E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; SP-7(8): 716-719
Received: 03-06-2024
Accepted: 11-07-2024

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Strategies for effective weed management in black gram (*Phaseolus mungo* L. Hepper) cultivation

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DOI: https://doi.org/10.33545/2618060X.2024.v7.i8Si.1478

Abstract
At Krishi Vigyan Kendra Farm in Dera Baba, Reasi, Jammu and Kashmir, India, a field experiment was repeated in 2022 and 2023 to select an appropriate herbicide for controlling weeds in rainfed blackgram. Pendimethalin (1.0 kg/ha) applied before emergence (PE) and quizalofop-ethyl (50 g/ha) applied 25 days after seeding (DAS) were the herbicides tested. The average seed yield of 0.82 t/ha, 48.35 percent higher than the grain yield of the control, showed that the herbicides reduced weed density and increased weed control efficiency (92.10 percent). Pendimethalin (PE) 1.0 kg/ha fb quizalofop-ethyl 50 g/ha (PoE) is an affordable and effective weed control method for rainfed blackgram.

Keywords: Blackgram, imazethapyr, pendimethalin, quizalofop-ethyl, weed control efficiency, yield and economics

Introduction

Pulses, also known as "the wizard of health," play a crucial role in the agricultural economy of India. When it comes to nutrition, they are the actual entryway to sustainable agriculture and a wonderful gift from nature to the living world. With 22% of the world's pulse output coming from this nation and is the leading producer, Grain legumes are fascinating because to their special capacity to meet their own nitrogen needs, rapid maturity, adaptability to a variety of agroclimatic and soil conditions, ability to provide crop cover against erosion, and ability to supply organic matter through leaf falls. The country has a very limited supply of pulses, compared to WHO recommendations of 80 grams per person. Over 80 million children in the nation continue to be protein- and energy-poorly fed (Mondal *et al*. 2004) [5]. As a result, there is a pressing need for time to increase average pulse productivity, and blackgram can play a significant role in meeting protein requirements.

The blackgram (*Phaseolus mungo* L. Hepper), a member of the leguminosae family of pulses, is also referred to as urd, udid, mash, or mungo. Its origins are in central Asia and India. In addition to having a significant number of amino acids including cystine, methionine, and lysine, the grain has 24% protein (Poehlman, 1991) [7]. It is also a good source of minerals (3.2%), fat (1.4%), and carbs (60%). Being a leguminous crop, it increases soil fertility and health by fixing atmospheric nitrogen to the soil by around 70-90 kg ha^{-1} through symbiosis.

Black gram's primary growing regions in India are Andhra Pradesh, Bihar, Madhya Pradesh, Maharashtra, Uttar Pradesh, West Bengal, Punjab, Haryana, Tamil Nadu, Karnataka, Orissa, and Gujarat. With an average yield of 555 kg/ha, India produces 1.5 to 1.9 million tons of black gram yearly from around 3.5 million hectares of land, making it the world's largest producer and consumer of the crop. India produces over 70% of the black gram used worldwide. Weed infestation is the main issue with blackgram production, especially during the *Kharif* season. Companion weeds fight for light, moisture, nutrients, and space. The inability and high cost of labor, along with persistent rains, make it challenging to physically pull weeds during the crucial stage of crop growth-a crucial step toward increased agricultural yield (Adhikary 2016) [1]. Unchecked weeds have been shown to significantly lower blackgram seed output in the summer (Bhandari *et al*., 2004) [2] and the Kharif season (Rathi *et al*., 2004) [8], by as much as 46-53 percent.

In Jammu and Kashmir, weeds cause more losses than any other group of agricultural pests. Thus, in these conditions, it could be preferable to employ herbicides to manage weeds, especially in the early stages, since this will control the weeds that have been growing for a long time. With a few exceptions, farmers in blackgram do not employ chemical weed management. Instead, they apply pre emergence herbicides and then manually weed one or two areas. Singh *et al*. (2014) [11] advocated for the use of post-emergence herbicide in order to lessen the demand for human labor and manage the second flush of weeds in pulse crops. Hence, the present study was undertaken to evaluate various weed management practices during critical period of crop weed competition in blackgram under rainfed conditions.

