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Efficacy of Pre and Post Emergence Herbicides against Complex Weed Flora, Yield and Economics of Blackgram under High Hills Wet Temperate Zone of Himachal Pradesh

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ABSTRACT

Background: Implementing integrated strategies for weed management is essential in maximizing blackgram yield. Unchecked weed proliferation leads to substantial decrease in crop productivity.

Methods: The current field experiment was conducted at Salooni, Himachal Pradesh, to evaluate the efficacy of different integrated weed management practices during *Kharif* 2022 and 2023. Eleven treatments targeting weed control were evaluated both at pre and post - emergence stages.

Result: The predominant weeds were *Echinochloa colona*, *Galinsoga parviflora*, *Cyperus* species and other broad leaf weeds were *Plantago lanceolata*, *Trifolium repens*, *Trianthema* species, *Ageratum conyzoides*. Data on weed dynamics revealed that; after weed-free treatment, the application of Imazethapyr 75 g/ha as PE fb HW at 30 DAS; Pendimethalin 1.0 kg/ha as PE fb HW at 30 DAS and Pendimethalin 1.0 kg/ha + imazethapyr 75 g/ha (PE) recorded a significantly lower total weed count as compared to other treatments. Parameters related to blackgram growth and yield, including plant height, number of branches per plant, pods per plant, grain yield, and haulm yield were significantly higher with weed-free treatment followed by application of imazethapyr 75 g/ha as PE fb HW at 30 DAS, remaining at par with application of pendimethalin 1.0 kg/ha + imazethapyr 75 g/ha (PE) and pendimethalin 1.0 kg/ha as PE fb HW at 30 DAS. The most economically efficient weed control method was the combination of pendimethalin 1.0 kg/ha + imazethapyr 75 g/ha (PE), as it resulted in the highest net returns and marginal benefit-cost ratio.

Key words: Blackgram, *Echinochloa colona,* Economics, Imazethapyr, Integrated weed management, Pendimethalin.

INTRODUCTION

In India, blackgram [*Vigna mungo* (L.) Hepper] holds the position of the fourth most valuable pulse crop, following chickpea, pigeonpea and greengram (Kaur *et al*., 2018; Kumar *et al*., 2023). Blackgram is also an important *Kharif* season pulse in Himachal Pradesh, cultivated across 9.4 thousand hectares, resulting in a production of 12 thousand tonnes and a productivity of 1286 kg/ha. While the yield of blackgram in the state surpasses the national average of 555 kg/ha, it falls below the potential of top varieties in the region, which is estimated at 1600 kg/ha (Kumar *et al*., 2013; Rana *et al*., 2019a and b).

Weeds are the primary production constraints, posing a substantial obstacle in realizing full production potential of a crop. Massive infestation of weeds remains a primary factor contributing to insufficient production, particularly during the *Kharif* season (July-September) (Mansoori *et al*., 2015). Weed competition further is the rigorous biological constraint to production in short-statured crops, particularly in the case of *Kharif* blackgram in Himachal Pradesh due to luxurious growth of weeds because of abundant rainfall in the growing season. Reports indicate that up to 45 per cent of the yield losses in blackgram; can be attributed to weed infestation (Kumar *et al*., 2013; Yadav *et al*., 2015). Blackgram receives less priority in Himachal Pradesh and is mainly cultivated in poor and marginal soils. Effective management of weeds in pulses has a potential to enhance both yield and nitrogen fixation. Blackgram exhibits limited competitiveness against weeds, particularly during the early stages of growth (3 to 6 weeks after sowing). Consequently, weed infestation during this critical phase intensifies crop-weed competition, leading to substantial yield losses (Choudhary *et al*., 2012; Shaktawat *et al*., 2020). Hence, there is a urgent need for suitable weed control method; as weeds cause more harm to agricultural crops than the accumulated damage caused by all other pests and diseases. Therefore, weed management

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using adequate means becomes very important to attain a high crop yield. Pendimethalin is the recommended pre-emergence herbicide for weed control in blackgram in Himachal Pradesh. However, its effectiveness in controlling all types of weeds is limited and it has restricted application period with relatively less persistent effects. Additionally, if pendimethalin is not applied as a pre-emergence measure, it cannot be utilized as post-emergence. In contrast, imazethapyr is a broad-spectrum herbicide (Rao *et al*., 2010; Rana *et al*., 2019 a and b) with the potential to manage both broad-leaved and grassy weeds in pulses. It can be employed in pre-sowing incorporation and during both Pre and Post periods. Furthermore, imazethapyr exhibits a long-term persistence effect, making it more favourable choice for weed control in pulses compared to pendimethalin. However, the Integrated Weed Management (IWM) approach holds significance in weed management as it prevents the shift of weeds towards perennial nature and guards against weed resistance to herbicides. The primary objective of this study is to evaluate various weed control options available and to identify the best treatment in terms of efficacy and economics.

