Indian Journal of Weed Science **53**(2): 158–163, 2021

Print ISSN 0253-8040 Online ISSN 0974-8164

Efficacy of sequential application of pre- and early post-emergence herbicides for management of weeds in blackgram

M. Jagadesh* and M. Raju

Tamil Nadu Rice Research Institute, Aduthurai, Tamil Nadu 612101, India

**Email: jagadesh743gmail.com*

Article information

DOI: 10.5958/0974-8164.2021.00029.0

Type of article: Research article

Received : 1 January 2021
Revised : 29 April 2021
Accepted : 2 May 2021

Key words
Blackgram
Early post-emergence
Pre-emergence
Nail weeder
Weed management

ABSTRACT

Field experiments were conducted at Tamil Nadu Rice Research Institute, Aduthurai, Thanjavur district, Tamil Nadu, India to evolve efficient and economic weed management practices for irrigated blackgram during *Kharif* (rainy season) 2018 and winter 2018-19. The results revealed that pre-emergence application of pendimethalin1.0 kg/ha on 3 DAS *fb* acifluorfen-sodium (16.5%) + clodinafop-propargyl (8% EC) 187.5 g/ha on 20 DAS effectively reduced weed density and dry matter production. Consequently, higher seed yields of 1.05 and 1.01 t/ha in the *Kharif* and winter seasons were recorded, respectively. The increase was 15.2, 78.7, and 9.2, 86.9% over hand weeding twice, unweeded check in *Kharif* and winter seasons, respectively. Among the treatment combinations, adoption of pendimethalin *fb* acifluorfen-sodium + clodinafop-propargyl on 20 DAS had highest gross return (₹ 64,234 and 72,383/ha), net return (₹ 37,374 and 44,722/ha) and B:C (2.39 and 2.62) during *Kharif* and winter seasons, respectively. Hence, this weed management practice could be a viable and cost effective in irrigated blackgram for enhancing production and productivity of blackgram.

INTRODUCTION

Blackgram (*Vigna mungo* L.) is one of the important pulse crops grown in India by contributing about 10% of total pulse production (Anonymous 2018). It can be cultivated in all seasons, but most of the area is under irrigated conditions. India produces about 1.5 to 1.9 million tonnes of blackgram annually from about 3.5 million hectares of area with average productivity of 555 kg/ha (Anonymous 2018). In Tamil Nadu, blackgram is one of the valuable crops among the pulses grown under both irrigated and rainfed situations. Recently, the area under winter blackgram is also increasing in Tamil Nadu due to higher demand in the market. It occupies an area of 0.354 million hectares with a production of 0.259 million tonnes and productivity of 731 kg/ha (Anonymous 2018). Severe competition by weeds especially under high rainfall, high temperature, and high humidity is the major reason for the low productivity. The weeds reduce blackgram yield as high as 66% (Singh *et al.* 2017). Most of the farmers are adopting hand weeding twice which consumes huge labours, time, and is also less economic under high rainfall conditions. Blackgram is very sensitive to weed infestation especially during the first four weeks of its growth period (Randhawa *et al.* 2002). Pre-emergence herbicides control weeds only upto a short period and thereafter late-emerging weeds start competing with crops. Therefore, the best alternative to mitigate crop-weed competition right from the early stages of the crop is either the use of pre-emergence and early post-emergence herbicides alone or in sequence. Keeping the above aspects and constraints in view, this experiment was undertaken to study the efficacy of sequential application of pre- and early post-emergence herbicides in blackgram under irrigated conditions.

MATERIALS AND METHODS

The field experiments were carried out in irrigated blackgram during *Kharif* 2018 and winter season 2018-19 in North Farm (Field No. B2b and F3b) of Tamil Nadu Rice Research Institute, Aduthurai, Thanjavur, Tamil Nadu, India. The experimental site was located in the Cauvery Delta Zone of Tamil Nadu at an altitude of 19.5 m above mean sea level, 11°00’ N latitude, and 79° 28’ E longitude. This location experiences a tropical humid climate with a hot dry summer from March to June and cool wet winter from September to February. Here North-East monsoon plays a major role in rainfall. The field soil in *Kharif* was sandy loam and neutral in pH (7.4) with low in available N (221 kg/