Materials and Methods

The experiment was conducted during two consecutive *Kharif* seasons of 2022 and 2023 at the Krishi Vigyan Kendra Farm, Reasi (latitude: 33.24096 N, longitude: 74.9681E and altitude: 391.21m) Dera Baba, Reasi, Jammu and Kashmir, India. This soil was medium in organic carbon content (0.67%) and the available nutrient status was medium range of nitrogen, phosphorus and the potassium status was high with neutral in soil reaction. The variety used was 'PU31'. The experiment was laid out in randomized block design with seven treatments, *viz*. pre-emergence application (PE) of pendimethalin 1.0 kg/ha (PE) fb interculture 25 days after seeding (DAS); interculture 15 DAS fb postemergence application (PoE) of imazethapyr 100 g/ha at 25 DAS; interculture 15 DAS fb quizalofop-ethyl 50 g/ha at 25 DAS; pendimethalin 1.0 kg/ha (PE) fb imazethapyr 100 g/ha at 25 DAS; pendimethalin1.0 kg/ha (PE) fb quizalofop-ethyl 50 g/ha 25 DAS; weed-free and weedy check. The test herbicides were sprayed with the spray volume of 500 liters/ha using knapsack sprayer with flood jet deflector WFN 040 nozzle. All the other recommended agronomic and plant protection measures were adopted to raise the crop and the intercultural practices were taken as need based. The data on weed density and biomass were recorded at 45 DAS and weed control efficiency (WCE) of different treatments was computed using data on weed biomass. The data were analyzed following analysis of variance (ANOVA) technique and mean differences were adjusted by the multiple comparison test.

Results and Discussion

Effect on weeds: The major weeds at the experimental site were: Cynodondactylon, Dactyloctenium aegyptium, Digitaria sanguinalis, Panicum maximum, Eleusine indica, Cyperus rotundus, Commelina bengalensis, Ageratum conyzoides, Euphorbia hirta, Tribulus terrestris, Trianthema monogynya, Fimbristylis penera, Digera arvensis, Cleome viscosa, Celosia argentia etc. Similar observations were made by Balyan *et al*. (2016) [3].

The weedy check had the greatest reported weed density (108.33 /m^2) and weed biomass (80.22 g /m^2) at 45 DAS (Table 1). The herbicide treatments pendimethalin 1.0 kg/ha (PE) fb quizalofop-ethyl 50 g/ha at 25 DAS and pendimethalin 1.0 kg/ha (PE) fb interculture 25 DAS and pendimethalin 1.0 kg/ha (PE) fb imazethapyr 100 g/ha at 25 DAS were the most effective at reducing weed density (11.67/m^2) at 45 DAS. These treatments were statistically superior to all other weed management strategies, with the exception of weed free treatment.

Table 1: Effect of different weed control treatments on weed density and biomass at 45 DAS of blackgram (pooled value)

Treatment	Weed density (no./m^2) 45 DAS	Weed b iomass (g/m^2) 45 DAS	Weed control efficiency (%) 45 DAS	Weed infestation (%)
Pendimethalin 1.0 kg/ha (PE) fb interculture 25 DAS	16.67	9.62	88.01	23.26
Interculture 15 DAS fb imazethapyr 100 g/ha 25 DAS	22.33	17.6	78.06	28.88
Interculture 15 DAS fb quizalofop-ethyl 50 g/ha 25 DAS	20.67	15.58	80.58	27.31
Pendimethalin 1.0 kg/ha (PE) fb imazethapyr 100 g/ha 25 DAS	14.33	10.78	86.56	20.67
Pendimethalin 1.0 kg/ha (PE) fb quizalofop-ethyl 50 g/ha 25 DAS	11.67	6.34	92.10	17.50
Weed-free	6.67	2.68	96.66	10.81
Weedy check	108.33	80.22	0	66.33
LSD (p=0.05)	5.98	3.24	-	-

With pendimethalin 1.0 kg/ha (PE) and fb quizalofop-ethyl 50 g/ha at 25 DAS, there was an impressive decrease in weed biomass (6.34 g/m^2) at 45 DAS. Balyan *et al*. (2016) [3] also reported that the application of pendimethalin 1.0 kg/ha (PE) fb quizalofop-ethyl 50 g/ha 30 DAS decreased weed biomass by almost 86%. At 25 DAS (92.10 percent), pendimethalin 1.0 kg/ha (PE) fb quizalofop-ethyl 50 g/ha and weed-free had the highest weed control efficacy (96.66 percent) at 45 DAS (Table 1). Other herbicides, such as pendimethalin, imazethapyr, and quizalofop-ethyl, were also found to be effective at controlling weeds, either on their own or in combination (78.06 to 88.01%).