MATERIALS AND METHODS

Experimental site

The field experiment was conducted at the research farm of Mountain Agricultural Research and Extension Station, Salooni (Chamba), Himachal Pradesh, India, during *kharif* 2022 and 2023. The farm is situated at 32°43′17.89″N latitude and 76°3′5.47″E longitude and has an elevation of 1725.22 m above sea level in the western part of the Himalayas. The experimental area is a part of high hills wet temperate zone of Himachal Pradesh.

Treatments and design

The field experiment was designed with eleven weed control treatments *viz*., T_1: Pendimethalin 1 kg/ha as PE fb quizalofop-p-ethyl 50 g/ha at 30 DAS; T_2: Pendimethalin 1 kg/ha as PE fb imazethapyr 75 g/ha at 30 DAS; T_3: Pendimethalin 1 kg/ha + imazethapyr 75 g/ha (PE); T_4: Pendimethalin 1 kg/ha as PE fb HW at 30 DAS; T_5: Oxyfluorfen 150 g/ha as PE fb quizalofop-p-ethyl 50 g/ha at 30 DAS; T_6: Oxyfluorfen 150 g/ha as PE fb imazethapyr 75 g/ha at 30 DAS; T_7: Oxyfluorfen 150 g/ha as PE fb HW at 30 DAS; T_8: Imazethapyr 75 g/ha as PE fb quizalofop-p-ethyl 50 g/ha at 30 DAS; T_9: Imazethapyr 75 g/ha as PE fb HW at 30 DAS; T_{10}: Weed free; and T_{11}: weedy check (no weed control). Weed management treatments were arranged in randomized block design (RBD) with three replications. The herbicides were applied as per treatments using a knapsack sprayer fitted with a flat fan nozzle at spray volume of 600 litres of water ha^{-1}.

Crop establishment method and management

Blackgram cultivar, Palampur 93, was sown at a plant spacing of 30 cm × 10 cm, on 4th July 2022 and 2nd July 2023 and harvested on 14th October 2022 and 20th October 2023. The crop was supplied with a fertilizer dose of 20 kg N, 40 kg P_2O_5 and 20 kg K_2O per hectare. Basal nutrients were applied through IFFCO complex fertilizer (12:32:16) and urea (46% N). Observations on the weed count were recorded after 1 month (30 DAS, days after sowing), 2 months (60 DAS) and at harvest through a quadrant (25cm × 25cm) in two randomly selected spots in each plot, which were then transformed into a one square metre area.

Economics

Gross returns were calculated by multiplying the value of the per unit yield in rupees and the yield obtained. Gross returns as a result of weed control were computed by deducting the gross returns obtained in the weedy check from the gross returns obtained in the weed management treatment.

Net returns =
Gross returns due to weed control - Cost of weed control

$$\text{Marginal Benefit - Cost ratio} = \frac{\text{Net returns due to weed control}}{\text{Cost of weed control}}$$

$$\text{Weed Index} = \frac{\text{Yield from weed free - Yield of particular treatment}}{\text{Yield of weed free}} \times 100$$

Statistical analysis

Weed count data were subjected to square-root transformation $\sqrt{x+0.5}$ to account for non-normality of distribution. The data were subjected to statistical analysis using analysis of variance (ANOVA) for the randomized block design to test the significance of overall differences among the treatments through the "F" test. Conclusions were drawn at the 5% probability level.

RESULTS AND DISCUSSION

Weed flora

The experimental field was infested with grassy, broadleaf weeds and sedges (Fig 1). Weed flora in blackgram were composed of *Echinochloa colona* (21-22%), *Galinsoga parviflora* (18-19%) and *Cyperus* species (17-20%). The other weeds *viz*., *Plantago lanceolata*, *Trifolium repens,Trianthema* species, *Ageratum conyzoides* as a whole constituted 40-43% of the total weed flora. Rana *et al*. (2019) also reported that in Himachal Pradesh, major weeds affecting blackgram include *Echinochloa* sp., *Dactyloctenium aegyptium* and *Cyperus iria*, which contributes to significant crop yield reductions.

