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Bio-efficacy of new post-emergent herbicides on growth and yield of blackgram

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ABSTRACT

A field experiment was conducted during *Kharif* 2018 Gandhi Krishi Vigyan Kendra, University of Agricultural Sciences, Bangalore, Karnataka. to evaluate the bio-efficacy of new herbicides with pre-mix formulations in blackgram. Major weeds were *Achyranthes aspera, Ageratum conyzoides, Alternanthra sessilis, Borreria articularis, Cynodon dactylon, Dactyloctenium aegyptium, Echinochloa colona, Eleusine indica* and *Cyperus rotundus*. Post-emergence application of fomesafen 18.8% SL + propaquizafop (5.83% EC) 252 + 78 g/ha recoded better crop growth seed yield (1.29 t/ha) along with higher net returns (₹ 50,106/ha) and benefit:cost ratio (3.27) without any phytotoxic effect on crop and was found comparable with two hand weeding at 15 and 30 days after sowing (seed yield 1.348 t/ha)

Blackgram [*Vigna mungo* (L.) Hepper] is one of the important nutritive pulse crops. In India, it is mostly grown in summer and rainy seasons, covering an area of 5.44 million hectares with total production of 3.56 million tones and average productivity of 655 kg/ha during 2017-18 (DPD 2018). Major production of blackgram comes from the states of Madhya Pradesh, Rajasthan, Andhra Pradesh, Uttar Pradesh, Tamil Nadu, Maharashtra, Jharkhand, Gujarat, Karnataka and West Bengal. Although India is the largest producer and consumer of blackgram in the world, its realizable productivity is comparatively lower than the potential level. Even blackgram productivity in the state of Karnataka is quite less than the national average (Anonymous 2018). Weeds are the principal biotic constraints in adversely influencing the productivity. They compete for different growth-limiting resources like nutrient, moisture and light during critical period of crop-weed competition (first 20-40 days after sowing). Season-long weed competition causes yield reduction to the extent of 27-84% depending on the kind and intensity of weed species (Bhowmick *et al.* 2015). Though hand weeding is usually preferred, it adds more to the cost of cultivation due to higher labour wages and does not ensure weed removal at the critical stages of crop-weed competition (Duary *et al.* 2015). Fomesafen at 250 g/ha is an effective post-emergence (PoE) herbicide for controlling non-grassy weeds (Singh *et al.* 2014), whereas propaquizafop at 50 g/ha takes care of grassy weeds in soybean (Tiwari and Mathew 2002). However, the efficacy of fomesafen + propaquizafop (pre-mix) has not been evaluated for weed management in blackgram under Eastern dry zone of Karnataka as well as other parts of the country. Hence, the present investigation was undertaken.

A field experiment was conducted during rainy season (*Kharif*), 2018 at the Gandhi Krishi Vignana Kendra (GKVK), University of Agricultural Sciences, Bengaluru, Karnataka. The experimental site was situated in the Eastern dry zone (Zone-V) of Karnataka (12º51' N Latitude and 77º35' E Longitude with an altitude of 930 m above mean sea level). The soil of the experimental site was sandy loam in texture and slightly acidic in reaction (pH 5.8), medium in organic carbon content (0.50%), low available nitrogen (253.60 kg/ha), medium available phosphorus (32.24 kg/ha) and high available potassium (283.20 kg/ha) with electrical conductivity of 0.32 dS/m. The moisture content at field capacity was 18.63% with bulk density of 1.43 g/cc. Eleven treatments were assigned in a randomized complete block design with three replications. Treatments included fomesafen 25% SL 250 g/ha at 20 days after sowing (DAS), propaquizafop 10% EC 100 g/ha (20 DAS), imazethapyr 10% SL 100 g/ha (20 DAS), fomesafen 18.8% SL + propaquizafop 5.83% EC (pre-mix) 168 + 52, 210 + 65, 252 + 78 and 294 + 91 g/ha (20 DAS), propaquizafop 2.5% EC + imazethapyr 3.7% SL (pre-mix) 50 + 75 g/ha (20

DAS), two hand weeding (15 and 30 DAS), weed free and weedy check. Seeds of blackgram variety '*LBG-625*' (*Rashmi*) were sown in lines at the rate of 25 kg/ha and at a depth of 2-3 cm, maintaining 30 cm row spacing. The crop was fertilized with 25-50-25 kg N-P-K/ha through urea, single super phosphate and muriate of potash, respectively. The crop was sown during 13th July and harvested at 24th October 2018.