ha), medium in available P (16 kg/ha) and K (249 kg/ ha). While in winter season, the field soil was sandy loam and neutral in pH (7.3) with available N 260 kg/ ha, P 21 kg/ha and K 276 kg/ha. The crop (VBN 8) was sown on 12.06.2018 during *Kharif* 2018 and 10.12.2018 during winter 2018-19 using a seed rate of 20 kg/ha and at a row spacing of 30 × 10 cm. Nine treatments consisted of pendimethalin 1.0 kg/ha applied at 3 DAS + hand weeding at 20 DAS, pendimethalin 1.0 kg/ha applied at 3 DAS+ mechanical weeding with nail weeder on 20 DAS, acifluorfen-sodium (16.5%) + clodinafop-propargyl (8% EC) 187.5 g/ha applied as early post emergence(20 DAS), propaquizafop (2.5%) + imazethapyr (3.75% ME) 125g/ha at 20 DAS, pendimethalin 1.0 kg/ha on 3 DAS *fb* acifluorfen-sodium (16.5%) + clodinafop-propargyl (8% EC) 187.5 g/ha at 20 DAS, pendimethalin 1.0 kg/ha on 3 DAS *fb* propaquizafop (2.5%) + imazethapyr (3.75% ME) 125 g/ha at 20 DAS, two mechanical weeding with nail weeder on 15 and 30 DAS, two hand weeding at 15 and 30 DAS, and weedy check in a randomized block design replicated thrice. Knap-sack sprayer fitted with flat-fan nozzle was used for applying herbicides using a spray volume of 500 L/ha. Nail weeder was operated in between crop rows at field capacity by moving in "to and fro" step-wise. Except for weed management practices, rest of all the crop cultivation practices were followed commonly across treatments for proper crop establishment and growth. The square root transformation method $\sqrt{x+0.5}$ was used to normalize the weed data distribution.

RESULTS AND DISCUSSION

Weed flora

The occurrence of weed species in the experimental fields was 29% grasses, 50.5% sedges, and 20.5% broad-leaved weeds (BLW). Grassy weed *Panicum javanicum* (42%) was dominating over other two *i.e*. *Echinochloa colona* (33%) and *Cynodon dactylon* (25%). In sedges, *Cyperus rotundus* (77%) was dominant than *Cyperus difformis* (33%). While among broad-leaved weeds, *Phyllanthus maderas-patensis* (36%) was dominant followed by *Acalypha indica* (14%),*Cleome viscose* (17%), *Eclipta alba* (10%), *Euphorbia geniculate* (4%), *Ipomoea obscura* (5%), *Malvastrum coromandelianum* (6%), and *Physalis minima* (8%).

Weed density

Total weed density was significantly influenced by different weed management practices in both seasons at all stages **(Table 1)**. Among the various weed management practices, hand weeding twice recorded lower weed density of 8.1 and 7.5 no./m^2 at 20 DAS during *Kharif* and winter seasons, respectively. Whereas at 40 and 60 DAS, application of pendimethalin *fb* acifluorfen-sodium + clodinafop-propargyl was found to be significantly superior in reducing total weeds to the minimum level of 15.9, 20.8 and 9.5, 13.3 no./m^2 in *Kharif* and winter seasons, respectively. It was on par with pendimethalin *fb* propaquizafop + imazethapyr. Pre-emergence application of pendimethalin on 3 DAS controlled the germination of weeds effectively in the very early stage itself. The effective weed control by pendimethalin during the early crop growth period was further extended upto 60 DAS by sequential application of early post-emergence herbicide acifluorfen-sodium + clodinafop-propargyl or propaquizafop + imazethapyr at 20 DAS. This might be due to suppressing the weeds even up to the later crop growth stages and also due to broad-spectrum weed control during both seasons.

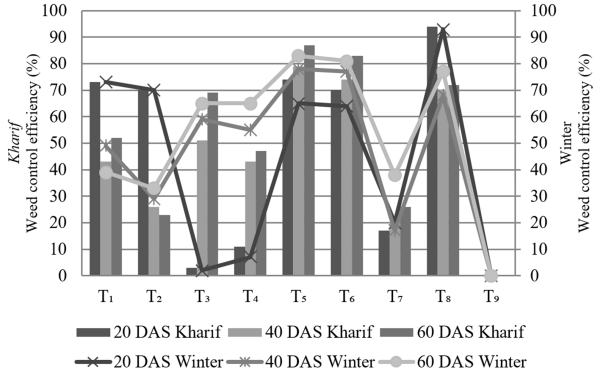
Weed dry matter

Weed management treatments exerted a significant effect on total weed dry matter at all stages in both seasons **(Table 1)**. Irrespective of the weed management practices, total weed dry matter ranged from 18.8 to 322.4 and from 22.5 to 330.7 kg/ha in the *Kharif* and winter season. At 20 DAS, hand weeding twice recorded the lowest total weed dry matter as compared to other treatments in both seasons. At 40 DAS, total weed dry matter ranged from 142.5 to 675.4 and from 113.5 to 845.7 kg/ha in the *Kharif* and winter seasons, respectively. Application of pendimethalin *fb* acifluorfen-sodium + clodinafop-propargyl showed lesser total weed dry matter of 142.5 and 113.5 kg/ha in the *Kharif* and winter seasons, respectively. It was closely followed by pendimethalin *fb* propaquizafop + imazethapyr and hand weeding twice. Unweeded control registered significantly higher dry matter production (DMP) at 40 DAS. A similar trend was observed at 60 DAS in both seasons.

