, respectively as compare to weedy check i.e. 41.95 number/plant, 31.17 mg/plant, 621 kg/ha and 138.95 kg/ha, respectively. Among herbicides, application of haloxyfop 108 g/ha at 20 DAS recorded higher plant population, nodule dry weight, seed yield and protein yield.

Keywords: Black gram, growth, nodule, protein, weed control, yield

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 (Kumar, 2014) [9]. 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 (Anonymous, 2017a) [2].

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) [3].

In Jharkhand, it is grown in about 94.9 thousand ha with an average productivity of 760 kg/ha (Anonymous, 2017c) [4].

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 (Sasikala *et al*. 2014) [4]. 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.

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 23º17" N latitude, 85º10"E longitude and 625 m above mean sea level in the Chhota Nagpur 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 (2008) [8]. Wherever statistical significance was observed, critical difference (CD) at 5 per cent level of probability was worked out for comparison. Periodic observations pant population and plant height were recorded at 15 days after sowing and at maturity stage. Five plants of black gram were uprooted from 3rd row of each plot at 30 DAS carefully in order to keep the nodules intact on the roots of plant. The soil was removed carefully from the roots with the help of *khurpi* and were washed gently/safely in the tap water. The nodules were separated from the roots and counted. The nodules were dried, first in sun then kept in oven at 65ºC (±5 ºC) till constant weight, thus dried samples were weighed as per treatment. To obtain the seed protein content, nitrogen content in grains of black gram was determined as per treatment wise by the Kjeldahl method according to the procedure suggested by AOAC (1995) [5]. After that, seed protein contents were determined by multiplying with 6.25 (factor). Protein content (%) =N content in seed (%) ×6.25. The harvesting was done by cutting the plants at ground level after complete maturity. The two border rows on four sides of the plot were first harvested and then net plots were harvested separately. The plants from net plot were bundled separately and dried. Threshing was done manually and seeds were separated and yield was recorded per plot at a moisture content of 12 per cent and given as kg/ha. Biological yield and grain yield were recorded on a plot basis and harvest index was calculated.

Results and discussion

Plant population

Plant population recorded at 15 DAS and at maturity stage of black gram crop revealed that different weed control methods did not influence plant population except under oxyfluorfen 100 g/ha at 3 DAS which drastically reduced plant population to the extent of 49.82, 37.09 & 43.66 and 48.19, 34.22 & 41.36 per cent compared to mean plant population i.e. 51.68, 48.50 & 50.09 observed at 15 DAS and 45.94, 44.16 & 45.05/m^2 observed at maturity stage during 2015, 2016 and under pooled data, respectively. Phyto-toxicity symptoms due to these herbicides were transient throughout experimentation (Table 1). Sharma *et al*. (1989) [14]. studied that oxyfluorfen resulted in visible chlorosis, curling of leaf appearance of irregular burnt patches. The visible injury was apparently more at higher concentrations (5 to 7 ppm) of oxyfluorfen. Similar findings have also been reported earlier by Kumar, (2014) [9], Punia, (2014) [13]. and Pankaj *et al*. (2017) [11].

Table 1: Plant population of black gram at 15 DAS and at maturity stage as influenced by weed control methods

Tr. No.	Treatments	Plant population (Number/m^2)					
		15 DAS			At maturity stage		
		2015	2016	Pooled	2015	2016	Pooled
T_1	Haloxyfop @ 81 g/ha at 20 DAS	53.90	49.41	51.66	48.33	45.68	47.01
T_2	Haloxyfop @ 108 g/ha at 20 DAS	51.20	50.88	51.04	47.43	47.01	47.22
T_3	Haloxyfop @ 135 g/ha at 20 DAS	53.40	47.08	50.24	46.80	45.18	45.99
T_4	Haloxyfop @ 270 g/ha at 20 DAS	55.40	51.81	53.61	47.33	45.83	46.58
T_5	Fenoxaprop-p-ethyl @ 61.9 g/ha at 20 DAS	51.00	47.59	49.29	47.00	40.42	43.71
T_6	Quizalofop-ethyl @ 43.8 g/ha at 20 DAS	49.87	46.22	48.04	46.60	44.11	45.35
T_7	Imazethapyr @ 100 g/ha at 20 DAS	52.87	48.00	50.43	45.67	45.39	45.53
T_8	Pendimethalin @ 1000 g/ha at 3 DAS	45.60	43.37	44.49	42.60	41.46	42.03

