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Effect of Spacing and Weed Management on Weed Dynamics of Summer Blackgram [*Vigna mungo* (L.) Hepper] under Nagaland Conditions

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ABSTRACT

Background: A study was conducted during *Zaid* season of 2021 on response of summer blackgram [*Vigna mungo* (L.) Hepper] to planting geometry and weed management under Nagaland conditions.

Methods: The experiment was laid out in Factorial Randomized Block Design (FRBD) with three replications and comprised of three levels of planting geometry *viz*., S_1-20 × 10 cm^2, S_2-30 × 10 cm and S_3-40 × 10 cm and four different levels of weed management *viz*., W_1-Weedy check, W_2-Two hand weedings at 20 DAS and 40 DAS, W_3 = Pendimethalin @ 1 kg a.i ha^{-1} + Imazethapyr @ 100 g ha^{-1} at 30 DAS and W_4= Pendimethalin @ 1 kg a.i ha^{-1} + one hand weeding at 30 DAS.

Result: The highest seed and stover yields (739 kg ha^{-1}, 2068.2 kg ha^{-1}) were recorded at 30 x 10 cm^2 spacing and it was at par with 20 × 10 cm^2. Pendimethalin @1 kg a.i ha + one hand weeding at 30 DAS recorded lowest weed population, weed dry weight and highest weed control efficiency. Combination of 30 × 10 cm^2 and Pendimethalin @ 1 kg a.i ha^{-1} + one hand weeding at 30 DAS recorded highest B:C ratio (1.32) among all the treatments and was found to be an economically achievable treatment combination for summer blackgram.

Key words: B:C ratio, Blackgram, Planting geometry, Weed dynamics, Weed management.

INTRODUCTION

Blackgram [*Vigna mungo* (L.) Hepper] is a short duration, self-pollinated annual pulse crop belonging to the family Leguminosae. It is a very nutritious crop with about 24% protein, 1.4% fat, 3.2% minerals, 1.2% oil, 0.9% fibre, 59.6% carbohydrates on dry weight basis and it is a rich source of calcium (154 mg/100 g), phosphorus (385 mg/100 g) and iron (9.1 mg/100 g). It also has significant quantities of vitamin B_1, B_2 and niacin (Tiwari and Shivhare, 2016). India is the world's largest producer as well as consumer of blackgram.

Globally, it accounts for more than 70% of the production. The total area under blackgram in India is about 29.03 m ha with production of 23.40 Mt at 806 kg ha^{-1} yield level (DES-GOI, 2019). The North-Eastern Region (NER) of India has a wider spectrum of pulses as compared to any other regions of the world and blackgram is one of the major pulses grown in this region (Babu *et al*., 2016). Among many crop production constraints, appropriate crop spacing contributes substantially to the seed yield of blackgram. Plant density can have a major effect on the yield of most of the legume crops and the general response of yield is well documented. Based on climatic conditions, researchers obtained differential response of blackgram in relation to row spacing (Davi *et al*., 1995; Mehmud *et al*., 1997). Maintaining optimum plant population per unit area provides maximum light interception, photosynthetic activity, assimilation and accumulation of more photosynthates. Therefore, maintenance of optimum space made available to individual plant is of prime importance to realize the maximum yield potential of black gram grown during summer and rainy season.

Similarly, among several factors responsible for low yields of pulse crops in India, weed infestation is considered as one of the major factors. Heavy weed infestation is the dominant reason for a low yield of blackgram (Rao *et al*., 2010). The magnitude of losses largely depends upon the composition of weed flora, the period of crop-weed competition and also its intensity. In general, yield loss due to uncontrolled weed growth in blackgram ranges from 27 to 100% (Mansoori *et al*., 2015). Weeds in blackgram may be controlled by manual, mechanical or chemical methods. Combination of herbicides or combining of herbicide with other control methods may be an efficient and cost-effective

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weed management strategy. Combining of cultural, mechanical and chemical methods of weed management give higher weed control efficiency and economic benefits than that of any individual weed control methods.