The dry matter accumulation of weeds is directly proportional to the yield decline of the crop rather than the weeds population by itself. Prevention of weed germination by pre-emergence application of pendimethalin at 3 DAS was the causal factor for greater reduction in weed dry matter in the early stage of crop growth. The application of pendimethalin showed lesser weed dry matter due to integration of early PoE herbicides acifluorfen-sodium + clodinafop-propargyl and propaquizafop + imazethapyr on 20 DAS at later stages. This result is in accordance with the findings of Panda (2015).

Weed control efficiency

Weed control efficiency (WCE) was higher with pendimethalin *fb* acifluorfen-sodium + clodinafop-propargyl at all the growth stages except at 20 DAS in both seasons **(Figure 1)**. At 20 DAS, hand weeding twice at 15 and 30 DAS registered WCE of 94.0 and 93.0% in *Kharif* and winter seasons, respectively. It was closely followed by pendimethalin PE, which registered 65 to 73% WCE in both seasons. Weed control efficiency was higher with pendimethalin *fb* acifluorfen-sodium + clodinafop-propargyl at 40 and 60 DAS irrespective of seasons. This might be due longer time and broad spectrum weed control provided by sequential application of these herbicides. Kewat *et al.* (2015) reported similar results on control of monocot and dicot weeds. Minimum WCE was associated with pendimethalin *fb* nail weeder and nail weeder twice at 15 and 30 DAS treatments in both seasons.



T_1- pendimethalin 1.0 kg/ha on 3 DAS + HW on 20 DAS, T_2- pendimethalin 1.0 kg/ha+ nail weeder on 20 DAS, T_3- acifluorfen-sodium (16.5%) + clodinafop-propargyl (8% EC) 187.5 g/ha on 20 DAS, T_4- propaquizafop (2.5%) + imazethapyr (3.75% ME) 125 g/ha on 20 DAS, T_5- pendimethalin 1.0 kg/ha on 3 DAS *fb* acifluorfen-sodium (16.5%) + clodinafop-propargyl (8% EC) 187.5 g/ha on 20 DAS, T_6- pendimethalin 1.0 kg/ha on 3 DAS *fb* propaquizafop (2.5%) + imazethapyr (3.75% ME) 125 g/ha on 20 DAS, T_7- two nail weeder on 15 and 30 DAS, T_8- two hand weeding on 15 and 30 DAS, T_9- weedy check.

Figure 1. Effect of weed management practices on weed control efficiency in irrigated blackgram

Growth attributes

The weed management practices were significantly influenced in DMP at 40 and 60 DAS except at 20 DAS in both seasons **(Table 2)**. At 20 DAS, higher crop dry matter production of 578 and 556 kg/ha was obtained with nail weeder during the *Kharif* season and pendimethalin *fb* propaquizafop + imazethapyr treatments during winter season. At 40 DAS, application of pendimethalin followed by acifluorfen-sodium + clodinafop-propargyl showed distinct variation in dry matter of 3.28 and 3.11 t/ha in *Kharif* and winter seasons, respectively. At 60 DAS, pendimethalin followed by acifluorfen-sodium + clodinafop-propargyl was significantly superior and recorded the highest DMP of 3.89 t/ha and 3.76 t/ha in *Kharif* and winter seasons, respectively. This was at par with pendimethalin *fb* propaquizafop + imazethapyr and hand weeding twice (3.70 t/ha). Unweeded check registered lower dry matter at all stages in both seasons.

