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**RESEARCH ARTICLE**

# Effect of haloxyfop on narrow-leaved weeds in blackgram and its residual effect on succeeding rice crop

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**ABSTRACT**

Blackgram (*Vigna mungo* (L.) Hepper) is one of the most remunerative legume crop which grown in *Kharif* or summer season. An experiment was conducted to evaluate the activity and selectivity of the post-emergence herbicide haloxyfop on weeds growth and blackgram productivity during *Kharif* season of 2015 and 2016 at N.E. Borlaug Crop Research Centre, G.B.P.U.A& T, Pantnagar, Uttarakhand. The grass weeds: *Echinochloa colona* (15.5 and 15.0%), *Eleusine indica* (48.6 and 32.3%), *Dactyloctenium aegyptium* (18.3 and 22.0%), *Digitaria sanguinalis* (3.5 and 6.4%), *Brachiaria* spp. (2.8 and 3.3%) and *Panicum maximum* (11.3 and 21.0%) dominated the field (during 2015 and 2016, respectively).The lowest weed density and biomass, and highest weed control efficiency and blackgram seed yield were recorded with post-emergence application (PoE) of haloxyfop 135 g/ha followed by and at par with its lower dose (108 g/ha) during both the years and statistically at par with standard check quizalofop-ethyl 50g/ha, only during 2015. No phytotoxicity occurred to blackgram on 1, 3, 5, 7, 10, 15 and 30 days after application at any of the tested haloxyfop doses and was found safe for growing succeeding transplanted rice as rice growth and yield were not affected by any of the doses of haloxyfop.

**Keywords:** Blackgram, Haloxyfop, Herbicides, Phytotoxicity, Rice, Weed management

## INTRODUCTION

Blackgram is one of the important pulse crops cultivated worldwide in tropical and subtropical regions of the world. In *Kharif* 2021-22, blackgram production was 20.5 lakh tons in an area of 39.43 lakh hectares (agricoop.nic). Blackgram is not a very good competitor against weeds (Choudhary *et al.* 2012) and is mostly susceptible to weed infestation during the first four weeks of its growth period (Randhawa *et al.* 2002). Unchecked weeds have been reported to cause a considerable reduction in the grain yield of blackgram ranging from 35.2 to 87% (Sukumar *et al.* 2018) and critical period for crop weed competition is around 15 to 45 DAS (Khot *et al.* 2016). The majority of farmers use hand weeding, which requires a lot of labors, time and is also less cost effective under rainy days condition. Pre-emergence herbicides only control weeds for a short period and there after late-emerging weeds begin to compete with crops. Hence, in order to keep free from weed competition, the use of pre-emergence herbicides to manage early emerging weeds and post-emergence herbicides in sequence to manage late emerging weeds may be essential. Recently, haloxyfop-methyl and fluazifop-p-butyl have been reported as potential herbicides in controlling perennial grasses in most of the oilseeds and pulse crops. The aim of the present study was to evaluate the efficacy of haloxyfop in managing weeds and improving the productivity of blackgram while assessing its residual effect on rice grown in succession.

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## MATERIALS AND METHODS

A field experiment was conducted during *Kharif* season of 2015 and 2016, at G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. The experimental site was situated at $29^0$N latitude, $27.3^0$E longitude and at an altitude of 243.8 MSL in subtropical climatic condition of Himalaya foot hill of Uttarakhand at Norman E. Borlaug, Crop Research Center of G.B. Pant University of Agriculture and Technology, Pantnagar. The soil of the experimental area was loamy, medium in organic matter (0.67%), available nitrogen (210 kg/ha), phosphorus (17.5 kg/ha) and potassium (181.2 kg/ha) with a pH value of 7.5. During the growing period of the crop temperature ranged 22.4-$33.8^0$C and total rainfall was 1216 mm in *Kharif* 2015 and in *Kharif* 2016, the temperature range was 22-$33.3^0$C and the total rainfall 750.4 mm.

