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Response of different weed management practices on growth and yield of black gram (*Vigna mungo* L.) under irrigated conditions of Punjab

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Abstract
The field experiment was carried out during the summer season of 2021-2022 to study the response of different weed management practices on growth and yield of black gram. Cyperus sp., *Phyllanthus niruri*, *Trianthema portulacastrum*, *Amaranthus viridis* were the dominant weeds. It was observed that besides weed free treatment the lowest weed count, dry weight of weeds (3.66 g m^{-2}), weed index (2.73%) as well as highest weed control efficiency (60.06%) were found with the pre-emergence (PE) application of pendimethalin1 kg ha^{-1} followed by one hand weeding at 40 days after sowing (DAS). The maximum growth attributes, yield attributes and yield were found with the pre-emergence application of Pendimethalin 1 kg a.i. ha^{-1} followed by one hand weeding at 40 DAS which was statistically at par with pre emergence application of Pendimethalin 1 kg a.i. ha^{-1} followed by post emergence application of imazethapyr 75 g a.i. ha^{-1} at 40 days after sowing. The economics parameters were recorded highest with the application of Pendimethalin (PE) 1 kg a.i. ha^{-1} followed by one hand weeding at 40 days after sowing. Hence Pendimethalin is most effective treatment among the other treatments.

Keywords: Blackgram, chemical control, integrated weed management, pendimethalin, growth, yield

Introduction
Black gram (*Vigna mungo* L.) is one of the important pulses grown in different agro-ecological areas throughout the country in summer and rainy season. It is also called Urd bean or Mash bean and belongs to the family Leguminaceae and subfamily Papilionaceae. It is the fourth most important pulse crop in India after Chickpeas, Pigeon pea and Green gram. It is widely cultivated in terms of area in Rajasthan (38.39 lakh ha), Madhya Pradesh (21.14 lakh ha), Maharashtra (19.28 lakh ha), Karnataka (18.32 lakh ha), Uttar Pradesh (8.53 lakh ha), Jharkhand (4.23 lakh ha), Tamil Nadu (1.79 lakh ha) In Punjab, it was grown on 2.0 thousand hectare in 2019-20 and total production was recorded 1.2 thousand tons (Anonymous. 2020) [1].
Black gram has a wide range of adaptability and has the ability to withstand stress conditions. It is a self-pollinated legume crop. It contains 24% protein, 60% carbohydrates, 1.3% fat, 3.2% minerals, 0.9% fiber, 154 mg calcium, 385 mg phosphorus, 9.1 mg iron and a small amount of vitamin B complex (Anonymous 2020) [1]. It can increase soil fertility because it can fix around 70-90 kg N ha^{-1}. After removing the pods, the plants can be used as high-quality green fodder or dry fodder or green manure (Carvalho *et al.* 2015) [3].
There are various factors which contribute to low yield of black gram. Among those various factors weeds are considered the most important. The losses caused by weeds exceed the losses caused by any other type of agricultural pests, such as insects, nematode, disease, rodents etc. The crop is not a good competitor against weeds during early stage (Choudhary *et al.* 2012) [2]. Black gram is generally grown in rainfed conditions during the *kharif* season, where weeds are the main cause of low crop productivity. Weeds at critical period of crop-weed competition caused reduction of 80-90% in yield depending upon type and intensity of weed infestation (Kumar *et al.* 2018) [6]. Uncontrolled weeds have been reported to cause a considerable reduction (46-53%) in seed yield of black gram (Singh *et al.* 2016) [9].

To control weeds, the traditional method of weed control i.e. hand weeding although is very effective but it is expensive, tedious and time consuming (Yadav *et al.* 2009) [11]. Due to this weeds are controlled by mechanical, chemical and biological methods which can be used alone or in combination with more than one method. 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. Imazethapyr, a broad-spectrum herbicide, has soil and foliar activity that allows flexibility in its application timing and has low mammalian toxicity (Tan *et al.* 2005) [10]. Pendimethalin is basically a pre-emergence herbicide that can effectively control weeds in beans.