Leaf area index was greater with herbicide applied plots over the unweeded check and two nail weeder at 15 and 30 DAS irrespective of stages and seasons **(Figure 2)**. At 40 DAS, pendimethalin followed by acifluorfen-sodium + clodinafop-propargyl was significantly superior and recorded

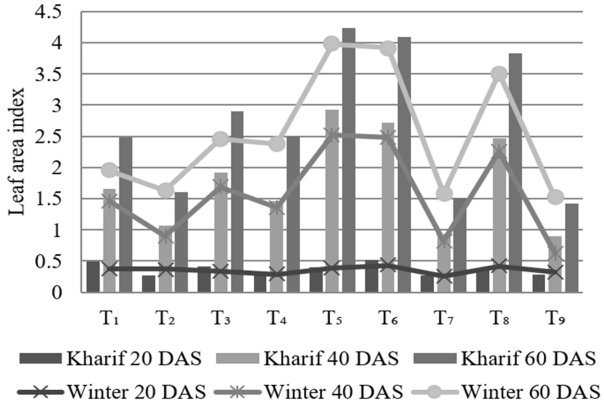
Table 1. Effect of weed management practices on density and dry weight of weed in irrigated blackgram

Treatment	Weed density (no./m^2)						Weed dry matter production (kg/ha)					
	20 DAS		40 DAS		60 DAS		20 DAS		40 DAS		60 DAS	
	Kharif	winter	*Kharif*	winter	*Kharif*	winter	*Kharif*	winter	*Kharif*	winter	*Kharif*	winter
Pendimethalin 3 DAS *fb* hand weeding 20 DAS	4.94 (24.8)	5.18 (27.2)	7.55 (57.1)	6.41 (41.3)	5.91 (34.9)	6.68 (44.6)	9.32 (86.9)	9.43 (88.9)	19.67 (387.6)	18.28 (334.9)	20.10 (406.6)	21.63 (468.6)
Pendimethalin 3 DAS *fb* Nail weeder 20 DAS	5.58 (31.1)	5.69 (32.7)	8.43 (71.5)	7.38 (55.5)	7.70 (59.2)	7.46 (55.8)	9.81 (96.5)	9.86 (98.2)	22.19 (496.5)	21.45 (465.5)	25.50 (650.2)	22.53 (508.2)
Acifluorfen-sodium + clodinafop-propargyl 20 DAS	9.31 (87.0)	8.57 (74.4)	6.94 (48.2)	5.98 (36.2)	5.66 (32.1)	5.63 (32.3)	17.68 (313.7)	17.96 (324.1)	18.17 (330.7)	16.32 (266.4)	16.29 (265.7)	16.23 (264.7)
Propaquizafop + imazethapyr 20 DAS	8.14 (66.8)	8.36 (70.9)	7.10 (50.8)	6.67 (45.3)	7.84 (61.6)	5.57 (31.6)	16.77 (286.6)	17.42 (307.2)	19.54 (384.6)	17.10 (293.9)	20.98 (444.6)	16.39 (268.6)
Pendimethalin 3 DAS *fb* acifluorfen-sodium + clodinafop-propargyl 20 DAS	4.93 (24.4)	5.45 (30.2)	3.91 (15.9)	4.51 (20.8)	3.07 (9.5)	3.89 (13.3)	9.22 (85.2)	10.65 (114.7)	11.72 (142.5)	12.01 (145.5)	10.53 (113.5)	11.18 (127.2)
Pendimethalin 3 DAS *fb* propaquizafop + imazethapyr 20 DAS	5.27 (28.0)	5.36 (28.7)	4.33 (19.2)	4.89 (24.1)	3.69 (13.7)	3.89 (15.2)	9.76 (96.4)	10.87 (118.5)	13.14 (173.4)	12.07 (150.1)	11.86 (142.10	12.06 (145.4)
Two NW 15 and 30 DAS	8.58 (74.3)	7.68 (59.3)	8.89 (79.9)	8.39 (70.9)	7.89 (62.3)	7.02 (49.6)	16.27 (266.6)	16.23 (264.6)	23.22 (540.9)	23.21 (540.3)	24.98 (624.3)	21.63 (472.3)
Two HW 15 and 30 DAS	2.84 (8.1)	2.74 (7.5)	5.42 (30.0)	4.82 (23.5)	4.12 (16.8)	3.91 (15.5)	4.31 (18.8)	4.69 (22.5)	14.04 (199.8)	14.46 (209.8)	15.36 (236.2)	13.24 (176.2)
Weedy check	9.31 (86.8)	8.72 (76.1)	9.21 (85.3)	8.68 (75.4)	9.71 (94.7)	9.13 (83.5)	17.95 (322.4)	18.18 (330.7)	25.93 (675.4)	25.54 (652.4)	29.07 (845.70	27.57 (762.4)
LSD (p=0.05)	1.07	1.17	1.39	1.33	0.68	1.15	2.34	1.75	3.13	2.70	2.70	2.51

Figures in parentheses are original values; Data subjected to square root transformation

higher LAI of 2.93 and 2.52 during the *Kharif* and winter seasons, respectively.