MATERIALS AND METHODS

The present experiment was carried out during *Zaid* season of 2021 at the experimental farm ofthe Department of Agronomy, School of Agricultural Sciences and Rural Development (SASRD), Nagaland University, Medziphema Campus. The experimental site, Medziphema (25°45′43″N latitude and 95°53′04″E longitude) falls under the second agro-climatic region of India *i.e.* Eastern Himalaya, lies in the humid sub-tropical zone with high relative humidity, moderate temperature and medium to high rainfall which varies between 2000-2500 mm per annum. The mean temperature ranges from 21-32°C during summer and goes down to about 8°C during the winter season. The experiment was laid out in Factorial Randomised Block Design (Factorial RBD) and comprised of three levels of planting geometry *viz*., S_1- 20 × 10 cm², S_2- 30 × 10 cm² and S_3- 40 × 10 cm² and four different levels of weed management *viz*., W1 = Weedy check, W_2 = Two hand weedings at 20 DAS and 40 DAS, W_3 = Pendimethalin @ 1 kg a.i ha^{-1}+ Imazethapyr @ 100 g ha^{-1} at 30 DAS and W_4 = Pendimethalin @ 1 kg a.i ha^{-1} + one hand weeding at 30 DAS. The soil of the experimental field was well drained and sandy loam in texture and acidic in reaction (pH 4.7) with high organic carbon (1.2%), medium in available nitrogen (263.42 kg/ha), phosphorus (25.64 kg/ha) and potassium (163.10 kg/ha). The ploughing of the experimental plot was done on the first week of April by using a tractor drawn plough. Later, the field was ploughed again by using tractor drawn rotavator, where the hard pan and clods were broken down. Then, finally all the stubbles and debris were removed manually from the entire experimental site and the plots were laid out according to the layout plan. SBC-40 variety of blackgram was used for sowing. The seeds were sown on 12th of April 2021 and were sown in lines at the rate of 30 kg ha^{-1} in 20 cm × 10 cm, 20 kg ha^{-1} in 30 cm × 10 cm and 15 kg ha^{-1} in 40 cm × 10 cm spacing according to the treatment. The depth of sowing was 3-4 cm. Prior to sowing seeds were treated with carbendazim @ 2 g kg^{-1} of seeds. The recommended dose of fertilizer N: P_2O_5: K_2O (20:40:40 kg ha^{-1}) was applied in the form of urea, single super phosphate (SSP) and muriate of potash (MOP). Thinning was done at 16 DAS and gap filling operations were carried out from time to time in order to maintain optimum plant population. Spraying of herbicides was done with a knapsack sprayer. The amounts of herbicides required for individual plot was calculated and mixed with water to get the desired concentration of the herbicidal spray and was calculated by using the following formula:

Quantity of formulated product =

$$\frac{\text{Rate of application in kg ha}^{-1} \times \text{Area in ha}}{\text{Active ingredient}} \times 100$$

Weed counts from each treatment were recorded at 20 DAS, 40 DAS and 60 DAS from inside an area of 0.5 m × 0.5 m and expressed as number of weeds m^{-2}. The weeds from inside the quadrate were uprooted and dried in the sun and finally oven dried at 70 -75°C for 48 hours. The data were then converted to number per square meter which were transformed by adopting the root transformation $\sqrt{X + 0.5}$

Where,

X = Actual weed count.

Weed control efficiency (WCE) was calculated by using the formula,

$$\text{WCE} = \frac{W_c - W_t}{W_c} \times 100$$

Where,

W_c = Dry weight per unit area in the unweeded control plot.

W_t = Dry weight of weeds per unit area in the plot under treatment.

