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Economics of Herbicides against Weeds of Black Gram (Vigna mungo (L). Hepper) Under Irrigated Condition

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Abstract: ***Field experiment was conducted at Agricultural College and Research Institute, Killikulam during Purattasipattam (September 2017 – November 2017) to evaluate the economics of herbicides against weeds of black gram under irrigated condition. Twelve treatments were tested in randomized block design with three replications. Among the weed control treatments, PE application of oxyfluorfen @ 0.18 kg a.i ha^{-1} + EPOE application of Imazethapyr @ 0.05 kg a.i ha^{-1} on 20 DAS recorded significantly lower total weed density (22.92 m^2) and higher weed control efficiency (93.2 %) than rest of the treatments including weedy check. The significantly higher grain (743 kg ha^{-1}) and haulm (2380 kg ha^{-1}) yield was recorded in weed free plot over all the treatments, which was followed by PE application of oxyfluorfen @ 0.18 kg a.i ha^{-1} + EPOE application of Imazethapyr @ 0.05 kg a.i ha^{-1} on 20 DAS (722 and 2314 kg ha^{-1}). However, the maximum net return of Rs.28832 ha^{-1} and B:C ratio (2.26) was found with PE application of oxyfluorfen @ 0.18 kg a.i ha^{-1} + EPOE application of Imazethapyr @ 0.05 kg a.i ha^{-1} on 20 DAS followed by PE application of pendimethalin @ 1.0 kg a.i ha^{-1} + EPOE Imazethapyr @ 0.05 kg a.i ha^{-1} on 20 DAS (Rs.27210 ha^{-1} and 2.18).***

Keywords: Blackgram, Economics, Herbicides, Weed control efficiency and Grain yield.

Introduction

Blackgram is usually accompanied by luxuriant weed growth during rainy (Kharif) season owing to abundant rainfall received during monsoon leading to serious crop losses by weeds. The crop is not very good competitor against weeds Choudhary *e al.* (2012) and therefore, weed control initiatives are essential to ensure proper growth of crop particularly in the early growth period. The initial 4 to 5 weeks are considered to be crucial for crop weed competition in blackgram (Patel *et al.*, 2015*)*. The magnitude of losses largely depends upon the composition of weed flora, period of crop weed

competition and its intensity. The manual weeding and mechanical hoeing is found to be laborious and time consuming, not only this, but in a peak period of crop growth, labour is not easily available and labour charges are also high due to the migration of agricultural laboures to industrial sector. Under such unfavorable conditions, the use of selective herbicides may probably be a suitable practice for controlling weeds. Therefore, in the present study, effect of various herbicides was compared with weed free check and weedy check for evaluating the reduction in weed dry weight and obtaining high yields of blackgram.

Material and Methods

A field experiment was conducted at Agricultural College and Research Institute, Killikulam during Purattasipattam (September 2017 – November 2017) to study the economics of herbicides against weeds of black gram under irrigated condition. The experiment was laid out in randomized block design with three replications. It consisted of twelve treatments *viz.*, T_1- PE Pendimethalin @ 1.0 kg a.i ha^{-1} + Hand weeding on 30 DAS, T_2- PE Isoproturon @ 0.375 kg a.i ha^{-1} + Hand weeding on 30 DAS, T_3- PE Oxyfluorfen @ 0.18 kg a.i ha^{-1} + Hand weeding on 30 DAS, T_4- PE Pendimethalin @ 1.0 kg a.i ha^{-1} + EPOE Quizalofop-ethyl @ 0.05 kg a.i ha^{-1} on 20 DAS, T_5- PE Isoproturon @ 0.375 kg a.i ha^{-1} + EPOE Quizalofop-ethyl @ 0.05 kg a.i ha^{-1} on 20 DAS, T_6- PE Oxyfluorfen @ 0.18 kg a.i ha^{-1} + EPOE Quizalofop-ethyl @ 0.05 kg a.i ha^{-1} on 20 DAS, T_7- PE Pendimethalin @ 1.0 kg a.i ha^{-1} + EPOE Imazethapyr @ 0.05 kg a.i ha^{-1} on 20 DAS, T_8- PE Isoproturon @ 0.375 kg a.i ha^{-1} + EPOE Imazethapyr @ 0.05 kg a.i ha^{-1} on 20 DAS, T_9- PE Oxyfluorfen @ 0.18 kg a.i ha^{-1} + EPOE Imazethapyr @ 0.05 kg a.i ha^{-1} on 20 DAS, T_{10}- Hand weeding twice on 15 DAS and 30 DAS, T_{11}- Weed free check, T_{12}-Unweeded control. Blackgram variey KKM 1 was sown under irrigated condition. Herbicides were applied as per the treatment schedule. Weed density, weed dry weight, yield and economics of blackgram were recorded.