The crop growth rate accelerated steadily upto 40 DAS and then turned to decline from 40 DAS to 60 DAS **(Table 2)**. During the early stages of the crop (20-40 DAS), significantly higher CGR was obtained with pendimethalin followed by acifluorfen-sodium + clodinafop-propargyl and it was comparable with pendimethalin *fb* propaquizafop + imazethapyr and hand weeding twice in both seasons. Whereas at later stages of the crop (40-60 DAS), though higher values of CGR was recorded with pendimethalin followed by acifluorfen-sodium + clodinafop-propargyl, it was at par with the pre-emergence applied pendimethalin alone or integrated with one hand weeding. The growth attributes of irrigated blackgram, *viz.* LAI, DMP, CGR were greater with the application of pendimethalin *fb* acifluorfen-sodium + clodinafop-propargyl due to effective suppression of emerging weeds especially grasses and broad-leaved weeds at the early as well as later stages of the crop growth period. Next in order, pendimethalin *fb* propaquizafop + imazethapyr also improved growth characters and it was statistically in line with hand weeding twice. This was supported by Marimuthu *et al.* (2016) who reported that sequential application of early and post-emergence herbicides is far better in weed control than two hand weeding in blackgram.



T_1- pendimethalin 1.0 kg/ha on 3 DAS + hand weeding on 20 DAS, T_2- pendimethalin 1.0 kg/ha+ nail weeder on 20 DAS, T_3- acifluorfen-sodium (16.5%) + clodinafop-propargyl (8% EC) 187.5 g/ha on 20 DAS, T_4- propaquizafop (2.5%) + imazethapyr (3.75% ME) 125 g/ha on 20 DAS, T_5- pendimethalin 1.0 kg/ha on 3 DAS *fb* acifluorfen-sodium (16.5%) + clodinafop-propargyl (8% EC) 187.5 g/ha on 20 DAS, T_6- pendimethalin 1.0 kg/ha on 3 DAS *fb* propaquizafop (2.5%) + imazethapyr (3.75% ME) 125g/ha on 20 DAS, T_7- two nail weeder on 15 and 30 DAS, T_8- two hand weeding on 15 and 30 DAS, T_9- weedy check.

Figure 2. Influence of weed management practices on LAI in irrigated blackgram

Table 2. Effect of weed management practices on growth attributes in irrigated blackgram

Treatment	Dry matter production (t/ha)						CGR (kg/ha/day)			
	20 DAS		40 DAS		60 DAS		20 - 40 DAS		40 - 60 DAS	
	Kharif	Winter	*Kharif*	Winter	*Kharif*	Winter	*Kharif*	Winter	*Kharif*	Winter
Pendimethalin 3 DAS *fb* hand weeding 20 DAS	0.47	0.49	2.58	2.16	2.97	2.65	106	83	19	25
Pendimethalin 3 DAS *fb* Nail weeder 20 DAS	0.37	0.42	2.22	2.07	2.57	2.43	93	82	17	18
Acifluorfen-sodium + clodinafop-propargyl 20 DAS	0.41	0.48	2.62	2.53	3.09	2.78	111	103	23	12
Propaquizafop + imazethapyr 20 DAS	0.32	0.50	2.47	2.34	2.67	2.70	107	92	10	18
Pendimethalin 3 DAS *fb* acifluorfen-sodium + clodinafop-propargyl 20 DAS	0.44	0.51	3.28	3.11	3.89	3.76	142	130	31	32
Pendimethalin 3 DAS *fb* propaquizafop + imazethapyr 20 DAS	0.43	0.56	2.89	3.07	3.51	3.70	123	126	31	32
Two NW 15 and 30 DAS	0.58	0.48	2.12	2.19	2.40	2.42	77	86	14	12
Two HW 15 and 30 DAS	0.53	0.49	2.79	2.73	3.38	3.39	113	112	29	33
Weedy check	0.46	0.53	2.06	2.10	2.36	2.34	80	78	15	12
LSD (p=0.05)	NS	NS	0.45	0.42	0.45	0.45	27.31	24.29	14	16

Table 3. Effect of weed management practices on yield attributes and grain yield in irrigated blackgram