The matured pods were harvested in three pickings starting from the 27th of June, 2021 and the last picking was on 7th July, 2021. The harvested pods were sun dried, threshed and cleaned manually. The stover was left to be sun dried for some time and both the dried grains as well as the stover were weighed and recorded separately with the help of a weighing balance. The cost of cultivation was calculated per hectare basis by taking into consideration the cost of different inputs used for each treatment in the experimental plot. The gross return was calculated by considering the monetary value of the economic produce of different treatments on the basis of prevailing local market price per hectare. The net return for each treatment was calculated by subtracting the total cost of cultivation from the gross return. Benefit cost ratio (BCR) was calculated by using the formula,

$$\text{B - C ratio} = \frac{\text{Gross return}}{\text{Cost of cultivation}}$$

All the data obtained were statistically analyzed as procedures given by Gomez and Gomez (1976).

RESULTS AND DISCUSSION

Population of weeds

The data on the effect of planting geometry and weed management on population of grassy weeds, broadleaved weeds, sedges and total weed population recorded at 20 and 60 DAS are presented in Table 1. Data on the population of weeds varied significantly at different planting geometry and weed management treatments at all the stages. The population of grassy and broadleaved weeds were recorded lowest (6.43, 9.75 and 7.03, 9.12 m^{-2}, at 20 DAS and 60 DAS, respectively) under 20 × 10 cm² planting geometry. Planting geometry 20 × 10 cm² was found to be statistically at par with 30 × 10 cm² and recorded the lowest population of sedges (2.37, 1.88) at 20 and 60 DAS respectively. Treatment pendimethalin @ 1 kg a.i ha^{-1} + one hand weeding at 30 DAS recorded the lowest grassy weed population (2.82, 7.32) at 20 and 60 DAS, while treatment pendimethalin @ 1 kg a.i ha^{-1} + imazethapyr @ 100 g a.i ha^{-1} at 30 DAS was found to be statistically at par. At 20 and 60 DAS, the population of broadleaved weeds and sedges were significantly lowest (5.88, 7.70 and 2.05, 1.82) under treatment pendimethalin @ 1 kg a.i ha^{-1} + one hand weeding at 30 DAS. The highest population of grassy, broadleaved and sedge weeds were observed under wider planting geometry 40 × 10 cm^2 under weed check at all the stages of observation.

The data on the effect of planting geometry and weed management on total weed population recorded at 20 and 60 DAS revealed that there was significant difference between the treatments and the lowest weed population (10.09, 13.78 m^{-2}) were recorded under 20 × 10 cm^2 and it was found to be statistically at par with 30 × 10 cm^2. Low weed population could be due to high plant density which developed smothering effect on the growth of weeds. The highest weed population was observed under wider planting geometry 40 × 10 cm^2. Reduced weed population under narrow spacing might be due to quicker canopy closure of the crops which caused reduction in germination and growth of weed seeds. Increasing the crop density seems to be an alternative way to reduce the crop-weed competition in favour of the crop. Weed density increased significantly with increasing row spacing (Daramola *et al*., 2019). Similarly, the weed management treatments had significant effect on total weed population at 20 and 60 DAS. Data showed that lowest weed population (6.85, 10.79) was observed under the treatment pendimethalin @ 1 kg a.i. ha^{-1} + one hand weeding at 30 DAS. Kumar *et al*. (2006) reported that in the middle of various weed control treatments in blackgram, maximum reduction in weed population and dry matter accumulation of weeds was obtained with pendimethalin (750 g ha^{-1}) at 3 DAS and hand weeding at 30 DAS though hand weeding twice was also found equally effective. Usage of chemical weed control method accompanied with cultural method suppressed the weeds timely, which caused favourable weed free condition during the critical crop-weed competition period (Raju, 2019).