Effect on weeds

Data on weed count were recorded at 30 DAS (Days after sowing), 60 DAS and at harvest. The impact of different weed control treatments on weed counts is illustrated graphically in Fig 2a and 2b for the years 2022 and 2023, respectively. It is evident from the figures that after weed free plots, application of pendimethalin 1.0 kg/ha + imazethapyr 75 g/ha (PE) had lower weed density at 30 DAS followed by imazethapyr 75 g/ha as PE fb HW 30 DAS as compared to other treatments for both the years. This reduction can be attributed to the more effective suppression of both grasses

and broad-leaved weeds during the early stages of crop growth with the application of imazethapyr. At 60 DAS, total weed count was less with pendimethalin 1 kg/ha as PE fb HW 30 DAS and imazethapyr 75 g/ha as PE fb HW 30 DAS. This was due to the complete removal of all weed types through hand weeding at 30 DAS. A similar trend was observed in total weed count at the harvest of the blackgram crop. These findings are in conformity with Rana *et al*. (2019), who observed that the application of imazethapyr at 80g/ha as a pre-emergence treatment was at par with imazethapyr at 70g/ha pre-emergence and the pre-emergence application of imazethapyr+ pendimethalin pre-mix resulted in significantly lower weed count and dry weight. Chandrakar *et al.* (2014) also supported the efficacy of early post-emergence application (15-20 DAS) of imazethapyr at 40g/ha and pendimethalin + imazethapyr as a pre-emergence treatment against weeds in black gram. The treatments constituting of oxyfluorfen 150 g/ha were toxic to blackgram and these plots shows less germination of crop as well as weeds.

The combination of pendimethalin + imazethapyr was more successful in controlling weeds. The increase in weed density and dry weight in various treatments can be attributed to the continuous growth of weeds with a higher competitive

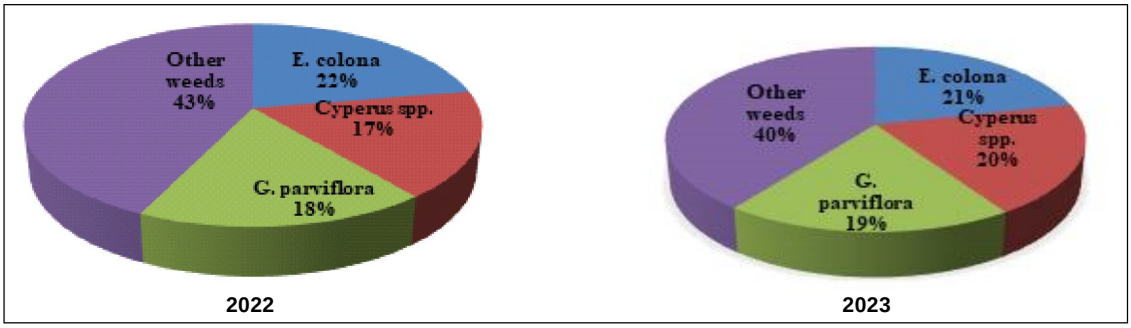

Fig 1: Distribution of weeds in experimental blackgram field and their density (%).

