ENHANCING YIELD OF BLACKGRAM VARIETIES BY APPLYING DIFFERENT HERBICIDES

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CERTIFICATE

This is to certify that the thesis entitled **"ENHANCING YIELD OF BLACKGRAM VARIETIES BY APPLYING DIFFERENT HERBICIDES"** *submitted to the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (M.S.)*** *in* ***AGRONOMY,*** *embodies the results of a piece of bona fide research work carried out by* **MD. MAJEDUL ISLAM**, *Registration. No. 11-04616 under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma***.**

I further certify that such help or source of information as has been availed of during the course of this investigation has duly been acknowledged.

Dated:

Dhaka, Bangladesh

(Prof. Dr. Md. Jafar Ullah)
Supervisor

Dedicated

To

My Beloved Parents

and

Supervisor

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ENHANCING YIELD OF BLACKGRAM VARIETIES BY APPLYING DIFFERENT HERBICIDES

ABSTRACT

An experiment was carried out at the central farm of Sher-e-Bangla Agricultural University, Dhaka during the period from March to June, 2017 to enhance the yield of blackgram by applying different herbicides. Three blackgram varieties *viz*. V_1 (BARI mash-1), V_2 (BARI mash-2) and V_3 (BARI mash-3) and four herbicides *viz*. T_1 = Hammer 24 EC (Carfentrazone Ethyl) at 2 ml liter^{-1}, T_2 = Gramaxon (Paraquate Dichloride) at 3 ml liter^{-1}, T_3 = Panida (Pendimethalin) at 4 ml liter^{-1} and T_4 = Whip super (Fenoxaprop-p-Ethyl) at 1.5 ml liter^{-1} were tested for the study. The experiment was laid out in a Randomized Complete Block Design with three replications. The effect of variety, herbicides and their interactions were significant on most of the parameter measured. In the study the combined effect of V_3T_4 was found to be significant in list of the highest number of pods plant^{-1} (16.30), number of seeds pod^{-1} (6.64), pod length (4.26 cm) and grain yield (1434.40 kg ha^{-1}). Whereas, the lowest number of pods plant^{-1} (3.90), number of seeds pod^{-1} (5.57) and grain yield (886.60 kg ha^{-1}) were recorded from the treatment combination of V_1T_3.

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SOME COMMONLY USED ABBREVIATIONS

%	=	Percentage
AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSRI	=	Bangladesh Council of Scientific Research Institute
Ca	=	Calcium
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
DMRT	=	Duncan's Multiple Range Test
e.g.	=	exempli gratia (L), for example
et al.,	=	And others
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	Gram (s)
GM	=	Geometric mean
i.e.	=	id est (L), that is
K	=	Potassium
Kg	=	Kilogram (s)
L	=	Litre
LSD	=	Least Significant Difference
M.S.	=	Master of Science
m^2	=	Meter squares
mg	=	Miligram
ml	=	MiliLitre
NaOH	=	Sodium hydroxide
No.	=	Number
^oC	=	Degree Celceous
P	=	Phosphorus
SAU	=	Sher-e-Bangla Agricultural University
USA	=	United States of America
var.	=	Variety
WHO	=	World Health Organization
µg	=	Microgram

CHAPTER I

INTRODUCTION

Blackgram (*Vigna mungo* L.) belongs to family Fabaceae sub-family Faboideae, is being grown as one of the principle pulse crop. Among the pulse crops, blackgram is one of the main edible pulse crops of Bangladesh. It ranks fourth among the pulses with an area of about 32002 ha (BBS, 2013). It has good digestibility and flavor.

Blackgram is perfect combination of all nutrients, which includes proteins (25-26%), carbohydrates (60%), fat (1.5%), minerals, amino acids and vitamins. It stands next to soybean in its dietary protein content. It is rich in vitamin A, B_1, B_3 and has small amount of thiamine, riboflavin, niacin and vitamin C in it. It contains 78% to 80% nitrogen in the form of albumin and globulin. The dry seeds are good source of phosphorus (Nilanthi *et al.*, 2014). The green plants can also be used as animal feed and its residues have manual value. The crop is potentially useful in improving cropping pattern. The yield of blackgram is very poor as compared to many other legume crops (Wahhab and Bhandari, 1981).

It can also fix atmospheric nitrogen through the symbiotic relationship between the host blackgram roots and soil bacteria and thus improves soil fertility. Though the agro ecological conditions of Bangladesh are favorable for blackgram cultivation, its area under cultivation and total production are low in this country (BBS, 2008). In Bangladesh, the average yield of blackgram is 0.70 t ha^{-1} (BBS, 2013), which is much lower than those of India and other countries of the world. There are many reasons of such lower yield of blackgram.

Variety of blackgram can play an important role for higher production. Reddy (1997) reported that the genotypic and phenotypic variation of blackgram were significant for branches/plant, 100-seed weight, pods/plant and grain yield/plant. Days to maturity, Clusters/plant, pods/cluster and seeds/pod also varied significantly due to genotypic variation.

Among various production factors, weed plays vital role in influencing blackgram yield. Weeds compete with the resources like nutrient, moisture and light. High temperature coupled with frequent rains during growing period infests the crop heavily with weeds which adversely affect the productivity of this crop. An initial period of 20-40 days is very critical (Samant and Mishra, 2014).

Weeds compete with main crop for space, nutrients, water and light. It is also recognized that a low weed population can be beneficial to the crop as it provides food and habitat for a range of beneficial organisms (Bueren *et al.*, 2002). The yield loss of blackgram due to weeds has been reported to the extent of 27 to 90% depending upon type and intensity of weed flora (Kumar *et al.*, 2000 and Singh *et al.*, 2010). The yield loss in mustard as a result of weed infestation is also to the tune of 10-58% (Gill *et al.*, 1989).

Weeds are controlled by various methods like cultural, manual, mechanical, biological and chemical. Manual and mechanical weeding is laborer intensive and tedious. Many times labours are not available at peak time of requirement for weeding. Even if they are available the escalating cost of laborers further limits its option. The cultural method of weed control like adoption of suitable crop rotation, stale seed bed method, reduced tillage and soil solarization etc. is long term planning. The chemical method of weed control is not only cost effective but also is efficient in minimizing weed infestation for longer period provided they are applied judiciously i.e. with suitable herbicide, in dose and time. Season long weed management in blackgram may also cover effective weed control for succeeding blackgram in seasons. There are herbicides which show prolonged persistence in soil resulting in reduced weed infestation in succeeding crops in the system. Contrary to this, sometimes undesirable herbicide in respect to crop its dose, time and method of application may lead to residual hazards in soil and produced, which can be harmful for human and animals (Arora *et al*., 2014).

Considering the above facts the present work was conducted to enhancing production of blackgram by applying different herbicide on blackgram production with the following objectives:-

1. To determine the suitable competitive variety amidst weed infestation for successful production;
2. To observe the effective herbicide to control weed in blackgram field;
3. To study the interaction effect of different variety and herbicide for controlling weed infestation in blackgram for achieving maximum yield.

CHAPTER II

REVIEW OF LITERATURE

An attempt was made in this section to collect and study relevant information available in the country and abroad regarding enhancing production of blackgram by applying different herbicide and other crops to gather knowledge helpful in conducting the present research work and subsequently writing up the result and discussion.

2.1 Effect of variety

Reddy *et al*. (2014) conducted for response of different varieties to climate vulnerabilities like floods and droughts. The demonstrations on improved cultivars along with the respective local checks were compared with the participating farmers. Reported that the improved varieties blackgram (LBG-645) and greengram (MGG-295)) were found stable in rainfed environment. It was recorded that 25-35% higher yield and net returns compared to respective local checks and gave higher productivity and profitability under rainfed conditions.

Shanti *et al*. (2014) reported that the effect of salinity in irrigation water on germination, crop stand at different stages and yield of nineteen released and pre-release varieties of blackgram was studied. Saline water with different electrical conductivities (dS/m) *viz*., control (best available water-BAW), 2 E.C., 4 E.C. and 6 E.C. was used as irrigation water for rabi blackgram crop in a non-saline sandy loam soil of Bapatla, Andhra Pradesh. It was important to observe that the different salinity levels did not affect the germination percentage of varieties tested during the two years of study. The results indicated that at 2.0 EC level, variety LBG- 623 recorded highest mortality rate followed by LBG-727, 17, 22 and LBG-733. Lowest mortality levels of below 10% were recorded in LBG-20, 402, 611, 648, 685, 726, 730, 733, 738 and T9. At 4.0 EC most of the varieties registered mortality rate between 20 and 50 percent, while at this E.C. varieties LBG-22, LBG-402 and LBG-738 recorded low mortality rates. At 6.0 E.C. (dS m^{-1}) LBG-402 and LBG-738 maintained lower mortality values during both the years of study, while in other varieties the mortality rate was still higher. This indicated that in other varieties, considerable damage has been done at 4.0 EC level itself. During two years of study, there was significant variation in grain yields between all four treatments. The highest yields of seed were recorded in varieties LBG-733, 726, 738, 723 and 727 under BAW. In other salinity levels (2.0, 4.0 and 6.0 EC levels), LBG-738 performed better than all other varieties recording 9.89 q ha^{-1}, 6.54 q ha^{-1} and 5.2 q ha-^{1}, respectively. Varieties LBG-648, LBG- 708, LBG-723 and LBG-726 also performed commendably as compared to other varieties.

Bhowaland and Bhowmik (2014) reported that variety and date of harvest had significant influences on various crop characters and seed yield. The variety BINA mung-7 showed superiority in plant height, number of branches/plant, number of effective pods and total pods/plant and number of seeds/pod over other two varieties resulting in highest seed yield of 1856 $kgha^{-1}$. Among the harvesting date treatments, H_3 (three times harvest) was superior in relation to number of branches $plant^{-1}$, number of effective and total pods $plant^{-1}$, number of seeds/pod, 1000-seed weight and plant population m^{-2} compared to H_1 and H_2 treatments which resulting the highest seed yield of 1792 kg ha^{-1}. In case of interaction effect of variety and date of harvest, V_3H_3 treatment combination showed superiority in crop characters and yield attributes and yield (1950 kg ha^{-1}) of summer mungbean variety than any other treatment combinations.

Gangwar *et al*. (2013) found that grain yield of uradbean increased significantly with delay in planting up to March 20, while further delay beyond March 20 reduced the yield. Pant U 31 variety produced significantly higher grain yield than other varieties.

Singh *et al*. (2012) a diverse set of 105 uradbean genotypes comprising of released cultivars, advance breeding lines of inter-varietial and interspecific origin, local germplasm collections, the wild progenitor of cultivated uradbean

(Vigna mungo var. *silvestris)* and 5 checks were evaluated for their pre-harvest sprouting (PHS) tolerance and other important agronomic traits. Analysis of variance revealed significant differences among the genotypes. Seed germination (%) in pods (SGP), which was used as a measure of PHS, ranged from 8.8 in *Vigna mungo* var. *silvestris* to 99.4 in PCPGR 8057 (a local collection from Uttarakhand hills). The character associations and direct and indirect effects provided a preliminary idea about various plant, pod and seed traits playing role in the governance of pre-harvest sprouting in uradbean. The information on the performance of some popular uradbean cultivars with respect to PHS tolerance has been generated and some genotypes with relatively low PHS have been identified. Comprehensive field evaluation, however, is required before these genotypes can be used in breeding programmes.

Jayamani *et al*. (2012) A high yielding blackgram culture COBG 653 is a cross derivative of DU 2 ×VB 20 and matures in 60 - 65 days. This culture recorded an average yield of 877 kg ha-1 with a yield increase of 24 per cent over the national checks varieties LBG 402 and LBG 17 under All India Coordinated trials. This was released for cultivation during rabi season in south zone consisting of Tamil Nadu, Andhra Pradesh, Karnataka and Odisha. In the state trials, it recorded an average yield of 733 kg ha-1 with a yield increase of 13.46 per cent over VBN (Bg) 4, 12.42 per cent over VBN (Bg) 5 and 16.86 per cent over CO 5. It has bold seeds with a mean 100 seed weight of 5.5 grams. It is determinate and has synchronized maturity. It has good batter qualities like high initial batter volume and volume after fermentation. The protein content is 23.8 per cent. It is moderately resistant to mungbean yellow mosaic virus (MYMV), stem necrosis and root rot diseases. It is tolerant to aphids, stemfly and spotted pod borer infestation. This variety was notified recently as per the reference S.O. 632(E) dt. 25.03.2011. It is best suited for cultivation during rabi season in Tamil Nadu.

Dodwadiya and Sharma (2012) reported that variety SML 668 gave the highest seed yield in both seasons, followed by Pusa Vishal and Pusa 9531. Zero tillage was more profitable in summer, while conventional tillage was the best practice in the rainy season. It is recommended to grow newly-released variety SML 668 during summer as well as rainy season for higher productivity and profitability.

Jat *et al.* (2011) conducted an experiment on management of drought through crops and varieties diversification under dry land area of western India. They highlighted that blackgram variety T-9 gave higher maize equivalent yield, net returns and B:C ratio that that of variety RBU-38.

Verma *et al*. (2011) reported that mungbean cv. HUM 12 gave significantly higher plant height, number of trifoliate leaflet/plant, number of branches/plant, dry matter accumulation/plant, pod length, number of pods/plant, number of seed/pods, 1000 grain weight, grain yield, harvest index, protein content uptake and protein yield (kg ha-1) than K 851 and NDM 1.