Dry weight of weeds

Planting geometry and weed management treatments had significant effect on the dry weight of weeds at 20 and 60 DAS (Table 2). The dry weight of grassy weeds as well as broadleaved weeds and sedges were recorded lowest under 20 × 10 cm^2 planting geometry at 20 and 60 DAS (1.06, 2.63 g m^{-2}; 1.16, 3.62 g m^{-2} and 1.06, 1.06 g m^{-2}), respectively and was found to be statistically at par with 30 × 10 cm^2. Similarly, at 20 and 60 DAS, the treatment pendimethalin @ 1 kg a.i ha^{-1} + one hand weeding at 30 DAS recorded the lowest dry weight of grassy weeds (0.82, 1.93), broadleaved weeds (0.94, 3.07) and sedges (0.81 and 0.81) which was superior to the other weed management treatments. Weeds dry weight was found to be highest under weedy check and at planting geometry of 40 × 10 cm^2.

The data on the effect of planting geometry and weed management on total weed dry weight recorded at 20 and 60 DAS revealed that there was significant difference between the treatments and the lowest weed dry weight

Table 1: Effect of planting geometry and weed management on population of different weeds and total weed population of summer blackgram (2021).

Treatment	Population of weeds (no. m^{-2})							
	Grassy weeds		Broadleaved weeds		Sedges		Total population of weeds	
	20 DAS	60 DAS	20 DAS	60 DAS	20 DAS	60 DAS	20 DAS	60 DAS
Planting geometry (S)								
S_1: 20 × 10 cm^2	6.43 (63.17)	9.75 (115.67)	7.03 (56.17)	9.12 (88.83)	2.37 (5.67)	1.88 (3.17)	10.09 (125.00)	13.78 (207.67)
S_2: 30 × 10 cm^2	6.79 (69.33)	10.24 (124.75)	7.60 (64.00)	9.76 (99.67)	2.44 (6.00)	2.00 (3.67)	10.80 (139.33)	14.42 (228.08)
S_3: 40 × 10 cm^2	9.54 (114.67)	12.94 (175.17)	9.74 (96.33)	11.59 (138.33)	3.11 (9.33)	2.48 (5.83)	14.27 (220.33)	17.54 (319.33)
CD (p=0.05)	1.63	2.01	1.34	1.15	0.31	0.27	1.64	1.48
Weed management (W)								
W_1: Weedy check	13.17 (180.67)	15.64 (250.33)	10.18 (108.00)	12.75 (163.56)	3.48 (11.78)	2.48 (5.78)	17.15 (300.44)	20.38 (419.67)
W_2: Two hand weeding's at 20 DAS and 40 DAS	10.93 (125.78)	7.84 (71.78)	9.26 (88.44)	9.01 (84.22)	2.76 (7.33)	1.88 (3.11)	14.61 (221.56)	12.44 (159.11)
W_3: Pendimethalin @ 1 kg a.i ha^{-1} + Imazethapyr @ 100 g a.i ha^{-1} at 30 DAS	3.43 (13.56)	13.10 (172.22)	7.18 (53.78)	11.16 (127.33)	2.26 (4.89)	2.31 (5.11)	8.27 (72.22)	17.39 (304.67)
W_4: Pendimethalin @ 1 kg a.i ha^{-1} + one hand weeding at 30 DAS	2.82 (9.56)	7.32 (59.78)	5.88 (38.44)	7.70 (60.67)	2.05 (4.00)	1.82 (2.89)	6.85 (52.00)	10.79 (123.33)
CD (p=0.05)	1.89	2.32	1.55	1.32	0.36	0.31	1.89	1.71

*The original data in parenthesis were subjected to square root transformation ($\sqrt{X+1}$) before statistical analysis.

(1.57, 4.50) were recorded under 20 × 10 cm^2 (Table 2). Low weed dry weight could be due to high plant population which developed smothering effect on the growth of weeds. Daramola *et al*. (2019) reported that the weed biomass reduced significantly with a reduction in row spacing. Similarly, the weed management treatments had significant effect on total dry weight of weeds at 20 and 60 DAS. Treatment pendimethalin @ 1 kg a.i ha^{-1} + one hand weeding at 30 DAS recorded the lowest weed dry weight (1.09, 3.58) as compared to the other treatments at 20 and 60 DAS. The highest values on total weed dry weight were observed under weedy check at all the stages of observation. Raju (2019) also stated that the integrated application of chemical and cultural method has been witnessed as more effective than their sole application in reducing the weed biomass.