The ability of weeds to withstand various herbicide treatments and their effectiveness in eradicating the weeds is expressed by the weed persistence index (WPI) and herbicide efficacy index (HEI) (Table 2). The pendimethalin 1.0 kg/ha (PE) fb interculture 25 DAS and the pendimethalin 1.0 kg/ha (PE) fb quizalofop-ethyl 50 g/ha 25 DAS had the lowest WPI (0.73%). Pendimethalin 1.0 kg/ha (PE) fb quizalofop-ethyl 50 g/ha 25 DAS generated greater HEI (11.85%) than all other herbicidal treatments. In weed-free plots, the maximum crop resistance index (CRI), 58.31, was observed. Similar findings were also made by Balyan *et al*. (2016) [3] in Blackgram.

Effect on crop

Germination was minimally affected by herbicide treatment (Table 3), with 93.50% to 97.23% of seeds germinating. Blackgram crop nodulation was clearly affected by herbicides. The number of root nodules affected by each treatment varied from 21.00 to 25.33. The highest number of nodules per plant (25.33) was observed in weed-free plots. After pre-emergence spraying with pendimethalin at 1.0 kg/ha and quizalofop-ethyl at 50 g/ha at 25 DAS, 24.00 nodules per plant were observed. While there were the fewest nodules in weedy check plots.

Significant variation in plant height were observed with pre-emergence and post-emergence herbicides applied alone or in combination ($p<0.05$). Plant height measured after pre-emergence treatment of pendimethalin (1.0 kg/ha) was 62.25 cm. The quizalofop-ethyl 50 g/ha at 25 DAS treatment yielded the highest height (61.67 cm) among the post-emergence treatments (Table 3). The maximum plant height of all the herbicidal treatments was reported at 25 DAS when quizalofop-ethyl 50 g/ha PoE and pendimethalin 1.0 kg/ha PE were applied together. The weedy check plots had the lowest plant heights (56.30 cm). There was no discernible difference in the tested herbicides' days to 50% bloom. Half of the blossoming has happened in 48 to 52 days. A comparable pattern was discovered by Balyan *et al*. (2016) [3].

Table 2: Effect of treatments on weed indices in blackgram (pooled value)

Treatment	HEI	WPI	CRI	WI	AMI
Pendimethalin 1.0 kg/ha (PE) fb interculture 25 DAS	6.62	0.78	14.96	7.89	-0.50
Interculture 15 DAS fb imazethapyr 100 g/ha 25 DAS	3.37	1.06	7.93	10.68	-0.46
Interculture 15 DAS fb quizalofop-ethyl 50 g/ha 25 DAS	3.91	1.02	9.06	9.71	-0.46
Pendimethalin 1.0 kg/ha (PE) fb imazethapyr 100 g/ha 25 DAS	6.42	1.02	13.86	4.37	-0.46
Pendimethalin 1.0 kg/ha (PE) fb quizalofop-ethyl 50 g/ha 25 DAS	11.85	0.73	24.50	0.61	-0.48
Weed-free	28.38	0.54	58.31	0.00	-0.50
Weedy check		0.00	1.00	1.00	48.67

HEI = Herbicide efficacy index; WPI= Weed persistence index; CRI = Crop resistance index; WI = Weed Index; AMI = Agronomic management index

The longest pod size (5.63 cm) was found in the weed-free plots, while the smallest pod size (5.27 cm) was found in the weedy check plots (Table 4). A pod measuring 5.50 cm in length was found in plots treated with pendimethalin 1.0 kg/ha and quizalofop-ethyl 50 g/ha, respectively.

Weed management techniques had a considerable impact on the number of pods per plant (Table 4). Applying pendimethalin 1.0 kg/ha (PE) fb quizalofop-ethyl 50 g/ha at 25 DAS resulted in a noticeably greater number of pods (17.55). Pendimethalin (1.0 kg/ha) and fb imazethapyr (100 g/ha) 25 DAS, however, were comparable to treatment T5. Weed-free plots had the greatest amount of pods per plant (19.24), whereas weedy check had the noticeably lowest number of pods per plant (14.5). The (T6) weed-free plots had the highest number of seeds per pod (8.86), followed by the (T5) pendimethalin 1.0 kg/ha (PE) fb quizalofop-ethyl 50 g/ha at 25 DAS (8.69). Conversely, the weedy check showed the fewest seeds per pod. Weed free had a significantly higher test weight (4.98 g), comparable to pendimethalin 1.0 kg/ha (PE) fb quizalofop-ethyl 50 g/ha at 25 DAS (4.66 g). Weedy check had the noticeably lowest test weight (3.67 g).