Materials and Methods

The field experiment was conducted during summer season of the year 2021-22 at Campus for Research and Advanced Studies, Dhablan, G.S.S.D.G.S. Khalsa College, Patiala. The field experiment is situated at about 30º19' North latitude, 76º 24' East longitude and altitude of 247 meter above the mean sea level. The cultivar of Black gram MASH 1008 was sown in lines during second week of April at spacing of 30 cm × 10 cm with the help of hand seed drill following all the recommended package and practices (Anonymous 2020) [1]. The soil of the experimental field was clayey in texture having pH 7.3. The soil was medium in available nitrogen (295.13 kg ha^{-1}), phosphorous (18.25 kg ha^{-1}) and potassium (157.59 kg ha^{-1}). The organic carbon was (0.6%). There were 11 weed control treatments *viz.* weedy check, weed free, one hand weeding (HW) at 20days after sowing (DAS), two HW at 20 and 40 DAS, Pendimethalin (PE) 1kg ha^{-1}, Pendimethalin (PE) 1kg ha^{-1} followed by one HW at 40 DAS, imazethapyr (PoE) 0.075 kg ha^{-1} at 20 DAS, quizalofop-ethyl (PoE) 0.050 kg ha^{-1} at 20 DAS, Pendimethalin (PE) 1kg ha^{-1} followed by imazethapyr (PoE) 0.075 kg ha^{-1} at 40 DAS, quizalofop-ethyl (PoE) 0.050 kg ha^{-1}at 20 DAS + HW at 40 DAS, Straw mulch (5 t ha^{-1}) and making the 33 experimental units. The data regarding weed and growth parameters were recorded at 25 and 50 DAS and at harvest stage. The data on number of weeds and dry weight of weeds were transformed using (√X+0.5) before subjected to statistical analysis and then weed control efficiency (WCE) was calculated. The experiment was laid out in randomized block design with three replications.

Details of layout

Experimental design	Randomized Block Design
No. of replications	3
No. of treatments	11
Total number of plots	33
Spacing	30 × 10 cm
Gross plot size	3.6 m × 4.05 m
Net plot size	3.3 m × 3.9 m
Variety	MASH 1008

Treatment Details

T_1	Weedy check
T_2	Weed free
T_3	One HW at 20 DAS
T_4	Two HW at 20 and 40 DAS
T_5	Pendimethalin (PE) 1 kg ha^{-1}
T_6	Pendimethalin (PE) 1 kg ha^{-1} *fb* one HW at 40 DAS
T_7	Imazethapyr (PoE) 0.075 kg ha^{-1} at 20 DAS
T_8	Quizalofop-ethyl (PoE) 0.050 kg ha^{-1} at 20 DAS
T_9	Pendimethalin (PE) 1 kg ha^{-1}*fb* Imazethapyr (PoE) 0.075 kg ha^{-1} at 40 DAS
T_{10}	Quizalofop-ethyl (PoE) 0.050 kg ha^{-1} at 20 DAS + HW at 40 DAS
T_{11}	Straw mulch (5 t ha^{-1})

Results and Discussion

Effect of different weed management practices on weeds population, dry weight of weeds (g m^{-2}), weed control efficiency (%) and weed index (%) at harvest of black gram.

The predominant weeds noticed in blackgram field were Cyperus sp., *Phyllanthus niruri*, *Trianthema portulacastrum*, *Amaranthus viridis*. As a result of this experiment, it was observed that beside weed free treatment, the lowest number of weeds, dry weight of weeds (3.66 g m^{-2}) and weed index (2.73%), highest weed control efficiency (60.06%) was recorded with an application of Pendimethalin (PE) 1 kg ha^{-1} followed by one HW at 40 DAS as shown in table no. 2. This might be due to the initial flush of weed germination were restricted by Pendimethalin herbicide and in later stage weeds were controlled by manual weeding. Our results are in comparison with the study conducted by Kumar *et al.* (2005) [5] in which it was recorded that with the application of Pendimethalin (PE) in combination with raised seed bed planting significantly less number of weeds along with increased yield of black gram were obtained.