Results and Discussion

Weed flora

The common weed flora found in the experimental field consisted of *Cynodon dactylon*, *Dactyloctenium aegyptium* and *Echinochloa colona* under grasses, *Cyperus rotundus* and *Cyperus iria* under sedges and *Amaranthus viridis*, *Boerhavia diffusa*, *Celosia argentia*, *Cleome viscosa*, *Digera arvensis*, *Phyllanthus madraspatensis*, *Phyllanthus niruri* and *Corchorus olitorius* under broad leaved weeds. This is in line with the findings of Pradeesh kumar and Chinnamuthu (2014) and Charan Teja *et al.* (2016). In this study, sedge weeds dominated the weed flora. The next dominant weed category was broad leaved weeds followed by grasses.

Total weed density

The total weed density was significantly influenced by the adoption of different weed management practices at 45 DAS (Table.1). Among the various weed management practices, weed free check recorded zero weed density at all the stages of observation. This might be due to reduced weed density through effective destruction of weeds by hand weeding as reported by Devendra Kumar *et al.* (2015).This treatment was followed by the PE application of Oxyfluorfen @ 0.18 kg a.i ha^{-1} + EPOE Imazethapyr @ 0.05 kg a.i ha^{-1} on 20 DAS (T_9) and PE application of pendimethalin @ 1.0 kg a.i ha^{-1} + EPOE Imazethapyr @ 0.05 kg a.i ha^{-1} on 20 DAS (T_7) significantly reduced the total weed density(22.92 m^{-2} and 24.11 m^{-2} respectively). This might be due to the control of weeds at germination phase by the application of pre emergence herbicides and significant reduction at later growth stage as late germinating weeds were controlled by early post emergence application of herbicides. Similar findings were reported by Rao *et al* (2010).

Total weed dry weight

Adoption of different weed management practices exerted significant influence on the total weed dry weight was zero with weed free check (Table. 1). At 45 DAS, PE application of Oxyfluorfen @ 0.18 kg a.i ha^{-1} + EPOE Imazethapyr @ 0.05 kg a.i ha^{-1} on 20 DAS (T_9) and PE application of pendimethalin @ 1.0 kg a.i ha^{-1} + EPOE Imazethapyr @ 0.05 kg a.i ha^{-1} on 20 DAS (T_7) recorded lower total weed dry weight of 19.94 g m^{-2} and 20.98 g m^{-2}. These two were on par with each other. In these treatments, application of herbicides at both early and later stages checked the weeds effectively resulting in lesser weed dry weight which was also reported by Devendra Kumar *et al.* (2015) and Rai *et al.* (2016).

Weed Control Efficiency

Weed control efficiency indicates the magnitude of reducing weed density effectively by different weed control treatments over weedy check (Table. 1). Among the weed management practices, PE application of Oxyfluorfen @ 0.18 kg a.i ha^{-1} + EPOE Imazethapyr @ 0.05 kg a.i ha^{-1} on 20 DAS (T_9) and PE application of pendimethalin @ 1.0 kg a.i ha^{-1} + EPOE Imazethapyr @ 0.05 kg a.i ha^{-1} on 20 DAS (T_7) registered more reduction of weed density and resulted in higher WCE (93.20 and 92.85 % respectively). This might be due to the greater reduction of wide spectrum of weeds at early stages of crop growth, which reduced the weed biomass. Similar finding was reported by Rai *et al.* (2016).

Weed Index

Weed index (Table.1) is a measure of yield loss caused due to varying degree of weed competition compared to the relatively weed free condition throughout the crop period leading to higher productivity. In the present study, PE application of Oxyfluorfen @ 0.18 kg a.i ha^{-1} + EPOE Imazethapyr @ 0.05 kg a.i ha^{-1} on 20 DAS (T_9) was the best treatment which recorded 2.8 per cent of yield reduction only. It was followed by the PE application of pendimethalin @ 1.0 kg a.i ha^{-1} + EPOE Imazethapyr @ 0.05 kg a.i ha^{-1} on 20 DAS (T_7) with a yield reduction of 5.4 per cent. The lesser yield reduction due to the above weed management practices might be due to the effective check on the weed growth which reduced the competition by weeds and provided favourable environment resulted in enhanced the yield levels compared to inefficient weed control treatments which were accounted with more yield reduction as reported by Shaikh *et al.*(2010). The largest yield reduction of 59.4 per cent was observed with unweeded control. Reduction in grain yield was caused by decrease in growth and yield components of pulses due to heavy weed competition over crop for space, light and nutrient etc. This is in accordance with the finding of Velmurugan *et al.* (2018) who reported the largest yield reduction to the tune of 63.19 per cent under weedy check treatment in urdbean.