"*Pant Urd* - 31" variety was sown on April 9, 2015 and March 15, 2016 with seeding rate of 15 kg/ha. The experiment was laid out in a randomized block design with three replications. There were seven treatments consisting of post-emergence application (PoE) of haloxyfop 81, 108, 135 g/ha; fenoxaprop 67.5 g/ha, quizalofop-ethyl at 50 g/ha, hand weeding twice at 20 and 40 days after seeding (DAS) and weedy check. The haloxyfop dose of 270 g/ha was used for phytotoxic study. Post-emergence application of herbicides was done at 20 days after seeding and the residual effect of the herbicide was evaluated on succeeding transplanted rice crop variety Pant-12. Knapsack sprayer fitted with boom along with flat-fan nozzle was used to apply the herbicidal solution with spray volume of 400 l water per hectare.

The density and biomass of dominant weed species was recorded at 60 DAS. For recording both weed density and biomass a quadrat of 0.25 $m^2$ was placed randomly at four places per plot and the data was presented on per $m^2$ basis. The relative weed density and weed control efficiency were calculated according to the method given by Moinuddin *et al.* (2018).

The relative weed density of grassy weed flora was evaluated at 60 after herbicide application (DAA) in weedy plot during both the year by the following formula:

Visual scoring on control of weeds and phytotoxic symptoms (chlorosis/stunting/leaf tip injury/wilting/vein clearing/epinasty and hyponasty) in blackgram were recorded on 1, 3, 5, 7, 10, 15 and 30 days DAA. In the carry over study, the rice plant populations (2m row length) at 15 DAT and yield and yield attributes were recorded at harvest. The grain yield of succeeding crop (transplanted rice) was recorded separately for each plot and converted to per hectare.

## RESULTS AND DISCUSSION

### Effect on weeds

The major grassy weed flora in blackgram crop consisted of: *Echinochloa colona, Eleusine indica, Dactyloctenium aegyptium, Digitaria sanguinalis, Brachiaria* spp. and *Panicum maximum* with the relative weed density of 15.5%, 48.6%, 18.3%, 3.5%, 2.8% and 11.3% during 2015 and 15.0%, 32.3%, 22.0%, 6.4%, 3.3% and 21% during 2016, respectively. Similar findings were also reported by Punia (2014). At 60 DAA, hand weeding twice and haloxyfop 135 g/ha PoE were proved to be significantly superior to all the treatments in reducing the density of *E. colona* during *Kharif* 2015 and 2016. Haloxyfop 135 g/ha PoE recorded lowest density of *E. indica, D. aegyptium* and *D. sanguinalis* followed by haloxyfop108 g/ha PoE and quizalofop-ethyl 50 g/ha PoE. Lowest density of *E. colona* was recorded with haloxyfop 135 g/ha PoE and quizalofop-ethyl 50 g/ha PoE which were comparable with haloxyfop 108 g/ha PoE. All the treatments were equally effective and recorded lowest density of *Brachiaria* spp. All doses of haloxyfop as well as quizalofop-ethyl 50 g/ha PoE caused complete control of *P. maximum* during 2015. In 2016, complete control of *P. maximum* was observed with haloxyfop 135 g/ha PoE and quizalofop-ethyl 50 g/ha PoE (**Table 1**). Better response of haloxyfop in controlling grass weeds might be due to its ready absorption and translocation to meristematic region where it exerts herbicide activity (Burton 1997) and due to possession of a eukaryotic type ACCase in the chloroplasts which is sensitive to ACCase inhibitors like haloxyfop (Incledon and Hall 1997).

Among the treatments lowest total weed density (no./$m^2$) and total weed dry biomass (g/$m^2$) and highest weed control efficiency were recorded with haloxyfop at 135 g/ha PoE which was significantly at par to its lower dose of 108 g/ha during both the year 2015 and 2016 and with quizalofop-ethyl at 50 g/ha PoE only at 2015 (**Table 2**). Better response of quizalofop-ethyl in controlling narrow-leaved weeds might be due to the fact that aryloxyphenoxy-propionates (AOPP) class to which this herbicide belongs is readily absorbed and translocated to meristematic region and exert herbicide activity. Mundra and Maliwal (2012) also reported similar findings in terms of lowest weed density, weed dry biomass and highest weed control efficiency in blackgram.