Table 1: Effect of different weed management practices on weeds population at harvest of black gram

Treatments	(*Cyperus* sp.)	Phyllanthus niruri	Trianthema portulacastrum	Amaranthus viridis
T_1: Weedy check	4.81 (22.17)	3.89 (14.17)	4.25 (17.10)	4.43 (18.68)
T_2: Weed free	0	0	0	0
T_3: One HW at 20 DAS	4.20 (16.67)	2.97(7.85)	3.5(11.25)	3.95 (14.65)
T_4: Two HW at 20 and 40 DAS	3.76 (13.18)	2.66 (6.10)	2.99 (7.95)	3.06 (8.41)
T_5: Pendimethalin (PE) 1 kg ha^{-1}	4.27 (17.28)	3.02 (8.16)	3.59(11.93)	3.73 (12.95)
T_6: Pendimethalin (PE) 1 kg ha^{-1} *fb* one HW at 40 DAS	3.45 (10.95)	2.42 (4.87)	2.71 (6.35)	2.93 (7.62)
T_7: Imazethapyr (PoE) 0.075 kg ha^{-1} at 20 DAS	3.93 (14.52)	2.78(6.73)	3.22 (9.37)	3.34 (10.16)
T_8: Quizalofop-ethyl (PoE) 0.050 kg ha^{-1} at 20 DAS	4.01 (15.16)	2.83 (7.05)	3.3 (9.89)	3.37 (10.36)
T_9: Pendimethalin (PE) 1 kg ha^{-1} *fb* Imazethapyr (PoE) 0.075 kg ha^{-1} at 40 DAS	3.65 (12.37)	2.57(5.65)	2.83(7.03)	3.02 (8.14)
T_{10}: Quizalofop-ethyl (PoE) 0.050 kg ha^{-1} at 20 DAS + HW at 40 DAS	3.86 (13.91)	2.73 (6.47)	3.10 (8.64)	3.20 (9.26)
T_{11}: Straw mulch (5 t ha^{-1})	4.11 (15.95)	2.91 (7.52)	3.38 (10.47)	3.45 (10.94)
SE (d)±	0.11	0.23	0.12	0.5
C.D. at 5%	0.26	0.56	0.25	0.12

Table 2: Effect of different weed management practices on dry weight of weeds (g m-^{2}), weed control efficiency (%), weed index (%) at harvest of black gram

Treatments	Dry weight of weeds (g m-^{2})	Weed control efficiency (%)	Weed index (%)
T_1: Weedy check	7.03 (48.46)	0	44.26
T_2: Weed free	0	100.00	0
T_3: One HW at 20 DAS	5.18 (25.85)	32.88	24.65
T_4: Two HW at 20 and 40 DAS	4.01 (15.10)	52.55	15.94
T_5: Pendimethalin (PE) 1 kg ha^{-1}	5.45 (28.75)	33.01	35.45
T_6: Pendimethalin (PE) 1 kg ha^{-1} *fb* one HW at 40 DAS	3.66 (12.41)	60.06	2.73
T_7: Imazethapyr (PoE) 0.075 kg ha^{-1} at 20 DAS	4.52 (19.42)	45.71	19.96
T_8: Quizalofop-ethyl (PoE) 0.050 kg ha^{-1} at 20 DAS	4.63 (20.51)	43.47	22.14
T_9: Pendimethalin (PE) 1 kg ha^{-1} *fb* Imazethapyr (PoE) 0.075 kg ha^{-1} at 40 DAS	3.96 (14.75)	56.81	11.31
T_{10}: Quizalofop-ethyl (PoE) 0.050 kg ha^{-1} at 20 DAS + HW at 40 DAS	4.2 (16.64)	48.71	19.36
T_{11}: Straw mulch (5 t ha^{-1})	4.77 (21.89)	40.25	31.51
SE (d)±	0.14	1.68	0.08
C.D. at 5%	0.32	3.50	0.16