Katiyar *et al*. (2010) Morphological characterization of uradbean varieties is essential for their protection under Plant Variety Protection (PVP) legislation, because varietal testing for Distinctness, Uniformity and Stability (DUS) are the basis for granting protection of new variety under PPV & FR Act, 2001. Keeping this in view, a total of 46 released varieties of uradbean were grouped for various agro-morphological descriptors. All the varieties showed similar expression for each character over the years depicting the stability of varieties. None of the attribute showed intra-varietal variation. On the basis of 21 descriptors, varieties were grouped into different categories for each character and may be used as reference varieties.

Goswami *et al*. (2010a) reported that significant variations were observed among the genotypes with respect to the morphological triats, dry matter partitioning pattern and yield. Among the morphological traits, number of primary branches, trifoliate leaflet and root nodules was found significantly higher in high yielding genotypes. The high yielding genotypes were found to possess higher leaf dry weight, stem dry weight and total dry weight as compared to medium yielding, low yielding genotypes and checks. Among the genotypes, M-446 and M-100 had higher seed yield and other yield components and may be used as genetic source for improvement of yield potentials in greengram.

Goswami *et al*. (2010b) reported that among the different mungbean genotypes, Pratap, KM 5-168 and AAU-34 were identified as physiologically efficient genotypes with respect to higher seed yield and other yield components.

Kumar *et al*. (2009) reported that the sowing of summer mungbean on 25th March recorded significantly higher grain yield (1346 kg ha^{-1}) with 14% increase over the late sowing (10th April). Variation in seed rate also brought a significant difference in grain yield. The highest grain yield (1384 kg ha^{-1}) was recorded with 40 kg ha-1 seed rate which was at par with the seed rate @ 35 kgha^{-1} (1349 kg ha-1) and significantly superior over the seed rates 25 kg ha^{-1} (1094 kgha^{-1}) and 30 kgha^{-1} (1224 kgha^{-1}). Variety 'SML 668' gave the highest grain yield (1332 kgha^{-1}) which was significantly higher than the 'Pusa Vishal' (1229 kg ha^{-1}) and 'Samrat' (1227 kg ha^{-1}).

Goswami *et al*. (2009) found that significant variations were observed among the genotypes with respect to the physiological traits analysed at different stages of plant growth. Among the various parameters; stomata conductance, photosynthetic rate, transpiration rate, total leaf chlorophyll and leaf nitrate reductase activity were found significantly higher in high yielding genotypes. However, the high yielding genotypes were found to possess lower seed protein as compared to medium yielding, low yielding genotypes and checks. Among the genotypes, M-446 and M-100 had higher seed yield and harvest index and identified as physiologically more efficient.

Anurag *et al*. (2009) reported that the seeds obtained from pods of 25 days after anthesis recorded maximum dry weight, vigour index mass and 100-seed weight. Both early and delayed harvest recorded reduced quality of seeds in this crop. The variety Asha was found to be most responsive for all the parameters studied for physiological maturity at 25 days after anthesis.

Sadeghipour (2008) reported that mungbean variety Partow, gave significantly higher number of pods plant^{-1}, number of seed/pod and seed yield than variety Barymung 2 and VC 638, against variety VC 6368 had higher 100-seed weight. The highest seed yield (243.39 g m^{-2}) was recorded in irrigation throughout the growing period by variety Partow and the lowest seed yield (32.77 g m^{-2}) was obtained where we stop irrigation at the flowering stage in VC 6368.

Malik *et al*. (2008) conducted studies on eighteen genotypes of blackgram *(Vigna mungo)* to evaluate their comparative performance under rainfed conditions. Highly significant differences were observed for all the traits except leaf area which showed non-significant differences. Leaf area, pods/plant, plant height and biological yield/plant showed high genotypic and phenotypic variances exhibiting greater variability in these traits. The magnitude of heritability was high for 100-seed weight (94%), pods/plant (91%), pod length (91%), biological yield (87%), grain yield (85%), days to maturity (80%), harvest index (76%), branches/plant (75%) and plant height (71%) indicating additive type of gene action. Pods plant^{-1}, branches plant^{-1} and biological yield plant^{-1} showed highly significant and positive correlation with grain yield showing that these traits have good positive effect on grain yield. Selection of genotypes on the basis of these traits can be useful. The present study enabled to identify early to medium duration lines without losing grain weight and yield potential.

Katiyar *et al*. (2008) carried out a study during 2004-06 on morphological characterization of greengram [*Vigna radiate* (L.) Wilezek] and establish distinctness of the candidate variety from all other varieties. A total of 73 released Indian cultivars of green gram were grouped for several agro-morphological descriptors. Wide diversity (38 to 70 cm) has been observed in plant height. Maximum varieties are of medium seed size (3-5 g/100-seed weight) except ‘Pusa Vishal’ and ‘SML 668’ (large seeded > 5 g/100 seed).

Bhowmik *et al*. (2008) reported from Murshidabad (W.B.) the genotype WBM 29 significantly yielded the highest (983.28 kg ha^{-1}) and was followed by WBM 4-34-1-1 (869.90 kg ha^{-1}), the later matured earlier than the other including B1 (state check) and PDM 54 national check. Sowing on March resulted in higher growth and yield of all the genotypes excepting PDM 54, which performed better under growth and yield of all the genotypes excepting PDM 54, which performed better under sowing on first week of March.

Singh *et al*. (2006) concluded that six genotypes of mungbean namely IC-39535, IC-39429, IC-39358, IC-39447, IC-39283 and IC-39313 (check) in a randomized block design. The genotypes showed significant variations in plant height, branches/plant, pods/plant, seeds/pod, 100-seed weight, seed yield, biological yield and harvest index. IC-39358 followed by IC- 39535 produced significantly higher seed yield than national check and rest of genotypes. Significantly higher number of pods and branches $plant^{-1}$ mainly attributes toward increased seed yield in IC-39358 and IC-39535. In general short duration genotypes IC-39535, IC -9429 and IC-39283 in comparison to normal duration genotypes showed efficient biological yield and yield attributes which resulted in higher overall harvest index and seed yield.

Rao *et al*. (2006) evaluated 180 germplasm lines of mungbean comprising both indigenous and exotic collections along with checks in augmented block design for yield and its components during *rabi* 2002-03. The checks were found to be superior to the test material for all the characters studied except for 100 seed weight. The ANOVA for yield indicated highly significant differences among test varieties and check. The traits plant height and number of clusters per plant recorded highly significant and positive association with grain yield, while number of seeds per pod showed negative association with seed yield.

Gupta and Sharma (2006) A field experiment was conducted during the rainy seasons of 2000 and 2001 on fanner’s field at Kangra (HP), to study the effect of biofertilizer (PSB, two levels) and phosphorus fertilization (4 levels) on yolk and economics of uradbean *(Vigna mungo* L.). The study revealed that crop responded favourably to seed inoculation with PSB and phosphorus fertilization (60 kg P_2Os/ha) in influencing seed yield. Mean values of two years showed that variety UG-218 was observed to give highest net return/ha and net return/rupee invested of Rs. 12,497 and Rs.7.5, respectively at its optimum dose, which was worked out *to* be 86.3 kg ha^{-1} while with inoculation net return/ha and net return/rupee investment at optimum dose were higher over their respective uninoculated treatment.

Singh and Ahlawat (2005) studied that Greengram [*Vigna radiata* (L.) *R.* Wilczek] and blackgram [*V. mungo* (L.) Hepper] are widely cultivated in India in different seasons. In general, these crops are grown in rainfed condition. During the past 40 years, the area and production of these crops have shown a positive trend, and now these crops are no more considered as minor crops. This has been achieved primarily owing to the availability of short-duration, disease-resistant varieties which fit well in the different cropping systems. However, the productivity has shown a slow progress. To increase the yielding ability with added advantage of stability, crossing programme involving wild relatives and land races may be followed. The cultivation practices as well as varieties suitable for intercropping systems may be developed. There is a need to incorporate resistance against cercospora leaf spot *(Cercospora* spp), anthracnose [*Colletotrichum lindemuthianum* (Sacc. & Magn.) Briosi & Cav.)], pre-hamest sprouting, drought and heat tolerance. The integrated pest management (IPM) module (s) for different seasons and cropping systems may also be developed for these crops.

Singh *et al*. (2005) reported that the genotypes showed significant differences for grain and straw and N content and P content in grain while P content in straw, N and P uptake differed non-significantly. Phosphorus application resulted in significant increase in N and P content and their uptake by all three genotypes. SML 134 recorded the significantly highest protein content among the genotypes. Protein content in the grains increased with subsequent increasing in the rate of phosphorous.

Flores *et al*. (2005) characterized the agronomical behavior, yield components and its correlation to the yield in genotypes of the *Vigna* genera identified as JA-01-00-02, JA-01-00-02, JA-01-00-05, MEM-02-00-19,AM-02- 00-016, MS-01-00-09 and the commercial variety "Tuy". Essays were carried out at Saman Mocho, Carabobo state and Maracay, Aragua state. The genotype that reached higher height of the plant was MEM-02-00-19. The variance analysis and the means test of Duncan detected significant differences for yield in Maracay. Materials with highest yield were of *Vigna unguiculata* species: MS -01-00-09 (2114.1 kg ha^{-1}) and JA-01-00-05 (1605.6 kg ha^{-1}). Pods of highest longitude and total seeds by pods were observed in MS-01-00-09 with 4.2 cm of longitude and total number of seeds per pods 10.9 seed/pods. In genotype of *Vigna unguiculata,* MEM-02-00-19 recorded the highest number of pods per plant 17.5.

Vanniarajan *et al*. (2004) accelerated ageing test was carried over in four rice fallow blackgram varieties *viz.,* LBG 20, VBN I, ADT 3 and ADT 5. The seeds were subjected to 15% moisture content and stored at 45 ^{0}C. Periodically seeds were taken out and subjected to observations like germination percentage, seedling vigour, speed of germination and electrical conductivity. The results revealed that VBN. 1 is good storer, have more viable and vigorous seeds as compared to others. The study was also indicated that electrical conductivity could be taken as an indicator of seed viability in blackgram.

Reddy *et al*. (2003) determined the performance of 13 blackgram cultivars (LBG 685, LBG 648, LBG 611, LBG 645, LBG 22, LBG 623, LBG 695, LBG 703, LBG 708, LBG 709, LBG 719, LBG 17 and LBG 402). LBG 645 recorded the highest number of branches $plant^{-1}$ (6.3), biomass production (4.80), number of pods $plant^{-1}$ (11.4), seed yield (10.82 q ha^{-1}) and nitrogen reductase activity (51.80 nmol/h/g). LBG 703, LBG 685 and LBG 719 recorded the tallest plants (37.9 cm), highest number of seeds per pod (6.73) and harvest index (37.2).

Parameswarappa and Lamani (2003) conducted experiments to evaluate the performance of 6 green gram cultivars (SEI-4, GMBL-1, GMBL-2, TM-97-55, SEL-3 and M-1), compared with 4 controls (Chaina Mung, PS-16, TAP-7 and Pusabaisaki), under rainfed conditions on medium black soil of the Northern Transitional Zone of Karnataka. Data for seed yield, plant height, pods/plant, test weight, days to flowering and days to maturity indicated that SEL-4 was the most suitable genotype for cultivation in the area.

Biswas *et al*. (2002a) evaluated the growth and yield performance of two blackgram varieties *i.e.*, Barimash 3 and Barimash 1 under three different population densities. The planting configurations were 40 cm x 10 cm, 30 cm x 10 cm and 40 cm x 5 cm representing 25, 33 and 50 plants m Both the blackgram varieties showed identical results in LAI, CGR, NAR, RGR as well as grain yield. But planting density had significant effects on LAI and CGR of the blackgram varieties. The highest planting density showed the highest LAI and CGR but the highest grain yield was recorded from intermediate population density due to the highest number of pods per unit area. The NAR and RGR did not differ due to different population densities.

Bishwas *et al*. (2002b) conducted an experiment to determine the highest seed yield of different varieties of blackgram in region of Bangladesh and reported that Barimash 3, produced the highest seed yield (972 kg ha^{-1}) which was statistically similar to that of Baramashi (960 kg ha^{-1}). Baramas 2 produced the lowest seed yield (866 kg ha^{-1}).

Patel and Munda (2001) evaluated that the growth pattern and yield potential of five cultivars (T-9, PU-19, PDU-1, DPU-88-1 and DPU-88-31) of blackgram. Results showed high potential for blackgram cultivation. Plant height (42.2 and 41.6 cm), root length (20.1 and 19.3 cm), days to flowering

(42.7 and 41.3) and maturity duration (84.3 and 84.7) were highest in DPU-88-1 for 1998 and 1999, respectively. DPU-88-31 recorded the lowest plant height (25.7 and 24.7 cm), days to 50% flowering (38.3 and 36.3) and maturity (82.7 and 81) respectively. The number of pods per plant was highest with T-9 (47.6) and lowest in PU-19 (33.3. Highest number of seeds per pod, 1000- seed weight, seed yield per plant, biomass per plant and yield were recorded by PDU-1.

Santella *et al*. (2001) evaluated that the number of pods per plant, pod length, number of seeds/pod, 100- seed weight and yield of mungbean ranged from 31.75 to 53.00, 7.48 to 9.58 cm, 8.59 to 9.85, 34.18 to 63.23 g and 1175.05 to 1815.05 kg ha-1, respectively.

Madhavi *et al*. (2001) The study aims at examining the growth of germ tube of *Corynespora cassiicola* on leaflet of different blackgram varieties viz., LBG 703, LBG 708, LBG 648, LBG 402, and LBG 17 at 15, 40 and 65 days age. The growth of the germ tube was less on the leaflet of LBG 703 followed by LBG 708 but the growth was maximum on LBG 402 followed by LBG 17 at all ages of plants. Irrespective of the variety the growth of germ tube was more on the leaflet of 65 days plants followed by 40-day and 15-day old plants.

