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RESEARCH ARTICLE

Efficacy of post-emergence herbicides in *Rabi* Blackgram (*Vigna mungo* L.)

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ABSTRACT

Field experiment was conducted at Agricultural Research Station, Jangamaheswarapuram, Guntur Dist. Andhra Pradesh, India to evolve efficient and economic weed management practices for irrigated Blackgram during Rabi 2017-18 and 2018-19. The results revealed that all growth and yield characters of Blackgram were significantly affected by distinct weed control practices. A similar trend was also observed in weed parameters. Post-emergence application of Sodium Acifluorfen + clodinafop-propargyl @ 300 g a.i ha-1 at 20 DAS effectively reduced weed density and dry matter production. Consequently, higher seed yields of 1180 and 998 kg/ha, highest net returns of Rs. 43,227 and Rs. 32,915/ha and return per rupee investment of 1.99 and 1.50 during 2017-18 and 2018-19, respectively were recorded.

Keywords: *Blackgram, Post Emergence Herbicides, weed management practices, weed control efficiency, Yield.*

INTRODUCTION

Blackgram [*Vigna mungo* (L.) *Hepper*)] is an important legume crop cultivated worldwide in tropical and subtropical regions and is valued for high protein in its seeds. It is a good source of phosphoric acid, calcium and vitamins like thiamine (B1), riboflavin (B2) and niacin (B3), grown primarily for its protein rich seeds and also used as dhal. India is the largest producer and consumer of Blackgram in the world. It provides good returns to farmers even with low level of farm inputs. It is the fourth important pulse crop in India and second most important in Andhra Pradesh in terms of extent of cultivation (Verma, A and Choudhary R., 2020). Severe competition by weeds especially under high rainfall, high temperature, and high humidity is the major reason for low productivity in Blackgram. The weeds reduce Blackgram yield as high as 66% (Singh *et al.* 2017). Blackgram is less competitive against many weeds during early stage of crop and the most sensitive period of weed competition is between 15 to 45 days after sowing (Khot *et al.*, 2016 & Lipi Meher *et al.*, 2020).

Controlling the weeds at optimum time is necessary for improving the yield of Blackgram. The manual method of weed control, no doubt, accomplish the job effectively but they are tedious, time taking and expensive. Moreover, many times labour is not available at the critical period of weed removal. Recent trend of herbicide use is to find out an alternative and effective weed management by using low dose high efficiency herbicides which will not only reduce the total volume of herbicide per unit area but also the application becomes easier and economical and time

saving process to the farmers.

Recently, some new post emergence herbicides viz., Imazethapyr, Acifluorfen Sodium and Clodinafop propargyl, Fluazifop-p-butyl, Fomesafen, Propaquizafop *etc*. are being marketed with the assurance of selective control of weeds in Blackgram. Although these are recommended for Blackgram, there are field reports of phytotoxicity in the crop after the application of Imazethapyr, Fluazifop-p-butyl, Fomesafen, Propaquizafop, Acifluorfen Sodium and Clodinafop propargyl. Keeping the above constraints, the present research was executed to reveal the appropriate and cost-effective weed management practice for irrigated Blackgram.

MATERIALS AND METHODS

A field experiment was conducted during two *Rabi* seasons (2017-18 and 2018-19) at Agricultural Research Station, Jangamaheswarapuram, Guntur Dist. Andhra Pradesh, India. The soil of the experimental site was black soil in texture, slightly alkaline in reaction (pH 7.9 and 7.6), medium in organic carbon (0.63 and 0.69%) and available nitrogen (377 and 386 kg ha^{-1}), low in available phosphorus (18 and 17 kg ha^{-1}) and high in available potassium (817 and 798 kg ha^{-1}).