Yield attributes

The grain yield of blackgram was mainly determined from the contribution of yield components like number of pods $plant^{-1}$, number of seeds pod^{-1} and test weight (Table. 2).

In the present study, adoption of different weed management practices significantly influenced the yield attributes of irrigated blackgram. Weed free check recorded higher values of yields components viz., number of pods $plant^{-1}$ (35.6); number of seeds pod^{-1} (6.41) and 100 seed weight (5.53g). It was comparable with the PE application of Oxyfluorfen @ 0.18 kg a.i ha^{-1} + EPOE Imazethapyr @ 0.05 kg a.i ha^{-1} on 20 DAS (T_9) and PE application of pendimethalin @ 1.0 kg a.i ha^{-1} + EPOE Imazethapyr @ 0.05 kg a.i ha^{-1} on 20 DAS (T_7) higher values of yields components viz., number of pods $plant^{-1}$ (34.9 and 33.7), number of seeds pod^{-1} (6.36 and 6.29) and 100 seed weight (5.51g and 5.40g). It might be due to the decreased weed competition and minimum nutrient removal by weeds which provided a competition free environment for the crop. This had increased the capacity of NPK uptake and enhanced source (LAI) and sink sizes which in turn increased the entire yield attributes. Similar observations were also made by Khot *et al*. (2012) and Devendra Kumar *et al.* (2015).

Yield

Weed free check had a favorable effect on the grain and haulm yields. The economic yield in the weed free treatment was found to be superior over all other treatments (Table.2). This result is in line with the findings of Balyan *et al.* (2016). Among various weed management practices followed, PE application of Oxyfluorfen @ 0.18 kg a.i ha^{-1} + EPOE Imazethapyr @ 0.05 kg a.i ha^{-1} on 20 DAS (T_9) recorded significantly higher grain yield as well as haulm yield (722 and 2314 kg ha^{-1}, respectively). This treatment was followed by the PE application of pendimethalin @ 1.0 kg a.i ha^{-1} + EPOE Imazethapyr @ 0.05 kg a.i ha^{-1} on 20 DAS (T_7), (703 and 2275 kg ha^{-1}). The percentage of yield increase due to weed free check, PE application of Oxyfluorfen @ 0.18 kg a.i ha^{-1} + EPOE Imazethapyr @ 0.05 kg a.i ha^{-1} on 20 DAS (T_9) and PE application of pendimethalin @ 1.0 kg a.i ha^{-1} + EPOE Imazethapyr @ 0.05 kg a.i ha^{-1} on 20 DAS (T_7) were 146.03, 139.07 and 132.8 per cent, respectively, over unweeded control. This was achieved by the way of effective early and later weed control through pre and post emergence herbicides which might have reduced the crop-weed competition. The increase in yield was mainly attributed to better control of weeds throughout the crop growth resulting in better availability of nutrients, moisture and light to the crop growth. Earlier findings by Devendra Kumar *et al.* (2015) and Charan Teja *et al.* (2016) agreed with the present findings.

Economics

Economic evaluation plays a paramount role from the point of technology recommendation and adaptation. As the yields produced by the various treatments show their benefits only when the production cost is lower and net return is higher which is finally benefitting the growers.

The economic evaluation of results revealed that application of Oxyfluorfen @ 0.18 kg a.i ha^{-1} as pre emergence + application of Imazethapyr @ 0.05 kg a.i ha^{-1} as early post emergence on 20 DAS and application of pendimethalin @ 1.0 kg a.i ha^{-1} as pre emergence + application of Imazethapyr @ 0.05 kg a.i ha^{-1} as early post emergence on 20 DAS registered higher gross return (Rs. 51697 ha^{-1} and Rs.50348 ha^{-1}), net return(Rs. 28832 ha^{-1} and Rs. 27210 ha^{-1}) and B: C ratio(2.26 and 2.18) (Table.3). This might be due to higher grain and haulm yield and effective weed control through pre and post emergence herbicides which requires less labour seems to be more ideal for getting higher net return and B:C ratio. This result was supported by Devendra Kumar *et al.* (2015) and Mishra *et al.* (2017).