Patra *et al*. (2000) found that variety 'Nayagarh Local' gave the maximum seed yield (978 kg ha-1), followed by 'Sujata' (937 kg ha^{-1}) and 'PAM 54' (878 kg ha^{-1}). Sowing on 10^{th} September was the best date with seed yield of 969 kg ha^{-1}. A delay of 10 and 20 days in sowing reduced the seed yield by 14.2 and 30.0% respectively. Most yield components varied significantly due to varieties but not due to dates of sowing. Incidence of yellow mosaic virus, cercospora leaf-spot and powdery mildew was the minimum in 'PAM 54' and in the crop sown on 10 September.

2.2 Effect of weed management

Rao *et al.* (2015) conducted a field experiment during *kharif* (rainy) season at Regional Agricultural Research Station, Lam, Guntur, India to study the effect of integrated weed management practices on growth and yield of pigeonpea. The weed free treatment significantly decreased the weed density, dry weight of weeds and also increased in weed control efficiency compared with weedy check. Integration of one hand weeding per intercultivation at 50 DAS with pendimethalin (PE) @ 0.75 kg *a.i.* ha^{-1}, PE proved effective in reducing total weed density and dry weights of weeds and also increased in weed control efficiency compared with weedy check. The maximum values of growth parameters, yield components and grain yield (2647 kg ha^{-1}) were recorded under weed free situation.

Shweta and Malik (2015) made a field study during *kharif* season at Crop Research Station, GBPUA and T, Pantnagar. Five weed management treatments comprised W1- weedy, W2- Hand weeding at 20 DAS, W3-Hand weeding (HW) 40 DAS, W4-Alachlor @ 2.0 kg ha^{-1} (PE) and W5- Alachlor @1.5 kg ha^{-1} (PE) and hand weeding at 40 DAS; and three seed rates S1- normal seed rate, S2-30 % higher seed rate than normal and S3- 50% higher seed rate than normal. *Echinochloa colonum* was dominant under weedy condition. The highest weed density (288.7 m^{-2}) and total weed dry matter production (159.2 g m^{-2}) at 30 DAS were recorded in weedy plots, whereas, the lowest total weed density (48.3 m^{-2}) and total weed biomass (11.3 g m^{-2}) were recorded under HW20 DAS followed by alachlor @ 2.0 kg ha^{-1} and alachlor @1.5 kg ha^{-1} + HW 40 DAS. Lower weed density (92.6 m^{-2}) and total weed biomass (62.8 g m^{-2}) associated with 50 per cent higher seed rate.

Kumar *et al.* (2015) set a field experiment to refining the weed management practices to increase the yield of blackgram (*Vigna mungo* L.). Growth and yield attributes were affected significantly due to different weed management practices. However, weed density and weed dry weight were decreased significantly with increasing number of hand weeding (20 and 40 DAS). Hand weeding at 20 and 40 DAS proved its superiority over other methods of weed control in respect of all the growth characters and yield attributes as well as grain and straw yield of blackgram crop followed by oxyfloufen @ 100 g *a.i.* ha^{-1} as pre-emergence + one hand weeding at 40 DAS.

Bhowmick *et al.* (2015) conducted a field experiment to evolve an integrated weed management (IWM) practice in blackgram. *Cynodon dactylon, Dactyloctenium aegyptium, Cyperus rotundus, Cleome viscosa* and *Physalis minima* were the dominant weeds. Pre-emergence application of pendimethalin either at lower dosage (0.75 kg ha^{-1}) along with one hand weeding at 40 days after sowing or at higher dosage (1.0 kg ha^{-1}) without any integration with hand weeding proved to record higher seed yield (1.09 and 1.3 t ha^{-1}, respectively. In addition, use of 30% higher seed rate than the normal rate of 22.0 kg ha^{-1} was found to effectively suppress the weeds and further enhance the yield level. Season-long weed competition caused an average yield reduction of 26.4% as compared to IWM in blackgram.

Das *et al.* (2014) conducted a field experiment to study the integrated weed management in blackgram *(Vigna mungo* L.) and its effect on soil microflora under sandy loam soil of West Bengal. Treatments comprised of T_1 - Pendimethalin @ 1.5 lit ha^{-1}, T_2 -Fluchloralin @ 1.5 lit ha^{-1}, T_3 -Pendimethalin @ 1.5 lit ha^{-1} + hand weeding at 25 DAS, T_4 - Fluchloralin @ 1.5 lit ha^{-1} + hand weeding at 25 DAS, T_5 -Two hand weeding at 15 and 25 DAS and T_6 - Weedy check. Result showed that T_5 recorded lowest weed population (84.1 no m^{-2} and 55.5 no m^{-2}) and dry weight (13.23 and 10.57 g m^{-2}) which was significantly superior over rest of the treatments. Though weed control efficiency (85.53%) and seed yield (1.441 t ha^{-1}), stover yield (3.419 t ha^{-1}) were highest under treatment T_5 but net return per rupee investment (2.2) was highest under T_3 as compared to other weed control treatments.

Pramanik *et al.* (2014) conducted an experiment to study the effect of bio fertilizer and weeding on the growth characters and yield of summer mungbean. Experimental treatments comprised of (a) five levels of biofertilizer: 0, 1, 2, 3, 4 kg ha^{-1} and (b) four levels of weeding: no weeding, one weeding, two weeding, and three weeding. The results indicate that the three times weeding produced highest plant height (41.69 cm) and dry weight $plant^{-1}$ (18.09 g) at 60 DAS and seed yield (1.96 t ha^{-1}) was attained significantly at maximum level from the application of 2 kg ha^{-1} biofertilizer. Application of 2 kg biofertilizer ha^{-1} with three times weeding was proved to be the best possible combination.

Akter *et al.* (2013) conducted an experiment to assess the effect of weeding on growth, yield and yield contributing characters of mungbean *(Vigna radiata* L.). The trial comprised seven treatments namely, T1=no weeding, T2=one-stage weeding (Emergence Flowering), T3=one-stage weeding (Flowering-Pod setting), T4=one-stage weeding (Pod setting- Maturity), T5=two-stage weeding (Emergence-Flowering and Flowering-Pod setting), T6=two-stage weeding (Flowering-Pod setting and Pod setting-Maturity) and T7=three-stage weeding (Emergence-Flowering and Flowering-Pod setting and Pod setting-Maturity). The growth parameters such as relative growth rate (0.075 g g^{-1} day^{-1}) and net assimilation rate (0.075 g m^{-2} day^{-1}) showed the best performance with T2 at one-stage weeding condition (Emergence-Flowering). Three-stage weeding ensured the highest plant height (58.62 cm) as well as the highest number of branches (4.45) and leaflet (10.34) $plant^{-1}$. Dry weight $plant^{-1}$ (12.38 g) was highest from three stage weeding and the lowest from no weeding treatment. The highest number of pods (22.03) $plant^{-1}$, the longest pod (5.95 cm), the highest number of seeds (17.07) pod^{-1} and the highest seed yield (1.38 t ha^{-1}) were obtained from three-stage weeding (Emergence-Flowering and Flowering-Pod setting and Pod setting-Maturity) in mungbean. On the other hand, the lowest seed yield was obtained under no weeding condition. The highest seed yield resulted in higher biological yield (4.70 t ha^{-1}) and the highest harvest index (37.15%) in three-stage weeding and the lowest from no weeding.

Mirjha *et al.* (2013) reported that yield attributes and yield of mungbean were significantly increased in weed control treatment over weedy check while a field trial was carried out in India with weed management.

An experiment was carried out by Asaduzzaman *et al.* (2010) to evaluate the impact of weeding and plant spacing on the growth and yield performance of blackgram. The differential weeding and plant spacing did not show remarkable differences in dry matter production at early stages of crop growth. Two weeding at 25 and 40 DAS significantly increased the number of pods plnat^{-1}, number of seeds pod^{-1}, seed weight and seed yield. Two weeding at 25 and 40 DAS contributed 56.18% and 25.23% higher seed yield compared to no weeding and single weeding, respectively. Two weeding at 25 and 40 DAS and 30 x 10 cm spacing performed the best giving the highest seed yield of 1.58 t ha^{-1}.

Awan *et* al.(2009) conducted an experiment on mungbean in Pakistan and pod length was recorded maximum in plots where treatments were terphali (9.9 cm) and hand weeding (9.7 cm); while in plots with 45cm row spacing + tractor and 60 cm + tractor, pod length was 9.2 cm and 9.6 cm, respectively compared to control (9.0 cm).

A field study was carried out by Vivek *et al.* (2008) to determine the critical period of crop-weed competition in blackgram *(Phaseolus mungo). Trianthema portulacastrum, Digera arvensis, Echinochloa crusgalli, Parthenium hysterophorus, Phyllanthus niruri* and *Cynodon dactylon* were the most predominating weeds. Grain yield loss increased with the increase in the duration of competition and maximum loss (67%) occurred due to full season competition. Significantly higher grain yield (12.42 q ha^{-1}) and yield attributing characters were obtained in plots remaining weed free upto harvest. The critical period of weed competition was between 30 to 45 DAS during which the crop should be kept free of weeds to prevent the potential loss in blackgram grain yield.

Kumar *et al.* (2005) conducted a study to evaluate the benefits of the resource conservation technologies in mungbean during kharif 2004 in Haryana, India. Among the weed control treatments, the maximum reduction in dry weight of weeds was recorded in treatment with hand weeding at 20 and 40 DAS.

Anwar *et al.* (2004) investigated the feasibility of sorghum extract as natural weed control in comparison with hand weeding and herbicide. Sorghum extract reduced the weed number and weed weight. It also increased fresh and dry weight of crops.

Malik *et al.* (2003) conducted an experiment to determine the effect of varying levels of weeding (0, 1 and 2 weeding) on the yield and quality of blackgram. They observed that number of flowers plant^{-1} and pods plant^{-1} was found to be significantly higher by two times of weeding.

In a study it was observed that among some herbicides, tank mixture of fenoxaprop-p- ethyl @ 50 g ha^{-1} + chlorimuron-ethyl @ 4.0 g ha^{-1} (PoE) consistenly increased all the yield attributes *viz.* pods plant^{-1}, pod length and grains pod^{-1} and was statistically at par to 2-HW. The results are in conformity with the findings of Dungarwal *et al.* (2003).

Weeds compete with main crop for space, nutrients, water and light. It is also recognized that a low weed population can be beneficial to the crop as it provides food and habitat for a range of beneficial organisms said by Bueren *et al.* (2002).

Khaliq *et al.* (2002) investigated the efficacy of different weed management strategies in mungbean and stated that hoeing treatments resulted in reduced weed dry weight by 79% compared to control and maximum plant height while conducting a field trial.

Mahla *et al.* (1999) conducted an experiment on weeding effect at 20, 30, 40 days after sowing and no weeding. Plant height, number of branches plant^{-1}, dry matter production plant^{-1} and yield of blackgram increased with increasing weeding. Three times of weeding had the best effect on plant height, number of branches plant^{-1}, dry matter production plant^{-1}.

Kalita *et al.* (1995) reported that the times of weeding (2 or 3 times) on blackgram resulted the greatest seed yield and harvest index which were reported to be associated with a greater number of pods plant^{-1} and seeds pod^{-1}.

Ahmed *et al.* (1993) found that one hand weeding at 10 or 20 DAE produced higher yield than unweeded plots in blackgram during early *kharif.* Although some information on the effect of weeding on yield and yield attributes are available, the effect of crop density and delay in weed removal of blackgram (duration of weed competition) on its yield and yield attributes, leaf area index (LAI), light interception, are not yet available for blackgram in agro-ecological conditions of Bangladesh.

Hamid (1988) conducted a field experiment to investigate the effect of weeding on the growth and yield performance of mungbean. He found that the plant height, dry matter production plant^{-1} and yield of mungbean were found to be increased with more weeding.

Pongkao and Inthong (1988) reported that proper weeding on blackgram was found to be superior giving 23 % higher biological yield over the control.

Kumar and Kairon (1988) found that weed biomass increased yield decreased with delay in weeding of blackgram. However, delay in weeding did not affect the number of seeds pod^{-1}. The higher percent yield reduction was recorded when the blackgram plants were exposed to longer weed competition. Dry matter was maximum under weed free condition followed by weed removal at 30 DAS.

Patel *et al.* (1984) studied the effect of weeding on the growth and seed yield of mungbean during summer season. They observed that two times of weeding significantly increased the 1000 seed weight of mungbean compared to control treatment.

While studying the competition, I observed that soybean seeds pod^{-1} and pods plant^{-1} were reduced due to long duration of wild oat competition (Rathmen and Miller, 1981).

Madrid and Manimtim (1977) stated that yield loss due to uncontrolled weed growth in blackgram range from 27 to 100%.

CHAPTER III

MATERIALS AND METHODS

The experiment was carried out during the period from March to June, 2017 aimed to enhancing production of blackgram by applying different herbicide. The details of the materials and methods have been presented below:

3.1 Description of the experimental site

3.1.1 Location

The location of the experimental field was in Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is 90°33´E longitude and 23°77´N latitude with an elevation of 8.2 m from sea level. Location of the experimental site presented in Appendix I.

3.1.2 Soil

The soil belongs to "The Modhupur Tract", AEZ – 28 (FAO, 1988). Top soil was silty clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 6.1 and has organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood level. The selected plot was medium high land. The details were presented in Appendix II.

3.1.3 Climate

The geographical location of the experimental site was under the subtropical climate, characterized by 3 distinct seasons, winter season from November to February and the pre-monsoon period or hot season from March to April and monsoon period from May to October. Details on the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was collected from the Weather Station of Bangladesh, Sher-e-Bangla Nagar, presented in Appendix III.

