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Effect of post emergent herbicides on yield and economics of blackgram (*Vigna mungo.* L)

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Abstract
The field experiment was conducted at the AICRP on Agro-forestry unit, University of Agricultural Sciences, GKVK, Bengaluru during *kharif* 2018 to evaluate the effect of weed management practices on weed dry weight, yield attributes, yield and economics of blackgram (*Vigna mungo* L.). Experiment consists of application of three post emergent herbicide molecules and their combinations (Fomesafen, Propaquizafop and Imazethapyr) at 20 DAS, two hand weedings at 15 and 30 DAS, weed free check and unweeded control were replicated thrice in RCBD. Major weeds observed were *Achyranthes aspera*, *Ageratum conyzoides*, *Alternanthra sessilis*, *Borreria articularis*, *Cynodon dactylon*, *Dactyloctenium aegyptium*, *Echinochloa colonum*, *Eleusine indica* and *Cyperus rotundus*. Post-emergent application of Fomesafen 18.8% SL @ 252 g a.i. ha^{-1} + Propaquizafop 5.83% EC @ 78 g a.i. ha^{-1} recoded a higher seed yield, net returns and BC ratio (1290 kg ha^{-1}, Rs. 50,106 ha^{-1} and 3.27, respectively) and it was on par with Fomesafen 18.8% SL @ 210 g a.i. ha^{-1} + Propaquizafop 5.83% EC @ 65 g a.i. ha^{-1} (1248 kg ha^{-1}, Rs. 48,030 ha^{-1} and 3.20, respectively) and two hand weedings at 15 and 30 DAS (1348 kg ha^{-1}, Rs. 48,776 ha^{-1} and 2.60, respectively). Unweeded control recorded a lower seed yield (456 kg ha^{-1}), lower net returns (Rs. 3,051 ha^{-1}), lower BC ratio (1:15) and higher weed index (68.27%) compared to other treatments.

Keywords: Blackgram, Fomesafen + Propaquizafop, yield and economics

Introduction
Black gram (*Vigna mungo* L. Hepper) also known as urdbean, mash, mungbean, black mapte *etc.* is another third important short duration pulse grown in many parts of India. India is the largest producer and consumer of blackgram in the world. It is mostly cultivated during both summer and *kharif* season. In India, it contributes to the total cultivated area of 5.44 M ha with the production of 3.56 MT with a productivity of 655 kg ha^{-1}. Major states contribute area to total production are Madhya Pradesh (38.76%), Uttar Pradesh (12.19%), Rajasthan (10.73%), Maharashtra (9.62%), Tamil Nadu (8.06%), Andra Pradesh (7.57%) and Karnataka (2.74%). In Karnataka, it is cultivated on an area of 1.38 lakh ha with a production of 0.47 lakh tonnes with average productivity of 507.94 kg ha^{-1} (Anon, 2018) [1]. Among various production factors, weed plays a vital role in influencing blackgram yield. Weeds compete with the resources like nutrient, moisture, and light. The critical period of crop-weed competition in blackgram is the first 20-40 days after sowing and season long weed competition has been found to reduce blackgram yield to the extent of 27-84 per cent depending on the kind and intensity of weed species (Singh, 2011 and Bhowmick *et al.*, 2015) [11, 2]. Hand weeding, which is usually preferred, adds to the cost of cultivation due to higher labour wages and does not ensure weed removal at critical stages of crop-weed competition (Duary *et al*., 2015) [4]. Moreover, continuous rainfall during the season makes the manual weeding uncertain and impracticable. Hence, chemical weed control became an effective and cheaper alternative to manage weeds in blackgram production

At presently, efficacy of Fomesafen and Propaquizafop ready mixture has not been tested for wide spectrum weed control in blackgram under Eastern Dry Zone of Karnataka and other parts of the country. Therefore, to study the efficacy of some weed management practices on blackgram, the present investigation was undertaken.