**Table 1. Effect of treatments on density of weeds at 60 days after seeding (DAS) in blackgram**

| Treatment | Dose g/ha | *E. colona* | | *E. indica* | | *D. aegyptium* | | *D. sanguinalis* | | *Brachiaria* spp. | | *P. maximum* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2015 | 2016 | 2015 | 2016 | 2015 | 2016 | 2015 | 2016 | 2015 | 2016 | 2015 | 2016 |
| Haloxyfop | 81 | 15.5(17.3) | 3.4(10.7) | 6.2(40.0) | 4.4(18.7) | 4.3(17.3) | 4.0(14.7) | 1.9(2.7) | 2.2(4.0) | 1.7(2.0) | 2.4(4.7) | 1.0(0.0) | 2.4(4.7) |
| Haloxyfop | 108 | 3.6(12.0) | 2.8(6.7) | 3.9(14.0) | 3.5(11.3) | 2.2(4.0) | 3.0(8.0) | 1.3(0.7) | 1.9(2.7) | 1.5(1.3) | 1.9(2.7) | 1.0(0.0) | 1.5(1.3) |
| Haloxyfop | 135 | 3.2(9.3) | 2.8(6.7) | 3.8(13.3) | 3.4(10.7) | 2.2(4.0) | 2.9(7.3) | 1.0(0.0) | 1.0(0.0) | 1.5(1.3) | 1.9(2.7) | 1.0(0.0) | 1.0(0.0) |
| Fenoxaprop-p | 67.5 | 3.8(13.3) | 3.2(9.3) | 6.0(36.0) | 4.0(14.7) | 2.7(6.7) | 4.0(14.7) | 1.5(1.3) | 2.4(4.7) | 1.5(1.3) | 1.9(2.7) | 2.5(5.3) | 1.9(2.7) |
| Quizalofop-ethyl | 50.0 | 3.0(8.0) | 2.9(7.3) | 4.1(16.0) | 3.6(12.0) | 2.9(5.3) | 3.5(11.3) | 1.0(0.0) | 2.2(4.0) | 1.7(2.0) | 1.9(2.7) | 1.0(0.0) | 1.0(0.0) |
| Hand weeding twice | 20&40 DAS | 2.5(5.3) | 3.2(9.3) | 5.2(26.7) | 4.9(22.7) | 3.0(8.0) | 3.8(13.3) | 2.2(4.0) | 3.2(9.3) | 1.5(1.3) | 1.0(0.0) | 1.9(2.7) | 1.9(2.7) |
| Weedy check | - | 5.5(29.3) | 4.4(18.7) | 9.6(92.0) | 9.2(84.0) | 5.9(34.7) | 6.8(45.3) | 2.8(6.7) | 5.0(24.0) | 2.5(5.3) | 3.1(8.7) | 4.7(21.3) | 3.0(8.0) |
| LSD (p=0.05) | - | 0.43 | 0.48 | 1.38 | 0.70 | 0.71 | 0.52 | 0.41 | 0.39 | 0.3 | 0.45 | 0.29 | 0.42 |

LSD: least significant difference at the 5% level of significance; Value in parentheses were original and transformed to square root ($\sqrt{x+1}$) for analysis

## Effect on blackgram

All the yield attributing characters of blackgram were significantly influenced by weed control treatments during both the years, except number of plants/m$^2$ and 100 seed weight (g) during 2015. Haloxyfop 135 g/ha PoE recorded the highest plant height, number of plants/m$^2$, pods/plant, grains/pod and 100 seed weight followed by its lower dose at 108 g/ha and was found statistically at par to hand weeding twice (**Table 3**). These findings were corroborated with Singh *et al.* (2010), who reported similar results in case of soybean cop.

The highest grain yield was obtained with application of haloxyfop 135 g/ha PoE followed by haloxyfop 108 g/ha PoE which were at par to hand weeding twice, during both years. These findings are in agreement with those of Pankaj and Dewangan (2017). The blackgram yield was higher in *Kharif* 2015 than in *Kharif* 2016 due to favourable environmental conditions in *Kharif* 2015 leading to vigorous crop growth (**Table 3**).

Blackgram yield and weed biomass at 60 DAS were negatively correlated during both the years with $R^2$ of 0.80 in 2015 and 0.83 in 2016(**Figure 1a** and **1b**).