Treatment	Clusters/plant		Pods/plant		Seeds/pod		100 seed weight (g)		Grain yield (kg/ha)	
	Kharif	Winter	*Kharif*	Winter	*Kharif*	Winter	*Kharif*	Winter	*Kharif*	Winter
Pendimethalin 3 DAS *fb* hand weeding 20 DAS	9.1	8.3	30.7	26.2	6.8	6.0	4.8	4.5	826	719
Pendimethalin 3 DAS *fb* Nail weeder 20 DAS	7.8	7.1	25.3	23.7	6.5	6.6	4.5	4.3	694	603
Acifluorfen-sodium + clodinafop-propargyl 20 DAS	9.7	9.4	33.5	30.8	7.2	6.7	4.6	4.9	887	815
Propaquizafop + imazethapyr 20 DAS	8.8	9.1	29.0	30.5	6.9	6.3	4.8	4.0	745	788
Pendimethalin 3 DAS *fb* acifluorfen-sodium + clodinafop-propargyl 20 DAS	12.5	11.0	44.4	41.3	7.5	6.9	4.6	4.3	1053	1019
Pendimethalin 3 DAS *fb* propaquizafop + imazethapyr 20 DAS	11.2	10.5	38.8	40.9	7.3	7.1	4.4	4.5	968	983
Two Nail weeder 15 and 30 DAS	7.1	7.0	22.4	23.0	6.1	6.3	4.7	4.1	627	571
Two hand weeding 15 and 30 DAS	10.6	10.1	36.3	36.0	7.5	6.6	4.9	4.7	914	933
Weedy check	6.4	7.0	20.9	21.3	6.2	6.4	4.6	4.3	589	545
LSD (p=0.05)	2.31	2.06	3.97	3.75	0.43	0.55	NS	NS	155	129

Yield attributes

All the yield attributes were significantly influenced by different weed management practices in both seasons **(Table 3)**. Pendimethalin 1.0 kg/ha at 3 DAS *fb* acifluorfen-sodium (16.5%) + clodinafop-propargyl (8% EC) 187.5 g/ha at 20 DAS showed improvement in yield attributes, *viz*. clusters/plant (95.3 and 57.1%), pods/plant (112.4 and 93.8%), seeds/pod (20.9 and7.81%) over unweeded check during *Kharif* and winter seasons, respectively. While unweeded check registered lower attributes as compared to all weed control treatments.

Higher leaf area, biomass and total branches production gained through effective and prolonged weed control by these promising treatments throughout the crop season might have supported the crop in the conversion of more branches and biomass into a productive one. This is in agreement with the findings of Patel *et al*. (2018). Whereas, unweeded control due to the severe weed competition exerted by weeds for the available resources throughout the crop growth period might have lowered pods/plant and seeds/pod. Similar results were observed in blackgram by Gupta *et al.* (2014).

Yield

Pre-emergence application of pendimethalin *fb* acifluorfen-sodium + clodinafop-propargyl enhanced the production potential of irrigated blackgram as evident from higher seed yield of 1053 and 1019 kg/ha with the increased yield of 78.7and 86.9% over unweeded control in *Kharif* and winter season, respectively **(Table 3)**. This could be mainly because of an excellent suppression of all weeds right from crop emergence to harvest. This created a congenial environment similar weed free situation for irrigated blackgram and improved the crop growth in terms of biomass and thus recorded superior yield attributes. This in turn was clearly reflected on the yield potential of the irrigated blackgram. Nail weeder adopted plots produced lesser seed yield than hand weeding twice treatment. It might be due to insufficient intra-row weed removal. On the other hand, weedy check with more weed density right from sowing to crop maturity, subjected crop to more stress for utilizing essential resources and therefore, resulted in inferior yield traits and lower yields.

Nutrient removal by weeds

The extent of weed competition with irrigated blackgram was also assessed through the removal of nutrients under unweeded conditions, where there was higher uptake of nitrogen by weeds varying from 14.1 to 13.13 kg/ha in both seasons **(Table 4)**. Pendimethalin *fb* acifluorfen-sodium + clodinafop-propargyl treatment curtailed the nitrogen (85 and 83%), phosphorous (86 and 83%), potassium (85 and 85%) uptake in *Kharif* and

Table 4. Effect of weed management practices on nutrient removal (kg/ha) at 60 DAS