Material and Methods

A field experiment was conducted during *kharif*-2018 at the field unit of AICRP on Agro - forestry, University of Agricultural Sciences, GKVK, Bengaluru. The experimental site is situated in the Eastern Dry Zone (Zone - V) of Karnataka which is situated between 12º 51' N Latitude and 77º 35' E Longitude at an altitude of 930 m above Mean Sea Level (MSL). The soil of the experimental site was sandy loam in its texture. The moisture content at field capacity was 18.63 per cent with a bulk density of 1.43 g cc^{-1}. The soil of the site is slightly acidic in reaction (pH 5.8) with medium electrical conductivity (0.32 dS m^{-1}) and organic carbon content (0.50%). It has low available nitrogen (253.60 kg ha^{-1}), medium phosphorus (32.24 kg ha^{-1}) and medium potassium (283.2 kg ha^{-1}), respectively. The experiment included of eleven treatments laid out in randomized complete block design with three replications. Treatments involved of post-emergence application of herbicides. T_1 Fomesafen 25% SL @ 250 g a.i. ha^{-1}, T_2 Propaquizafop 10% EC @ 100 g a.i. ha^{-1}, T_3 Imazethapyr 10% SL @ 100 g a.i. ha^{-1}, T_4 Fomesafen 18.8% SL @ 168 g a.i. ha^{-1} + Propaquizafop 5.83% EC @ 52 g a.i. ha^{-1}, T_5 Fomesafen 18.8% SL @ 210 g a.i. ha^{-1} + Propaquizafop 5.83% EC @ 65 g a.i. ha^{-1}, T_6 Fomesafen 18.8% SL @ 252 g a.i. ha^{-1} + Propaquizafop 5.83% EC @ 78 g a.i. ha^{-1}, T_7 Fomesafen 18.8% SL @ 294 g a.i. ha^{-1} + Propaquizafop 5.83% EC @ 91 g a.i. ha^{-1}, T_8 Propaquizafop 2.5% EC @ 50 g a.i. ha^{-1} + Imazethapyr 3.7% SL @ 75 g a.i. ha^{-1}, T_9 two hand weedings at 15 and 30 DAS, T_{10} Weed free Check and T_{11} Unweeded Check. Treatment imposition was done at 20 DAS. The blackgram variety LBG-625 (Rashmi) seeds were sown in lines at the rate of 25 kg ha^{-1} at a depth of 2-3 cm, maintaining 30 cm row spacing. The crop was fertilized with 25 kg N, 50 kg P_2O_5 and 25 kg K_2O through urea, single super phosphate and muiate of potash respectively, and labour input for all the operations. The predominant market prices of the blackgram after harvest was attained from the Zonal Agricultural Research Station, GKVK Bengaluru was used for the calculation of gross returns. Gross returns, net returns and benefit cost ratio were worked out by using the following formulae and expressed in rupees per hectare.

Gross return = [Grain yield x market rate of grain]

Net returns = Gross returns – total cost of cultivation

$$\text{Benefit cost ratio} = \frac{\text{Gross returns (₹ ha}^{-1})}{\text{Cost of cultivation (₹ ha}^{-1})}$$

Results and Discussion

The experiment results were discussed in the subsequent sub-headings:

Effect on weed growth

The dominated weed flora observed in the experimental plots were *Achyranthes aspera, Ageratum conyzoides, Alternanthra sessilis, Borreria articularis* and *Emilia sanchifolia.* Among the grassy weeds *Cynodon dactylon, Dactyloctenium aegyptium, Digitaria marginata, Echinochloa colonum, Eleusine indica* and among sedges *Cyperus rotundus.*

All the weed species were effectively controlled by combined application of Fomesafen and Propaquizafop ready mixture as compared to alone application. Post emergence application of Fomesafen 18.8% SL @ 252 g a.i. ha^{-1} + Propaquizafop 5.83% EC @ 78 g a.i. ha^{-1} recorded lowest weed density and weed dry weight (33.27 m^{-2} and 21.90 g m^{-2}) and on par with the two hand weedings at 15 and 30 DAS (23.3 m^{-2} and 18.91 g m^{-2}). Whereas, unweeded check recorded highest total weed density and dry weight (96.0 m^{-2} and 85.0 g m^{-2}) at 70 days of the crop stage. due to better control of weeds throughout the critical stages of crop growth. Whereas, weedy check recorded the higher weed density and dry weight due to the non-interruption for growth of weeds. These results are also endorsed by several researchers Tiwari *et al.,* 2006, Pandey *et al.,* 2007, Shete *et al.,* 2008 and Chetan *et al.,* 2015 [12, 8, 10, 3]. (Table 1)

Table 1: Effect of post emergent herbicides on weed population and weed dry weight of blackgram