3.2 Test crop

Seeds of BARI mash-1, BARI mash-2 and BARI mash-3 were used for the experiment as test crops.

3.3 Experimental details

3.3.1 Treatments

The experiment comprised two factors.

Factor A: Variety - Three blackgram variety

1. V_1 = BARI mash-1
2. V_2 = BARI mash-2
3. V_3 = BARI mash-3

Factor B: Herbicide - Four levels of herbicides application

1. T_1 = Hammer 24 EC - 2 ml litre^{-1}
2. T_2 = Gramaxon -3 ml liter^{-1}
3. T_3 = Panida 33 EC - 4 ml liter^{-1}
4. T_4 = Whip super - 1.5 ml liter^{-1} .

The chemical name of Hammer 24 EC is Carfentrazone Ethyl. The manufacturing company of Hammer 24 EC is FMC Chemical International AG. It is applicable on the crops name Rice, Wheat, Potato, Mungbean, Blackgram etc. It mainly effects on weeds name *Echinochloa crusgalli, Echinochloa colonum, Cyperus difformis, Cyperus iria, Fimbristylis miliacea, Eclipta alba, Laudwigia pulviflor, leptochloa chinensis, Monochoera vaginalis, Pancium repens.*

Gramaxone **(**Paraquate dichloride) is produced by Syngenta Bangladesh Limited. It is applicable to Potato, Cotton, Blackgram, Greengram, Blackgram Rubber, Rice, Wheat, Tea, Maize, Grapes etc. It has great effect on *Chenopodium sp. Anagallis arvensis, Triantherma monogyna, Cyperus rotandus, Fumaria pariaflora, Digera arvensis, Cyperus iria, Trianthema portulacastrum, Digitaria sp., Eragrostis sp., Eupatorium odoratum, Ageratum* *conyzides, Commelina benghalensis, Echinochola crusgalli, Pancium repens, Brachiaria mutica, Marsilea quadrifoliata, Grassy & Broadleaved weeds, Imperata cylindrica Seteria sp., Boerhavia haispida, Paspaulam conjugatum, Clerodendron infortunatum.* Gramaxone is a group A type herbicide.

Panida 33 EC (Pendimethalin) is manufactured by Auto Crop Care Limited in Bangladesh. In Wheat, Rice, Cotton, Soyabean, Chillies, Groundnut, Mungbean, Blackgram it is applicable. It mainly effects on controlling *Phalaris minor, Chenopodium album, Melitious alba, Portulaca oleracea, Angalls arvensls, Fumaria parviflora, Poa annua, Echinochola colonum, Echinochloa, crusgall fimbristylis miliaece, Marsilia quadrifoliata, Altarnanthera sessilis, Ludvugua parvlflora, Echinno cloa spp, Amaranthus viridis, Portulaca oleracea, Trianthema spp, Eleusine indica, Cleoma viscosa digitaria spp, Echinochola spp, Trianthema monogyna, Dactyloctenium aeyypticum, Digitaria sanguinalis.*

The chemical name of Whip Super 9 EC is Fenoxaprop-p-Ethyl. And it is produced by Bayer Crop Science Limited. It can be use in Soybean, Rice, Cotton, Blackgram, Potato,Beans,Vegetables etc. The weeds on which it acts are *Echinichloa crusagalli, Echinochloa colona, Digitaria sp., Dactylotenium aegyptium*.

.3.3.2 Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing the combination of blackgram variety and herbicide application. The 12 treatment combinations of the experiment were assigned at random into 36 plots. The size of each unit plot 1.6 m× 1.0 m. The distance between blocks and plots were 1 m and 0.50 m, respectively. Layout of experiment field is presented in Appendix IV.

3.4 Growing of crops

3.4.1 Seed collection

Seed of BARI mash-1, BARI mash-2 and BARI mash-3 were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur .

3.4.2 Preparation of the main field

The plot selected for the experiment was opened in the first week of March, 2017 with a power tiller, and was exposed to the sun for a week, after, which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed and finally obtained a desirable tilth of soil for sowing.

3.4.3 Seed sowing

Seeds were sown at the rate of 40 kg ha^{-1} in the furrow on 28^{th} March, 2017 and the furrows were covered with the soils soon after seeding. The line to line (furrow to furrow) distance was maintained as per treatment arrangements with continuous sowing of seeds in the line.

3.4.4 Fertilizers and manure application

The fertilizers were applied as basal dose @ N, P and K as 20, 17.20 and 17.6 kg ha-1 at final land preparation respectively in all plots. All fertilizers were applied by broadcasting and mixed thoroughly with soil.

3.4.5 Intercultural operation

After establishment of seedlings, various intercultural operations were accomplished for better growth and development of the blackgram.

3.4.5.1 Irrigation and drainage

Pre-sowing irrigation was given to ensure the maximum germination percentage. During experimental period, there was heavy rainfall for several times. So it was essential to remove the excess water from the field.

3.4.5.2 Plant protection

The crop was infested by insects and diseases. Those were effectively and timely controlled by applying recommended insecticides and fungicides.

3.5 Harvesting, threshing and cleaning

The crop was harvested at 90 DAS. The crop was harvested plot wise when about 80% of the pods became matured. Samples were collected from different places of each plot leaving undisturbed plant in the center. The harvested crops were tied into bundles and carried to the threshing floor. The crop bundles were sun dried by spreading those on the threshing floor. The seeds were separated, cleaned and dried in the sun for 3 to 5 consecutive days for achieving safe moisture of seed.

3.6 Data Collection and Recording

Ten plants were selected randomly from each unit plot for recording data on crop parameters and the yield of grain and straw were taken plot wise.

The following parameters were recorded during the study:

1. Plant height (cm)
2. Number of leaflets plant^{-1}
3. Number of branches plant^{-1}
4. Leaf area plant^{-1}
5. Dry weight plant^{-1} (g)
6. Number of pods plant^{-1}
7. Number of seeds pod^{-1}
8. Pod length (cm)
9. 1000 seed weight (g)
10. Seed yield (kg ha^{-1})
11. Stover yield (kg ha^{-1})
12. Biological yield (kg ha^{-1})
13. Harvest index (%)

3.7 Procedure of recording data

3.7.1 Plant height (cm)

The height of plant was recorded in centimeter (cm) at different days after sowing of crop duration. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the tippets leaf.

3.7.2 Number of leaflet plant^{-1}

Number of leaflet plant^{-1} was counted at different days after sowing of crop duration. Leaflet number plant^{-1} was recorded from pre-selected 10 plants by counting all leaflet from each plot and mean was calculated.

3.7.3 Number of branches plant^{-1}

The branches were counted from the 10 randomly selected plant and mean value was determined. Only the primary branches were counted.

3.7.4 Dry weight plant^{-1} (g)

Five sample plants in each plot were selected at random in the sample rows outside the central 1 m^2 of effective harvesting area and cut close to the ground surface at different days of crop duration. They were first air dried for one hour, then oven dried at 80±5°C till a constant weight was attained. Mean dry weight was expressed as per plant basis.

3.7.5 Number of pods plant^{-1}

Number of total pods of 10 plants from each plot was noted and the mean number was expressed per plant basis.

3.7.6 Number of seeds pod^{-1}

Number of total seeds of ten pods from each plot was noted and the mean number was expressed per pod basis.

3.7.7 Pod length (cm)

Length of 10 pods of 10 selected plants from each plot was noted and the mean number was expressed per pod basis.

3.7.8 Weight of 1000 seeds (g)

One thousand cleaned and dried seeds were counted randomly form $1m^2$ area and weight by using a digital electric balance and the weight was expressed in gram.

3.7.9 Seed yield (kg ha^{-1})

The plants of the central 1.0 m^2 from the plot were harvested for taking grain yield. The grains were threshed from the plants, cleaned, dried and then weighed. The yield of grain in kg $plot^{-1}$ was adjusted at 12% moisture content of grain and then converted to t ha^{-1}.

3.7.10 Stover yield (kg ha^{-1})

The stover of the harvested crop in each plot was sun dried to a constant weight. Then the stovers were weighted and thus the stover yield $plot^{-1}$ was determined. The yield of stover in kg $plot^{-1}$ was converted to kg ha^{-1}.

3.7.11 Biological yield (kg ha^{-1})

Grain yield and stover yield together were regarded as biological yield. The biological yield was calculated with the following formula:

Biological yield = Grain yield + Stover yield.

3.7.12 Harvest index (%)

Harvest index was calculated from the ratio of grain yield to biological yield and expressed in percentage. It was calculated by using the following formula.

$$\text{HI (\%)} = \frac{\text{Seed yield}}{\text{Biological yield}} \times 100$$

3.8 Statistical Analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among the treatment by using the MSTAT-C computer package program. The mean values of all the characters were calculated and analysis of variance was performed. The significance of the difference among the treatments means was estimated by the Least Significant Deferent Test (LSD) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to enhancing production of blackgram by applying different herbicide. The results obtained from the study have been presented, discussed and compared in this chapter through different tables, figures and appendices.

4.1 Growth parameters

4.1.1 Plant height

Effect of variety

Plant height of blackgram at different growth stages varied significantly due to different variety (Figure 1 and Appendix V). It was found that the highest plant height (23.33, 35.33 and 42.01 cm at 30, 45 and 60 DAS respectively) was found from the variety, V_3 (BARI mash-3) where the lowest plant height (21.93, 29.04 and 36.06 cm at 30, 45 and 60 DAS respectively) was recorded from the variety, V_2 (BARI mash-2) which was statistically identical with V_3 (BARI mash-3). Similar findings were also reviewed by Bhowaland and Bhowmik (2014), Verma *et al*. (2011) and Malik *et al*. (2008).

Effect of herbicide

Different herbicide application showed significant variation on plant height of blackgram at different growth stages (Figure 2 and Appendix V). Results indicated that the highest plant height (22.99, 32.82 and 39.23 cm at 30, 45 and 60 DAS respectively) was found from the treatment, T_3 (Panida - 4 ml liter^{-1}) which was statistically identical with T_2 (Gramaxon - 3 ml liter^{-1}) at 30 DAS followed by T_4 (Whip super - 1.5 ml liter^{-1}). The lowest plant height (21.02, 29.60 and 37.29 cm at 30, 45 and 60 DAS, respectively) was recorded from the treatment, T_1 (Hammer 24 EC - 2 ml liter^{-1}). Significant variation on plant height with different herbicide was also observed by Pramanik *et al.* (2014), Akter *et al.* (2013) and Khaliq *et al.* (2002).

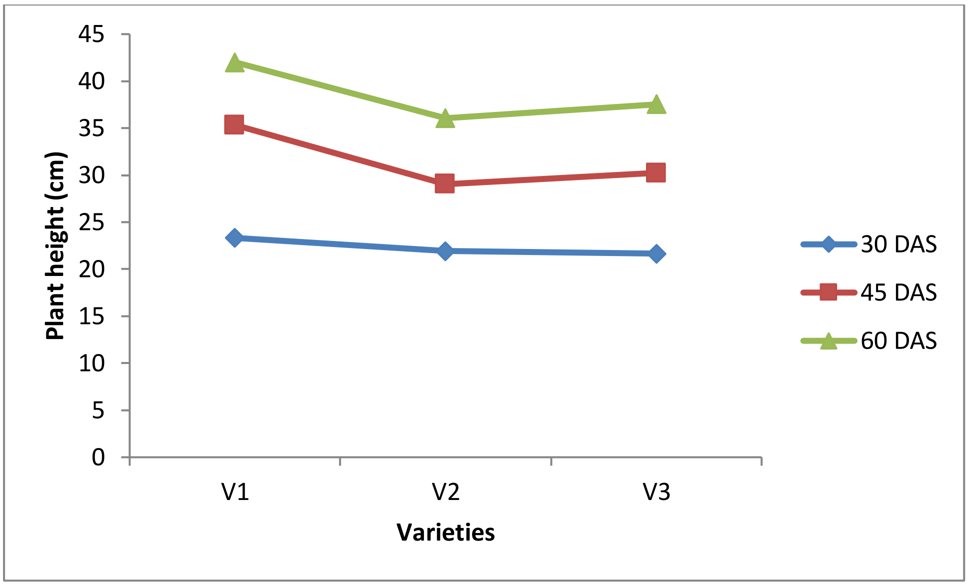

Figure 1. Effect of different varieties on the plant height of blackgram

V_1 = BARI mash-1, V_2 = BARI mash-2, V_3 = BARI mash-3

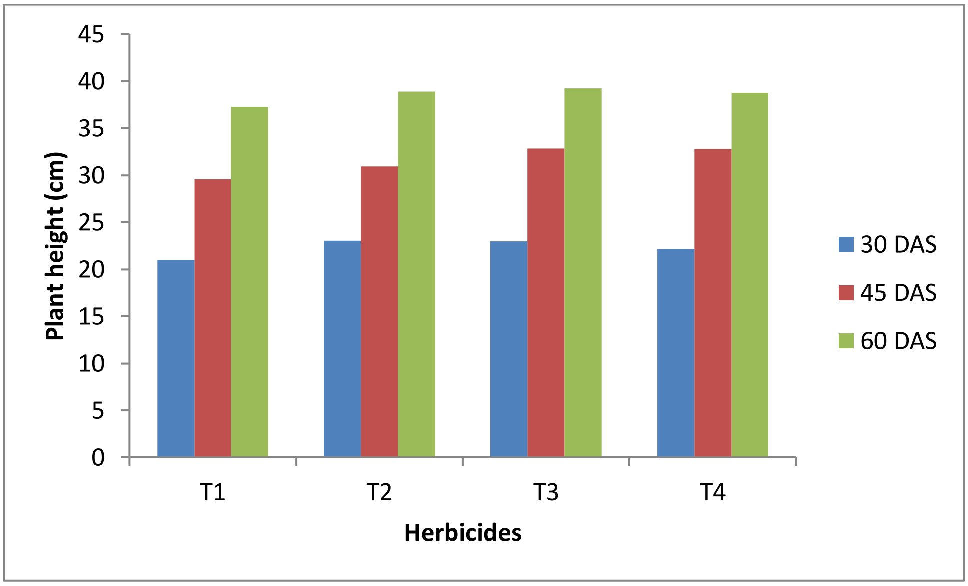

Figure 2. Effect of different herbicides on the plant height of blackgram

T_1 = Hammer 24 EC - 2 ml liter^{-1}, T_2 = Gramaxon - 3 ml liter^{-1}, T_3 = Panida - 4 ml liter^{-1} , T_4 = Whip super - 1.5 ml liter^{-1}

Combined effect of variety and herbicide

Significant influence was examined on plant height of blackgram at different growth stages affected by combined effect of variety and herbicide application (Table 1 and Appendix V). It was noted that the highest plant height (25.39, 39.00 and 44.78 cm at 30, 45 and 60 DAS respectively) was obtained from the treatment combination of V_1T_3 which was statistically identical with V_1T_4 at 45 DAS and 60 DAS. The lowest plant height (19.59, 24.89 and 31.15 cm at 30, 45 and 60 DAS respectively) was recorded from the treatment combination of V_2T_1 which was significantly different from all other treatment combinations but close to the treatment combination of V_2T_4 and V_3T_3.