The field experiment was laid out in a Randomised Block Design with eight treatments in three replications. The eight treatments consisted of Imazethapyr @ 50 g a.i. ha^{-1} (T_1), Fluazifop-p-butyl + fomesafen @ 300 g a.i. ha^{-1} (T_2), Sodium Acifluorfen + clodinafop-propargyl @ 300 g a.i ha^{-1} (T_3), Propaquizafop + imazethapyr @ 60 g a.i. ha^{-1} (T_4), Imazethapyr + Imazamox @ 80 g a.i ha^{-1} (T_5), Hand weeding at 20 and 40 DAS (T_6), Weed free (T_7) and Weedy check (T_8). A Blackgram variety, LBG-787 was selected for sowing and all the herbicides were applied at 20 days after sowing of crop. Knap-sack sprayer fitted with flat-fan nozzle was used for applying herbicides using a spray volume of 500 l/ha. The fertilizers such as urea and SSP were used for the supply of N and P and the entire quantity of fertilizers applied as basal. The seed rate used for study was 25 kg ha-1 with a spacing of 30 x 10 cm. Weed species present in the experimental plot were identified at flowering stage of crop from weedy check plot and grouped as grasses, sedges and broad leaved weeds. The data on weed dry weight were recorded with the help of a quadrate (0.25 m^{-2}) at four places randomly chosen and then expressed in number per square meter and gram per square meter. The weed control efficiency (WCE) was worked out on the basis of weed dry matter recorded in each treatment at 20,40,60 DAS and at harvest by using the formula suggested by Mani *et al.,*1973.

$$WCE\ (\%) = \frac{DMC - DMT}{DMC} X\ 100$$

Where,
DMC = Dry matter of weeds in the un weeded check (control) (g m^{-2})

DMT = Dry matter of weeds in the treated plot (g m^{-2})

Data on crop and weeds were analyzed statistically by applying the analysis of variance (ANOVA) techniques for randomized block design as laid down by Gomez and Gomez (1984). ANOVA was performed with the square root transformed data ($\sqrt{x}$ + 0.5) on weed density Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

Weed flora

The weed flora of the experimental field consisted of *Echinochloa colona and Cynodon dactylon* among grasses; *Cyperus rotundus,* the sedge and *Trianthama portalacastrum, Physalis minima, Euphorbia hirta, Digera arvensis, Eclipta alba* and *Parthanium hysterophorus* among the broad-leaved weeds. The occurrence of above weeds at varying population significantly differs under different treatments of various times of observations.

Weed density and biomass

All chemical and manual weed control treatments significantly curtailed the weed population and their biomass over the weedy check (Table 1). At all the growth stages, among all the treatments, the highest weed density of total weeds was recorded under the weedy check and lowest weed density was noticed under the weed free due to reduced weed growth because of complete removal of all types of weeds like grasses, sedges and broad leaved weeds during early stages of crop growth. During 2017-18 at 30 and 60 DAS, among all the herbicide based treatments Sodium Acifluorfen + clodinafop-propargyl @ 300 g a.i ha^{-1} and Propaquizafop + imazethapyr @ 60 g a.i. ha^{-1} were at par and recorded significantly lowest total weed density over rest of the treatments and in 2018-

Table 1. Density (No. m^{-2}) and dry weight of total weeds (g $plant^{-1}$) at different growth stages of Blackgram as influenced by weed management practices during Rabi 2017-18 and 2018-19