Treatment	Weed density at 70 DAS			Weed dry weight at 70 DAS			Weed control efficiency (%) at 70 DAS	Weed index (%)
	Sedge+	Grasses+	Broad leaf weeds#	Sedge+	Grasses#	Broad leaf weeds+		
T_1	2.20 (3.87)	5.72 (31.80)	1.40 (23.40)	1.29 (0.72)	1.40 (23.20)	3.73 (12.97)	68.3	46.42
T_2	1.99 (3.00)	4.38 (18.40)	1.65 (43.07)	1.11 (0.27)	1.07 (10.00)	5.14 (25.50)	74.5	44.05
T_3	2.11 (3.53)	5.56 (30.00)	1.54 (32.83)	1.87 (2.50)	1.44 (25.80)	5.21 (26.17)	61.7	47.67
T_4	2.27 (4.20)	4.80 (22.13)	1.48 (28.73)	1.46 (1.18)	1.38 (22.37)	4.41 (18.50)	75.1	34.03
T_5	1.96 (2.87)	4.33 (17.93)	1.40 (23.17)	1.24 (0.57)	1.30 (18.13)	4.47 (18.97)	89.7	13.15
T_6	1.88 (2.53)	3.66 (12.40)	1.31 (18.33)	1.00 (0.00)	1.09 (10.43)	4.06 (15.47)	91.1	10.23
T_7	2.02 (3.13)	4.72 (21.40)	1.38 (22.30)	1.40 (1.07)	1.21 (14.47)	4.50 (19.27)	88.8	31.20
T_8	2.54 (5.53)	4.94 (23.40)	1.59 (37.27)	1.55 (1.43)	1.40 (23.23)	4.66 (20.80)	78.0	30.06
T_9	1.77 (2.20)	3.15 (9.43)	1.13 (11.67)	1.08 (0.17)	0.95 (6.93)	3.57 (11.80)	92.3	6.19
T_{10}	1.00 (0.00)	1.00 (0.00)	0.30 (0.00)	1.00 (0.00)	0.30 (0.00)	1.00 (0.00)	100.0	0.00
T_{11}	2.78 (6.87)	6.08 (36.20)	1.74 (53.00)	2.10 (3.47)	1.69 (48.07)	5.86 (33.47)	0.0	68.27
S.Em±	0.08	0.15	0.09	0.13	0.12	0.17	NA	NA
C. D. @ 5%	0.25	0.75	0.27	0.39	0.37	0.53		

Data within parentheses are original values; # - data analyzed using log(x+2) transformation, + - square root (x+1) transformation; NA- Not analyzed.

Effect on yield

Among different weed management treatments, two hand weedings at 15 and 30 DAS recorded significantly higher grain (1348 kg ha^{-1}) and haulm yield (4134 kg ha^{-1}) compared to all the treatments. However, it was statistically on par with post emergence application of Fomesafen 18.8% SL @ 252 g a.i. ha^{-1} + Propaquizafop 5.83% EC @ 78 g a.i. ha^{-1} (1290 and 3947 kg ha^{-1}) and Fomesafen 18.8% SL @ 210 g a.i. ha^{-1} + Propaquizafop 5.83% EC @ 65 g a.i. ha^{-1} (1248 and 3852 kg ha^{-1}, respectively). This was mainly due to higher yield attributing characters due to better control of different kinds of weed flora of critical growth periods of between 15 to 35

days after sowing, which otherwise were quite notorious for imposing competition for light, space and nutrients with crop. Whereas, the lower grain yield (456 kg ha^{-1}) and haulm yield (2715 kg ha^{-1}) was noticed in weedy check. It is mainly due to severe competition by weeds which affected the growth, nutrient uptake and yield parameters of the crop drastically. These results are in conformity with the findings of Goverdhan (2018), Mundra and Maliwal (2012), Khot *et al*. (2015) [5, 7] (Table 2).

Table 2: Effect of post emergent herbicides on yield, harvest index and weed index of blackgram

Treatments	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Harvest index	Weed index (%)
T_1: Fomesafen 25% SL @ 250 g a.i. ha^{-1} as PoE	770	2955	0.207	46.42
T_2: Propaquizafop 10% EC @ 100 g a.i. ha^{-1} as PoE	804	2906	0.217	44.05
T_3: Imazethapyr 10% SL @ 100 g a.i. ha^{-1} as PoE	752	2885	0.208	47.67
T_4: Fomesafen 18.8% SL @ 168 g a.i. ha^{-1} + Propaquizafop 5.83% EC @ 52 g a.i. ha^{-1} as PoE	948	2978	0.241	34.03
T_5: Fomesafen 18.8% SL @ 210 g a.i. ha^{-1} + Propaquizafop 5.83% EC @ 65 g a.i. ha^{-1} as PoE	1248	3852	0.245	13.15
T_6: Fomesafen 18.8% SL @ 252 g a.i. ha^{-1} + Propaquizafop 5.83% EC @ 78 g a.i. ha^{-1} as PoE	1290	3947	0.246	10.23
T_7: Fomesafen 18.8% SL @ 294 g a.i. ha^{-1} + Propaquizafop 5.83% EC @ 91 g a.i. ha^{-1} as PoE	988	2992	0.229	31.20
T_8: Propaquizafop 2.5% EC @ 50 g a.i. ha^{-1} + Imazethapyr 3.7% SL @ 75 g a.i. ha^{-1} as PoE	1005	3655	0.214	30.06
T_9: Hand weeding at 15 and 30 DAS	1348	4134	0.246	6.19
T_{10}: Weed free Check	1437	4215	0.254	0.00
T_{11}: Unweeded Check	456	2715	0.144	68.27

