Original Research Article

Efficacy of herbicides against complex weed flora and yield of summer blackgram (*Vigna mungo* L.)

ABSTRACT

A field experiment was conducted at Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India during summer season of the year 2022 to study the "Efficacy of herbicides against complex weed flora and yield of summer blackgram (*Vigna mungo* L.)". Experiment comprised of ten different weed management treatments, *viz.* pre-emergence application of pendimethalin (30% EC) 750 g/ha (T_1), oxyfluorfen (23.5% EC) 117.5 g/ha (T_2), pyroxasulfone (85% w/w WG) 127.5 g/ha (T_3), diclosulam (84% WDG) + pendimethalin (30% EC) (tank mix) 21.0+750 g/ha (T_4), pendimethalin (30%) + imazethapyr (2% SL) EC (pre-mix) 800 g/ha (T_5), PoE application of imazethapyr (35%) + imazamox (35%) WG (pre-mix) 70 g/ha (T_6), quizalofop ethyl 7.5% + imazethapyr 15% (w/w EC) (pre mix) 112.5 g/ha (T_7), propaquizafop (2.5%) + imazethapyr (3.75%) ME (pre-mix) 125 g/ha (T_8), IC *fb* HW at 20 and 40 DAS (T_9) and weedy check (T_{10}) were laid out in randomized block design with four replication. Results revealed that pre-emergence application of pendimethalin + imazethapyr 800 g/ha PE followed by IC *fb* HW at 20 and 40 DAS registered lower density and dry weight of weed, higher weed control efficiency, yield attributes and yield of blackgram. While maximum net return (₹ 40324/ha) and BC ratio (2.62) were under pre-emergence application of pendimethalin (30%) + imazethapyr (2% SL) EC (pre-mix) 800 g/ha (T_5) over rest of the treatments.

Keywords: Black gram, herbicides, pendimethalin, imazethapyr, weed control efficiency, economics

1. INTRODUCTION

Blackgram {*Vigna mungo* (L.) Hepper} is one of the major pulse crops of India and is cultivated in tropical and subtropical regions. It can be grown in all the seasons of the year as seed crop and also as fodder crop. Blackgram improves the soil health and maintains its environment. It is third most important pulse crop grown under rainfed, rice fallow, irrigated conditions and during *kharif*, *rabi* and summer seasons and India is major producer and consumer of blackgram (Raju, 2019) [1]. In India, it is mainly grown in the states of Maharashtra, Odisha, Rajasthan, Bihar, Madhya Pradesh, Andhra Pradesh, Gujarat and Uttar Pradesh. About 70 per cent of the world's blackgram production comes from India. It produces about 24.5 lakh tonnes of Urad annually from about 4.6 million hectares of area, with an average productivity of 533 kg/ha in 2020-21 (Anon., 2020) [2]. In Gujarat, it is more or less grown in almost all districts and its cultivation is mainly centered in Sabarkantha, Panchmahal, Dahod, Vadodara, Mehsana and Bharuch. It is also cultivated to some extent in Rajkot, Surendranagar and Junagadh districts. In blackgram severe weed-crop competition occurs between 15 to 45 days after sowing due to less competitiveness of this crop against complex weed flora during early stage of crop. Bhowmick *et al.* (2015) [3] observed that season long weed competition causes yield reduction to the extent of 27-84% depending on the kind and intensity of weed species in blackgram. Weeds can be checked by adopting various methods like eco-physical, biological, chemical and recently through combining direct and indirect approach i.e. integrated weed management. Increasing in labour cost and constraints in availability on time, manual weed control is less economical practice for most of the agricultural crops (Kumar *et al.,* 2016) [4], which make us to explore the possibility of herbicidal weed control in blackgram. Therefore, the present study was conducted to study the efficacy of herbicides against complex weed flora and yield of summer blackgram.