Weed free check recorded higher cost of cultivation, which might be due to high labour requirement for weeding. Hand weeding is laborious, time consuming and expensive due to high cost

of labour particularly during peak period of labour requirement (Komal *et al.*(2015). Weed free check though gave higher grain yield, haulm yield and gross return , but cost of cultivation was more, and so net return and B:C ratio were reduced compared to the application of Oxyfluorfen @ 0.18 kg a.i ha^{-1} as pre emergence + application of Imazethapyr @ 0.05 kg a.i ha^{-1} as early post emergence on 20 DAS and application of pendimethalin @ 1.0 kg a.i ha^{-1} as pre emergence + application of Imazethapyr @ 0.05 kg a.i ha^{-1} as early post emergence on 20 DAS. This is in line with the findings of Devendra Kumar *et al.* (2015) and Charan teja *et al.* (2016).

Conclusion

From the above results, it could be concluded that application of Oxyfluorfen @ 0.18 kg a.i ha^{-1} as pre emergence + application of Imazethapyr @ 0.05 kg a.i ha^{-1} as early post emergence on 20 DAS or application of pendimethalin @ 1.0 kg a.i ha^{-1} as pre emergence + application of Imazethapyr @ 0.05 kg a.i ha^{-1} as early post emergence on 20 DAS was found to be the viable and economic weed management practice for achieving higher productivity and profitability of irrigated blackgram.

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Table.1 Effect of different weed management practices on the weed parameters in irrigated blackgram at 45 DAS

T.No.	Treatments	Total weed density (no. m^{-2})	Total weed dry weight (g m^{-2})	WCE* (%)	WI* (%)
T_1	PE Pendimethalin @ 1.0 kg a.i ha^{-1} + Hand weeding on 30 DAS	36.60(6.09)	31.84 (5.69)	89.14	15.5
T_2	PE Isoproturon @ 0.375 kg a.i ha^{-1} + Hand weeding on 30 DAS	74.67 (8.67)	66.46 (8.18)	77.85	36.1
T_3	PE Oxyfluorfen @ 0.18 kg a.i ha^{-1} + Hand weeding on 30 DAS	36.15 (6.05)	31.45 (5.65)	89.28	11.6
T_4	PE Pendimethalin @ 1.0 kg a.i ha^{-1} + EPOE Quizalofop-ethyl @ 0.05 kg a.i ha^{-1} on 20 DAS	63.68 (8.01)	56.04 (7.52)	81.11	27.3
T_5	PE Isoproturon @ 0.375 kg a.i ha^{-1} + EPOE Quizalofop-ethyl @ 0.05 kg a.i ha^{-1} on 20 DAS	97.98 (9.92)	87.20 (9.36)	70.94	43.1
T_6	PE Oxyfluorfen @ 0.18 kg a.i ha^{-1} + EPOE Quizalofop-ethyl @ 0.05 kg a.i ha^{-1} on 20 DAS	63.29 (7.99)	55.70 (7.50)	81.23	23.3
T_7	PE Pendimethalin @ 1.0 kg a.i ha^{-1} + EPOE Imazethapyr @ 0.05 kg a.i ha^{-1} on 20 DAS	24.11 (4.96)	20.98 (4.63)	92.85	5.4
T_8	PE Isoproturon @ 0.375 kg a.i ha^{-1} + EPOE Imazethapyr @ 0.05 kg a.i ha^{-1} on 20 DAS	73.35 (8.59)	65.28 (8.11)	78.24	34.1
T_9	PE Oxyfluorfen @ 0.18 kg a.i ha^{-1} + EPOE Imazethapyr @ 0.05 kg a.i ha^{-1} on 20 DAS	22.92 (4.84)	19.94 (4.52)	93.20	2.8
T_{10}	Hand weeding twice on 15 DAS and 30 DAS	48.38 (6.99)	42.57 (6.56)	85.65	21.8
T_{11}	Weed free check	0.00 (0.71)	0.00 (0.71)	100	0.0
T_{12}	Unweeded control	337.16 (18.37)	252.87 (15.91)	-	59.4

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SEd	0.18	0.16	-	-
CD(P=0.05)	0.37	0.32	-	-

Figure in parenthesis are √(X+0.5) transformed values *Data not statistically analysed. PE – Pre emergence EPOE - Early post emergence

Table.2 Effect of different weed management practices on the yield attributes and yield of irrigated blackgram