Weed control efficiency

The data on weed control efficiency recorded at 20, 40 and 60 DAS revealed that there was significant difference between the treatments and presented in Table 3. It was revealed that the highest weed control efficiency (56.8%, 46.6%, 46.1%) at 20, 40 and 60 DAS, respectively were recorded at 20 × 10 cm^2 spacing and it was found to be statistically at par with 30 × 10 cm^2. The lowest values of weed control efficiency were recorded under wider planting geometry 40 x 10 cm^2 at all the stages of observation. At 20, 40 and 60 DAS, the weed control efficiency was significantly highest (90.76%, 73.59 % and 71.58%) under treatment pendimethalin @ 1 kg a.i ha^{-1} + one hand weeding at 30 DAS and it was at par with two hand weedings at 20 DAS and 40 DAS. The lowest values on weed control efficiency were under weedy check at all the stages of observation. Tomar and Singh (2016) noted that all types of weed flora were effectively managed by application of pendimethalin followed by hand weeding and was found at par with two hand weedings.

Seed and stover yield and harvest index

From the observations recorded at harvest, it is revealed that planting geometry and weed management treatments significantly affected the seed and stover yield of blackgram (Table 4). The crop under planting geometry 30 × 10 cm^2 recorded the highest seed yield (663 kg ha^{-1}) and stover yield (2007.7 kg ha^{-1}) and it was observed to be statistically at par with 20 × 10 cm^2 with 654.60 kg ha^{-1} seed yield and 1958.16 kg ha^{-1}stover yield. Higher grain yield in food legumes under narrow spacing could be due to increased number of plant population that compensated for the decrease of yield components (Shamsi, 2010). Increase in stover yield of blackgram was observed by at closer spacing might be due to more plant population per unit area which contributed to more crop biomass and hence higher stover yield (Bhatt, 2020). Weed management treatments had significant effect on seed and stover yield. Highest seed yield (739 kg ha^{-1}) and stover yield (2068.2 kg ha^{-1}) were observed under treatment pendimethalin @ 1 kg a.i ha^{-1} + one hand weeding at 30 DAS and were found at par with

Table 2: Effect of planting geometry and weed management on dry weight of different weeds and total dry weight of weeds of summer blackgram (2021).

Treatment	Dry weight of weeds (g m^{-2})							
	Grassy weeds		Broadleaved weeds		Sedges		Total dry weight of weeds	
	20 DAS	60 DAS	20 DAS	60 DAS	20 DAS	60 DAS	20 DAS	60 DAS
Planting geometry (S)								
S_1: 20 × 10 cm^2	1.06 (0.73)	2.63 (7.42)	1.16 (0.92)	3.62 (13.26)	1.06 (0.72)	1.06 (0.73)	1.57 (2.37)	4.50 (21.41)
S_2: 30 × 10 cm^2	1.13 (0.90)	2.85 (8.70)	1.22 (1.10)	3.72 (13.94)	1.12 (0.89)	1.11 (0.86)	1.70 (2.88)	4.71 (23.50)
S_3: 40 × 10 cm^2	1.38 (1.58)	3.40 (12.00)	1.46 (1.78)	4.24 (18.09)	1.38 (1.57)	1.32 (1.35)	2.20 (4.93)	5.50 (31.45)
CD (p=0.05)	0.07	0.22	0.07	0.16	0.08	0.06	0.14	0.26
Weed management (W)								
W_1: Weedy check	1.67 (2.33)	4.26 (17.83)	1.73 (2.52)	4.93 (23.95)	1.67 (2.32)	1.61 (2.10)	2.74 (7.16)	6.64 (43.88)
W_2: Two hand weeding's at 20 DAS and 40 DAS	1.39 (1.47)	2.11 (4.11)	1.46 (1.67)	3.20 (9.76)	1.39 (1.46)	0.86 (0.26)	2.23 (4.61)	3.80 (14.12)
W_3: Pendimethalin @ 1 kg a.i ha^{-1} + Imazethapyr @ 100 g a.i ha^{-1} at 30 DAS	0.88 (0.29)	3.53 (12.23)	0.99 (0.49)	4.24 (17.67)	0.88 (0.28)	1.36 (1.39)	1.23 (1.05)	5.59 (31.29)
W_4: Pendimethalin @ 1 kg a.i ha^{-1}+ one hand weeding at 30 DAS	0.82 (0.19)	1.93 (3.34)	0.94 (0.39)	3.07 (9.02)	0.81 (0.18)	0.81 (0.18)	1.09 (0.75)	3.58 (12.54)
CD (p=0.05)	0.09	0.25	0.08	0.19	0.09	0.07	0.16	0.3