2. MATERIALS AND METHODS

The experiment was undertaken at Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India during summer season of the year 2022. The experimental field had an even topography with a gentle slope having good drainage and loamy sand in texture having pH 7.93, organic carbon 0.48%, and 30.56, 270 kg/ha available P_2O_5 and K_2O, respectively. The experiment was laid out in a randomized block design with ten weed management practices and four replications. In the trial, ten weed management practices *viz.,* pre-emergence (PE) application of pendimethalin (30% EC) 750 g/ha (T_1), oxyfluorfen (23.5% EC) 117.5 g/ha (T_2), pyroxasulfone (85% w/w WG) 127.5 g/ha (T_3), diclosulam (84% WDG) + pendimethalin (30% EC) (tank mix) 21.0+750 g/ha (T_4), pendimethalin (30%) + imazethapyr (2% SL) EC (pre-mix) 800 g/ha (T_5), PoE application of imazethapyr (35%) + imazamox (35%) WG (pre-mix) 70 g/ha (T_6), quizalofop ethyl 7.5% + imazethapyr 15% (w/w EC) (pre mix) 112.5 g/ha (T_7), propaquizafop (2.5%) + imazethapyr (3.75%) ME (pre-mix) 125 g/ha (T_8), IC *fb* HW at 20 and 40 DAS (T_9) and weedy check (T_{10}). Blackgram cultivar 'GAU 4 (Shayamal)' was sown on 4th March, 2022 at a spacing of 30 cm and was harvested on 3rd June, 2022. A common fertilizer dose of 20: 40: 0 (N: P: K kg/ha) was applied. Urea and single super phosphate were used as the source of nitrogen and phosphorus, respectively. Full dose of N and P was applied as basal. Pre-emergence herbicides were applied within 48 hours of sowing and post-emergence herbicides were applied at 22 DAS. Required quantities of herbicides were applied as per treatment with manually operated knapsack sprayer fitted with flat-fan nozzle using a spray volume of 500 L water/ha. The counting of species wise weeds was done randomly by quadrate of 0.25 m^2 from each plot. The observations were recorded at 30, 60 days after sowing (DAS) and at harvest. The weed uprooted randomly at one place by quadrate of 0.25 m^2 with the help of khurpi in each plot. These were oven dried and their weight was recorded in gram. The weed index (WI) was calculated by using the formula given by Kumar and Gill (1969). Weed control efficiency of various treatments were worked out with the help of formula as prescribed by Mani *et al.* (1973). The net plot was harvested by sickles and the harvested material kept as such for drying for few days, and then weighed to record biological yield per plot. The produce of each plot was threshed separately to get seed yield and stover yield was calculated by subtracting seed yield from biological yield. For different treatments gross returns were calculated on the basis of prevailing market rate of produce and net profit by subtracted cost of cultivation per hectare from gross income. Benefit: Cost Ratio (BCR) was calculated as gross return / cost of cultivation. Square root (Y = X + 1) transformation scales was used for satisfying the condition of homogeneity of variance; where X is the original value of species wise weed population. Statistical analysis performed as per standard procedure as prescribed by Gomez and Gomez (1984).

Table 1: Density and dry weight weeds, weed control efficiency (WCE) and weed index of blackgram as influenced by different weed management practices