DAS-Days after sowing, PoE- Post emergence application at 20 DAS, NA- Not analyzed.

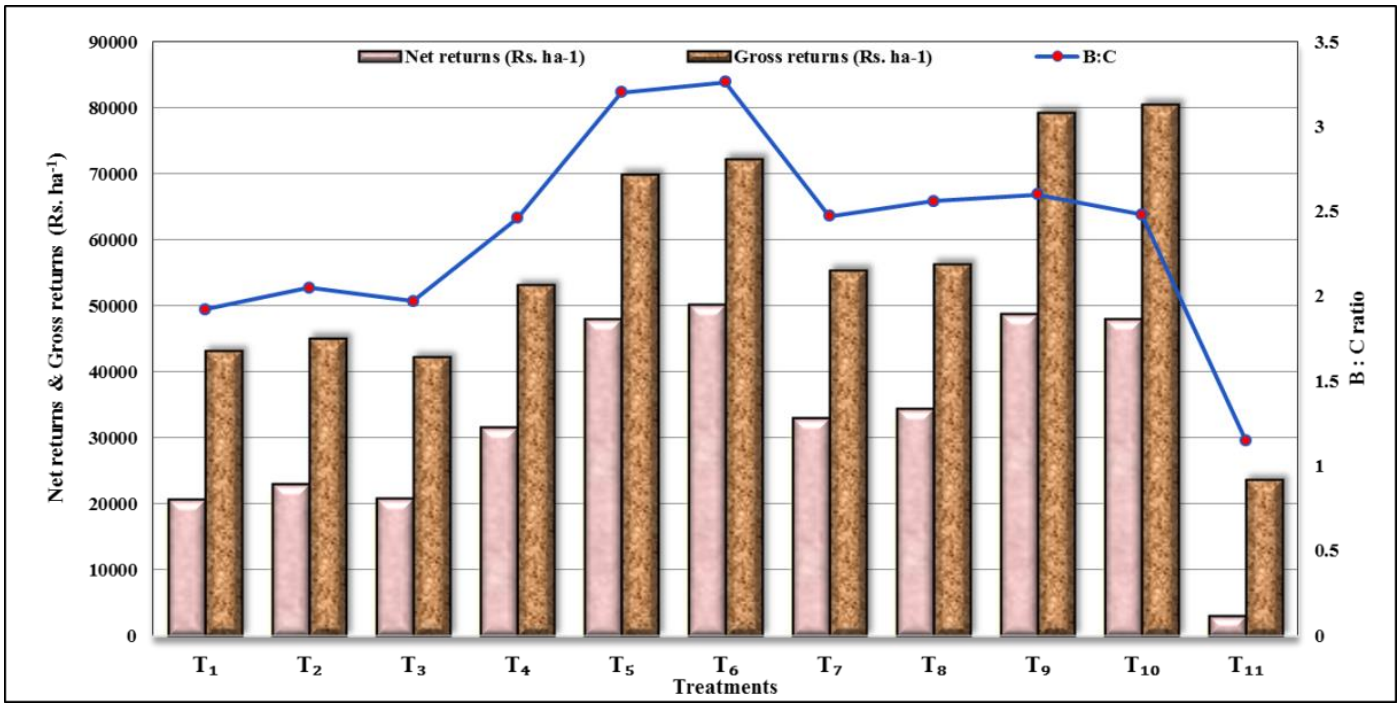
Economics

Among all treatment combinations, post-emergence application of Fomesafen 18.8% SL @ 252 g a.i. ha^{-1} + Propaquizafop 5.83% EC @ 78 g a.i. ha^{-1} recorded higher net returns (₹ 50,106 ha^{-1}) and B:C ratio (3.26) on par with Fomesafen 18.8% SL @ 210 g a.i. ha^{-1} + Propaquizafop 5.83% EC @ 65 g a.i. ha^{-1} (₹ 48,030 ha^{-1}) and B:C ratio (3.2) compared to two hand weedings at 15 and 30 DAS (₹ 48,766 and 2.60, respectively). While, weedy check noticed negative net returns and the lowest B: C ratio (₹ 3,051 ha^{-1} and 1.15) Fig.1. Even though highest gross returns were recorded in weed free check followed by two hand weedings at 15 and 30 DAS, higher labour wages increased the cost of cultivation and lowered the BC ratio. Whereas in herbicide treatments, T_6 and T_5 lower cost of cultivation (Rs. 21,858 and 22,134 ha^{-1}) due to lower labour requirement for herbicide application decreased the cost of cultivation which further increased the BC ratio. Similar results were reported by Komal *et al*. (2015) and Sakthi *et al*. (2018) [6, 9]. (Table 3).

Table 3: Economics of weed control by different post emergent herbicides in blackgram

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	BC
T_1: Fomesafen 25% SL @ 250 g a.i. ha^{-1} as PoE	22485	43120	20635	1.92
T_2: Propaquizafop 10% EC @ 100 g a.i. ha^{-1} as PoE	21985	45024	23039	2.05
T_3: Imazethapyr 10% SL @ 100 g a.i. ha^{-1} as PoE	21385	42112	20727	1.97
T_4: Fomesafen 18.8% SL @ 168 g a.i. ha^{-1} + Propaquizafop 5.83% EC @ 52 g a.i. ha^{-1} as PoE	21584	53088	31504	2.46
T_5: Fomesafen 18.8% SL @ 210 g a.i. ha^{-1} + Propaquizafop 5.83% EC @ 65 g a.i. ha^{-1} as PoE	21858	69888	48030	3.20
