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Bio-Efficacy of Post-Emergent Herbicides on Weed Dynamics, Yield and Economics of Horsegram

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Abstract

The field experiment entitled 'Bio-efficacy of post-emergent herbicides on growth and yield of horsegram (*Macrotyloma uniflorum* L.)' was conducted at AICRP on Arid legumes field unit, University of Agricultural Sciences, GKVK, Bengaluru during *kharif* 2020. The experiment consisted of eight treatments including the application of six post emergent herbicides (Quizalofop ethyl, propaquizafop, imazethapyr, haloxyfop r-methyl, chlodinafop propargyl and fenoxafrop-p-ethyl at 15 DAS), two hand weedings (20 and 40 DAS) and weedy check were replicated thrice in RCBD. Major weeds observed were *Borreria hispida, Alternanthera sessilis, Euphorbia geniculata, Acanthospermum hispidum, Parthenium hysterophorus* among broad-leaved weeds, *Eleusine indica, Dactyloctenium aegyptium* and *Cynodon dactylon* among the grassy weeds and *Cyperus rotundus* among sedges. The results revealed that hand weedings at two intervals (20 and 40 DAS) recorded significantly higher seed yield (1155 kg ha^{-1}) and was found on par with post emergent application of quizalofop ethyl 5 per cent EC 50 g a.i. ha^{-1} (1121 kg ha^{-1}) and imazethapyr 10 per cent SL 40 g a.i. ha^{-1} (1082 kg ha^{-1}) without having any phytotoxicity on horsegram. The net returns and B:C ratio was recorded higher in the treatments receiving post emergent application of quizalofop ethyl 5 per cent EC 50 g a.i. ha^{-1} (Rs.21,874 ha^{-1} and 2.1, respectively) and imazethapyr 10 per cent SL 40 g a.i. ha^{-1} (Rs. 20,541 ha^{-1} and 2.0, respectively).

Keywords : Horsegram, Hand weeding, Quizalofop ethyl, Imazethapyr economics, Yield

Pulses are recognized as an integral part of Indian diet and protein supplements particularly for vegetarian by virtue of their high protein and essential amino acid content. The per capita recommendation of pulses is 60 g day^{-1} as per FAO and WHO, but the availability is 42 g day^{-1}. Significant increasing trends during 2016-17 and 2017-18, whereby the pulses production reached at 23 MT and 25.23 MT, respectively is a success story. The productivity of pulses has increased by 13 per cent to reach 841 kg ha^{-1} during 2017- 18 from the level of 743 kg ha^{-1} during 2014-15. The production growth has been 43 per cent (Anonymous, 2018).

Horsegram (*Macrotyloma uniflorum*) is a pulse and fodder crop native to Southeast Asia and tropical Africa. The name Macrotyloma is derived from the Greek words makros meaning large, tylos meaning knob and loma meaning margin, in reference to knobby statures on the pods (Anitha *et al.,* 2013). It is a true diploid having chromosome number 2n=2x=20. It is cultivated in India, Myanmar, Nepal, Malaysia, Mauritius and Sri Lanka for food purposes and in Australia and Africa primarily for fodder. The limited use of dry seeds of horsegram is due to its poor cooking quality. However, it is consumed as soups and sprouts in many parts of India.

Being a leguminous crop, it adds nitrogen to the soils where it grows, thus improving the soil fertility. The

protein content in cultivated horsegram is reported to be 16.9–30.4 per cent. It also has high lysine content, an essential amino acid. Horsegram is also rich in phosphorus, iron and vitamins such as carotene, thiamine, riboflavin, niacin and vitamin C. It is known to contain many medicinal and therapeutic benefits, although many of them are yet to be proven scientifically.

The critical period of crop–weed competition for the crop varies from 15-35 days after sowing. Weed control during early stages of crop growth period assumes important as reveal from the significant decrease in yield due to delay in weeding. Moreover, continuous rainfall during the season makes chemical weed control uncertain and unpracticable. Presently, weed management in horsegram has not been tested. Therefore, to study efficacy of some weed management practices on horsegram, the present investigation was undertaken.