Effect of different weed management practices on growth parameters of black gram

Beside weed free treatment, maximum plant height (39.50 cm), dry weight plant^{-1} (11.94 g), number of branches plant^{-1} (6.48), leaf area index (1.31) were recorded with an application of Pendimethalin (PE) 1 kg ha^{-1} followed by one HW at 40 DAS. The minimum values of all the growth parameters were observed under the weedy check. There is lesser crop-weed competition which resulted in the higher utilization of available nutrients and moisture by the crop that results in the vigorous growth of black gram plants. Khot *et al.* (2016) [8] and Komal *et al*. (2015) [7] conducted an experiment to study the effect of different sowing time and weed management practices with respect to yield, quality and nutrient uptake on summer black gram and observed significant reduction in weed growth with the application of Pendimethalin followed by one HW at 40 DAS.

Table 3: Effect of different weed management practices on growth parameters of black gram

Treatments	Plant height (cm)	Dry weight plant^{-1}	Number of branches plant^{-1}	Leaf area index
T_1: Weedy check	24.73	7.20	4.83	0.97
T_2: Weed free	40.90	12.17	7.10	1.43
T_3: One HW at 20 DAS	26.53	8.55	5.42	1.04
T_4: Two HW at 20 and 40 DAS	35.10	10.31	6.16	1.25
T_5: Pendimethalin (PE) 1 kg ha^{-1}	25.57	7.80	5.25	0.99
T_6: Pendimethalin (PE) 1 kg ha^{-1}followed by one HW at 40 DAS	39.50	11.94	6.48	1.31
T_7: Imazethapyr (PoE) 0.075 kg ha^{-1} at 20 DAS	31.27	9.53	5.67	1.18
T_8: Quizalofop-ethyl (PoE) 0.050 kg ha^{-1} at 20 DAS	30.23	9.08	5.59	1.15
T_9: Pendimethalin (PE) 1 kg ha^{-1} *followed by* Imazethapyr (PoE) 0.075 kg ha^{-1} at 40 DAS	37.87	10.90	6.25	1.29
T_{10}: Quizalofop-ethyl (PoE) 0.050 kg ha^{-1} at 20 DAS + HW at 40 DAS	33.27	9.93	5.98	1.20
T_{11}: Straw mulch (5 t ha^{-1})	28.27	8.84	5.48	1.09
SE (d)±	2.15	0.79	0.16	0.02
C.D. at 5%	4.48	1.65	0.33	0.03

Effect of different weed management practices on the yield parameters of black gram

The yield parameters were significantly influenced with an application of different weed control parameters. The maximum yield attributing parameters such as number of pods plant^{-1} (25.22), number of seed pod^{-1} (5.69) and seed index (4.72 g) as

well as grain yield (12.81 q ha^{-1}), straw yield (27.84 q ha^{-1}), biological yield (38.65 q ha^{-1}) and harvest index (33.06%) were recorded with the application of Pendimethalin (PE) 1 kg ha^{-1}followed by one HW at 40 DAS. While the minimum yield was recorded from the weedy check. It might be due to the effective integrated weed control treatments as it minimized the state of crop-weed competition, so that the plants do not face the moisture or nutrients stress conditions might be due to lesser weed infestation. With the better nutrient supply and weed competition free optimum soil environment, the seed size of crop ultimately improves and results in the enhancement of all the yield parameters.