Treatment	Weeds						Crop					
	Nitrogen		Phosphorous		Potassium		Nitrogen		Phosphorous		Potassium	
	Kharif	Winter	*Kharif*	Winter	*Kharif*	Winter	*Kharif*	Winter	*Kharif*	Winter	*Kharif*	Winter
Pendimethalin 3 DAS *fb* hand weeding 20 DAS	7.07	8.14	1.16	1.26	6.47	7.73	49.9	45.6	6.36	5.50	50.6	45.4
Pendimethalin 3 DAS *fb* Nail weeder 20 DAS	11.43	8.87	1.74	1.38	10.34	8.47	40.4	37.0	5.45	4.70	43.8	39.0
Acifluorfen-sodium + clodinafop-propargyl 20 DAS	4.67	4.40	0.71	0.68	4.32	3.83	56.3	52.3	7.37	7.16	54.8	51.9
Propaquizafop + imazethapyr 20 DAS	7.93	4.97	1.19	0.74	7.13	4.33	42.8	48.1	6.03	6.70	46.3	50.1
Pendimethalin 3 DAS *fb* acifluorfen-sodium + clodinafop-propargyl 20 DAS	2.13	2.29	0.32	0.34	1.80	1.88	73.4	68.6	8.77	9.17	66.5	66.4
Pendimethalin 3 DAS *fb* propaquizafop + imazethapyr 20 DAS	3.13	2.50	0.46	0.39	2.67	2.23	67.2	68.5	8.12	8.77	60.1	63.3
Two Nail weeder 15 and 30 DAS	10.67	8.10	1.69	1.29	9.83	8.30	36.4	36.0	4.97	4.57	39.1	37.7
Two hand weeding 15 and 30 DAS	4.29	3.11	0.66	0.47	3.90	2.70	60.4	59.8	7.65	7.90	57.6	58.3
Weedy check	14.10	13.13	2.25	2.06	12.77	12.67	34.7	34.8	4.62	4.54	36.1	36.0
LSD (p=0.05)	1.88	1.92	0.71	0.70	2.11	2.08	8.68	10.21	1.49	0.70	9.07	8.82

Table 5. Influence of weed management practices on economics in irrigated blackgram

Treatment	Cost of cultivation (x10^3 ₹/ha)		Gross income (x10^3 ₹/ha)		Net income (x10^3 ₹/ha)		B:C ratio	
	Kharif	Winter	*Kharif*	Winter	*Kharif*	Winter	*Kharif*	Winter
Pendimethalin 3 DAS *fb* hand weeding 20 DAS	28.05	29.07	50.40	51.12	22.35	22.05	1.80	1.76
Pendimethalin 3 DAS *fb* Nail weeder 20 DAS	26.61	27.53	42.41	42.91	15.79	15.38	1.59	1.56
Acifluorfen-sodium + clodinafop-propargyl 20 DAS	26.03	26.81	54.09	57.91	28.06	31.10	2.08	2.16
Propaquizafop + imazethapyr 20 DAS	28.21	28.99	45.45	55.93	17.25	26.94	1.61	1.93
Pendimethalin 3 DAS *fb* acifluorfen-sodium + clodinafop-propargyl 20 DAS	26.86	27.66	64.23	72.38	37.37	44.72	2.39	2.62
Pendimethalin 3 DAS *fb* propaquizafop + imazethapyr 20 DAS	29.03	29.83	59.03	69.84	29.99	40.01	2.03	2.34
Two Nail weeder 15 and 30 DAS	27.80	28.84	38.32	40.61	10.52	11.77	1.38	1.41
Two hand weeding 15 and 30 DAS	30.68	31.92	55.76	66.24	25.08	34.32	1.82	2.08
Weedy check	23.77	24.53	35.98	38.81	12.21	14.28	1.51	1.58

winter seasons, respectively. While weedy check resulted into higher uptake of NPK throughout the crop period. Lower removal of nutrients by weeds under pendimethalin *fb* acifluorfen-sodium + clodinafop-propargyl, pendimethalin *fb* propaquizafop + imazethapyr and even hand weeding twice was due to lesser weed population and dry matter even at a later stage. Similar reports were expressed by Komal *et al.* (2015) that nutrient uptake by weeds was less in green gram with herbicide applied treatments than any other treatments.

Nutrient uptake by crop

In general, the blackgram crop utilized more of N and K than P in both seasons. In *Kharif* and winter season, application of pendimethalin followed by acifluorfen-sodium + clodinafop-propargyl was found to be superior with an increased uptake of nitrogen (112 and 97%), phosphorous (90 and 101%) and potassium (84 and 84.4%) as well over the weedy check **(Table 4)**. All the weed control practices showed higher uptake of nutrients by blackgram than the unweeded check. This finding is in close confirmity with the results reported by Poornima *et al.* (2018). Among distinct weed control measures, pendimethalin *fb* acifluorfen-sodium + clodinafop-propargyl accumulated higher nutrients than the other treatments in blackgram. This is due to effective weed control especially grasses and broad-leaved weeds during the critical stage of the crop.