Material and Methods

A field experiment was conducted during *kharif* 2020 at the field unit of AICRP on Arid-legumes, University of Agricultural Sciences, GKVK, Bengaluru. The experimental site is situated in the Eastern Dry Zone (Zone-V) of Karnataka which is situated between 12°58' North latitude and 77°35' East longitude with an altitude of 924 m above mean sea level. The soil of the experimental site was sandy loam in its texture. The soil of the site is slightly acidic in reaction (pH 6.1) with medium electrical conductivity (0.68 dS m^{-1}) and organic carbon content (0.38%). It has low available nitrogen (247.60 kg ha^{-1}), medium phosphorus (28.26 kg ha^{-1}) and medium potassium (278.41 kg ha^{-1}), respectively. The experiment included of eight treatments laid out in randomized complete block design with three replications. Treatments involved of post-emergence application of herbicides. T_1 Quizalofop ethyl @ 50 g a.i. ha^{-1}, T_2 Haloxyfop- R-methyl @ 100 g a.i. ha^{-1}, T_3 Clodinafop propagyl @ 60 g a.i. ha^{-1}, T_4 Fenoxaprop p ethyl @ 90 g a.i. ha^{-1}, T_5 Propaquizafop @ 100 g a.i. ha^{-1}, T_6 Imazethapyr @ 40 g a.i. ha^{-1}, T_7 two hand weedings at 20 and 40 DAS and T_8 Weedy Check. Treatment imposition was done at 15 DAS. The horsegram variety PHG-9 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, 37.5 kg P_2O_5 and 25 kg K_2O through urea, single super phosphate and murate of potash respectively, and labour input for all the operations. The predominant market prices of the horsegram after harvest was attained from the AICRP on Arid Legumes field unit, Zonal Agricultural Research Station, GKVK, Bengaluru was used for the calculation of gross returns. Grossreturns, 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

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

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, *Borreria hispida, Ageratum conyzoides, Alternanthra sessilis, Euphorbia geniculate* and *Parthenium hysterophorus.* Among the grassy weeds *Cynodon dactylon, Dactyloctenium aegyptium, Digitaria marginata* and *Eleusine indica* and among sedges *Cyperus rotundus*. All the weed species were effectively controlled by two hand weedings which was done on 22.09.2020 (20 DAS) and on 12.10.2020 (40 DAS). Hand weedings at two intervals (20 and 40 DAS) recorded lowest weed density and weed dry weight (6.30 m^{-2} and 1.04 g m^{-2}) and on par with the post emergence application of Quizalofop ethyl @ 50 g a.i. ha^{-1} (21.5 m^{-2} and 8.53 g m^{-2}) and Imazethapyr @ 40 g a.i. ha^{-1} (25.5 m^{-2} and 10.03 g m^{-2}) due to better control of weeds throughout the critical stages of crop growth. Whereas, weedy check recorded highest total weed density and dry weight (56.40 m^{-2} and 32.69 g m^{-2}) at 60 days of the crop stage depicted

TABLE 1

Effect of post emergent herbicides on weed density and weed dry weight of horsegram

Treatment	Weed density at 60 DAS				Weed dry weight at 60 DAS			
	Sedge +	Grasses +	Broad leafweeds #	Total	Sedge +	Grasses +	Broad leafweeds #	Total
T_1	1.73 (2.0)	2.81 (6.9)	3.68 (9.1)	1.37 (21.5)	1.04 (0.08)	1.75 (2.07)	2.97 (7.88)	2.34 (4.49)
T_2	2.24 (4.0)	3.70 (12.7)	4.47 (19.0)	1.58 (35.7)	1.07 (0.15)	2.19 (3.81)	3.64 (12.28)	2.59 (5.64)
T_3	1.92 (2.7)	3.32 (10.0)	3.86 (13.9)	1.46 (26.6)	1.09 (0.20)	2.08 (3.36)	3.15 (8.90)	2.56 (5.58)
T_4	2.39 (4.7)	3.78 (13.3)	4.75 (21.6)	1.62 (39.6)	1.10 (0.22)	2.23 (3.99)	3.91 (14.2)	2.62 (5.88)
T_5	2.65 (6.0)	4.12 (16.0)	4.40 (18.4)	1.63 (40.04)	1.13 (0.27)	2.41 (4.80)	3.57 (11.7)	2.69 (6.31)
T_6	2.24 (4.0)	3.15 (8.9)	3.18 (12.6)	1.38 (22.0)	1.08 (0.16)	1.92 (2.7)	2.59 (5.73)	2.48 (5.16)
T_7	1.30 (0.70)	1.84 (2.40)	2.05 (3.20)	0.92 (6.30)	1.01 (0.02)	1.02 (0.05)	1.56 (0.97)	1.00 (0.00)
T_8	2.88 (7.3)	4.84 (22.4)	5.26 (26.7)	1.77 (56.4)	1.24 (0.1)	3.16 (8.6)	4.38 (18.2)	2.79 (6.81)
S.Em±	0.05	0.11	0.14	0.07	0.04	0.06	0.13	0.12
C. D. @5%	0.16	0.33	0.43	0.22	0.12	0.19	0.38	0.36

in (Table 1) These results are also endorsed by several researchers Tiwari *et al.,* 2016, Pandey *et al.,* 2017 and Chetan *et al.,* 2015 in pulses.