T_9	Oxyfluorfen @ 100 g/ha at 3 DAS	25.93	30.51	28.22	23.80	29.05	26.42
T_{10}	Two mechanical weeding at 25 and 45 DAS	51.41	51.48	51.45	41.60	42.09	41.85
T_{11}	Two hand weeding at 25 and 45 DAS	56.20	52.14	54.17	49.43	47.25	48.34
T_{12}	Weedy check	47.60	45.53	46.57	42.53	41.36	41.95
SEm (±)		3.99	3.98	2.58	3.26	3.40	2.42
CD (P=0.05)		11.71	11.67	7.57	9.56	9.96	7.09
CV (%)		13.97	14.67	9.27	12.80	13.71	9.63

Plant height

Plant height of black gram was significantly affected by weed control methods at 30 DAS during 2015, 2016 and under pooled data (Table 2). The plant height under weedy check being *at par* with haloxyfop 81 g/ha, haloxyfop 108 g/ha, haloxyfop 270 g/ha, fenoxaprop-p-ethyl 61.9 g/ha each applied at 20 DAS and two mechanical weeding at 25 and 45 DAS recorded significantly taller plants compared to rest of treatments during 2015, 2016 and under pooled data, respectively.

At 60 DAS weedy check recorded tallest plant of black gram however, it was *at par* with all other treatments except haloxyfop 108 g/ha at 20 DAS and two hand weeding at 25 and 45 DAS in 2015. While during 2016 it being *at par* with haloxyfop 81 g/ha, haloxyfop 270 g/ha and fenoxaprop-p-ethyl 61.9 g/ha each applied at 20 DAS recorded maximum plant height compare to rest of treatments. Under pooled data weedy check being similar to haloxyfop 270 g/ha at 20 DAS and two hand weeding at 25 and 45 DAS recorded significantly taller plant height compare to rest of treatments.

At maturity stage of black gram plant height under weedy check being *at par* with haloxyfop 270 g/ha, fenoxaprop-p-ethyl 61.9 g/ha each applied at 20 DAS, pendimethalin 1000 g/ha, oxyfluorfen 100 g/ha each applied at 3 DAS and two hand weeding at 25 and 45 DAS during 2015, and also similar to haloxyfop 81 g/ha at 20 DAS in 2016 recorded significantly taller plants compared to rest of treatments. Under pooled data plant height under weedy check recorded significantly taller plants compared to rest of treatments. Weedy check plots observed taller plants due to competition for space, between weeds and crop plants and in search of solar light. These finding are in conformity with those of Singh and Chaudhary (1992) [15], who observed taller plants in weedy check compared to weed free plots at harvest of crop. Under hand & mechanical weeding and herbicides treatments shorter plant height was observed due to lesser weed infestation and better utilization of resources which resulted more number of primary branches and more lateral growth of plants.