T.No.	Treatments	No. of pods plant^{-1}	No. of Seeds pod^{-1}	100 seed weight (g)	Grain yield (kg ha^{-1})	Haulm Yield (kg ha^{-1})
T_1	PE Pendimethalin @ 1.0 kg a.i ha^{-1} + Hand weeding on 30 DAS	30.9	5.96	5.35	628	2029
T_2	PE Isoproturon @ 0.375 kg a.i ha^{-1} + Hand weeding on 30 DAS	23.9	5.40	5.11	475	1550
T_3	PE Oxyfluorfen @ 0.18 kg a.i ha^{-1} + Hand weeding on 30 DAS	31.3	6.07	5.37	657	2122
T_4	PE Pendimethalin @ 1.0 kg a.i ha^{-1} + EPOE Quizalofop-ethyl @ 0.05 kg a.i ha^{-1} on 20 DAS	26.9	5.60	5.26	540	1736
T_5	PE Isoproturon @ 0.375 kg a.i ha^{-1} + EPOE Quizalofop-ethyl @ 0.05 kg a.i ha^{-1} on 20 DAS	21.4	5.22	5.08	423	1351
T_6	PE Oxyfluorfen @ 0.18 kg a.i ha^{-1} + EPOE Quizalofop-ethyl @ 0.05 kg a.i ha^{-1} on 20 DAS	27.8	5.62	5.27	570	1835
T_7	PE Pendimethalin @ 1.0 kg a.i ha^{-1} + EPOE Imazethapyr @ 0.05 kg a.i ha^{-1} on 20 DAS	33.7	6.29	5.40	703	2275
T_8	PE Isoproturon @ 0.375 kg a.i ha^{-1} + EPOE Imazethapyr @ 0.05 kg a.i ha^{-1} on 20 DAS	24.4	5.42	5.22	490	1577
T_9	PE Oxyfluorfen @ 0.18 kg a.i ha^{-1} + EPOE Imazethapyr @ 0.05 kg a.i ha^{-1} on 20 DAS	34.9	6.36	5.51	722	2314

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T_{10}	Hand weeding twice on 15 DAS and 30 DAS	28.2	5.67	5.30	581	1876
T_{11}	Weed free check	35.6	6.41	5.53	743	2380
T_{12}	Unweeded control	13.2	3.04	4.72	302	1099
	SEd	1.2	0.06	0.23	21	66
	CD(P=0.05)	2.4	0.13	NS	44	136

PE – Pre emergence EPOE - Early post emergence

Table.3 Economics of different weed management practices in irrigated blackgram

T.No.	Treatments	Cost of* cultivation Rs. ha^{-1}	Gross* return Rs. ha^{-1}	Net* return Rs. ha^{-1}	B:C*
T_1	PE Pendimethalin @ 1.0 kg a.i ha^{-1} + Hand weeding on 30 DAS	24173	44975	20802	1.86
T_2	PE Isoproturon @ 0.375 kg a.i ha^{-1} + Hand weeding on 30 DAS	22823	34025	11202	1.49
T_3	PE Oxyfluorfen @ 0.18 kg a.i ha^{-1} + Hand weeding on 30 DAS	23900	47051	23151	1.97
T_4	PE Pendimethalin @ 1.0 kg a.i ha^{-1} + EPOE Quizalofop-ethyl @ 0.05 kg a.i ha^{-1} on 20 DAS	24038	38668	14630	1.61
T_5	PE Isoproturon @ 0.375 kg a.i ha^{-1} + EPOE Quizalofop-ethyl @ 0.05 kg a.i ha^{-1} on 20 DAS	22688	30286	7598	1.33

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T_6	PE Oxyfluorfen @ 0.18 kg a.i ha^{-1} + EPOE 0.05 kg a.i ha^{-1} on 20 DAS	Quizalofop-ethyl @	23765	40818	17053	1.72
T_7	PE Pendimethalin @ 1.0 kg a.i ha^{-1} + EPOE kg a.i ha^{-1} on 20 DAS	Imazethapyr @ 0.05	23138	50348	27210	2.18
T_8	PE Isoproturon @ 0.375 kg a.i ha^{-1} + EPOE kg a.i ha^{-1} on 20 DAS	Imazethapyr @ 0.05	21788	35089	13301	1.61
T_9	PE Oxyfluorfen @ 0.18 kg a.i ha^{-1} + EPOE kg a.i ha^{-1} on 20 DAS	Imazethapyr @ 0.05	22865	51697	28832	2.26
T_{10}	Hand weeding twice on 15 DAS and 30 DAS		26006	41608	15602	1.60
T_{11}	Weed free check		28715	53200	24485	1.85
T_{12}	Unweeded control		17179	21690	4511	1.26

*Data not statistically analysed. PE – Pre emergence EPOE - Early post emergence