Monocot and dicot weeds were counted separately within a random quadrat of 0.5 x 0.5 m in each net plot at 25, 50 DAS and harvest, and expressed as number of weeds/m^2. Weed dry weight was recorded at 25, 50 DAS and at harvest. Weeds were cut close to the ground level within a quadrat in each net plot and dried at 70^{o}C to a constant weight. Dry weight of weeds was recorded, expressed in g/m^2 and subjected to square root transformation before statistical analyses to normalize their distribution. Observations were recorded on crop growth (plant height, number of branches), yield attributes, seed and stover yield at harvest. Uptake of nutrients (nitrogen, phosphorus and potassium) by crop plants as well as weeds was also recorded at harvest. Visual observations were recorded at 1, 3, 5, 7 and 10 days after spraying of herbicides to know the extent of their toxicity on crop by using phytotoxicity rating scale of 0-10 with 0 being no toxicity and 10 being 100% toxicity. The phytotoxicity rating was done on the basis of symptoms like epinasty, hyponasty, necrosis, wilting, vein clearing and stunted growth. Economics of different treatments were also worked out.

Weed control efficiency (WCE) and weed index (WI) were calculated as per standard formulae as:

$$\text{WCE (\%)} = \frac{\text{Dry matter of weeds in unweeded plot - Dry matter of weeds in treated plot}}{\text{Dry matter of weeds in unweeded plot}} \times 100$$

$$\text{WI (\%)} = \frac{\text{Yield of weed free plot – Yield of treated plot}}{\text{Yield of weed free plot}} \text{ x } 100$$

Weed flora

The major weed flora and their relative density at 50 days after sowing in the experimental plots were *Achyranthes aspera* (7.45%), *Ageratum conyzoides* (14.51%), *Alternanthera sessilis,* (13.72%), *Borreria articularis* (12.47%) and *Emilia sonchifolia* (5.44%) among broad-leavedweeds *Cynodon dactylon*, (7.13%) *Dactyloctenium aegyptium* (7.92%), *Digitaria marginata*, (6.31%) *Echinochloa colona*, (6.18%) *Eleusine indica* (14.29%) among the grassy weeds and *Cyperus rotundus* (5.24%) among sedges.

Effect on weed

Among different treatments, PoE application of fomesafen + propaquizafop at 252 + 78 g/ha caused significant reduction in density of all categories of weeds at harvest (**Table 1**). But it was at par with two rounds of hand weeding at 15 and 30 DAS. Lower weed density and weed dry weight in the plots of two hand weeding (15 and 30 DAS) was due to elimination of all categories of weeds through physical uprooting of both above and below ground parts of weeds. Two hand weeding was found comparable with fomesafen + propaquizafop (pre-mix) in registering lower weed density and weed dry weight due to its broader spectrum effect on weed flora. Similar results were reported by Goverdhan (2018). On the other hand, sole application of fomesafen at 250 g/ha (PoE) caused more reduction in density and dry weight of broad-leaved weeds only because of its contact activity. Fomesafen was reported to inhibit the key enzyme 'protoporphyrinogen oxidase' (PROTOX) with its involvement in chlorophyll synthesis and heme biosynthesis, leading to breaking chain of reactions, causing the cells and cell organelles to dry and disintegrate rapidly in case of broad-leaved weeds (Tiwari and Mathew 2002, Goverdhan 2018). Similarly, PoE application of propaquizafop 100 g/ha reduced both density and dry weight of grassy weeds for its selective nature, causing reduced cell division and growth through inhibition in 'acetyl CoA carboxylase' (ACCase) enzyme functioning (Tiwari and Mathew, 2002, Shiva Pratap *et al.* 2018). Weedy check plots recorded higher values of weed density and dry weight (**Table 1**).

Higher WCE (92.3%) and lower WI (6.19%) were recorded with two hand weeding (15 and 30 DAS), which was at par with PoE application of fomesafen + propaquizafop at 252 + 78 g/ha with WCE of 91.1% and WI of 10.23%. This was mainly due to effective control of weeds at critical stages of crop growth, enabling the crop to better utilize available resources like light, nutrients, moisture and space and resulting in higher yields with lower WI. Kewat *et al.* (2014) were of similar opinion.

Effect on crop

PoE application of pre-mix herbicides significantly recorded higher values of growth and yield attributes as compared to their sole application and remained at par with weed free plot. Weed free plot was significantly superior to all other treatments in respect of growth and yield attributes. Higher plant height (39.2 and 38.3 cm) along with more number of branches/plant (8.2 and 8.1), pods/plant (43.5 and

42.0) and pod length (5.3 and 5.2 cm) were recorded under fomesafen + propaquizafop at 252 + 78 and 210 + 65 g/ha, respectively. Minimum values were recorded under weedy check treatment. Higher seed yield (1.45 t/ha) and stover yield (4.21 t/ha) was recorded in weed free check (**Table 2**), which was significantly on par with two hand weeding at 15 and 30 DAS (1.35 and 4.13 t/ha) and fomesafen + propaquizafop 252 + 78 g/ha (1.29 and 3.95 t/ha). This was due to better control of both grassy as well as broad-leaved weeds during early crop growth period. It provided a congenial environment for better expression of growth stature and yield attributes, resulting in increased seed yield. These results corroborated with the findings of Sylvestre *et al.* (2013) and Khot *et al.* (2015).