Table 4: Effect of different weed management practices on the yield parameters of black gram

Treatments	No. of pods plant^{-1}	No. of seed pod^{-1}	Seed index (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Biological yield (q ha^{1})	Harvest index (%)
T_1: Weedy check	21.64	4.97	4.07	7.34	18.85	26.19	28.06
T_2: Weed free	25.40	5.80	4.80	13.17	29.22	42.39	31.07
T_3: One HW at 20 DAS	23.48	5.15	4.29	9.91	23.49	33.40	29.69
T_4: Two HW at 20 and 40 DAS	24.96	5.53	4.63	11.07	25.25	36.32	30.49
T_5: Pendimethalin (PE) 1 kg ha^{-1}	23.02	5.09	4.20	8.50	21.08	29.58	28.76
T_6: Pendimethalin (PE) 1 kg ha^{-1}followed by one HW at 40 DAS	25.22	5.69	4.72	12.81	27.84	38.65	33.06
T_7: Imazethapyr (PoE) 0.075 kg ha^{-1} at 20 DAS	24.43	5.38	4.51	10.54	24.46	35.00	30.10
T_8: Quizalofop-ethyl (PoE) 0.050 kg ha^{-1} at 20 DAS	24.03	5.29	4.44	10.24	24.21	34.45	29.71
T_9: Pendimethalin (PE) 1 kg ha^{-1} followed by Imazethapyr (PoE) 0.075 kg ha^{-1} at 40 DAS	25.08	5.60	4.67	11.68	26.49	37.28	31.34
T_{10}: Quizalofop-ethyl (PoE) 0.050 kg ha^{-1} at 20 DAS HW at 40 DAS	24.81	5.43	4.56	10.62	24.87	35.49	29.93
T_{11}: Straw mulch (5 t ha^{-1})	23.70	5.22	4.37	9.02	21.91	30.93	29.11
SE (d)±	0.13	0.098	0.29	0.55	0.72	0.75	0.86
C.D. at 5%	0.26	0.20	0.62	1.15	1.51	1.57	1.80

Effect of different weed management practices on economy of black gram

The economic parameters such as gross return, net return and benefit cost ratio (B:C ratio) was significantly influenced by all the weed treatments. The highest gross return (Rs. 80703), net return (Rs.55297) and B:C ratio (2.18) was observed with an application of Pendimethalin (PE) 1 kg ha^{-1} followed by one HW at 40 DAS.

Table 5: Effect of different weed management practices on economy of black gram

Treatments	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
T_1: Weedy check	46,242	25,392	1.21
T_2: Weed free	82,971	53,721	1.84
T_3: One HW at 20 DAS	62,433	38,783	1.64
T_4: Two HW at 20 and 40 DAS	69,741	43,291	1.64
T_5: Pendimethalin (PE) 1 kg ha^{-1}	53,550	30,944	1.37
T_6: Pendimethalin (PE) 1 kg ha^{-1} followed by one HW at 40 DAS	80,703	55,297	2.18
T_7: Imazethapyr (PoE) 0.075 kg ha^{-1} at 20 DAS	66,402	44,542	2.04
T_8: Quizalofop-ethyl (PoE) 0.050 kg ha^{-1} at 20 DAS	64,512	41,502	1.80
T_9: Pendimethalin (PE) 1 kg ha^{-1} followed by Imazethapyr (PoE) 0.075 kg ha^{-1} at 40 DAS	73,584	49,978	2.12
T_{10}: Quizalofop-ethyl (PoE) 0.050 kg ha^{-1} at 20 DAS + HW at 40 DAS	66,906	41,096	1.59
T_{11}: Straw mulch (5 t ha^{-1})	56,826	32,076	1.30
SE (d)±	3464	3464	0.13824
C.D. at 5%	7226	7226	0.28836

Conclusion

The current study revealed that among all the treatments, the application of Pendimethalin (PE) 1 kg ha^{-1} followed by one HW at 40 DAS gives the profitable results with respect to the growth, yield as well as economic parameters and was found most efficient treatment to control the weeds.

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