Table 1. Interaction effect of different varieties and herbicides on the plant height of blackgram, change at all places

Treatment	Plant height (cm)		
	30 DAS	45 DAS	60 DAS
V_1T_1	22.74 d	33.38 b	40.64 b
V_1T_2	22.43 d	30.30 d	38.88 c
V_1T_3	25.39 a	39.00 a	44.78 a
V_1T_4	23.71 bc	38.65 a	43.73 a
V_2T_1	19.59 f	24.89 g	31.15 g
V_2T_2	24.43 b	33.51 b	41.75 b
V_2T_3	23.03 cd	32.03 c	37.84 cd
V_2T_4	19.70 f	25.74 g	33.49 f
V_3T_1	20.74 e	29.68 de	37.75 cd
V_3T_2	21.33 e	29.05 e	36.04 de
V_3T_3	21.51 e	27.78 f	35.08 ef
V_3T_4	23.06 cd	34.37 b	41.35 b
$LSD_{0.05}$	0.8500	1.064	1.731
CV (%)	9.24	13.71	12.13

V_1 = BARI mash-1, V_2 = BARI mash-2, V_3 = BARI mash-3
T_1 = Hammer 24 EC - 2 ml liter^{-1}, T_2 = Gramaxon - 3 ml liter^{-1}, T_3 = Panida - 4 ml liter^{-1}, T_4 = Whip super - 1.5 ml liter^{-1}

4.1.2 Number of leaflet plant^{-1}

Effect of variety

Significant influence was noted for number of leaflet plant^{-1} at different growth stages influenced by different variety of blackgram (Figure 3 and Appendix VI). Results revealed that the highest number of leaflet plant^{-1} (8.44, 12.00 and 15.48 at 30, 45 and 60 DAS respectively) was found from the variety, V_3 (BARI mash-3) where the lowest number of leaflet plant^{-1} (7.02, 10.82 and 14.46 at 30, 45 and 60 DAS respectively) was recorded from the variety, V_2 (BARI mash-2) which was statistically identical with V_1 (BARI mash-1) at 60 DAS. Similar results were also observed by Verma *et al*. (2011), Goswami *et al*. (2010a) and Madhavi *et al*. (2001).

Effect of herbicide

Remarkable variation was examined in terms of number of leaflet plant^{-1} at different growth stages of blackgram affected by different herbicide application (Figure 4 and Appendix VI). It was observed that the highest number of leaflet plant^{-1} (8.99, 12.60 and 16.00 at 30, 45 and at harvest respectively) was found from the treatment, T_2 (Gramaxon - 3 ml liter^{-1}) which was significantly different from others. The lowest number of leaflet plant^{-1} (7.04, 10.72 and 14.09 at 30, 45 and at harvest respectively) was recorded from the treatment, T_1 (Hammer 24 EC - 2 ml liter^{-1}) which was statistically identical with T_3 (Panida - 4 ml liter^{-1}) and T_4 (Whip super - 1.5 ml liter^{-1}) at 30 and 60 DAS. Akter *et al.* (2013) also found similar result with the present study.

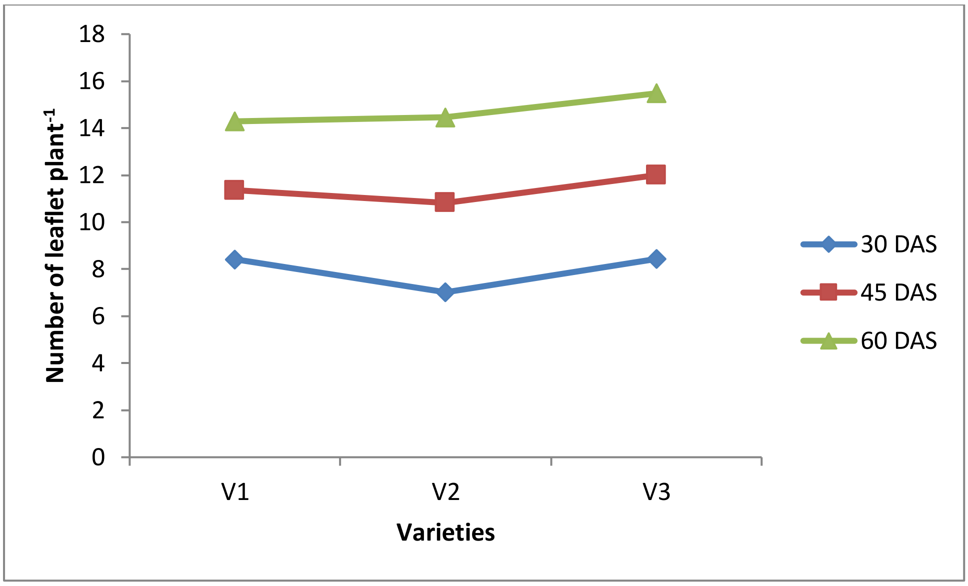

Figure 3. Effect of different varieties on the leaflet plant^{-1} of blackgram

V_1 = BARI mash-1, V_2 = BARI mash-2, V_3 = BARI mash-3

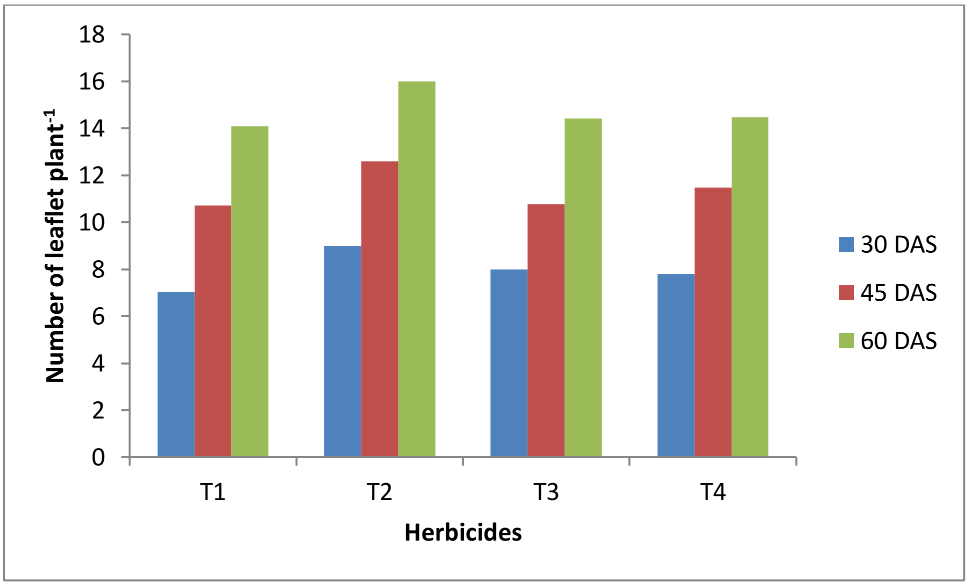

Figure 4. Effect of different herbicides on the leaflet plant^{-1} of blackgram

T_1 = Hammer 24 EC - 2 ml liter^{-1}, T_2 = Gramaxon - 3 ml liter^{-1}, T_3 = Panida - 4 ml liter^{-1} , T_4 = Whip super - 1.5 ml liter^{-1}

Combined effect of variety and herbicide

Variation on number of leaflet plant^{-1} was significant at different growth stages affected by combined effect of variety and herbicide application (Table 2 and Appendix VI). Results revealed that the highest number of leaflet plant^{-1} (10.97, 15.47 and 18.81 at 30, 45 and at harvest respectively) was obtained from the treatment combination of V_3T_2 which was significantly different from all other treatment combinations followed by V_3T_4. The lowest number of leaflet plant^{-1} (5.80, 9.17 and 13.10 at 30, 45 and at harvest respectively) was recorded from the treatment combination of V_2T_1 which was statistically identical with V_2T_4 and significantly similar with V_1T_4, V_3T_3 and V_3T_1 at 60 DAS.

Table 2. Interaction effect of different varieties and herbicides on the leaflet plant^{-1} of blackgram

Treatment	Number of leaflet plant^{-1}		
	30 DAS	45 DAS	60 DAS
V_1T_1	8.60 c	11.67 c	15.01 c
V_1T_2	7.60 e	11.07 cd	14.41 cd
V_1T_3	9.66 b	11.87 c	14.41 cd
V_1T_4	7.80 e	10.80 de	13.79 de
V_2T_1	5.80 g	9.173 g	13.10 e
V_2T_2	8.40 cd	11.27 cd	14.78 cd
V_2T_3	8.00 de	11.13 cd	15.13 c
V_2T_4	5.88 g	9.900 fg	13.32 e
V_3T_1	6.71 f	10.18 ef	14.15 cde
V_3T_2	10.97 a	15.47 a	18.81 a
V_3T_3	6.33 fg	10.70 de	13.71 de
V_3T_4	9.73 b	13.45 b	16.32 b
$LSD_{0.05}$	0.554	0.7303	0.9609
CV (%)	8.37	10.83	9.72

V_1 = BARI mash-1, V_2 = BARI mash-2, V_3 = BARI mash-3

T_1 = Hammer 24 EC - 2 ml liter^{-1}, T_2 = Gramaxon - 3 ml liter^{-1}, T_3 = Panida - 4 ml liter^{-1}, T_4 = Whip super - 1.5 ml liter^{-1}

4.1.3 Number of branches plant^{-1}

Effect of variety

Number of branches plant^{-1} of blackgram at different growth stages varied significantly due to different variety (Figure 5 and Appendix VII). Results verified that the highest number of branches plant^{-1} (1.57, 2.58 and 3.27 at 30, 45 and at harvest respectively) was found from the variety, V_3 (BARI mash-3) which was significantly different at all growth stages from others except at 30 DAS with V_2 (BARI mash-2). The lowest number of branches plant^{-1} (1.14, 1.67 and 2.74 at 30, 45 and at harvest respectively) was recorded from the variety, V_1 (BARI mash-1). Similar findings was also observed by Bhowaland and Bhowmik (2014), Verma *et al*. (2011), Goswami *et al*. (2010a) and Malik *et al*. (2008).

Effect of herbicide

Different herbicide application showed significant variation on number of branches plant^{-1} of blackgram at different growth stages (Figure 6 and Appendix VII). The highest number of branches plant^{-1} (1.60, 2.58 and 3.37 at 30, 45 and at harvest respectively) was found from the treatment, T_4 (Whip super – 1.5 ml liter^{-1}) which was statistically identical with T_3 (Panida - 4 ml liter^{-1}) at 45 and 60 DAS. The lowest number of branches plant^{-1} (0.99, 1.66 and 2.72 at 30, 45 and at harvest respectively) was recorded from the treatment, T_1 (Hammer 24 EC - 2 ml liter^{-1}) which was statistically identical with T_2 (Gramaxon - 3 ml liter^{-1}) at 60 DAS. The result was in agreement with the findings of Akter *et al.* (2013) and Mahla *et al.* (1999).