There was a positive correlation between nutrient uptake by crop plants with seed and stover yields at harvest. Seed and stover yields were significantly higher with more uptake of nitrogen, phosphorus and potassium by crop plants as recorded in weed free check, two hand weeding and fomesafen + propaquizafop 252 + 78 g/ha due to better weed control and less crop-weed competition (**Table 3**). The lowest level of nutrient uptake by the crop was recorded in unweeded control due to intense crop-weed competition, causing lower dry matter production. Similar observation was also reported by Younesabadi *et al.* (2013) and Chhodavadia *et al.* (2013).

Crop yield and nutrient uptake by weeds were negatively correlated. More nutrient removal by weeds resulted in luxuriant weed growth that suppressed crop growth and development, causing poor crop yield as reflected in weedy check. Significantly the lowest removal of nutrients by the weeds was recorded under two hand weeding as a consequence of effective weed removal (**Table 3**). The results were in conformity with the findings of Komal *et al.* (2015) and Prachand *et al.* (2015).

Production economics

PoE application of fomesafen + propaquizafop 252 + 78 g/ha fetched higher net return (₹ 50,106/ha) with benefit/cost ratio (BCR) of 3.26, which was at par with fomesafen + propaquizafop 210 + 65 g/ha with net return of ₹ 48,030/ha and BCR of 3.20 as compared to two hand weeding (BCR of 2.60).

Table 1. Effect of treatments on weed growth, weed control efficiency and weed index in blackgram

Treatment	Weed density (no./m^2) at harvest			Weed dry weight (g/m^2) at harvest			WCE (%) at 30 DAS	WI (%)
	Sedge	Grasses	Broad-leaved	Sedge	Grasses	Broad-leaved		
Fomesafen 250 g/ha (20 DAS)	1.41(1.10)	1.36(19.80)	2.74(6.57)	1.51(1.32)	1.58(36.73)	1.43(24.97)	68.3	46.42
Propaquizafop 100 g/ha (20 DAS)	1.14(0.33)	1.10(6.60)	5.05(24.57)	1.36(0.87)	1.30(18.03)	1.56(34.97)	74.5	44.05
Imazethapyr 100 g/ha (20 DAS)	1.80(2.27)	1.38(23.03)	4.79(22.00)	2.02(3.10)	1.57(35.33)	1.59(37.40)	61.7	47.67
Fomesafen + propaquizafop 168 + 52 g/ha (20 DAS)	1.11(0.25)	1.20(18.97)	3.83(13.87)	1.66(1.78)	1.52(31.17)	1.49(28.93)	75.1	34.03
Fomesafen + propaquizafop 210 + 65 g/ha (20 DAS)	1.30(0.73)	1.06(14.73)	3.68(12.57)	1.46(1.17)	1.46(26.93)	1.51(30.97)	89.7	13.15
Fomesafen + propaquizafop 252 + 78 g/ha (20 DAS)	1.20(0.53)	0.87(7.03)	3.17(9.07)	1.26(0.60)	1.32(19.23)	1.46(27.47)	91.1	10.23
Fomesafen + propaquizafop 294 + 91 g/ha (20 DAS)	1.57(1.52)	1.17(11.07)	3.72(12.87)	1.61(1.67)	1.40(23.27)	1.52(31.27)	88.8	31.20
Propaquizafop + imazethapyr 50 + 75 g/ha (20 DAS)	2.11(3.47)	1.39(22.93)	4.22(16.87)	2.00(3.03)	1.64(42.03)	1.54(32.80)	78.0	30.06
Two hand weeding (15 and 30 DAS)	1.14(0.33)	0.67(6.63)	2.51(5.40)	1.33(0.77)	1.24(15.73)	1.31(18.80)	92.3	6.19
Weed free	1.00(0.00)	0.30(0.00)	1.00(0.00)	1.00(0.00)	0.30(0.00)	0.30(0.00)	100.0	0.00
Weedy check	1.99(3.07)	1.44(44.67)	5.28(27.07)	2.24(4.07)	1.83(66.20)	1.71(50.13)	0.0	68.27
LSD (p=0.05)	0.16	0.43	0.70	0.13	0.24	0.15	NA	NA

DAS: Days after sowing, WCE: Weed control efficiency, WI: Weed index. Original figures within parentheses were subjected to log ($\sqrt{x+2}$) transformation for grasses and square root ($\sqrt{x+1}$) transformation for sedge and broad-leaved