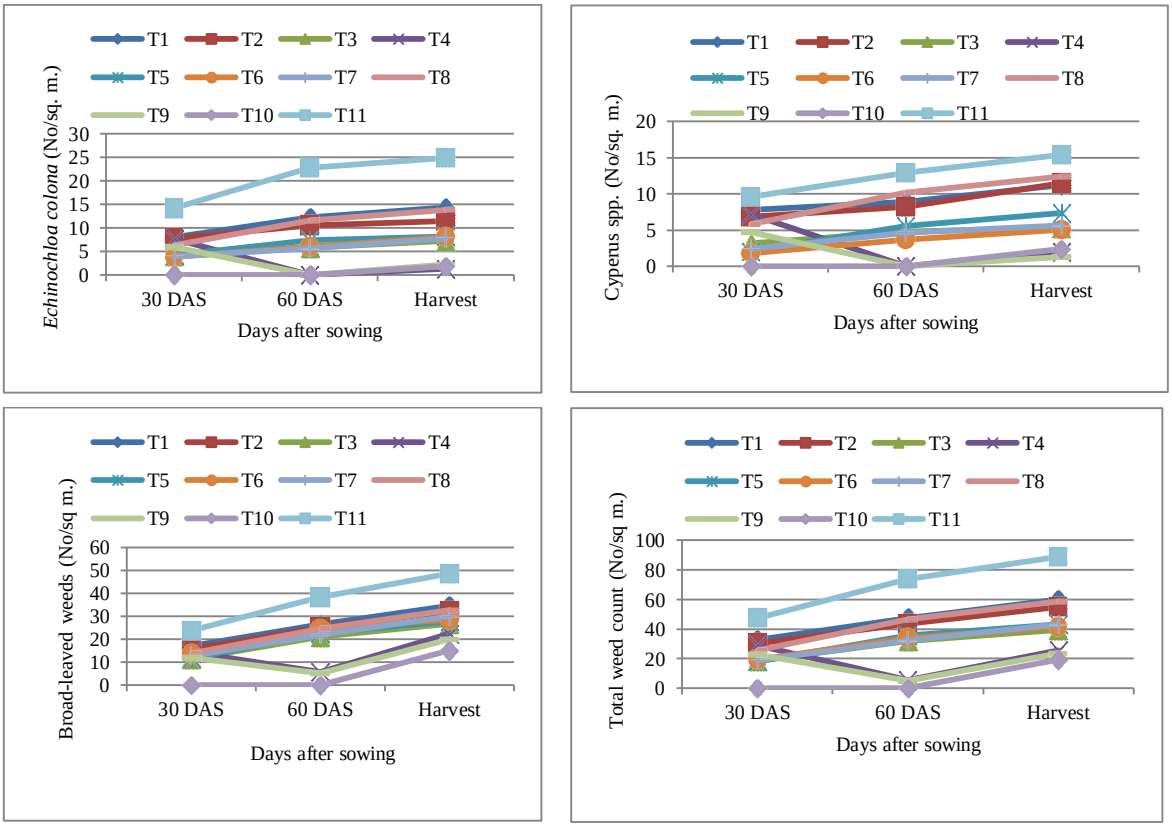

Fig 2a: Effect of treatments on count of major weeds in blackgram during 2022.

ability than the crop. The pre-emergent application of herbicides, such as pendimethalin + imazethapyr, initially inhibits the germination of weed flora. However, with time, the herbicide dissipates and deactivates in the soil, leading to subsequent increase in the next flush of weeds.

All weed control treatments significantly reduced weed density in blackgram compared to the weedy check (Table 1). With the exception of the application of imazethapyr 75 g/ha as PE fb HW 30 DAS, pendimethalin 1 kg/ha as PE fb HW 30 DAS and pendimethalin 1.0 kg/ha + imazethapyr 75 g/ha (PE) had recorded significantly lower total weed count as compared to other treatments. The weed index, which signifies the percentage decrease in yield compared to weed-free conditions (achieved through hand weeding in the current scenario), exhibited its highest value in the weedy check treatment followed by oxyfluorfen 150 g/ha as PE fb imazethapyr 75 g/ha at 30 DAS and oxyfluorfen 150 g/ha as PE fb HW at 30 DAS.

Effect on crop growth and yield attributes

Weed control treatments resulted in significant variation in plant height, number of branches per plant and pod number per plant of blackgram (Table 2). After weed free, the application of imazethapyr 75 g/ha as PE fb HW 30 DAS remaining at par with pendimethalin 1.0 kg/ha + imazethapyr 75 g/ha (PE) and pendimethalin 1 kg/ha as PE fb HW 30 DAS; had significantly higher values for growth parameters and yield attributes *viz.*, plant height, number of branches per plant and number of pods per plant. The weedy check treatment had recorded lower values for growth attributing characters. The maximum plant height observed under the noted treatments might be attributed to a reduced weed population, leading to decreased competition for soil moisture, solar radiation, plant nutrients and space during the active growth period. This reduction in competition likely resulted in better nutrient availability, fostering rapid cell development and facilitating luxurious crop growth. Similar results were reported by Susmitha *et al.* (2019). The higher number of branches and pods per plant obtained could be attributed to the effective control of weeds including grasses, broad-leaved plants and sedges, during the early crop growth period. This finding aligns with results reported by Yadav *et al.* (2015). The treatments containing oxyfluorfen at 150 g/ha were found to be toxic to black gram.