## Economics

The highest net returns and B:C were observed with haloxyfop 135 g/ha PoE followed by haloxyfop108 g/ha during both the years (**Table 4**) due to higher seed yield with comparatively low cost of cultivation of blackgram in these treatments as reported by Karki *et al.* (2002), Rathore *et al.* (2014), Singh *et al.* (2016).

## Phytotoxicity

No phytotoxic effect was observed on blackgram due to haloxyfop 135 g/ha PoE and 270 g/ha.

## Carry over effect on succeeding crop

The transplanted rice yield attributing characters and yield were not affected significantly due to weed control treatments applied in blackgram. Hence haloxyfop use in blackgram during *Kharif* season was safe to transplanted rice crop grown after blackgram.

It was concluded that haloxyfop 135 g/ha PoE is economical and effective to manage weeds and economically improving blackgram productivity and it has no phytotoxic effect on blackgram or succeeding rice crop.

**Table 2. Effect of treatments on dry biomass of weeds and weed control efficiency at 60 DAA in blackgram**

| Treatment | Dose (g/ha) | Total weed density (no./m$^2$) | | Total weed biomass (g/m$^2$) | | WCE (%) | |
|---|---|---|---|---|---|---|---|
| | | 2015 | 2016 | 2015 | 2016 | 2015 | 2016 |
| Haloxyfop | 81 | 8.9(79.3) | 7.6(57.3) | 13.9(191.9) | 16.6(274.5) | 74.2 | 54.3 |
| Haloxyfop | 108 | 5.7(32.0) | 5.8(32.7) | 10.2(103.6) | 13.8(188.7) | 86.1 | 68.6 |
| Haloxyfop | 135 | 5.4(28.0) | 5.3(27.3) | 9.6(91.3) | 12.9(165.9) | 87.7 | 72.4 |
| Fenoxaprop | 67.5 | 8.0(64.0) | 7.0(48.7) | 14.2(202.2) | 16.2(260.9) | 72.8 | 56.6 |
| Quizalofop-ethyl | 50.0 | 5.7(31.30 | 6.2(37.3) | 10.5(109.7) | 14.7(214.1) | 85.2 | 64.4 |
| Hand weeding twice | 20 and 40 DAS | 7.0(48.0) | 7.6(57.3) | 10.2(102.5) | 16.1(257.5) | 86.2 | 57.2 |
| Weedy | - | 13.8(189.3) | 13.8(188.7) | 27.3(743.1) | 24.5(601.2) | - | - |
| LSD (p=0.05) | - | 1.1 | 0.78 | 1.3 | 1.5 | - | - |

LSD, least significant difference at the 5% level of significance, Value in parentheses were original and transformed to square root ($\sqrt{x+1}$) for analysis, DAA: Days after herbicide application, DAS- days after sowing

**Table 3. Effect of weed management treatments on blackgram yield attributing characters and yield**

| Treatment | Dose g/ha | Plant height (cm) | | Plants (no./m$^2$) | | Pods/plant | | Grains/pod | | 100-seed weight (g) | | Grain yield (kg/ha) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2015 | 2016 | 2015 | 2016 | 2015 | 2016 | 2015 | 2016 | 2015 | 2016 | 2015 | 2016 |
| Haloxyfop | 81 | 48.3 | 38.7 | 32.0 | 29.0 | 22.7 | 20.4 | 3.77 | 3.88 | 3.8 | 3.7 | 1033 | 933 |
| Haloxyfop | 108 | 49.8 | 39.8 | 33.8 | 32.5 | 29.1 | 25.7 | 3.93 | 3.93 | 4.0 | 4.0 | 1533 | 1300 |
| Haloxyfop | 135 | 50.4 | 41.4 | 34.0 | 33.0 | 29.0 | 24.7 | 3.93 | 4.02 | 4.1 | 3.9 | 1583 | 1308 |
| Fenoxaprop | 67.5 | 45.9 | 38.9 | 32.3 | 32.0 | 24.3 | 22.7 | 3.87 | 3.55 | 3.9 | 3.7 | 1200 | 967 |
| Quizalofop-ethyl | 50.0 | 49.7 | 39.0 | 33.5 | 32.5 | 24.7 | 23.0 | 3.87 | 3.67 | 4.0 | 3.8 | 1317 | 1050 |
| Hand weeding twice | 20 and 40 DAS | 50.6 | 40.7 | 33.7 | 33.0 | 30.2 | 26.6 | 3.97 | 4.02 | 4.1 | 3.8 | 1650 | 1333 |
| Weedy check | - | 44.0 | 39.2 | 28.8 | 25.3 | 18.7 | 17.9 | 2.90 | 2.20 | 3.6 | 3.4 | 567 | 408 |
| LSD (p=0.05) | - | 2.92 | 2.9 | NS | 3.8 | 4.6 | 1.9 | 0.46 | 0.61 | NS | 0.40 | 151.8 | 108.4 |