Table 2. Effect of treatments on crop growth, yield parameters and yield of blackgram

Treatment	Plant height (cm)	Branches /plant	Productive pods/plant	Pod length (cm)	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)	Net returns (x10^3₹/ha)	B:C ratio
Fomesafen 250 g/ha (20 DAS)	28.5	5.7	21.8	4.5	0.77	2.95	20.7	20.64	1.92
Propaquizafop 100 g/ha (20 DAS)	27.6	6.1	26.3	4.6	0.80	2.91	21.7	23.04	2.05
Imazethapyr 100 g/ha (20 DAS)	26.9	5.3	23.0	4.6	0.75	2.88	20.8	20.73	1.97
Fomesafen + propaquizafop 168 + 52 g/ha (20 DAS)	30.2	6.2	26.5	4.7	0.95	2.98	24.1	31.50	2.46
Fomesafen + propaquizafop 210 + 65 g/ha (20 DAS)	38.3	8.1	42.0	5.2	1.25	3.85	24.5	48.03	3.20
Fomesafen + propaquizafop 252 + 78 g/ha (20 DAS)	39.2	8.2	43.5	5.3	1.29	3.95	24.6	50.11	3.26
Fomesafen + propaquizafop 294 + 91 g/ha (20 DAS)	28.5	5.7	28.5	4.7	0.99	2.99	22.9	32.92	2.47
Propaquizafop + imazethapyr 50 + 75 g/ha (20 DAS)	30.0	5.8	32.3	4.6	1.00	3.65	21.4	34.30	2.56
Two hand weeding (15 and 30 DAS)	40.3	8.4	44.6	5.4	1.35	4.13	24.6	48.78	2.60
Weed free	42.1	9.2	45.1	5.7	1.44	4.21	25.4	47.99	2.48
Weedy check	23.9	3.9	13.4	4.3	0.46	2.71	14.4	3.05	1.15
LSD (p=0.05)	4.61	0.40	3.4	0.57	0.19	0.36	4.61	20.64	1.92

Table 3. Nutrient uptake (kg/ha) by crop and weeds at harvest as influenced by different post-emergent herbicides

Treatment	Crop			Weeds		
	Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
Fomesafen 250 g/ha (20 DAS)	49.4	11.9	21.4	9.40	3.83	5.60
Propaquizafop 100 g/ha (20 DAS)	50.6	12.4	23.1	6.93	3.47	5.33
Imazethapyr 100 g/ha (20 DAS)	49.1	11.5	22.5	8.87	3.83	6.87
Fomesafen + propaquizafop 168 + 52 g/ha (20 DAS)	58.2	12.4	26.3	6.67	3.17	5.03
Fomesafen + propaquizafop 210 + 65 g/ha (20 DAS)	77.5	15.3	34.6	5.83	3.20	4.87
Fomesafen + propaquizafop 252 + 78 g/ha (20 DAS)	78.9	15.4	35.2	4.83	2.90	4.13
Fomesafen + propaquizafop 294 + 91 g/ha (20 DAS)	62.9	13.4	24.8	6.93	3.43	5.47
Propaquizafop + imazethapyr 50 + 75 g/ha (20 DAS)	50.9	11.6	26.5	8.47	4.30	7.10
Two hand weeding (15 and 30 DAS)	79.0	15.9	35.4	4.57	2.83	4.03
Weed free	81.8	16.7	36.9	0.0	0.0	0.0
Weedy check	36.9	8.2	15.3	11.30	5.57	8.90
LSD (p=0.05)	5.10	1.46	2.87	1.17	0.47	0.96

Weedy check recorded the lowest net return (₹ 3,051/ha) with minimum BCR (1.15). Use of herbicides provided cost-effective control of weeds since beginning of crop establishment, compared with cost-prohibitive hand weeding (**Table 2**). These results were in harmony with the findings of Khot *et al*. (2015) and Sakthi *et al*. (2018).

Crop phytotoxicity

Application of fomesafen + propaquizafop at 294 + 91 g/ha caused epinasty and stunted growth of crop plants at 1, 3, 5, 7 and 10 days after spraying. Although the treatment initially displayed slight yellowing of leaves and epinasty symptoms at 3 days after application, the crop plants gradually recovered with progress of growth after 7 days of spraying with almost disappearance of symptoms after 15 days of application Similar findings were also reported by Singh *et al*. (2014) and Goverdhan (2018).

Application of fomesafen 18.8% SL + propaquizafop 5.83% EC 252 + 78 g/ha proved to be the most efficient weed management practice for obtaining higher yields with more profit. Combined application of herbicides was found to be more effective than single herbicide application in ensuring broad spectrum weed management in blackgram.

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