Effect on seed and haulm yield

The data pertaining to grain yield and haulm yield varied significantly due to different weed management practices and is presented in the Table 3. In 2022, significantly the highest seed yield was recorded with weed free which remained at par with imazethapyr 75 g/ha as PE fb HW 30 DAS. Application of imazethapyr 75 g/ha as PE fb HW 30 DAS also remained at par with the application of pendimethalin 1.0 kg/ha + imazethapyr 75 g/ha (PE) and

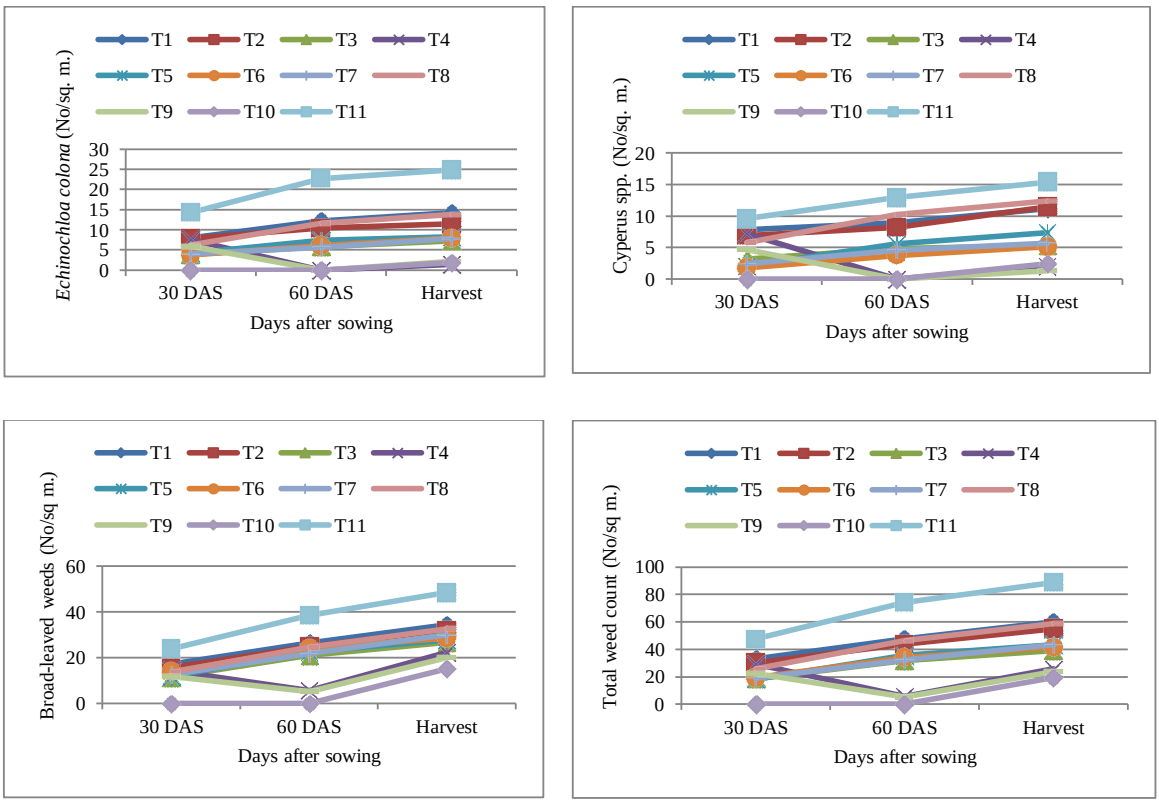

Fig 2b: Effect of treatments on count of major weeds in blackgram during 2023.

Table 1: Effect of weed control treatments on count of weeds (No.m^{-2}) in blackgram.