Table 2: Plant height of black gram at different stages on black gram as influenced by weed control methods

Tr. No.	Treatments	Plant height (cm)								
		30 DAS			60 DAS			At maturity stage		
		2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1	Haloxyfop @ 81 g/ha at 20 DAS	42.74	44.07	43.40	67.02	66.40	67.46	67.89	70.33	69.11
T_2	Haloxyfop @ 108 g/ha at 20 DAS	42.13	43.40	42.77	63.42	62.20	64.17	64.92	65.80	65.36
T_3	Haloxyfop @ 135 g/ha at 20 DAS	41.70	42.67	42.18	64.21	61.87	65.29	66.36	67.53	66.95
T_4	Haloxyfop @ 270 g/ha at 20 DAS	43.46	45.13	44.30	69.33	68.87	70.15	70.96	73.23	72.10
T_5	Fenoxaprop-p-ethyl @ 61.9 g/ha at 20 DAS	42.42	44.20	43.31	68.14	65.77	68.67	69.21	71.20	70.20
T_6	Quizalofop-ethyl @ 43.8 g/ha at 20 DAS	40.56	42.67	41.61	64.54	62.80	65.13	65.72	67.33	66.53
T_7	Imazethapyr @ 100 g/ha at 20 DAS	38.56	39.67	39.11	66.51	62.27	67.09	67.68	66.80	67.24
T_8	Pendimethalin @ 1000 g/ha at 3 DAS	38.14	39.93	39.04	66.94	64.60	68.31	69.69	70.40	70.04
T_9	Oxyfluorfen @ 100 g/ha at 3 DAS	32.64	33.73	33.19	66.54	63.47	67.63	68.72	69.33	69.03
T_{10}	Two mechanical weeding at 25 and 45 DAS	43.91	46.00	44.95	65.78	62.34	66.07	66.36	67.40	66.88
T_{11}	Two hand weeding at 25 and 45 DAS	40.78	41.80	41.29	70.52	64.87	71.21	71.90	69.33	70.62
T_{12}	Weedy check	49.97	51.53	50.75	78.32	77.60	79.42	80.52	82.93	81.73
	SEm (±)	2.69	3.06	2.79	4.85	4.21	3.63	4.11	4.66	3.24
	CD (P=0.05)	7.88	8.98	8.17	14.22	12.35	10.65	12.05	13.67	9.51
	CV (%)	11.24	12.37	11.45	12.42	11.18	9.20	10.29	11.51	8.07

Nodule count

Number of nodules per plant of black gram was not affected significantly by weed control methods at 30 DAS during 2015, 2016 and under pooled data (Table 3). However, maximum number of nodules was recorded under two hand weeding at 25 and 45 DAS during 2015, 2016 and under pooled data, respectively. These results are in agreement with the findings of Choudhary *et al*. (2012) [7]. and Aggarwal *et al*. (2014) [1].

Nodule dry weight

Nodule dry weight per plant of black gram did not differ significantly by weed control methods at 30 DAS during 2015, 2016 and under pooled data (Table 3). However, maximum nodule dry weight was recorded under two hand weeding at 25 and 45 DAS during 2015, 2016 and under pooled data, respectively. These results are in agreement with the findings of Choudhary *et al*. (2012) [7]. and Aggarwal *et al*. (2014) [1].

Table 3: Nodule count and nodule dry weight at 30 DAS on black gram as influenced by weed control methods

Tr. No.	Treatments	Nodule count (No./plant) at 30 DAS			Nodule dry weight (mg/plant) at 30 DAS		
		2015	2016	Pooled	2015	2016	Pooled
T_1	Haloxyfop @ 81 g/ha at 20 DAS	20.33	20.71	20.52	28.33	29.30	28.82
T_2	Haloxyfop @ 108 g/ha at 20 DAS	20.73	21.41	21.07	28.33	32.42	30.38
T_3	Haloxyfop @ 135 g/ha at 20 DAS	22.71	23.27	22.99	30.00	30.29	30.15
T_4	Haloxyfop @ 270 g/ha at 20 DAS	23.49	23.30	23.39	31.67	30.48	31.07