*The original data in parenthesis were subjected to square root transformation ($\sqrt{X+1}$) before statistical analysis.

Table 3: Effect of planting geometry and weed management on weed control efficiency of summer blackgram (2021).

Treatment	Weed control efficiency (%)		
	20 DAS	40 DAS	60 DAS
Plant geometry (S)			
S_1: 20 × 10 cm^2	56.9	46.7	46.2
S_2: 30 × 10 cm^2	54.3	43.8	43.0
S_3: 40 × 10 cm^2	49.2	39.0	37.1
CD (p=0.05)	4.4	5.1	5.6
Weed management (W)			
W_1: Weedy check	0.00	0.00	0.00
W_2: Two hand weeding's at 20 DAS and 40 DAS	37.1	69.0	67.8
W_3: Pendimethalin @ 1 kg a.i ha^{-1} + Imazethapyr @ 100 g a.i ha^{-1} at 30 DAS	86.0	30.0	29.0
W_4: Pendimethalin @ 1 kg a.i ha^{-1}+ one hand weeding at 30 DAS	90.8	73.6	71.6
CD (p=0.05)	5.1	5.9	6.5

Table 4: Effect of planting geometry and weed management on seed yield, stover yield and harvest index of summer blackgram (2021).

Treatment	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
Plant geometry (S)			
S_1: 20 × 10 cm^2	655	1958.1	24.8
S_2: 30 × 10 cm^2	663	2007.7	24.6
S_3: 40 × 10 cm^2	570	1927.7	22.6
CD (p=0.05)	10.5	50.5	0.4
Weed management (W)			
W_1: Weedy check	453	1772.9	20.3
W_2: Two hand weeding's at 20 DAS and 40 DAS	728	2033.0	26.3
W_3: Pendimethalin @ 1 kg a.i ha^{-1} + Imazethapyr @ 100 g a.i ha^{-1} at 30 DAS	598	1983.9	23.1
W_4: Pendimethalin @ 1 kg a.i ha^{-1}+ one hand weeding at 30 DAS	739	2068.2	26.3
CD (p=0.05)	12.1	58.3	0.5

Table 5: Effect of planting geometry and weed management on cost of cultivation, gross return, net return and benefit-cost ratio in summer blackgram (2021).