Treatment	*E. colona*		*Cyperus* spp.		Broad-leaf weed		Total weed count		Weed index
	2022	2023	2022	2023	2022	2023	2022	2023	Pooled
Pendimethalin 1 kg/ha as PE fb quizalofop-p-ethyl 50 g/ha at 30 DAS	3.4 (11.5)	2.5 (5.8)	3.1 (9.3)	3.2 (10.0)	5.1 (26.0)	5.1 (25.6)	6.8 (46.8)	6.4 (41.4)	27.8
Pendimethalin 1 kg/ha as PE fb imazethapyr 75 g/ha at 30 DAS	3.2 (9.9)	2.5 (5.8)	3.0 (8.9)	3.2 (9.8)	4.9 (24.2)	4.9 (23.7)	6.5 (43.0)	6.2 (39.2)	21.2
Pendimethalin 1 kg/ha + imazethapyr 75 g/ha (PE)	2.5 (5.6)	2.4 (5.9)	2.2 (4.4)	2.3 (5.0)	4.4 (19.8)	4.4 (19.1)	5.4 (29.8)	5.4 (30.0)	7.3
Pendimethalin 1 kg/ha as PE fb HW at 30 DAS	1.6 (3.0)	2.2 (4.4)	1.7 (3.1)	2.2 (4.3)	3.7 (14.1)	3.3 (11.3)	4.4 (20.2)	4.4 (20.1)	10.1
Oxyfluorfen 150 g/ha as PE fb quizalofop-p-ethyl 50 g/ha at 30 DAS	2.6 (6.6)	2.6 (6.2)	2.3 (5.0)	2.5 (5.7)	4.5 (20.7)	4.5 (20.2)	5.6 (32.3)	5.6 (32.1)	42.6
Oxyfluorfen 150 g/ha as PE fb imazethapyr 75 g/ha at 30 DAS	2.5 (6.0)	2.4 (5.6)	2.0 (3.5)	2.1 (4.2)	4.7 (22.2)	4.6 (21.4)	5.6 (31.7)	5.6 (31.2)	45.7
Oxyfluorfen 150 g/ha as PE fb HW at 30 DAS	2.5 (5.8)	2.3 (5.1)	2.2 (4.2)	2.3 (4.8)	4.6 (21.5)	4.5 (20.7)	5.6 (31.5)	5.5 (30.5)	47.4
Imazethapyr 75 g/ha as PE fb quizalofop-p-ethyl 50 g/ha at 30 DAS	3.3 (10.6)	2.7 (6.8)	3.1 (9.5)	3.2 (10.0)	4.8 (23.7)	4.8 (23.2)	6.6 (43.7)	6.3 (40.0)	22.8
Imazethapyr 75 g/ha as PE fb HW at 30 DAS	1.6 (2.7)	2.5 (6.0)	1.4 (2.0)	1.9 (3.2)	3.5 (12.3)	3.2 (10.2)	4.0 (17.0)	4.4 (19.4)	5.8
Weed free	1.0 (0.6)	0.9 (0.4)	1.0 (0.8)	1.1 (0.9)	1.8 (5.0)	1.7 (4.7)	2.0 (6.5)	1.9 (6.0)	0.0
Weedy check	4.6 (20.6)	5.1 (26.4)	3.6 (12.6)	3.7 (13.6)	6.1 (36.9)	6.0 (36.5)	8.3 (70.1)	8.7 (76.5)	63.3
SE(m±)	0.3	0.2	0.3	0.2	0.4	0.3	0.5	0.4	-
LSD(P=0.05)	1.0	0.6	0.9	0.6	1.0	1.0	1.6	1.2	-

Value in parentheses indicate the means of original values. Data transformed to square root transformations ($\sqrt{x+0.5}$).

Table 2: Effect of weed control treatments on growth and yield attributes of blackgram.