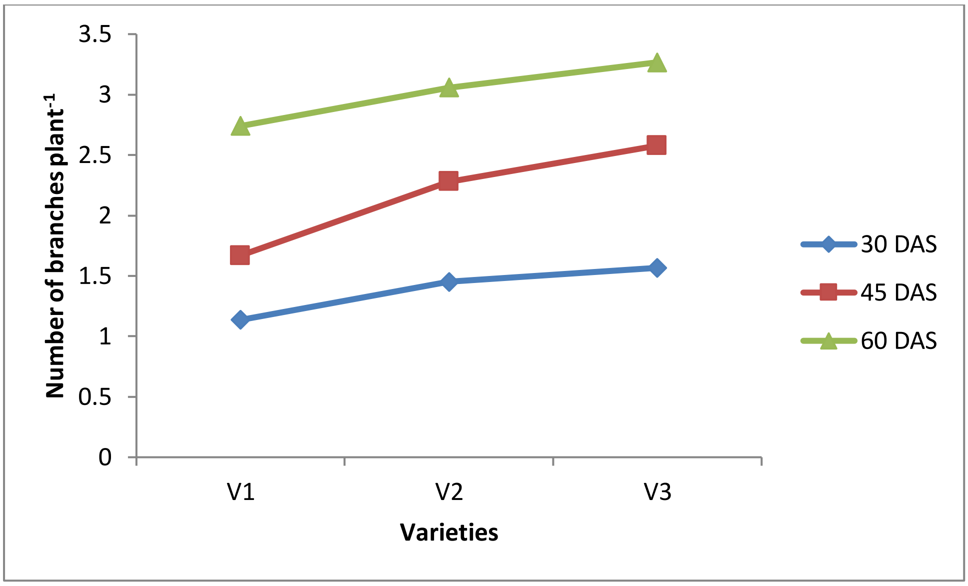

Figure 5. Effect of different varieties on the branches plant^{-1} of blackgram

V_1 = BARI mash-1, V_2 = BARI mash-2, V_3 = BARI mash-3

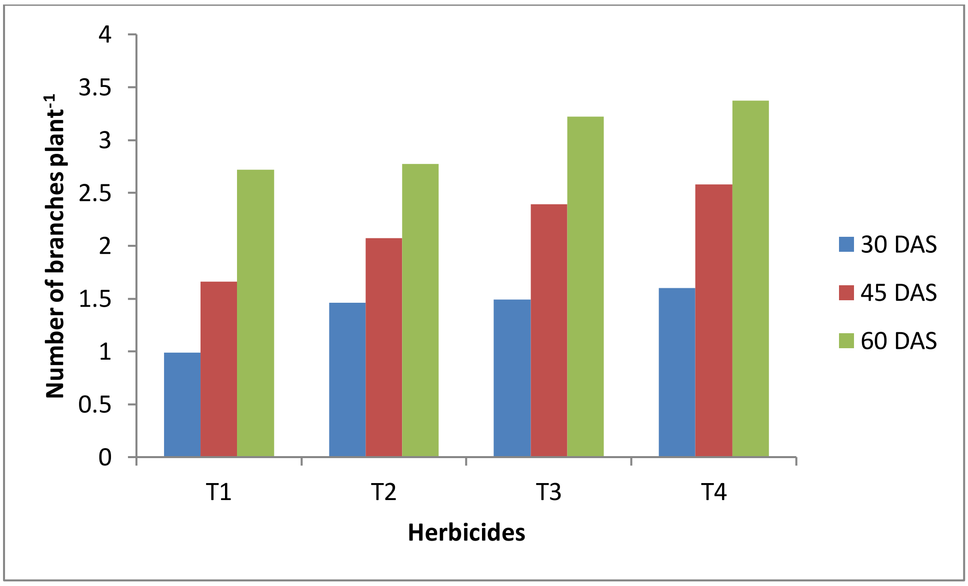

Figure 6. Effect of different herbicides on the branches plant^{-1} of blackgram

T_1 = Hammer 24 EC - 2 ml liter^{-1}, T_2 = Gramaxon - 3 ml liter^{-1}, T_3 = Panida - 4 ml liter^{-1} , T_4 = Whip super - 1.5 ml liter^{-1}

Combined effect of variety and herbicide

Significant influence was examined on number of branches plant^{-1} of blackgram at different growth stages affected by combined effect of variety and herbicide application (Table 3 and Appendix VII). The highest number of branches plant^{-1} (2.60, 4.10 and 4.78 at 30, 45 and at harvest respectively) was obtained from the treatment combination of V_3T_4 which was significantly different from all other treatment combinations followed by V_1T_3 and V_2T_4 60 DAS. The lowest number of branches plant^{-1} (0.50, 1.17 and 2.23 at 30, 45 and at harvest respectively) was recorded from the treatment combination of V_1T_1 which was statistically identical with V_2T_2 and V_3T_2 and significantly similar with V_1T_2 and V_1T_4 at 60 DAS.

Table 3. Interaction effect of different varieties and herbicides on the branches plant^{-1} of blackgram

Treatment	Number of branches plant^{-1}		
	30 DAS	45 DAS	60 DAS
V_1T_1	0.500 g	1.167 g	2.233 f
V_1T_2	1.000 f	1.867 d	2.467 ef
V_1T_3	2.200 b	2.993 b	3.877 b
V_1T_4	0.667 g	1.840 de	2.520 ef
V_2T_1	1.867 c	2.507 c	3.300 d
V_2T_2	1.200 e	1.507 ef	2.260 f
V_2T_3	1.333 de	1.667 de	2.760 e
V_2T_4	1.510 d	2.337 c	3.720 bc
V_3T_1	0.600 g	1.310 fg	2.247 f
V_3T_2	2.267 b	2.840 b	3.460 cd
V_3T_3	0.867 f	1.973 d	2.633 e
V_3T_4	2.600 a	4.100 a	4.780 a
$LSD_{0.05}$	0.1855	0.3213	0.2833
CV (%)	5.11	4.75	5.34

V_1 = BARI mash-1, V_2 = BARI mash-2, V_3 = BARI mash-3
T_1 = Hammer 24 EC - 2 ml liter^{-1}, T_2 = Gramaxon - 3 ml liter^{-1}, T_3 = Panida - 4 ml liter^{-1},
T_4 = Whip super - 1.5 ml liter^{-1}

4.1.4 Leaf area plant^{-1}

Effect of variety

Significant variation was found for leaf area plant^{-1} at all growth stages (Figure 7 and Appendix VIII). It was observed that the highest leaf area plant^{-1} (34.94, 37.90 and 40.04 at 30, 45 and at harvest respectively) was found from the variety, V_3 (BARI mash-3) which was statistically identical with V_1 (BARI mash-1) at 45 and 60 DAS where the lowest leaf area plant^{-1} (26.60, 35.38 and 38.51 at 30, 45 and at harvest, respectively) was recorded from the variety, V_2 (BARI mash-2). Malik *et al*. (2008) also observed similar result with the present study.

Effect of herbicide

Different herbicide application showed significant influence on leaf area plant^{-1} (Figure 8 and Appendix VIII). Results revealed that the highest leaf area plant^{-1} (32.55, 39.05 and 41.60 at 30, 45 and at harvest respectively) was found from the treatment, T_2 (Gramaxon - 3 ml liter^{-1}) followed by T_1 (Hammer 24 EC - 2 ml liter^{-1}) and T_4 (Whip super - 1.5 ml liter^{-1}) where the lowest leaf area plant^{-1} (27.53, 33.73 and 36.90 at 30, 45 and at harvest respectively) was recorded from the treatment, T_3 (Panida - 4 ml liter^{-1}). Similar result was also found with Ahmed *et al.* (1993).

Combined effect of variety and herbicide

Combined effect of variety and herbicide application also gave significant influence on leaf area plant^{-1} at all growth stages (Table 4 and Appendix VIII). It was exposed that the highest leaf area plant^{-1} (39.73, 41.72 and 47.68 at 30, 45 and at harvest, respectively) was obtained from the treatment combination of V_3T_2 which was significantly different from all other treatment combinations followed by V_3T_3. The lowest leaf area plant^{-1} (18.75, 27.26 and 32.37 at 30, 45 and at harvest respectively) was recorded from the treatment combination of

V_2T_3 which was also significantly different from all other treatment combinations.

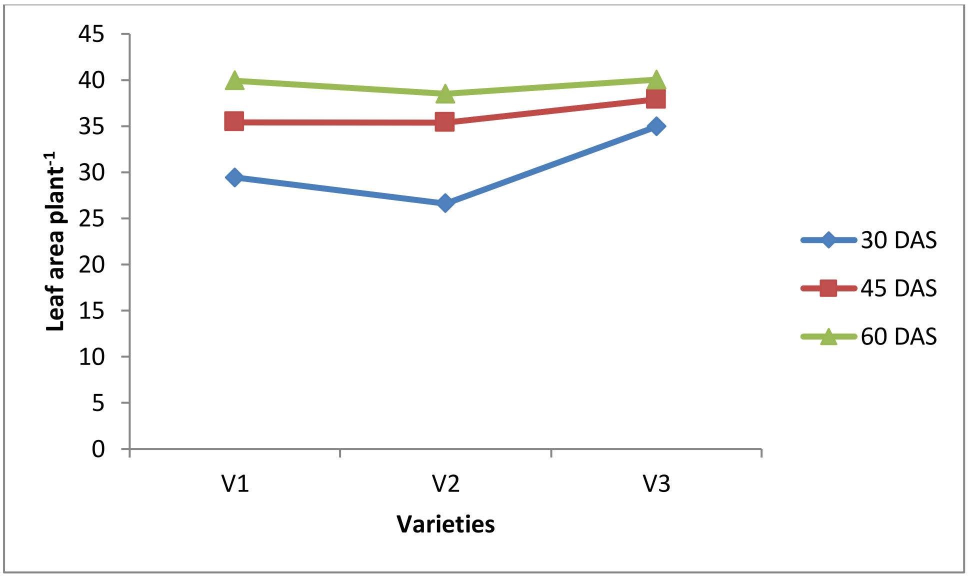

Figure 7. Effect of different varieties on the leaf area plant^{-1} of blackgram

V_1 = BARI mash-1, V_2 = BARI mash-2, V_3 = BARI mash-3

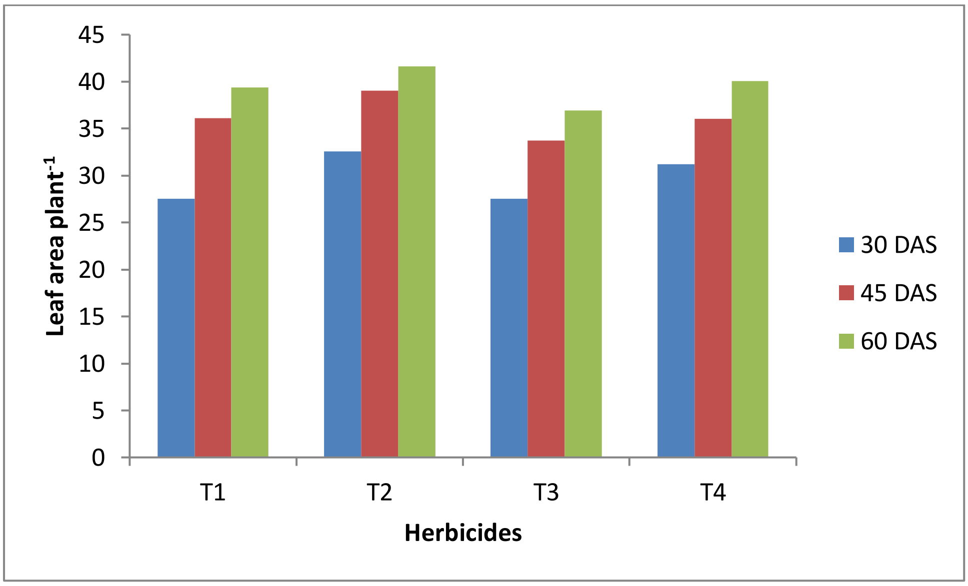

Figure 8. Effect of different herbicides on the leaf area plant^{-1} of blackgram

T_1 = Hammer 24 EC - 2 ml liter^{-1}, T_2 = Gramaxon - 3 ml liter^{-1}, T_3 = Panida - 4 ml liter^{-1} , T_4 = Whip super - 1.5 ml liter^{-1}

Table 4. Interaction effect of different varieties and herbicides on the leaf area plant^{-1} of blackgram

Treatment	Leaf area plant^{-1} (cm^2)		
	30 DAS	45 DAS	60 DAS
V_1T_1	34.63 bc	35.50 e	37.32 d
V_1T_2	29.18 d	35.92 e	37.46 d
V_1T_3	30.58 d	30.50 f	35.10 e
V_1T_4	36.21 b	39.82 bc	42.56 bc
V_2T_1	21.15 f	34.39 e	38.73 d
V_2T_2	33.87 c	40.34 ab	42.32 bc
V_2T_3	18.75 g	27.26 g	32.37 f
V_2T_4	32.62 c	38.14 d	41.38 bc
V_3T_1	29.20 d	31.30 f	34.66 e
V_3T_2	39.73 a	41.72 a	47.68 a
V_3T_3	25.28 e	38.68 cd	41.11 c
V_3T_4	32.71 c	41.19 ab	43.15 b
$LSD_{0.05}$	1.948	1.501	1.714
CV (%)	13.58	12.47	9.78

V_1 = BARI mash-1, V_2 = BARI mash-2, V_3 = BARI mash-3
T_1 = Hammer 24 EC - 2 ml liter^{-1}, T_2 = Gramaxon - 3 ml liter^{-1}, T_3 = Panida - 4 ml liter^{-1} ,
T_4 = Whip super - 1.5 ml liter^{-1}

4.1.5 Dry weight plant^{-1}

Effect of variety

Non-significant influence was noted for dry weight plant^{-1} at different growth stages (Figure 9 and Appendix IX). It was observed that the highest dry weight plant^{-1} (2.41, 6.19 and 7.13 g at 30, 45 and at harvest respectively) was found from the variety, V_3 (BARI mash-3) where the lowest dry weight plant^{-1} (2.29, 5.79 and 6.74 g at 30, 45 and at harvest respectively) was recorded from the variety, V_1 (BARI mash-1). Similar result was also achieved by Verma *et al.* (2011) and Anurag *et al.* (2009).