T_5	Fenoxaprop-p-ethyl @ 61.9 g/ha at 20 DAS	20.56	20.15	20.36	28.33	29.49	28.91
T_6	Quizalofop-ethyl @ 43.8 g/ha at 20 DAS	20.86	21.12	20.99	28.00	29.55	28.78
T_7	Imazethapyr @ 100 g/ha at 20 DAS	21.27	20.14	20.70	29.00	30.65	29.82
T_8	Pendimethalin @ 1000 g/ha at 3 DAS	22.50	20.41	21.46	31.33	30.09	30.71
T_9	Oxyfluorfen @ 100 g/ha at 3 DAS	20.45	21.06	20.76	29.67	30.59	30.13
T_{10}	Two mechanical weeding at 25 and 45 DAS	24.15	24.82	24.49	32.00	33.22	32.61
T_{11}	Two hand weeding at 25 and 45 DAS	24.28	25.41	24.85	34.00	35.20	34.60
T_{12}	Weedy check	23.37	23.12	23.25	31.33	31.01	31.17
SEm (±)		1.76	1.90	1.68	2.22	2.39	1.97
CD (P=0.05)		NS	NS	NS	NS	NS	NS
CV (%)		13.79	14.88	13.17	12.74	13.36	11.16

Seed yield

Two hand weeding at 25 and 45 DAS being similar to rest of the treatments except recorded 103.40, 104.80 and 104.09 per cent higher seed yield compared to minimum observed under weedy check during 2015, 2016 and under pooled data, respectively (Table 4). Two mechanical weeding at 25 and 45 DAS 32.02 and 39.47, 35.53 & 37.64 per cent higher seed yield compared to lower yield obtained during 2015, 2016 and under pooled data, respectively.

Among herbicides, application of haloxyfop 108 g/ha at 20 DAS recorded 50.08, 48.38 & 49.28 per cent higher seed yield compared to lowest yield observed under weedy check, respectively. Similar results were also reported by Chhodavadia *et al.* (2012) [6], Mundra and Maliwal (2012) [10], Tayade, (2013) and Upasani *et al.* (2017) [16].

Straw yield

Straw yield of black gram was not influenced significantly by different weed control methods during 2015, 2016 and under pooled data (Table 4). However, two mechanical weeding at 25 and 45 DAS recorded maximum straw yield i.e. 2709, 2646 and 2678 kg/ha during 2015, 2016 and under pooled data, respectively as compare to all other treatments. Similar results were also reported by Chaudhary *et al.* (2011) and Mundra and Maliwal (2012) [10], Kumar (2014) [9], Punia (2014) [12]. and Upasani *et al.* (2017) [16].

Harvest index

Harvest index of black gram was significantly influenced during 2015, 2016 and under pooled data (Table 4). Two hand weeding at 25 and 45 DAS being similar to rest of the treatments during 2015, 2016 and under pooled data, respectively. The increase was 42.60, 42.70 and 42.60 per cent compare to weedy check per i.e. 19.50, 18.80 and 19.15% during 2015, 2016 and under pooled data, respectively, while, two mechanical weeding at 25 and 45 DAS recorded 31.05, 27.24 & 29.23 per cent higher harvest index compared to weedy check, respectively.

Among herbicides, application of haloxyfop 108 g/ha at 20 DAS being similar to all treatments except fenoxaprop-p-ethyl 61.9 g/ha and imazethapyr 100 g/ha each applied at 20 DAS during 2015 recorded 75.59, 70.32 and 73.00 per cent higher harvest index compared to lower harvest index observed under weedy check. Similar results were also reported by Chaudhary *et al.* (2011) and Mundra and Maliwal (2012) [10], Kumar (2014) [9], Punia (2014) [12]. and Upasani *et al.* (2017) [16].