Treatments	Density of total weeds				Dry weight of total weeds			
	30DAS		60DAS		30DAS		60DAS	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
T_1) Imazethapyr @ 50 g a.i. ha^{-1}at 20 DAS	11.2 (127.7)	12.19 (149.8)	12.50 (157.0)	14.72 (218.33)	3.45 (11.5)	3.5 (11.7)	4.77 (22.65)	5.3 (27.6)
T_2) Fluazifop-p-butyl + fomesafen @300 g a.i. ha^{-1}at 20 DAS	9.1 (97.7)	7.50 (56.0)	10.67 (113.87)	9.46 (89.33)	2.94 (8.38)	2.7 (6.7)	4.07(16.30)	3.4 (11.4)
T_3) Sodium Acifluorfen + clodinafop-propargyl @300 g a.i ha^{-1} at 20 DAS	6.8 (45.7)	7.43 (54.67)	9.27 (86.22)	10.22 (104.00)	2.11 (4.11)	2.2 (4.3)	2.69 (6.76)	2.8 (7.8)
T_4) Propaquizafop + imazethapyr @ 60 g a.i. ha^{-1} at 20 DAS	7.2 (53.7)	11.01 (123.00)	9.58 (91.32)	12.92 (167.67)	2.56 (6.20)	2.8 (7.5)	3.16 (9.56)	3.8 (14.2)
T_5) Imazethapyr + Imazamox @ 80 g a.i ha^{-1} at 20 DAS	8.9 (79.7)	10.84 (117.33)	10.22 (104.16)	12.74 (162.33)	2.84 (7.62)	3.0 (8.9)	3.72 (13.57)	4.2 (17.1)
T_6) Hand weeding at 20 and 40 DAS	5.1 (25.7)	4.93 (24.00)	6.35 (40.06)	5.91 (34.67)	1.83 (2.94)	1.7 (2.5)	2.54 (6.07)	2.5 (5.7)
T_7) Weed free	0.7 (0.00)	0.71 (0.0)	0.71(0.00)	0.71 (0.00)	0.71 (0.00)	0.7 (0.0)	0.71 (0.00)	0.7 (0.0)
T_8) Weedy check	14.37 (207.00)	16.58 (274.67)	18.25 (333.67)	20.43 (419.33)	4.42 (19.30)	5.0 (24.5)	6.92 (48.39)	7.6 (57.6)
SEm ±	0.49	0.60	0.44	0.70	0.24	0.26	0.34	0.29
CD (P = 0.05)	1.49	1.83	1.33	2.12	0.73	0.79	1.03	0.87

Note: Data transformed to √x+0.5 transformations. Figures in parenthesis are original values

19 parity was observed between Sodium Acifluorfen + clodinafop-propargyl @ 300 g a.i ha^{-1} and Fluazifop-p-butyl + fomesafen @ 300 g a.i. ha^{-1}. The broad spectrum activity of application of post emergence herbicide, Sodium Acifluorfen + clodinafop-propargyl @ 300 g a.i ha^{-1} on weed and their greater efficiency to retard cell division of meristems as a result of which weeds died rapidly. Channappagoudar *et al.* 2013 reported that weed biomass is a better parameter to measure the competition than the weed number. Weed management treatments exerted a significant effect on total weed dry matter at all stages, in both the years of study. The herbicidal treatments show similar trend as in weed density in case of dry weight of total weeds during both the years of study. The results are in agreement with the findings of Harithavardhini *et al.,* (2016), Susmitha *et al.,* (2019), Elankavi *et al.,* (2019), Jagadesh *et al.,* (2019) and Jagadesh and Raju (2021).

Weed control efficiency

At 30 DAS and 60 DAS, higher weed control efficiency was found with weed free treatment followed by two hands weeding during both the years of study. Among the herbicide application, Sodium Acifluorfen + clodinafop-propargyl @ 300 g a.i ha^{-1} (63.03& 64.6), Propaquizafop + imazethapyr @ 60 g a.i. ha^{-1} (55.82& 54.7) and Fluazifop-p-butyl + fomesafen @300 g a.i. ha^{-1} (47.9& 57.9) were showed maximum weed control efficiency at 30 and similar trend was followed at 60 DAS in both the years. This could be associated with minimum weed population and weed biomass at later stages due to the residual effect of herbicides for a longer period. The results are in conformity with the findings of Elankavi *et al.,* (2019), Jagadesh *et al.,* (2019) and Jagadesh and Raju (2021).