Treatment	Weed density (no./m^2)			Dry weight of weeds (g/m^2)			WCE (%) at 60 DAS	Weed Index (%)
	At 30 DAS	At 60 DAS	At harvest	At 30 DAS	At 60 DAS	At harvest		
Pendimethalin 750 g/ha PE	5.47^{d} (29)	6.14^{e} (37)	6.18^{d} (38)	4.64^{e} (20.54)	11.47^{d} (131.35)	15.86^{d} (251.46)	69.74	10.06
Oxyfluorfen 117.5 g/ha PE	6.16^{cd} (37)	7.02^{d} (49)	8.97^{bc} (80)	6.19^{c} (37.26)	14.43^{bc} (207.45)	20.82^{b} (433.50)	52.20	23.28
Pyroxasulfone 127.5 g/ha PE	4.33^{e} (18)	7.19^{d} (51)	9.41^{b} (88)	5.29^{d} (27.01)	13.97^{c} (195.12)	20.16^{b} (405.88)	55.04	19.35
Diclosulam + pendimethalin (tank mix) 21.0+750 g/ha PE	1.00^{g} (0)	4.54^{f} (20)	5.98^{d} (35)	1.00^{g} (0.00)	8.47^{e} (70.94)	15.72^{d} (246.38)	83.65	14.99
Pendimethalin + Imazethapyr 800 g/ha PE	2.43^{f} (5)	5.54^{e} (30)	5.08^{e} (26)	2.19^{f} (3.82)	8.66^{e} (74.04)	15.38^{d} (235.90)	82.94	1.59
Imazethapyr + Imazamox 70 g/ha PoE	7.06^{b} (49)	9.43^{c} (88)	9.74^{b} (94)	6.69^{bc} (43.81)	16.02^{b} (256.57)	20.06^{bc} (403.42)	40.88	29.39
Quizalofop	6.48^{bc}	10.43^{b}	9.42^{b}	6.77^{b}	15.61^{bc}	21.53^{b}	43.72	31.16

ethyl + imazethapyr 112.5g/ha PoE	(41)	(108)	(88)	(44.88)	(244.25)	(462.53)		
Propaquizafop + Imazethapyr 125 g/ha PoE	5.72^{d} (32)	9.85^{bc} (96)	8.41^{c} (70)	5.38^{d} (27.93)	14.76^{bc} (217.70)	18.32^{c} (335.21)	49.84	26.33
IC *fb* HW at 20 and 40 DAS	2.27^{f} (5)	5.64^{e} (31)	6.37^{d} (40)	1.94^{f} (2.80)	9.47^{e} (89.41)	13.68^{e} (186.75)	79.40	-
Weedy check	10.86^{a} (117)	11.61^{a} (134)	10.48^{a} (109)	11.32^{a} (128.05)	20.76^{a} (434.03)	26.54^{a} (708.46)	-	65.18
S. Em.±	0.23	0.24	0.25	0.16	0.53	0.54	-	-
CD (*p=0.05*)	0.66	0.70	0.73	0.47	1.54	1.57	-	-
CV%	8.76	6.19	6.31	6.29	7.94	5.74	-	-

Note: Data subjected to √(x+1) transformation. Figures in parentheses are means of original values. Treatment means with the letter/letters in common are not significant by Duncan's New multiple range test at 5% level of significance. PE- pre emergence, PoE-Post emergence, DAS-Days after sowing, IC- inter culture, HW – hand weeding

3. RESULTS AND DISCUSSION

3.1 Weed flora

Throughout the crop growing period, a total of fifteen weed species came to light in the experimental area. Among all the weed species observed in the experiment, *Eleusine indica*, *Digitaria sanguinalis* and *Dactyloctenium aegyptium* as monocot and *Trianthema monogyna*, *Boerhavia diffusa*, *Phyllanthus niruri, Tribulus terrestris* and *Portulaca oleracea* as dicot were found dominant.

3.2 Weed density (no./m^2)

All the weed control treatments significantly reduced the weed density (no./m^2) at all the stages of crop growth as compared to weedy check. At 30 DAS and 60 DAS, pre emergence application of diclosulam (84% WDG) + pendimethalin (30% EC) (tank mix) 21.0+750 g/ha, recorded least density of total weed which was significantly superior in reducing density of weed than any other treatments tried in the experiment. While at harvest, significantly least density of weed was recorded under pendimethalin (30%) + imazethapyr (2% SL) EC (pre-mix) 800 g/ha as compared to rest of the treatments. Due to their complementary effects on weed control and multiple modes of action, it might have been proven to be beneficial in reducing weed density. The highest density of weed was associated with weedy check at all the stages of sampling. Similar results were also obtained by Singh *et al.* (2009) [5] in soybean in case of diclosulam + pendimethalin and Shashidhar *et al*. (2020) [6] in case of pendimethalin + imazethapyr.