Table 3: Effect of different weed control treatments on growth parameters of blackgram (pooled value)

Treatment	Germination (%)	Plant height (cm)	Nodules/ plant	Days to 50% bloom
Pendimethalin 1.0 kg/ha (PE) fb interculture 25 DAS	94.67	62.25	23.67	48.33
Interculture 15 DAS fb imazethapyr 100 g/ha 25 DAS	95.33	59.59	22.67	51.67
Interculture 15 DAS fb quizalofop-ethyl 50 g/ha 25 DAS	94.23	61.67	21.67	50.67
Pendimethalin 1.0 kg/ha (PE) fb imazethapyr 100 g/ha 25 DAS	93.50	60.59	22.00	49.67
Pendimethalin 1.0 kg/ha (PE) fb quizalofop-ethyl 50 g/ha 25 DAS	97.23	63.39	24.00	51.33
Weed-free	97.00	65.42	25.33	50.33
Weedy check	96.5	56.30	21.00	49.67
LSD (P=0.05)	-	2.65	3.14	-

Table 4: Effect of different weed control treatments on yield attributing characters, yield and economics of blackgram (pooled value)

Treatment	Pod size (cm)	Pods/ plant	Seeds / pod	100-seed weight (g)	Yield (t/ha)	Yield increase (%)	Gross cost (x10^3 `/ha)	Gross return (x10^3 `/ha)	BB:C ratio
Pendimethalin 1.0 kg/ha (PE) fb interculture 25 DAS	5.47	16.40	7.87	4.59	0.76	44.27	24.75	41.74	1.69
Interculture 15 DAS fb imazethapyr 100 g/ha 25 DAS	5.43	15.98	7.38	4.28	0.74	42.53	24.60	40.48	1.65
Interculture 15 DAS fb quizalofop-ethyl 50 g/ha 25 DAS	5.33	16.33	7.55	4.39	0.74	43.15	24.65	40.92	1.66
Pendimethalin 1.0 kg/ha (PE) fb imazethapyr 100 g/ha 25 DAS	5.20	17.45	8.05	4.43	0.79	46.32	24.85	43.34	1.74
Pendimethalin 1.0 kg/ha (PE) fb quizalofop-ethyl 50 g/ha 25 DAS	5.50	17.55	8.69	4.66	0.82	48.35	24.54	45.04	1.84
Weed-free	5.63	19.24	8.86	4.98	0.82	48.67	25.50	45.32	1.78
Weedy check	5.27	14.50	6.56	3.67	0.42	0.00	21.50	23.26	1.08
LSD (P=0.05)	1.37	2.01	1.28	NS	0.13	-	-	-	-

A seed yield of 0.82 t/ha was achieved when pendimethalin 1.0 kg/ha (PE) fb quizalofop-ethyl 50 g/ha 25 DAS was applied, representing a 48.35 percent increase over the weedy control (Table 4). When weeds were removed, the blackgram seed output increased by the greatest percentage (48.67%) when compared to the weedy check. While there was a positive correlation between the seed yield and plant density (number/m^2), pods/plant, seed/pod, and 100-seed weight (g), there was a negative correlation between the weed biomass and overall weed density. This could be the result of less crop weed competition during the crop growth phase as a result of improved characteristics of crop growth brought about by effective weed management. These results concurred with Rajput and Kushwah (2004) [10] and Singh *et al*. (2014) [11]. The weed-free condition had the best gross return (45320) and B:C ratio (1.78), whereas the pendimethalin 1.0 kg/ha (PE) fb quizalofop-ethyl 50 g/ha at 25 DAS had the highest B:C ratio (1.84). Applying pendimethalin 1.0 kg/ha (PE) and fb quizalofop-ethyl 50 g/ha at 25 DAS might be an alternate, cost-effective method of controlling weeds in blackgram under a rainfed conditions in the Shivalik foothills.

Conclusion

the field experiments conducted at Krishi Vigyan Kendra Farm in Dera Baba, Reasi, Jammu and Kashmir, demonstrated that the combination of Pendimethalin (1.0 kg/ha) applied before emergence and Quizalofop-ethyl (50 g/ha) applied 25 days after seeding significantly enhances weed control and blackgram yield. This herbicide regimen not only achieved the highest weed control efficiency (92.10%) but also resulted in an impressive 48.35% increase in seed yield compared to the weedy check. The pendimethalin plus quizalofop-ethyl treatment provided a notable improvement in yield attributes such as pod size, pods per plant, and seed weight, while maintaining cost-effectiveness with the highest benefit-cost ratio (1.84). These findings underscore the efficacy and affordability of this herbicide combination for managing weeds in rainfed blackgram cultivation in the region. Thus, adopting this method can significantly boost blackgram production while addressing the prevalent weed issues under rainfed conditions.

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