Effect of herbicide

Remarkable variation was not found in terms of dry weight plant^{-1} at different growth stages of blackgram influenced by herbicide application (Figure 10 and Appendix IX). But the highest dry weight plant^{-1} (2.38, 6.07 and 6.96 g at 30, 45 and at harvest respectively) was found from the treatment, T_4 (Whip Super – 1.5 ml liter^{-1}) where the lowest dry weight plant^{-1} (2.31, 5.93 and 6.88 g at 30, 45 and at harvest respectively) was recorded from the treatment, T_3 (Panida - 4 ml liter^{-1}). Rao *et al.* (2015), Shweta and Malik (2015) and Das *et al.* (2014) also found similar result with the present study.

Combined effect of variety and herbicide

Variation on dry weight plant^{-1} was significant at different growth stages affected by combined effect of variety and herbicide application (Table 5 and Appendix IX). It was found that the highest dry weight plant^{-1} (2.46, 6.29 and 7.18 g at 30, 45 and at harvest respectively) was obtained from the treatment combination of V_3T_4 which was statistically identical with V_3T_1, V_3T_2 and V_3T_3 where the lowest dry weight plant^{-1} (2.24, 5.70 and 6.61 g at 30, 45 and at harvest respectively) was recorded from the treatment combination of V_1T_3 which was statistically similar with V_1T_4.

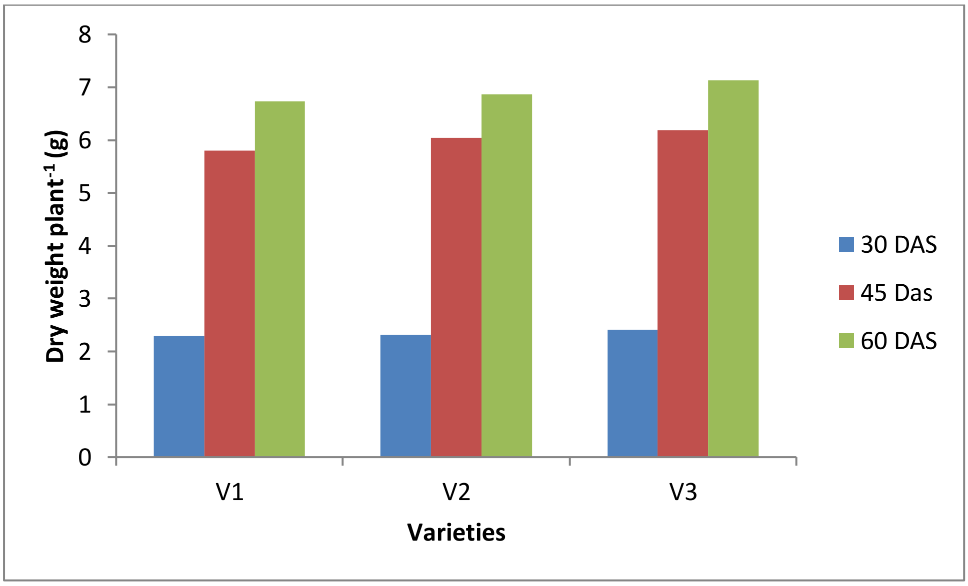

Figure 9. Effect of different varieties on the dry weight plant^{-1} of blackgram

V_1 = BARI mash-1, V_2 = BARI mash-2, V_3 = BARI mash-3

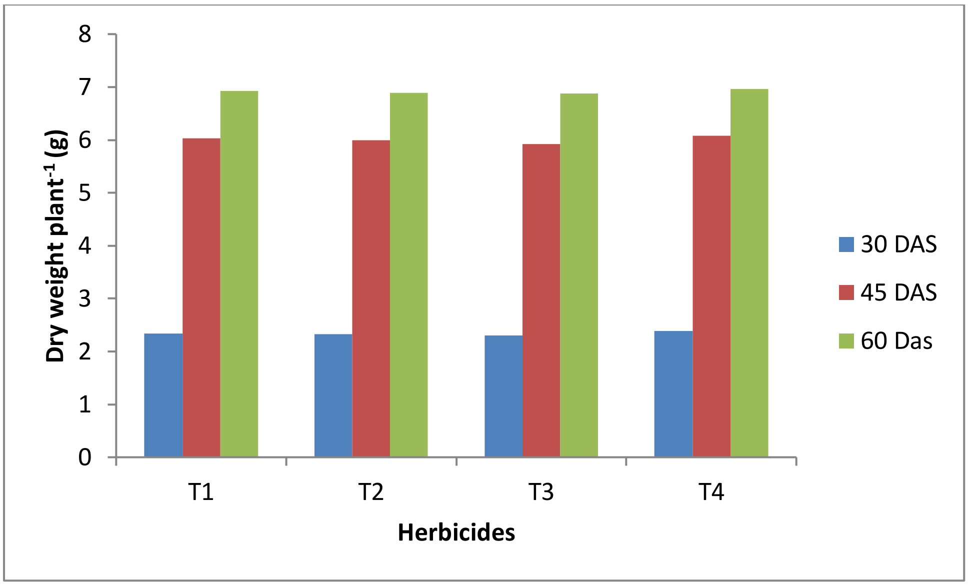

Figure 10. Effect of different herbicides on the dry weight plant^{-1} of blackgram

T_1 = Hammer 24 EC - 2 ml liter^{-1}, T_2 = Gramaxon - 3 ml liter^{-1}, T_3 = Panida - 4 ml liter^{-1} , T_4 = Whip super - 1.5 ml liter^{-1}

Table 5. Interaction effect of different varieties and herbicides on the dry weight plant^{-1} of blackgram,

Treatment	Dry weight plant^{-1} (g)		
	30 DAS	45 DAS	60 DAS
V_1T_1	2.287	5.940 de	6.863 b
V_1T_2	2.257	5.743 f	6.807 bc
V_1T_3	2.243	5.703 f	6.610 d
V_1T_4	2.377	5.793 ef	6.667 cd
V_2T_1	2.267	6.100 bc	6.840 b
V_2T_2	2.400	5.970 cd	6.900 b
V_2T_3	2.403	5.927 de	6.837 b
V_2T_4	2.390	6.150 ab	6.907 b
V_3T_1	2.407	6.180 ab	7.080 a
V_3T_2	2.317	6.160 ab	7.083 a
V_3T_3	2.277	6.147 ab	7.187 a
V_3T_4	2.460	6.287 a	7.177 a
$LSD_{0.05}$	NS	0.1417	0.1515
CV (%)	3.62	2.13	2.76

V_1 = BARI mash-1, V_2 = BARI mash-2, V_3 = BARI mash-3

T_1 = Hammer 24 EC - 2 ml liter^{-1}, T_2 = Gramaxon - 3 ml liter^{-1}, T_3 = Panida - 4 ml liter^{-1} , T_4 = Whip super - 1.5 ml liter^{-1}

4.2 Yield contributing parameters

4.2.1 Number of pods plant^{-1}

Effect of variety

Significant influence was noted on number of pods plant^{-1} affected by different variety of blackgram (Table 6 and Appendix X). The highest number of pods plant^{-1} (12.33) was found from the variety, V_3 (BARI mash-3) followed by V_2 (BARI mash-2) where the lowest number of pods plant^{-1} (7.07) was recorded from the variety, V_1 (BARI mash-1). Similar results were also observed by Bhowaland and Bhowmik (2014), Verma *et al*. (2011), Anurag *et al*. (2009) and Malik *et al*. (2008).

Effect of herbicide

Number of pods plant^{-1} varied significantly due to herbicide application (Table 6 and Appendix X). The highest number of pods plant^{-1} (10.96) was found from the treatment, T_4 (Whip super - 1.5 ml liter^{-1}) followed by T_2 (Gramaxon - 3 ml liter^{-1}) where the lowest number of pods plant^{-1} (8.32) was recorded from the treatment, T_3 (Panida - 4 ml liter^{-1}) followed by T_1 (Hammer 24 EC - 2 ml liter^{-1}). Similar results were also observed by Akter *et al.* (2013), Asaduzzaman *et al.* (2010), Malik *et al.* (2003) and Kalita *et al.* (1995).

Combined effect of variety and herbicide

Significant variation was remarked as influenced by combined effect of variety and herbicide application (Table 6 and Appendix X). The highest number of pods plant^{-1} (16.30) was obtained from the treatment combination of V_3T_4 which was significantly different from all other treatment combinations followed by V_3T_3. The lowest number of pods plant^{-1} (3.90) was recorded from the treatment combination of V_1T_3 followed by the treatment combination of V_1T_2.

4.2.2 Number of seeds pod^{-1}

Effect of variety

Number of seeds pod^{-1} was found significant with different variety of blackgram (Table 6 and Appendix X). The highest number of seeds pod^{-1} (6.08) was found from the variety, V_3 (BARI mash-3) followed byV_2 (BARI mash-2) where the lowest number of seeds pod^{-1} (5.81) was recorded from the variety, V_1 (BARI mash-1). Similar results were also observed by Bhowaland and Bhowmik (2014) and Singh *et al*. (2006)

Effect of herbicide

Variation on number of seeds pod^{-1} was not influenced by herbicide application (Table 6 and Appendix X). But the highest number of seeds pod^{-1} (5.99) was found from the treatment, T_4 (Whip Super – 1.5 ml liter^{-1}) where the lowest number of seeds pod^{-1} (5.90) was recorded from the treatment, T_3 (Panida - 4 ml liter^{-1}). Similar results were also observed by Akter *et al.* (2013) and Asaduzzaman *et al.* (2010).

Combined effect of variety and herbicide

Number of seeds pod^{-1} of blackgram affect by combined effect of variety and herbicide application was significant (Table 6 and Appendix X). The highest number of seeds pod^{-1} (6.64) was obtained from the treatment combination of V_3T_4 which was significantly different from all other treatment combinations followed by V_2T_1. The lowest number of seeds pod^{-1} (5.57) was recorded from the treatment combination of V_1T_3 which was close to the treatment combination of V_1T_1, V_2T_4 and V_3T_1.

4.2.3 Pod length

Effect of variety

The recorded data on pod length was significant with the different variety of blackgram (Table 6 and Appendix X). Results indicated that the highest pod length (4.06 cm) was found from the variety, V_3 (BARI mash-3) where the lowest pod length (3.87 cm) was recorded from the variety, V_1 (BARI mash-1) which was statistically identical with V_2 (BARI mash-2). Similar results were also observed by Verma *et al*. (2011), Malik *et al*. (2008) and Patel and Munda (2001).

Effect of herbicide

Considerable influence was observed on pod length persuaded by herbicide application (Table 6 and Appendix X). The highest pod length (4.08 cm) was found from the treatment, T_4 (Whip super - 1.5 ml liter^{-1}) followed by T_1 (Hammer 24 EC - 2 ml liter^{-1}) where the lowest pod length (3.84 cm) was recorded from the treatment, T_2 (Gramaxon - 3 ml liter^{-1}). Similar results were also observed by Awan *et al*. (2009) and Dungarwal *et al.* (2003).

Combined effect of variety and herbicide

Remarkable variation was identified on pod length due to the combined effect of variety and herbicide application (Table 6 and Appendix X). The highest pod length (4.26 cm) was obtained from the treatment combination of V_3T_4 which was statistically identical with V_2T_1. The lowest pod length (3.73 cm) was recorded from the treatment combination of V_1T_2 which was statistically similar with V_1T_1, V_2T_3, V_3T_1 and V_3T_3.

4.2.4 Weight of 1000 seed

Effect of variety

The recorded data on 1000 seed weight was significant affected by different variety of blackgram (Table 6 and Appendix X). The highest 1000 seed weight (36.53) was found from the variety, V_3 (BARI mash-3) followed by V_2 (BARI mash-2) where the lowest 1000 seed weight (34.83) was recorded from the variety, V_1 (BARI mash-1). Similar results were also observed by Bhowaland and Bhowmik (2014), Verma *et al*. (2011) and Patel and Munda (2001).

Effect of herbicide

Considerable influence was observed on 1000 seed weight persuaded by herbicide application (Table 6 and Appendix X). The highest 1000 seed weight (36.64) was found from the treatment, T_2 (Gramaxon - 3 ml liter^{-1}) followed by T_3 (Panida - 4 ml liter^{-1}) where the lowest 1000 seed weight (34.96) was recorded from the treatment, T_1 (Hammer 24 EC - 2 ml liter^{-1}) which was statistically identical with T_4 (Whip super - 1.5 ml liter^{-1}). Similar result was also observed by Patel *et al.* (1984).

Combined effect of variety and herbicide

Remarkable variation was identified on 1000 seed weight due to the combined effect of variety and herbicide application (Table 6 and Appendix X). The highest 1000 seed weight (37.82) was obtained from the treatment combination of V_3T_2 which was statistically identical with V_3T_4 followed by V_2T_2 and V_3T_3. The lowest 1000 seed weight (34.11) was recorded from the treatment combination of V_1T_1 which was statistically similar with V_2T_1.