Blackgram growth parameters and yield attributes

All the growth and yield attributes were significantly influenced by different weed management practices in both seasons (Table 3 & 4). Weed free treatment, hand weeding twice and Sodium Acifluorfen + clodinafop-propargyl @ 300 g a.i ha^{-1} at 20 DAS were equally effective without any statistically significant difference in improvement of growth and yield attributes, *viz.* plant height, branches and pods per plant over weedy check during both the years of study. While weedy check registered lower attributes

Table 2. Weed Control Efficiency (%) at different growth stages and plant height (cm) and branches per plant at harvest of Blackgram as influenced by weed management practice during Rabi 2017-18 and 2018-19

Treatments	Weed Control Efficiency*				Plant height		Branches plant^{-1}	
	30DAS		60DAS		At harvest		At harvest	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
T_1) Imazethapyr @ 50 g a.i. ha^{-1}at 20 DAS	38.83 (39.35)	45.3 (50.5)	46.1 (52.07)	46.3 (52.3)	33.45	27.41	7.43	6.72
T_2) Fluazifop-p-butyl + fomesafen @300 g a.i. ha^{-1}at 20 DAS	47.90 (54.84)	57.9 (71.6)	53.32 (63.88)	63.7 (80.4)	35.69	36.17	8.36	8.36
T_3) Sodium Acifluorfen + clodinafop-propargyl @300 g a.i ha^{-1} at 20 DAS	63.03 (79.24)	64.6 (81.4)	67.28 (84.80)	68.5 (85.9)	39.49	36.32	9.63	8.89
T_4) Propaquizafop + imazethapyr @ 60 g a.i. ha^{-1} at 20 DAS	55.82 (68.33)	54.7 (65.3)	62.40 (77.89)	60.0 (74.5)	38.50	35.02	9.09	7.86
T_5) Imazethapyr + Imazamox @ 80 g a.i ha^{-1} at 20 DAS	48.84 (56.40)	53.5 (64.5)	57.74 (71.41)	56.5 (69.1)	36.38	34.24	8.73	7.48
T_6) Hand weeding at 20 and 40 DAS	66.36 (82.84)	71.3 (89.6)	68.39 (85.77)	71.6 (89.6)	41.97	38.16	9.96	9.39
T_7) Weed free	90.00 (100.00)	90.00 (100.0)	90.0 (100.0)	90.0 (100.0)	44.73	39.29	10.74	9.76
T_8) Weedy check	0.00 (0.0)	0.00 (0.0)	0.00 (0.00)	0.00	28.02	25.69	5.66	5.30
SEm ±	3.75	3.85	2.72	2.43	2.97	2.81	0.71	0.69
CD (P = 0.05)	11.38	11.66	8.26	7.37	9.01	8.51	2.15	2.10
*Note: Data transformed to arc sine transformations. Figures in parenthesis are original values								

Table 3. Pods per plant, Seeds per pod and seed yield (kg ha^{-1}) at harvest of blackgram as influenced by weed management practice during Rabi 2017-18 and 2018-19

Treatments	Pods plant^{-1}		Seeds pod^{-1}		Seed yield (kg ha^{-1})	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
T_1) Imazethapyr @ 50 g a.i. ha^{-1}at 20 DAS	11.69	10.36	6.11	5.67	726.33	576.47
T_2) Fluazifop-p-butyl + fomesafen @300 g a.i. ha^{-1}at 20 DAS	12.37	12.57	6.10	6.14	813.33	990.20
T_3) Sodium Acifluorfen + clodinafop-propargyl @300 g a.i ha^{-1} at 20 DAS	15.06	12.81	6.59	6.07	1180.33	998.04
T_4) Propaquizafop + imazethapyr @ 60 g a.i. ha^{-1} at 20 DAS	14.33	11.72	6.34	5.71	920.00	740.20
T_5) Imazethapyr + Imazamox @ 80 g a.i ha^{-1} at 20 DAS	12.88	11.64	6.39	6.14	867.04	665.03
T_6) Hand weeding at 20 and 40 DAS	15.40	13.35	6.60	6.14	1213.00	1031.70
T_7) Weed free	16.52	14.09	6.71	6.24	1423.33	1111.50
T_8) Weedy check	9.46	8.79	5.65	5.50	512.60	416.67
SEm ±	1.24	0.99	1.04	0.44	104.04	60.34
CD (P = 0.05)	3.76	3.00	3.15	1.33	315.58	183.02

as compared to all weed control treatments. This could be mainly due to the reduced weed density and growth thus providing weed free environment during initial and later stages of crop growth, due to which all the growth resources were optimally utilized by the crop plants for better vegetative growth and reproductive potential that reflected as noticed with increased growth parameters and yield attributes as reported by Harithavardhini *et al.,* (2016), Susmitha *et al.,* (2019), Elankavi *et al.,* (2019), Jagadesh *et al.,*