3.3 Weed dry weight (g/m^2)

Dry weight of weed was significantly reduced due to weed control treatments at 30 and 60 DAS and at harvest. All the weed control treatments observed lower weed dry weight compared with untreated check. At 30 DAS, zero weed dry weight was observed under diclosulam (84% WDG) + pendimethalin (30% EC) (tank mix) 21.0+750 g/ha due to zero density of monocot and dicot weed was reported. Application of diclosulam (84% WDG) + pendimethalin (30% EC) (tank mix) 21.0+750 g/ha reported its supremacy throughout the growing period except at harvest. At 60 DAS, diclosulam (84% WDG) + pendimethalin (30% EC) (tank mix) 21.0+750 g/ha reported significantly lower dry weight but it was at par with pendimethalin (30%) + imazethapyr (2% SL) EC (pre-mix) 800 g/ha and IC *fb* HW at 20 and 40 DAS. The better performance of combination of herbicides was due to its synergistic effect in controlling population as well as dry matter accumulation of different weed species as pre-emergence application of pendimethalin was shown to be effective against all species of grasses and its activity prolonged owing to the addition of diclosulam. While at harvest IC *fb* HW at 20 and 40 DAS reported significantly lower weed dry weight among all the treatments which might be due to its effectiveness in removing all established weeds as the treatment was imposed at 20 and 40 DAS. At all the stages of observations, the highest dry weight of weed was observed with weedy check. Similar results were also reported by Chicham *et al.* (2020) [7] in case of weedy check and Tripathy *et al.* (2022) [8] in case of manual weeding.

3.4 Weed control efficiency (%) and weed index (%)

The higher weed control efficiency was recorded under diclosulam + pendimethalin (tank mix) 21.0+750 g/ha as pre emergence (83.65%). The next effective treatment was pendimethalin + imazethapyr 800 g/ha PE (82.94%) followed by IC *fb* HW at 20 and 40 DAS (79.40%). The maximum weed control efficiency under these treatments was reflected through to lower dry weight of weed. These results are in tune with the findings of Chaithanya *et al.* (2022) [9] in case of pendimethalin and diclosulam in *rabi* greengram, Mahajan *et al*. (2020) [10] in case of pendimethalin + imazethapyr and Machhar *et al.* (2020) [11] in case of cultural operation. Weed index is indirectly related to the reduction in yield due to weed population and weed dry weight. The lowest weed index (1.59%) was registered under application of pendimethalin (30%) + imazethapyr (2% SL) EC (pre-mix) 800 g/ha followed by pendimethalin (30% EC) 750 g/ha which also recorded lower weed index (10.06%) while the highest weed index (65.18%) was recorded in weedy check.

Table 2: Growth and yield attributes of blackgram as influenced by different weed management practices