Weed Control Efficiency and Weed Index

The results on the weed control efficiency and weed index are presented in (Table 2). Among the treatments, in hand weeding weed control efficiency of 100 per cent at all the stages was observed as compared to all other treatments.

The crop yield is directly proportional to weed control efficiency (WCE) and inversely related to weed index (WI). At 60 DAS, higher weed control efficiency was observed in hand weeding at 15-20 and 35-40 DAS (T_7) (96.24 %) followed by post emergent application of Quizalofop ethyl 5 per cent EC 50 g a.i. ha^{-1} (T_1) (69.09 %) and Imazethapyr 10 per cent SL 40 g a.i. ha^{-1} (T_6) (63.78 %) This might be due to reduction in the weed dry weight as a result of effective weed control in these treatments.

TABLE 2

Weed control efficiency and weed index at 60 DAS in horsegram as influenced by different post emergent herbicides

Treatments	Weed control efficiency (%)	Weed index (%)
T_1 : Quizalofop ethyl 5% EC (50 g a.i ha^{-1})	69.09	3.01
T_2 : Haloxyfop-R-methyl 10.5 % EC (100 g a.i. ha^{-1})	41.35	12.54
T_3 : Clodinafop propagyl 15 % WP (60 g a.i. ha^{-1})	55.04	10.06
T_4 : Fenoxaprop-p-ethyl 9.3 % EC (90 g a.i. ha^{-1})	39.18	16.55
T_5 : Propaquizafop 10 % EC (100 g a.i. ha^{-1})	33.30	23.31
T_6 : Imazethapyr 10 % SL (40 g a.i. ha^{-1})	63.78	6.31
T_7 : Hand weeding @ 15-20 & 35-40 DAS	96.24	-
T_8 : Weedy check	-	36.36

PoE- Post emergence spray at 15-20 Days After Sowing (DAS)

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TABLE 3

Effect of post emergent herbicides on yield, harvest index and weed index of horsegram

Treatments	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Harvest index	Weed index (%)
T_1 : Quizalofop ethyl 5% EC (50 g a.i. ha^{-1})	1121	1521	0.42	3.01
T_2 : Haloxyfop-R-methyl 10.5 % EC (100 g a.i. ha^{-1})	1010	1426	0.41	12.54
T_3 : Clodinafop propagyl 15 % WP (60 g a.i. ha^{-1})	1039	1457	0.42	10.06
T_4 : Finoxaprop p ethyl 9.3 % EC (90 g a.i. ha^{-1})	964	1360	0.41	16.55
T_5 : Propaquizafop 10 % EC (100 g a.i. ha^{-1})	886	1337	0.40	23.31
T_6 : Imazethapyr 10 % SL (40 g a.i. ha^{-1})	1082	1487	0.42	6.31
T_7 : Hand weeding @ 15-20 & 35-40 DAS	1155	1535	0.43	00
T_8 : Weedy check	735	1265	0.37	36.36

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

Weed index indicating yield reduction due to weed competition, which was higher in weedy check (36.36 %). Due to higher weed index and lower seed yield associated with unweeded check and this in turn due to poor nourishment of the crop throughout the crop growth period (Table 2). However, the lower weed index was noticed in hand weeding at 15-20 and 35-40 DAS (T_7) followed by post emergent application of Quizalofop ethyl 5 per cent EC 50 g a.i. ha^{-1} (T_1) (3.01) and Imazethapyr 10 per cent SL 40 g a.i. ha^{-1} (T_6) (6.31) as a result of satisfactory control of weeds owing to reduction in the crop weed competition.

The higher weed control efficiency and lower weed index attributed to reduction in the weed dry weight as a result of effective weed control in these treatments (Table 2). Higher weed control efficiency is a result of lower weed dry weight and elimination of competition from weeds during critical period of crop weed competition. Lower weed index is a result of satisfactory control of weeds owing to increase in yield. This enabled the crop to utilize available resources like light, nutrients, moisture and space resulting in higher yield. These results are in accordance with Choudhry *et al.* (2012), Raj *et al.* (2012), Gupta *et al.* (2013) and Kewat *et al.* (2014) in pulses.