Treatment	Cost of cultivation (` ha^{-1})	Gross returns (` ha^{-1})	Net returns (` ha^{-1})	B:C ratio
S_1W_1: 20 × 10 cm with weedy check	17900	30472	12572	1.70
S_1W_2: 20 × 10 cm with Two hand weedings at 20 DAS and 40 DAS	22700	46797	24097	2.06
S_1W_3: 20 × 10 cm with Pendimethalin @ 1 kg a.i ha^{-1} + Imazethapyr @ 100 g a.i ha^{-1} at 30 DAS	22178	39414	17236	1.78
S_1W_4: 20 × 10 cm with Pendimethalin @ 1 kg a.i ha^{-1} + one hand weeding at 30 DAS	22698	48255	25557	2.13
S_2W_1: 30 × 10 cm with Weedy check	16100	30623	14523	1.90
S_2W_2: 30 × 10 cm with Two hand weeding's at 20 DAS and 40 DAS	20900	47838	26938	2.29
S_2W_3: 30 × 10 cm with Pendimethalin @ 1 kg a.i ha^{-1} + Imazethapyr @ 100 g a.i ha^{-1} at 30 DAS	20378	40247	19869	1.98
S_2W_4: 30 × 10 cm with Pendimethalin @ 1 kg a.i ha^{-1} + one hand weeding at 30 DAS	20898	48507	27609	2.32
S_3W_1: 40 × 10 cm with Weedy check	15200	25690	10490	1.69
S_3W_2: 40 × 10 cm with Two hand weeding's at 20 DAS and 40 DAS	20000	42546	22546	2.13
S_3W_3: 40 × 10 cm with Pendimethalin @ 1 kg a.i ha^{-1} + Imazethapyr @ 100 g a.i ha^{-1} at 30 DAS	19478	33963	14485	1.74
S_3W_4: 40 × 10 cm with Pendimethalin @ 1 kg a.i ha^{-1} + one hand weeding at 30 DAS	19998	42415	22417	2.12

two hand weedings at 20 DAS and 40 DAS. Application of pre-emergence herbicide supplemented with hand weeding produced maximum economic and biological yield which was on a par with hand weeding twice. Similar findings of superiority of hand weeding and integrated treatments were also noted by Patel *et al*. (2017).

The data revealed that planting geometry and weed management treatments had significant effect on harvest index (Table 4). Spacings of 30 × 10 cm^2 and 20 × 10 cm^2 were at par with each other and recorded the highest harvest index as compared to 40 × 10 cm^2. Among weed management treatments, highest harvest index was observed under treatment pendimethalin @ 1 kg a.i ha^{-1} + one hand weeding at 30 DAS and found at par with the treatment two hand weeding's at 20 DAS and 40 DAS.

Economics

The major consideration for the farmers while taking decision regarding the adoption of any cultivation practices is economics as ultimately it decides the acceptance or rejection of any recommended agri-techniques by farmers. The treatment combination of 20 × 10 cm^2 and two hand weeding's at 20 DAS and 40 DAS recorded the highest cost of cultivation (Table 5). This was due to higher seed cost and labour cost in performing the operations under narrow spacing and hand weeding. The treatment combination of weedy check and 40 × 10 cm^2 planting geometry recorded the lowest cost of cultivation. The highest gross returns and net returns were recorded in treatment combination 30 × 10 cm^2 and pendimethalin @ 1 kg a.i ha^{-1} + one hand weeding at 30 DAS while the lowest gross returns and net returns were recorded under weedy check at 40 × 10 cm^2. Velayudham (2007) also reported significantly higher net returns in weed management practice involving pre-emergence application of pendimethalin with cultural practices. The highest benefit-cost ratio was observed under treatment combination 30 × 10 cm^2 and pendimethalin @ 1 kg a.i ha^{-1} + one hand weeding at 30 DAS. In blackgram, pendimethalin 1.0 kg ha^{-1} *fb* hand weeding at 30 DAS resulted in higher gross monetary return, net monetary return and B: C ratio (Kavad *et al*., 2016).

CONCLUSION

On the basis of present investigation, it can be concluded that maintaining a closer planting geometry (20 × 10 cm^2), application of pre-emergence herbicide (pendimethalin) followed by one hand weeding was found effective for producing higher seed and stover yield and gave the highest net returns and benefit-cost ratio.

Conflict of interest: None.

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