Treatment	Plant height (cm)			Plant dry biomass (g/plant) at 39 DAS	Number of pods/plant	Seed index (g) (100 seed weight)
	At 30 DAS	At 60 DAS	At Harvest			
Pendimethalin 750 g/ha PE	13.11^{abc}	44.94^{abc}	51.00^{ab}	4.48^{abc}	27.87^{ab}	4.16
Oxyfluorfen 117.5 g/ha PE	12.83^{abc}	45.50^{abc}	46.98^{abc}	4.10^{cd}	23.48^{cde}	4.15
Pyroxasulfone 127.5 g/ha PE	13.07^{abc}	45.11^{abc}	46.48^{abc}	4.32^{bcd}	24.52^{cd}	4.16
Diclosulam + pendimethalin (tank mix) 21.0+750 g/ha PE	11.64^{c}	41.67^{c}	43.50^{c}	3.90^{d}	25.57^{bc}	4.14
Pendimethalin + Imazethapyr 800 g/ha PE	13.80^{ab}	48.92^{ab}	51.24^{ab}	4.60^{ab}	29.56^{a}	4.18
Imazethapyr + Imazamox 70 g/ha PoE	12.22^{bc}	45.33^{abc}	46.81^{abc}	4.25^{bcd}	21.77^{de}	4.13
Quizalofop ethyl + imazethapyr 112.5 g/ha PoE	12.04^{c}	43.23^{c}	45.05^{bc}	3.98^{d}	21.00^{e}	4.12
Propaquizafop + Imazethapyr 125 g/ha PoE	12.55^{bc}	44.54^{bc}	48.83^{abc}	4.23^{bcd}	22.53^{de}	4.16
IC *fb* HW at 20 and 40 DAS	14.20^{a}	50.09^{a}	53.00^{a}	4.81^{a}	30.52^{a}	4.20
Weedy check	13.75^{ab}	48.69^{ab}	49.09^{abc}	2.13^{e}	15.10^{f}	4.11
S. Em.±	0.48	1.57	1.96	0.15	0.95	0.07
CD (*p=0.05*)	1.40	4.54	5.68	0.44	2.75	NS
CV%	7.45	8.52	8.12	8.41	7.84	3.21

Note: Treatment means with the letter/letters in common are not significant by Duncan's New multiple range test at 5% level of significance. PE- pre emergence, PoE-Post emergence, DAS-Days after sowing, IC- inter culture, HW – hand weeding

3.5 Growth attribute

With respect to growth characteristics such as plant height and plant dry biomass, various weed control techniques were found to have a substantial impact on these variables. Significantly higher values of plant height was observed under IC *fb* HW at 20 and 40 DAS which was at par with pre emergence application of pendimethalin (30%) + imazethapyr (2% SL) EC (pre-mix) 800 g/ha, weedy check, pendimethalin (30% EC) 750 g/ha, pyroxasulfone (85% w/w WG) 127.5 g/ha and oxyfluorfen (23.5% EC) 117.5 g/ha throughout all observational phases. IC *fb* HW at 20 and 40 DAS recorded significantly higher values of plant dry biomass as compared to rest of the treatments except pendimethalin (30%) + imazethapyr (2% SL) EC (pre-mix) 800 g/ha and pendimethalin (30% EC) 750 g/ha. Similar findings were also reported by Nirala *et al.* (2016) [12]. Weedy check recorded significantly the lowest plant dry biomass among all the treatments. The increase in growth parameters was due to the reduction in weed competitiveness with the crop which ultimately favored weed free environment for improved resource utilization and better crop growth and development.

3.6 Yield attributes and yield

Among different weed management practices, IC *fb* HW at 20 and 40 DAS significantly recorded higher values of yield attributes, *viz.,* number of pods/plant (30.52) which was at par with pendimethalin (30%) + imazethapyr (2% SL) EC (pre-mix) 800 g/ha and pendimethalin (30% EC) 750 g/ha. Weedy check lagged behind all other treatment by producing significantly the lowest number of pods/plant. Higher yield attributes might be due to weeds were not let to develop throughout the crop's growing period. The crop grew lavishly, as a result, producing additional branches, blossoms and green pods, all of which increased the number of pods/plant. Similar results were also observed by Chaudhry *et al.* (2014) [13], Kumar *et al.* (2015) [14] and Mansoori *et al.* (2015) [15].

Among different weed management practices IC *fb* HW at 20 and 40 DAS out performed over other weed management practices by producing significantly higher seed yield (1012 kg/ha) however, it was statistically comparable with pre emergence application of pendimethalin (30%) + imazethapyr (2% SL) EC (pre-mix) 800 g/ha and pendimethalin (30% EC) 750 g/ha. The higher seed yield might be due to least competition from weeds for nutrients, light, space and other above-and below-ground resources, which in turn led to effective weed control, reduced crop weed competition and provided almost weed-free environment, caused significant increase in growth and yield characters ultimately led to higher seed yield of blackgram. The results were in agreement with the earlier findings of Elankavi *et al.* (2019) [16] and Nautiyal *et al.* (2022) [17]. Like seed yield, haulm yield (1780 kg/ha) was also significantly increased under IC *fb* HW at 20 and 40 DAS over weedy check. However significantly the lowest seed and stover yields were recorded in weedy situations due to excessive weed infestations. These findings agree with those of Tiwari *et al.* (2018) [18] and Harisha *et al.* (2021) [19].