LSD, least significant difference at the 5% level of significance, DAS- days after sowing, NS- non significant

**Table 4. Effect of weed management treatments on cost of cultivation, gross return, net return and B:C ratio in blackgram**

| Treatment | Dose (g/ha) | Cost of cultivation ($x10^3$ `/ha) | | Gross returns ($x10^3$ `/ha) | | Net returns ($x10^3$ `/ha) | | B:C | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2015 | 2016 | 2015 | 2016 | 2015 | 2016 | 2015 | 2016 |
| Haloxyfop | 81 | 22.62 | 23.12 | 44.94 | 43.15 | 22.32 | 20.03 | 0.99 | 0.87 |
| Haloxyfop | 108 | 22.97 | 23.47 | 66.69 | 60.12 | 43.72 | 36.65 | 1.90 | 1.56 |
| Haloxyfop | 135 | 23.32 | 23.82 | 68.86 | 60.49 | 45.54 | 36.66 | 1.95 | 1.54 |
| Fenoxaprop | 67.5 | 22.95 | 23.45 | 52.20 | 44.72 | 29.25 | 21.27 | 1.27 | 0.91 |
| Quizalofop-ethyl 5% EC | 50.0 | 23.63 | 24.13 | 57.29 | 48.56 | 33.66 | 24.43 | 1.42 | 1.01 |
| Hand weeding | 20 & 40 DAS | 33.00 | 33.50 | 71.77 | 61.65 | 38.77 | 28.15 | 1.18 | 0.84 |
| Weedy check | - | 21.00 | 21.50 | 24.66 | 18.87 | 3.66 | -2.63 | 0.17 | -0.12 |

MSP blackgram ₹: 43500/t (2015-16), ₹ 46250/t (2016-17), General cost of cultivation of blackgram: ₹ 21000/ha, Hand weeding (2 HW): ₹ 6000/ha

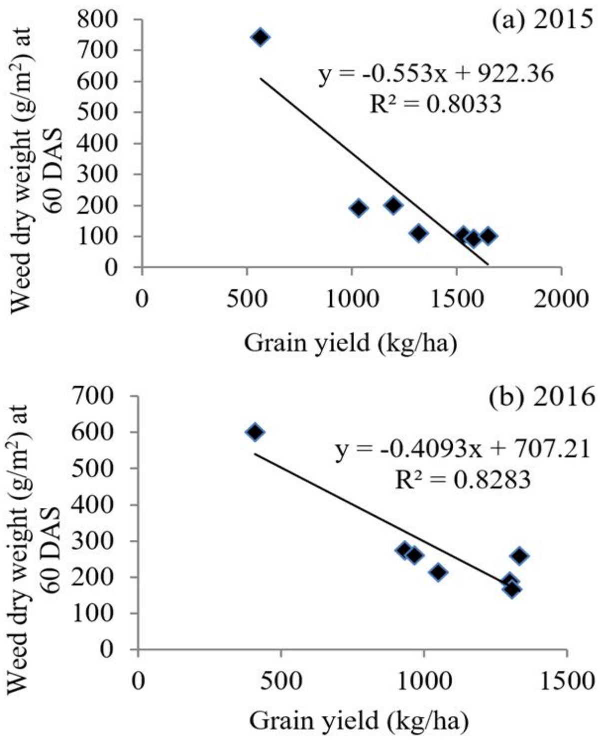


**Figure 1. Correlation between grain yield and weed biomass at 60 DAS during (a) 2015 and (b) 2016**

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