Table 4: Seed yield, straw yield and harvest index of black gram as influenced by weed control methods

Tr. No.	Treatments	Seed yield (kg/ha)			Straw yield (kg/ha)			Harvest Index (%)		
		2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1	Haloxyfop 10.8% EC @ 81 g/ha at 20 DAS	1187	1104	1145	2553	2419	2486	31.80	31.57	31.68
T_2	Haloxyfop 10.8% EC @ 108 g/ha at 20 DAS	1296	1151	1223	2502	2459	2480	34.24	32.02	33.13
T_3	Haloxyfop 10.8% EC @ 135 g/ha at 20 DAS	1220	1075	1148	2549	2459	2504	32.35	30.47	31.41
T_4	Haloxyfop 10.8% EC @ 270 g/ha at 20 DAS	998	884	941	2524	2584	2554	28.82	25.58	27.20
T_5	Fenoxaprop-p-ethyl 9.3% EC @ 61.9 g/ha at 20 DAS	776	767	771	2687	2498	2593	22.32	23.63	22.98
T_6	Quizalofop-ethyl 5% EC @ 43.8 g/ha at 20 DAS	1040	896	968	2653	2558	2605	28.15	26.02	27.08
T_7	Imazethapyr 10% SL @ 100 g/ha at 20 DAS	1135	993	1064	2582	2444	2513	30.64	28.85	29.74
T_8	Pendimethalin 30 EC @ 1000 g/ha at 3 DAS	1087	945	1016	2616	2580	2598	29.42	26.90	28.16
T_9	Oxyfluorfen 23.5% EC @ 100 g/ha at 3 DAS	660	693	676	2682	2605	2644	19.70	21.12	20.41
T_{10}	Two mechanical weeding at 25 and 45 DAS	1069	922	995	2709	2646	2678	28.28	25.84	27.06
T_{11}	Two hand weeding at 25 and 45 DAS	1316	1217	1266	2556	2493	2525	33.98	32.80	33.39
T_{12}	Weedy check	647	594	621	2659	2582	2621	19.50	18.80	19.15
SEm (±)		85.64	66.48	55.78	172.86	181.8	164.3	2.23	1.92	1.54
CD (P=0.05)		251.14	194.95	163.58	NS	NS	NS	6.55	5.62	4.52
CV (%)		14.32	12.29	9.80	11.49	12.5	11.1	13.68	12.31	9.67

Protein content in seed

Protein content in seed was not significantly influenced by different weed control methods during 2015, 2016 and under pooled data (Table 5). However, two hand weeding at 25 and 45 DAS recorded higher protein content in seed 22.27, 23.92 and 23.09 per cent as compare to all other treatments during 2015, 2016 and under pooled data, respectively. Similar results were also reported by Chhodavadia *et al.* (2012) [6]. and Choudhary *et al.* (2012) [7].

Protein yield

Protein yield significantly influenced by different weed control methods during 2015, 2016 and under pooled data (Table 5). 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, 2016 and under pooled data recorded 51.97, 52.67 and 52.31 per cent protein yield compared to weedy check i.e. 141.27, 136.62 and 138.95 kg/ha 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 during 2015, 2016 and under pooled data recorded 39.88, 36.98 and 38.48 per cent protein yield 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 herbicides except fenoxaprop-p-ethyl 61.9 g/ha at 20 DAS and oxyfluorfen 100 g/ha at 3 DAS during 2015, 2016 and under pooled data recorded 43.38, 40.78 and 42.13 per cent higher protein yield compared to weedy check during 2015, 2016 and under pooled data, respectively. Similar results were also reported by Chhodavadia *et al.* (2012) [6]. and Choudhary *et al.* (2012) [7].

Table 5: Protein content and protein uptake by grain in black gram as influenced by weed control methods