Economics

The cost of cultivation varied greatly among the different weed management practices under irrigated blackgram **(Table 5)**. Pre-emergence application of pendimethalin *fb* acifluorfen-sodium + clodinafop propargyl fetched higher gross returns (₹ 64,234 and 72,383/ha) and net returns (₹ 37,374 and 44,722/ha) in *Kharif* and winter respectively. It was *fb* PE of pendimethalin *fb* propaquizafop + imazethapyr. The higher returns are mainly due to lower cost of cultivation especially for the labour wages engaged in spraying. In terms of B:C ratio, PE of pendimethalin *fb* acifluorfen-sodium + clodinafop-propargyl on 20 DAS recorded higher B:C values of 2.39 and 2.62 in *Kharif* and winter season respectively. Similarly, Shruthi and Salakinkop (2015) reported that higher net returns and B:C was fetched with sequential application of PE and PoE herbicides over hand weeding.

Conclusion

Based on the present investigation, PE of pendimethalin 1.0 kg/ha at 3 DAS *fb* acifluorfen-sodium (16.5%) + clodinafop-propargyl (8% EC) 187.5 g/ha at 20 DAS and pendimethalin 1.0 kg/ha at 3 DAS *fb* propaquizafop (2.5%) + imazethapyr (3.75% ME) 125 g/ha at 20 DAS were most effective treatments to control weeds effectively and attain higher yield and higher income in irrigated blackgram.

REFERENCES

Anonymous. 2018. *Pulses in India: Retrospect and Prospects-2018*. Directorate of Pulses Development, Govt. of India, Bhopal.

Singh G, Virk HK and Sharma P. 2017. Efficacy of pre- and post-emergence herbicides for weed control in greengram. *Indian Journal of Weed Science* **49**(3): 252–255.

Gupta V, Singh M, Kumar A, Sharma BC and Kher D. 2014. Effect of different weed management practices in urdbean (*Vigna mungo* L. Hepper) under sub-tropical rainfed conditions of Jammu, India. *Legume Research* **37**(4): 424–429.

Kewat ML, Saini MK, Sharma JK and Panda S. 2015. Efficacy of propaquizafop and imazethapyr mixture against weeds in blackgram. pp. 236. In: *Proceedings* 25th Asian-Pacific Weed Science Society Conference, Hyderabad, India.

Komal, Singh SP and Yadav RS. 2015. Effect of weed management on growth, yield and nutrient uptake of greengram. *Indian Journal of Weed Science* **47**(2): 206–210.

Mahatale PV, Sabale SN, Gawande VL, Ladole MY, and Bhuyar AR. 2014. Effect of post-emergence herbicides in *Kharif* groundnut. In: *Proceedings Biennial Conference of Indian Society of Weed Science on Emerging Challenges in Weed Management* held during February.

Marimuthu S, Venkataraman NS and Sanbagavalli S. 2016. Weed management practices on weed control efficiency and yield of blackgram. *International Journal of Advanced Research* **4**(12): 965–969.

Panda S. 2015. Efficacy of propaquizafop and imazethapyr mixture against weeds in soybean. pp. 185. In: *Proceedings 25th Asian-Pacific Weed Science Society Conference on Weed Science for Sustainable Agriculture, Environment and Biodiversity*, Hyderabad, India.

Patel S, Dhonde MB and Kamble AB. 2018. Effect of integrated weed management on growth and yield of soybean. *International Journal of Agriculture Sciences* **10**(10): 6058–6062.

Poornima S, Lakshmi YS, Prakash TR and Srinivas A. 2018. Weed management through early post-emergence herbicides to improve productivity and nutrient uptake in greengram. *Indian Journal of Weed Science* **50** (1): 82–84.

Randhawa JS, Deol JS, Sardana V and Singh J. 2002. Crop-weed competition studies in summer blackgram (Phaseolus mungo). *Indian Journal of Weed Science* **34**(3&4): 299–300.

Ramesh T. 2016. Bio-efficacy of quizalofop-ethyl + imazethapyr in blackgram. *Indian Journal of Weed Science* **48**(3): 339–340.

Raju M. 2019. Study on constraints and adoption of black gram seed production technologies by the farmers of Cauvery delta zone of Tamil Nadu. *Journal of Pharmacognosy and Phytochemistry* **8**(4): 1031–1035.

Shruthi GK and SR Salakinkop. 2015. Efficacy of sequential application of pre- and post-emergent herbicides in *Kharif*greengram (Vigna radiata L.). *Karnataka Journal of Agriculture Sciences* **28**: 155–159.