Table 4. Gross returns (Rs. ha^{-1}), Net returns (Rs. ha^{-1}) and returns per rupee investment of blackgram as influenced by weed management practice during Rabi 2017-18 and 2018-19

Treatments	Gross returns		Net returns		Returns per rupee investment	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
T_1) Imazethapyr @ 50 g a.i. ha^{-1}at 20 DAS	39948	31706	19808	11279	0.98	0.55
T_2) Fluazifop-p-butyl + fomesafen @300 g a.i. ha^{-1}at 20 DAS	44733	54461	22911	32352	1.05	1.46
T_3) Sodium Acifluorfen + clodin-afop-propargyl @300 g a.i ha^{-1} at 20 DAS	64918	54892	43227	32915	1.99	1.50
T_4) Propaquizafop + imazethapyr @ 60 g a.i. ha^{-1} at 20 DAS	50600	40711	30344	20169	1.50	0.98
T_5) Imazethapyr + Imazamox @ 80 g a.i ha^{-1} at 20 DAS	47687	36577	26395	14998	1.24	0.70
T_6) Hand weeding at 20 and 40 DAS	66715	56743	42181	32209	1.72	1.31
T_7) Weed free	78283	61132	48749	31598	1.65	1.07
T_8) Weedy check	28193	22917	8945	3383	0.46	0.17

(2019) and Jagadesh and Raju (2021).

Seed yield

Results of the study revealed that all the weed control treatments have a salutary effect on yield of Blackgram over weedy check. Among different treatments, weed free treatment registered the maximum seed yields (1423.33 & 1111.50 kg ha^{-1} in 2017 & 2018, respectively) over control (1423.33 & 1111.50 kg ha^{-1} in 2017 & 2018, respectively) (Table 3). This might be due to better control of all categories of weeds which reduced the crop weed competition by providing no weed situation in Blackgram field. Thus, the crop plants being vigorous by efficient utilization of nutrients, moisture, sunlight with space and gave better yield and it was on par with the twice hand weeding and post emergence application Sodium Acifluorfen + clodinafop-propargyl @ 300 g a.i. ha^{-1} during both the years of study. Increased in yield might be due to shifting crop-weed competition in favor of crop resulting in better accumulation of photosynthates. Analogous results were also observed by Harithavardhini *et al.,* (2016), Susmitha *et al.,* (2019), Elankavi *et al.,* (2019), Jagadesh *et al.,* (2019) and Jagadesh and Raju (2021).

Economics

The cost of cultivation varied greatly among the different weed management practices in Blackgram (Table 4). Application of Sodium Acifluorfen + clodinafop-propargyl @ 300 g a.i. ha^{-1} at 20 DAS fetched higher gross returns (64,918 and 54892 Rs. ha^{-1}), net returns (43,227 and 32,915 Rs. ha^{-1}) and Returns per rupee investment (1.99 and 1.50) in 2017-18 and 2018-19, respectively. The higher returns are mainly due to lower cost of cultivation especially for the labour wages engaged in spraying. Similarly, Susmitha *et al.,* (2019), Elankavi *et al.,* (2019), Jagadesh and Raju (2021) reported that higher net returns and return per rupee investment was fetched with application of post emergence herbicides over hand weeding.

CONCLUSION

It could be resolved that applying Sodium Acifluorfen + clodinafop-propargyl @ 300 g a.i. ha^{-1} at 20 DAS was found superior in respect of decreasing the density and biomass of weeds and recorded higher economic yield with higher net return per rupee as compared to other treatments. Hence, applying Sodium Acifluorfen + clodinafop-propargyl @300 g a.i. ha^{-1} at 20 DAS can be considered as appropriate option for broad spectrum weed suppression as well as higher return per rupee investment in Blackgram

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