Tr. No.	Treatments	Protein content in grain (%)			Protein yield (kg/ha)		
		2015	2016	Pooled	2015	2016	Pooled
T_1	Haloxyfop @ 81 g/ha at 20 DAS	21.51	23.51	22.51	251.67	256.77	254.22
T_2	Haloxyfop @ 108 g/ha at 20 DAS	21.67	23.40	22.53	279.97	265.46	272.71
T_3	Haloxyfop @ 135 g/ha at 20 DAS	21.21	23.08	22.15	258.57	245.16	251.87
T_4	Haloxyfop @ 270 g/ha at 20 DAS	21.58	23.50	22.54	209.05	207.52	208.29
T_5	Fenoxaprop-p-ethyl @ 61.9 g/ha at 20 DAS	21.79	23.67	22.73	168.64	180.56	174.60
T_6	Quizalofop-ethyl @ 43.8 g/ha at 20 DAS	21.49	23.44	22.46	225.06	209.60	217.33
T_7	Imazethapyr @ 100 g/ha at 20 DAS	22.16	23.39	22.77	249.50	230.69	240.10
T_8	Pendimethalin @ 1000 g/ha at 3 DAS	21.91	23.44	22.67	237.95	224.28	231.12
T_9	Oxyfluorfen @ 100 g/ha at 3 DAS	21.38	23.33	22.35	142.44	161.59	152.01
T_{10}	Two mechanical weeding at 25 and 45 DAS	21.94	23.35	22.65	234.97	216.72	225.85
T_{11}	Two hand weeding at 25 and 45 DAS	22.27	23.92	23.09	294.12	288.64	291.38
T_{12}	Weedy check	21.19	23.17	22.18	141.27	136.62	138.95
SEm (±)		1.47	1.46	1.45	24.34	20.69	19.07
CD (P=0.05)		NS	NS	NS	71.39	60.68	55.94
CV (%)		11.75	10.79	11.15	18.79	16.39	14.91

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References

1. Aggarwal N, Singh G, Ram H, Khanna V. Effect of post-emergence application of imazethapyr on symbiotic activities growth and yield of black gram (*Vigna mungo* L.) cultivars and its efficacy. Indian Journal of Agronomy. 2014; 59(3):421-426.
2. Anonymous. Pulses in India: Retrospect and Prospects. Publication: DPD/Pub.1/2016. Published by Director, Govt. of India, Ministry of Agri. & Farmers Welfare, Directorate of Pulses Development, Vindhyachal Bhavan, Bhopal, Madhya Pradesh, 2017a, 2.
3. Anonymous. Economics Survey of India, Directorate of Economics and Statistics, Government of India, 2017b.
4. Anonymous. Directorate of Agriculture, Jharkhand, Annual Report, 2017c.
5. AOAC. Official methods of analysis 16th edn. Association of official analytical chemicals, Washington, DC, 1995.
6. Chhodavadia SK, Sagarka BK, Gohil BS, Dobariya VK. Herbicidal weed control in green gram. Agriculture: towards a new paradigm of sustainability, 2012, 207-211.
7. Choudhary VK, Kumar SP, Bhagawati R. Integrated weed management in black gram (*Vigna mungo* L.) under mid hills of Arunachal Pradesh. Indian Journal of Agronomy. 2012; 57(4):382-385.
8. Gomez KA, Gomez AA. Statistical procedures for agricultural Research. A Willey-Interscience Publication, John Willey and Sons, New York, 2008.
9. Kumar S. 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, 2014.
10. Mundra SL, Maliwal PL. Influence of quizalofop-ethyl on narrow-leaved weeds in black gram and its residual effect on succeeding crops. Indian Journal of Weed Science. 2012; 44(4):231-234.
11. Pankaj SC, Dewangan PK. 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. 2017; 6(11):865-881.
12. Punia R. 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, 2014.
13. Sasikala K, Boopathi SN, Ramachandra M, Ashok P. 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. 2014; 4(1):81-91.
14. Sharma D, Bhardwaj R, Maheshwari V. Inhibition of photosynthesis by oxyfluorfen. Current Science. 1989; 58(23):1334-1336.
15. Singh R, Chaudhary GR. Effect of weed control and phosphorus on yield attributes of green gram (*Phaseolus radiatus)*. Indian Journal of Agronomy. 1992; 37(2):373-374.
16. Upasani RR, Barla S, Hassan D, Puran AN. Weed management in black gram and its residual effect on succeeding mustard crop. Indian Journal of Weed Science. 2017; 49(4):346-349.