Treatment	Plant height (cm)			No. of branches/plant			Pods/plant		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
Pendimethalin 1 kg/ha as PE fb quizalofop-p-ethyl 50 g/ha at 30 DAS	47.1	45.7	46.4	5.0	4.7	4.8	21.3	21.0	21.2
Pendimethalin 1 kg/ha as PE fb imazethapyr 75 g/ha at 30 DAS	51.5	51.6	51.6	5.3	5.7	5.5	23.0	23.3	23.2
Pendimethalin 1 kg/ha + imazethapyr 75 g/ha (PE)	54.6	53.4	54.0	5.7	6.0	5.8	27.7	26.7	27.2
Pendimethalin 1 kg/ha as PE fb HW at 30 DAS	55.4	54.9	55.2	6.0	5.7	5.8	27.3	28.3	27.8
Oxyfluorfen 150 g/ha as PE fb quizalofop-p-ethyl 50 g/ha at 30 DAS	39.4	39.6	39.5	4.3	4.3	4.3	18.3	18.0	18.2
Oxyfluorfen 150 g/ha as PE fb imazethapyr 75 g/ha at 30 DAS	41.7	41.0	41.4	4.7	4.3	4.5	17.3	17.7	17.5
Oxyfluorfen 150 g/ha as PE fb HW at 30 DAS	41.8	41.5	41.7	5.0	5.0	5.0	17.0	17.0	17.0
Imazethapyr 75 g/ha as PE fb quizalofop-p-ethyl 50 g/ha at 30 DAS	49.6	48.8	49.2	5.0	5.3	5.2	22.3	22.7	22.5
Imazethapyr 75 g/ha as PE fb HW at 30 DAS	55.6	53.4	54.5	6.0	6.7	6.3	28.7	29.0	28.8
Weed free	64.7	62.2	63.5	7.3	8.0	7.7	33.7	34.3	34.0
Weedy check	35.8	35.1	35.4	3.7	3.3	3.5	14.7	14.0	14.3
SE(m±)	0.6	0.6	0.5	0.4	0.3	0.2	1.1	0.6	0.4
LSD(P=0.05)	1.7	1.8	1.6	1.2	1.0	0.7	3.1	1.8	1.1

pendimethalin 1 kg/ha as PE fb HW 30 DAS. However, in 2023 weed free treatment being at par with imazethapyr 75 g/ha as PE fb HW 30 DAS and pendimethalin 1.0 kg/ha + imazethapyr 75 g/ha (PE) had the highest seed yield. This might be attributed to the lower weed population, creating a favorable environment for the crop with minimal competition from weeds. This condition led to a higher photosynthetic accumulation rate and improved translocation to the sink. The trend in haulm yield of blackgram was similar during both the years of study. Sasikala *et al.* (2014) observed that application of imazethapyr 100 g/ha at 15 days after sowing (DAS) provided excellent control of both grasses and broad-leaf weeds in blackgram, resulting in a higher yield. Ramesh *et al.* (2016) reported higher seed yield of blackgram with application of different levels of imazethapyr as compared to quizalofop ethyl. Aggarwal *et al.* (2014) also reported the effectiveness of imazethapyr with 75 and 100 g/ha applied at 15 DAS in blackgram, leading to increased crop yield. The weedy check, on the other hand, had registered the lowest seed yield.

Economics

The cost of weed control treatments was computed based on the current market prices of various common and variable agro-inputs. The economics presented in Table 4 revealed that maintaining weed-free conditions incurred the highest cost on weed control. Gross returns were highest due to weed free, but its highest cost of cultivation resulted in lower net return due to weed control in this treatment than pendimethalin 1.0 kg/ha + imazethapyr 75 g/ha (PE), imazethapyr 75 g/ha as PE fb HW 30 DAS and pendimethalin

Table 3: Effect of weed control treatments on seed and haulm yield of blackgram.

Treatment	Seed yield (kg/ha)			Haulm yield (kg/ha)		
	2022	2023	Pooled	2022	2023	Pooled
Pendimethalin 1 kg/ha as PE fb quizalofop-p-ethyl 50 g/ha at 30 DAS	991	973	982	1487	1460	1472
Pendimethalin 1 kg/ha as PE fb imazethapyr 75 g/ha at 30 DAS	1035	1108	1072	1553	1663	1608
Pendimethalin 1 kg/ha + imazethapyr 75 g/ha (PE)	1222	1299	1261	1834	1949	1891
Pendimethalin 1 kg/ha as PE fb HW at 30 DAS	1216	1230	1223	1824	1845	1833
Oxyfluorfen 150 g/ha as PE fb quizalofop-p-ethyl 50 g/ha at 30 DAS	785	778	781	1177	1167	1171
Oxyfluorfen 150 g/ha as PE fb imazethapyr 75 g/ha at 30 DAS	733	744	739	1100	1117	1108
Oxyfluorfen 150 g/ha as PE fb HW at 30 DAS	719	712	716	1079	1068	1073
Imazethapyr 75 g/ha as PE fb quizalofop-p-ethyl 50 g/ha at 30 DAS	1046	1054	1050	1569	1581	1575
Imazethapyr 75 g/ha as PE fb HW at 30 DAS	1268	1294	1281	1902	1941	1921
Weed free	1348	1373	1360	2022	2059	2041
Weedy check	503	495	499	755	743	748
SE(m±)	27	28	20.4	41	42	31
LSD(P=0.05)	80	83	60.4	120	125	89.4

Table 4: Economics of treatments as influenced by different weed control treatments in blackgram.