Effect on Yield

Among different weed management treatments, two hand weedings at 15 and 30 DAS recorded significantly

TABLE 4

Economics of weed control by different post emergent herbicides in horsegram

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
T_1 : Quizalofop ethyl 5% EC (50 g a.i. ha^{-1})	19900	42024	21874	2.1
T_2 : Haloxyfop-R-methyl 10.5 % EC (100 g a.i. ha^{-1})	20750	37888	17138	1.8
T_3 : Clodinafop propagyl 15 % WP (60 g a.i. ha^{-1})	20150	38966	1881	1.9
T_4 : Finoxaprop p ethyl 9.3 % EC (90 g a.i. ha^{-1})	20750	36154	15404	1.7
T_5 : Propaquizafop 10 % EC (100 g a.i. ha^{-1})	20800	33226	12426	1.6
T_6 : Imazethapyr 10 % SL (40 g a.i. ha^{-1})	20050	40591	20877	2.0
T_7 : Hand weeding @ 15-20 & 35-40 DAS	22450	43327	20541	1.9
T_8 : Weedy check	18950	27570	8620	1.5

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

higher grain (1155 kg ha^{-1}) and haulm yield (1535 kg ha^{-1}) compared to all the treatments. However, it was statistically on par with post emergence application of Quizalofop ethyl 5 per cent EC (50 g a.i. ha^{-1}) (1121 and 1521 kg ha^{-1}) and Imazethapyr 10 per cent SL (40 g a.i. ha^{-1}) (1082 and 1487 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 (735 kg ha^{-1}) and haulm yield (1265 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 Lodha (2018) and Mundra and Maliwal (2014) in pulses (Table 3).

Economics

Among all treatment combinations, post-emergence application of Quizalofop ethyl 5 per cent EC (50 g a.i. ha^{-1}) recorded higher net returns (Rs.21,874 ha^{-1}) and B:C ratio (2.1) on par with Imazethapyr 10 per cent SL (40 g a.i. ha^{-1}) (Rs.20,877 ha^{-1}) and B:C ratio (2.0) compared to two hand weedings at 20 and 40 DAS (Rs.20,541 and 1.9, respectively). While, weedy check noticed negative net returns and the lowest B:C ratio (Rs.8,620 ha^{-1} and 1.5) Fig. 1. Even though highest gross returns were recorded in two hand weedings at 20 and 40 DAS, higher labour wages increased the cost of cultivation and lowered the B:C ratio. Whereas, in herbicide treatments, T_1 and T_6 lower cost of cultivation (Rs.19,900 and 20,050 ha^{-1}) due to lower labour requirement for herbicide application decreased the cost of cultivation which further increased the B:C ratio. Similar results were reported by Mamatha (2017) and Sakthi *et al.* (2018) in pulses (Table 4) and depicted in Fig. 1.

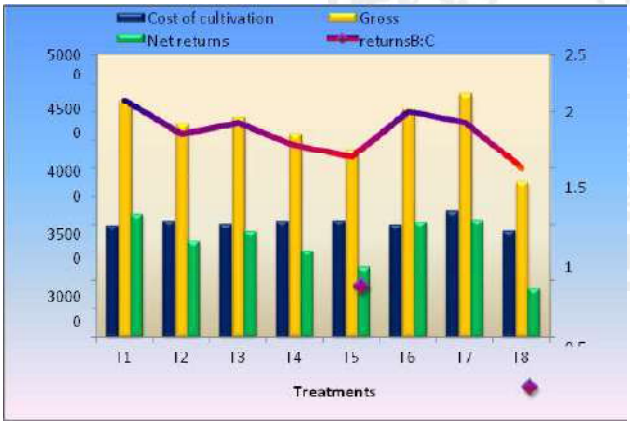

Fig. 1 : Economics of horsegram cultivation as influenced by different post emergent herbicides

T_1 : Quizalofop ethyl 5% EC (50 g a.i. ha^{-1})
T_2 : Haloxyfop-R-methyl 10.5 % EC (100 g a.i. ha^{-1})
T_3 : Clodinafop propagyl 15 % WP (60 g a.i. ha^{-1})
T_4 : Fenoxaprop-p-ethyl 9.3 % EC (90 g a.i. ha^{-1})
T_5 : Propaquizafop10% EC (100 % g a.i. ha^{-1})
T_6 : Imazethapyr 10% SL (40 g a.i. ha^{-1})
T_7 : Hand weeding at 15-20 and 35-40 DAS
T_8 : Weedy check

All the herbicides are applied as post-emergence at 15-20 DAS

Application Quizalofop ethyl 5 per cent EC (50 g a.i. ha^{-1}) and Imazethapyr 10 per cent SL (40 g a.i. ha^{-1}) in areas of labour scarcity was found to be most the efficient weed management practice for obtaining higher productivity and profitability of horsegram. Application of post emergent herbicides was found to be more effective in broad spectrum weed control increasing the yield thereby higher income in horsegram.

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