T_6: Fomesafen 18.8% SL @ 252 g a.i. ha^{-1} + Propaquizafop 5.83% EC @ 78 g a.i. ha^{-1} as PoE	22134	72240	50106	3.26
T_7: Fomesafen 18.8% SL @ 294 g a.i. ha^{-1} + Propaquizafop 5.83% EC @ 91 g a.i. ha^{-1} as PoE	22408	55328	32920	2.47
T_8: Propaquizafop 2.5% EC @ 50 g a.i. ha^{-1} + Imazethapyr 3.7% SL @ 75 g a.i. ha^{-1} as PoE	21985	56280	34295	2.56
T_9: Hand weeding at 15 and 30 DAS	30485	79261	48776	2.60
T_{10}: Weed free Check	32485	80472	47987	2.48
T_{11}: Unweeded Check	20485	23536	3051	1.15

DAS-Days after sowing, PoE- Post emergence application at 20 DAS



Legend:
T1: Fomesafen 25% SL @ 250 g a.i. ha^{-1} as PoE
T2: Propaquizafop 10% EC @ 100 g a.i. ha^{-1} as PoE
T3: Imazethapyr 10% SL @ 100 g a.i. ha^{-1} as PoE
T4: Fomesafen 18.8% SL @ 168 g a.i. ha^{-1} + Propaquizafop 5.83% EC @ 52 g a.i. ha^{-1} as PoE
T5: Fomesafen 18.8% SL @ 210 g a.i. ha^{-1} + Propaquizafop 5.83% EC @ 65 g a.i. ha^{-1} as PoE
T6: Fomesafen 18.8% SL @ 252 g a.i. ha^{-1} + Propaquizafop 5.83% EC @ 78 g a.i. ha^{-1} as PoE
T7: Fomesafen 18.8% SL @ 294 g a.i. ha^{-1} + Propaquizafop 5.83% EC @ 91 g a.i. ha^{-1} as PoE
T8: Propaquizafop 2.5% EC @ 50 g a.i. ha^{-1} + Imazethapyr 3.7% SL @ 75 g a.i. ha^{-1} as PoE
T9: Hand weeding at 15 and 30 DAS
T10: Weed free
T11: Weedy check (Untreated)

Fig. 1: Economics of weed control in blackgram by different post emergent herbicides

Summary
Application of Fomesafen 18.8% SL @ 252 g a.i. ha-1 + Propaquizafop 5.83% EC @ 78 g a.i. ha^{-1} in areas of labour scarcity was found to be most efficient weed management practice for obtaining higher productivity and profitability of blackgram. Combined application of herbicides than single herbicide was found to be more effective in broad spectrum weed control increasing the yield thereby higher income in blackgram.

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