All the weed management practices did not differ significantly among themselves with respect to seed protein content. Although the result was non-significant but numerically higher protein content of seeds was recorded under IC *fb* HW at 20 and 40 DAS which was closely followed by pendimethalin (30%) + imazethapyr (2% SL) EC (pre-mix) 800 g/ha while the lowest value was observed in weedy check. The results of Singh *et al.* (2018) [20] and these findings closely align.

Table 3: Yield, protein content of seed and economics of blackgram as influenced by different weed management practices

Treatment	Seed yield (kg/ha)	Haulm yield (kg/ha)	Protein content of seed (%)	Gross realization (₹/ha)	Net realization (₹/ha)	B:C ratio
Pendimethalin 750 g/ha PE	910^{ab}	1668^{a}	24.69	59756	35532	2.47
Oxyfluorfen 117.5 g/ha PE	776^{cd}	1414^{b}	24.45	50940	27092	2.14
Pyroxasulfone 127.5 g/ha PE	816^{bcd}	1573^{ab}	24.53	53738	24094	1.81
Diclosulam + pendimethalin (tank mix) 21.0+750 g/ha PE	860^{bc}	1654^{a}	24.61	56628	30526	2.17
Pendimethalin + Imazethapyr 800 g/ha PE	996^{a}	1755^{a}	24.76	65262	40324	2.62
Imazethapyr + Imazamox 70 g/ha PoE	714^{d}	1388^{b}	24.26	47044	21875	1.87
Quizalofop ethyl + imazethapyr 112.5 g/ha PoE	696^{d}	1331^{b}	23.36	45814	20019	1.78
Propaquizafop + Imazethapyr 125 g/ha PoE	745^{cd}	1405^{b}	24.44	49000	23434	1.92
IC fb HW at 20 and 40 DAS	1012^{a}	1780^{a}	24.86	66304	36715	2.24
Weedy check	352^{e}	832^{c}	23.90	23488	1649	1.08
S. Em.±	39.84	78.64	0.36	-	-	-
CD (*p=0.05*)	115.61	228.20	NS	-	-	-
CV%	10.12	10.63	2.96	-	-	-

Note: Treatment means with the letter/letters in common are not significant by Duncan's New multiple range test at 5% level of significance. PE- pre emergence, PoE-Post emergence, DAS-Days after sowing, IC- inter culture, HW – hand weeding

3.7 Economics

Different weed control techniques resulted in varied gross returns (₹/ha), with higher gross returns (₹ 66304/ha) being reported under IC *fb* HW at 20 and 40 DAS followed by pendimethalin (30%) + imazethapyr (2% SL) EC (pre-mix) 800 g/ha, pendimethalin (30% EC) 750 g/ha and diclosulam (84% WDG) + pendimethalin (30% EC) (tank mix) 21.0+750 g/ha. While pre-emergence application of pendimethalin (30%) + imazethapyr (2% SL) EC (pre-mix) 800 g/ha fetched higher net return of ₹ 40324/ha and benefit cost ratio of 2.62. The outcomes are consistent with those of Gupta *et al.* (2017) [21]. Weedy check reported minimum net return (₹ 1649/ha) and benefit to cost ratio (1.08) among all the treatment.

4. CONCLUSION

On the basis of results obtained from the present investigation, it can be concluded that effective weed management, higher yield and monetary return of summer black gram could be achieved by either carrying out twice inter culturing and hand weeding at 20 and 40 DAS or pre-emergence application of pendimethalin (30%) + imazethapyr (2% SL) EC (pre-mix) 800 g/ha.

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