Treatment	Gross return (INR/ha)			Cwc	GRwc	NRwc	MBCR
	2022	2023	Mean				
Pendimethalin 1 kg/ha as PE fb quizalofop-p-ethyl 50 g/ha at 30 DAS	128608	126290	127449	2967	62157	59190	20.0
Pendimethalin 1 kg/ha as PE fb imazethapyr 75 g/ha at 30 DAS	134292	143806	139049	2722	73757	71035	26.1
Pendimethalin 1 kg/ha + imazethapyr 75 g/ha (PE)	158597	168545	163571	2022	98279	96257	47.6
Pendimethalin 1 kg/ha as PE fb HW at 30 DAS	157725	159549	158637	9467	93345	83878	8.9
Oxyfluorfen 150 g/ha as PE fb quizalofop-p-ethyl 50 g/ha at 30 DAS	101802	100946	101374	2570	36081	33511	13.0
Oxyfluorfen 150 g/ha as PE fb imazethapyr 75 g/ha at 30 DAS	95106	96577	95841	2325	30549	28224	12.1
Oxyfluorfen 150 g/ha as PE fb HW at 30 DAS	93287	92382	92835	8370	27542	19172	2.3
Imazethapyr 75 g/ha as PE fb quizalofop-p-ethyl 50 g/ha at 30 DAS	135714	136757	136235	2155	70943	68788	31.9
Imazethapyr 75 g/ha as PE fb HW at 30 DAS	164512	167897	166204	9705	100912	91207	9.4
Weed free	174903	178104	176503	29050	111211	82161	2.8
Weedy check	65292	64226	64759	0	-533	-533	
SE (d±)	3520	3668	2675				
LSD (P=0.05)	10383	10820	7893				

Cwc: Cost on weed control; GRwc: Gross return due to weed control; NRwc: Net return due to weed control; MBCR: Marginal benefit-cost ratio.

1 kg/ha as PE fb HW 30 DAS. Maximum MBCR of 47.6 was recorded in pendimethalin 1.0 kg/ha + imazethapyr 75 g/ha (PE), followed by imazethpyr 75 g/ha as PE fb quizalofop-p-ethyl 50 g/ha at 30 DAS, pendimethalin 1 kg/ha as PE fb imazethapyr 75 g/ha at 30 DAS and pendimethalin 1 kg/ha as PE fb quizalofop-p-ethyl 50 g/ha at 30 DAS. Mansoori *et al.* (2015) observed that applying imazethapyr + imazamox (pre-mix) at 50 g/ha as post-emergence (20 DAS) resulted in the highest net returns and B: C in blackgram. This was followed by imazethapyr + pendimethalin (pre-mix) at 1000 g/ha as pre-emergence. In a similar vein, Ram *et al.* (2013) reported higher gross and net returns with imazethapyr at 75 and 100 g/ha compared to 50 g/ha in soybean. Aggarwal *et al.* (2014) also reported that in blackgram, application of imazethapyr at 100 g/ha at 15 DAS produced the highest gross and net returns, closely followed by imazethapyr at 100 g/ha applied at 25 DAS and hand weeding twice.

CONCLUSION

Weeds in blackgram are a major factor responsible for yield reduction as they reduce the crop yield by 62.7 and 64% during 2022 and 2023 respectively. Here, the application of herbicides reduced the weed infestation and increased the crop yield by more than double when compared with the weedy check. The application of imazethapyr 75 g/ha as PE fb HW at 30 DAS, pendimethalin 1 kg/ha as PE fb HW 30 DAS and pendimethalin 1.0 kg/ha + imazethapyr 75 g/ha (PE) were found to be the most efficient methods in controlling weeds as well as in raising crop yields. However, the application of pendimethalin 1.0 kg/ha + imazethapyr 75 g/ha (PE) produced the highest net returns (due to weed control) of Rs. 96257 and marginal benefit-cost ratio of 47.6.

Conflict of Interest

The authors declare no conflict of interest.

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