Table 6. Effect on yield contributing parameters of blackgram influenced by different variety and herbicide application

Treatment	Yield contributing parameters			
	Number of pods plant^{-1}	Number of seeds pod^{-1}	Pod length (cm)	1000 seed weight (g)
Effect of variety				
V_1	7.071 c	5.809 c	3.866 b	34.83 c
V_2	9.117 b	5.924 b	3.897 b	35.13 b
V_3	12.33 a	6.079 a	4.058 a	36.53 a
$LSD_{0.05}$	0.8517	0.0464	0.0379	0.114
CV (%)	6.341	6.381	3.226	9.714
Effect of herbicide				
T_1	8.994 c	5.924	3.967 b	34.96 c
T_2	9.756 b	5.931	3.843 c	36.64 a
T_3	8.323 d	5.903	3.873 c	35.29 b
T_4	10.96 a	5.991	4.078 a	35.09 c
$LSD_{0.05}$	0.3122	NS	0.0818	0.152
CV (%)	6.341	6.381	3.226	9.714
Combined effect of variety and herbicide				
V_1T_1	4.80 gh	5.767 f	3.843 cd	33.64 g
V_1T_2	5.65 g	5.930 de	3.733 d	35.96 bc
V_1T_3	3.90 h	5.573 g	4.000 b	34.36 ef
V_1T_4	9.13 ef	5.967 cd	3.887 c	35.37 cd
V_2T_1	10.3 de	6.200 b	4.250 a	34.11 fg
V_2T_2	10.8 d	5.830 ef	4.040 b	36.15 b
V_2T_3	8.40 f	5.907 de	3.837 cd	35.20 d
V_2T_4	7.93 f	5.760 f	4.097 b	35.04 de
V_3T_1	11.1 cd	5.743 f	3.797 cd	34.47 ef
V_3T_2	12.2 c	6.033 c	3.757 d	37.82 a
V_3T_3	13.7 b	5.900 de	3.783 cd	36.32 b
V_3T_4	16.3 a	6.640 a	4.260 a	37.51 a
$LSD_{0.05}$	1.205	0.0928	0.107	0.661
CV (%)	6.341	6.381	3.226	9.714

V_1 = BARI mash-1, V_2 = BARI mash-2, V_3 = BARI mash-3

T_1 = Hammer 24 EC - 2 ml liter^{-1}, T_2 = Gramaxon - 3 ml liter^{-1}, T_3 = Panida - 4 ml liter^{-1} , T_4 = Whip super - 1.5 ml liter^{-1}

4.3 Yield parameters

4.3.1 Grain yield

Effect of variety

There was a significant variation on grain yield influenced by different variety of blackgram (Table 7 and Appendix XI). Results showed that the highest grain yield (1407.18 kg ha^{-1}) was found from the variety, V_3 (BARI mash-3) followed by V_2 (BARI mash-2) where the lowest grain yield (1004.05 kg ha^{-1}) was recorded from the variety, V_1 (BARI mash-1). Similar results were also observed by Reddy *et al.* (2014), Shanti *et al.* (2014), Jayamani *et al*. (2012) and Dodwadiya and Sharma (2012).

Effect of herbicide

Significant variation was observed on grain yield of blackgram influenced by herbicide application (Table 7 and Appendix XI). Results exposed that the highest grain yield (1237.23 kg ha^{-1}) was found from the treatment, T_4 (Whip Super – 1.5 ml $liter^{-1}$) which was significantly different from others followed by T_2 (Gramaxon - 3 ml $liter^{-1}$) where the lowest grain yield (1147.10 kg ha^{-1}) was recorded from the treatment, T_3 (Panida - 4 ml $liter^{-1}$). Similar results were also observed by Rao *et al.* (2015), Kumar *et al.* (2015) and Bhowmick *et al.* (2015).

Combined effect of variety and herbicide

Remarkable variation was observed on grain yield influenced by combined effect of variety and herbicide application (Table 7 and Appendix XI).It was examined that the highest grain yield (1434.40 kg ha^{-1}) was obtained from the treatment combination of V_3T_4 which was significantly different from all other treatment combinations. The treatment combinations of V_3T_1, V_3T_2 and V_3T_3 also gave comparatively higher grain yield but significantly different from V_3T_4. Similarly, the lowest grain yield (886.60 kg ha^{-1}) was recorded from the treatment combination of V_1T_3 which was close to the treatment combinations of V_1T_1 and V_1T_2 but significantly different from V_1T_3.

4.3.2 Stover yield

Effect of variety

Variation on stover yield was noted influenced by different variety of blackgram (Table 7 and Appendix XI). Results signified that the highest stover yield (5741.45 kg ha^{-1}) was found from the variety, V_3 (BARI mash-3) followed by V_2 (BARI mash-2) where the lowest stover yield (4228.23 kg ha^{-1}) was recorded from the variety, V_1 (BARI mash-1).

Effect of herbicide

Significant variation was observed on stover yield at different growth stages influenced by herbicide application (Table 7 and Appendix XI). The highest stover yield (6039.33 kg ha^{-1}) was found from the treatment, T_2 (Gramaxon - 3 ml $liter^{-1}$) which was significantly different from others where the lowest stover yield (4492.67 kg ha^{-1}) was recorded from the treatment, T_4 (Whip Super – 1.5 ml $liter^{-1}$). Similar results were also observed by Das *et al.* (2014).

Combined effect of variety and herbicide

Significant influence was noted on stover yield affected by combined effect of variety and herbicide application (Table 7 and Appendix XI). The highest stover yield (6892.00 kg ha^{-1}) was obtained from the treatment combination of V_3T_2 which was significantly different from all other treatment combinations but nearest to the treatment combination of V_3T_1. The lowest stover yield (3362.60 kg ha^{-1}) was recorded from the treatment combination of V_1T_1 which was closed to V_1T_3 but significantly different.

4.3.3 Biological yield

Effect of variety

There was a significant variation on biological yield influenced by different variety of blackgram (Table 7 and Appendix XI). The highest biological yield (7148.63 kg ha^{-1}) was found from the variety, V_3 (BARI mash-3) followed by V_2 (BARI mash-2) where the lowest biological yield (5232.28 kg ha^{-1}) was recorded from the variety, V_1 (BARI mash-1). Similar findings were also observed by Malik *et al*. (2008 and Singh *et al*. (2006).

Effect of herbicide

Significant variation was observed on biological yield of blackgram influenced by herbicide application (Table 7 and Appendix XI). Results revealed that the highest biological yield (7252.93 kg ha^{-1}) was found from the treatment, T_2 (Gramaxon - 3 ml $liter^{-1}$) which was significantly different from all other treatment combinations followed by T_4 (Whip super - 1.5 ml $liter^{-1}$). The lowest biological yield (5699.87 kg ha^{-1}) was recorded from the treatment, T_1 (Hammer 24 EC - 2 ml $liter^{-1}$) which was statistically identical with T_3 (Panida - 4 ml $liter^{-1}$). The results from the present study was in agreement with the findings of Akter *et al.* (2013) and Pongkao and Inthong (1988).

Combined effect of variety and herbicide

Significant influence was noted on biological yield affected by combined effect of variety and herbicide application (Table 7 and Appendix XI). The highest biological yield (8283.10 kg ha^{-1}) was obtained from the treatment combination of V_3T_2 which was significantly different from all other treatment combinations followed by V_3T_1. The lowest biological yield (4310.80 kg ha^{-1}) was recorded from the treatment combination of V_1T_1 which was close to the treatment combinations of V_1T_3 but significantly different.

4.3.4 Harvest index

Effect of variety

Significant variation was remarked on harvest index as influenced by different variety of blackgram (Table 7 and Appendix XI). The highest harvest index (20.31%) was found from the variety, V_2 (BARI mash-2) which was statistically identical with V_3 (BARI mash-3) where the lowest harvest index (19.47%) was recorded from the variety, V_1 (BARI mash-1). Verma *et al*. (2011), Goswami *et al*. (2009) and Anurag *et al*. (2009) also found similar results with present study.

Effect of herbicide

Variation on harvest index was noted influenced by herbicide application (Table 7 and Appendix XI). The highest harvest index (21.53%) was found from the treatment, T_4 (Whip super - 1.5 ml liter^{-1}) which was statistically identical with T_1 (Hammer 24 EC- 2 ml liter^{-1}) where the lowest harvest index (16.69%) was recorded from the treatment, T_2 (Gramaxon - 3 ml liter^{-1}). Akter *et al.* (2013), Kalita *et al.* (1995) and Ahmed *et al.* (1993) also found similar results with the present study.

Combined effect of variety and herbicide

Significant variation was observed on harvest index influenced by combined effect of variety and herbicide application (Table 7 and Appendix XI). It was found that the highest harvest index (23.89%) was obtained from the treatment combination of V_2T_1 which was significantly different from all other treatment combinations followed by V_3T_4 the lowest harvest index (15.59%) was recorded from the treatment combination of V_1T_2 followed by V_3T_2.

Table 7. Yield parameters of blackgram as influenced by variety and herbicide application

Treatment	Yield parameters			
	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
Effect of variety				
V_1	1004.05 c	4228.23 c	5232.28 c	19.47 b
V_2	1184.38 b	4723.03 b	5907.40 b	20.31 a
V_3	1407.18 a	5741.45 a	7148.63 a	19.96 a
$LSD_{0.05}$	10.376	12.689	14.24	0.367
CV (%)	9.361	11.48	12.76	8.266
Effect of herbicide				
T_1	1196.20 c	4503.67 c	5699.87 c	21.43 a
T_2	1213.60 b	6039.33 a	7252.93 a	16.69 c
T_3	1147.10 d	4554.60 b	5701.70 c	20.00 b
T_4	1237.23 a	4492.67 c	5729.90 b	21.53 a
$LSD_{0.05}$	1.084	13.142	15.363	0.544
CV (%)	9.361	11.48	12.76	8.266
Combined effect of variety and herbicide				
V_1T_1	948.20 i	3362.60 k	4310.80 k	22.00 bc
V_1T_2	990.80 h	5366.00 d	6356.80 e	15.59 h
V_1T_3	886.60 j	3742.30 j	4628.90 j	19.15 e
V_1T_4	1190.60 e	4442.00 g	5632.60 h	21.14 cd
V_2T_1	1251.60 d	3988.40 i	5240.00 i	23.89 a
V_2T_2	1258.90 d	5860.00 c	7118.90 c	17.68 fg
V_2T_3	1140.30 f	4893.70 f	6034.00 g	18.90 e
V_2T_4	1086.70 g	4150.00 h	5236.70 i	20.75 d
V_3T_1	1388.80 c	6160.00 b	7548.80 b	18.40 ef
V_3T_2	1391.10 c	6892.00 a	8283.10 a	16.79 g
V_3T_3	1414.40 b	5027.80 e	6442.20 d	21.96 bc
V_3T_4	1434.40 a	4886.00 f	6320.40 f	22.69 b
$LSD_{0.05}$	10.326	12.529	13.376	1.041
CV (%)	9.361	11.48	12.76	8.266

V_1 = BARI mash-1, V_2 = BARI mash-2, V_3 = BARI mash-3

T_1 = Hammer 24 EC - 2 ml liter^{-1}, T_2 = Gramaxon - 3 ml liter^{-1}, T_3 = Panida - 4 ml liter^{-1} , T_4 = Whip super - 1.5 ml liter^{-1}

CHAPTER V

SUMMARY AND CONCLUSION

The present study was conducted at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka during the period from March to June, 2017 to find out the enhancing production of blackgram by applying different herbicide. The experiment was laid out in a Randomized Complete Block Design with three replications. The experiment comprised with two factors (i) Variety *viz.* V_1 (BARI mash-1), V_2 (BARI mash-2) and V_3 (BARI mash-3) and (ii) Herbicide application *viz.* T_1 = Hammer 24 EC (Carfentrazone Ethyl) at 2 ml liter^{-1} T_2= Gramaxon (Paraquate Dichloride) at 3 ml liter^{-1}, T_3 = Panida (Pendimethalin) at 4 ml liter^{-1} and T_4 = Whip super (Fenoxaprop-p-Ethyl) at 1.5 ml liter^{-1},. There were 12 treatment combinations. Data on different growth, yield contributing characters and yield were recorded from the experimental field and analyzed statistically. The data on different parameters were collected and was found that most of the parameters were found significant with variety and herbicide application and also their combinations.

Results revealed that in terms of growth parameters, considering varietal influence, the highest number of leaflets plant^{-1} (8.44, 12.00 and 15.48 at 30, 45 and at harvest respectively), number of branches plant^{-1} (1.57, 2.58 and 3.27 at 30, 45 and at harvest respectively), leaf area plant^{-1} (34.94, 37.90 and 40.04 at 30, 45 and at harvest respectively) and dry weight plant^{-1} (2.41, 6.19 and 7.13 g at 30, 45 and at harvest respectively) were found from the variety, V_3 (BARI mash-3). The lowest plant height (21.93, 29.04 and 36.06 cm at 30, 45 and at harvest respectively), number of leaflets plant^{-1} (7.02, 10.82 and 14.46 at 30, 45 and at harvest respectively) and leaf area plant^{-1} (26.60, 35.38 and 38.51 at 30, 45 and at harvest respectively) were recorded from the variety, V_2 (BARI mash-2) but the lowest number of branches plant^{-1} (1.14, 1.67 and 2.74 at 30, 45 and at harvest respectively) and dry weight plant^{-1} (2.29, 5.79 and 6.74 g at

30, 45 and at harvest respectively) were recorded from the variety, V_1 (BARI mash-1).

Regarding yield and yield contributing parameters, influenced by variety, the highest number of pods plant^{-1} (12.33), number of seeds pod^{-1} (6.08), pod length (4.06 cm), 1000 seed weight (16.09), grain yield (1407.18 kg ha^{-1}), stover yield (5741.45 kg ha^{-1}) and biological yield (7148.63 kg ha^{-1}) were found from the variety, V_3 (BARI mash-3) but the highest harvest index (20.31%) was found from the variety, V_2 (BARI mash-2). Again, the lowest number of pods plant^{-1} (7.07), number of seeds pod^{-1} (5.81), pod length (3.87 cm), 1000 seed weight (9.65 g), grain yield (1004.05 kg ha^{-1}), stover yield (4228.23 kg ha^{-1}), biological yield (5232.28 kg ha^{-1}) and harvest index (19.47%) were recorded from the variety, V_1 (BARI mash-1).

In case of herbicide application, regarding growth parameters, the highest plant height (22.99, 32.82 and 39.23 cm at 30, 45 and at harvest respectively) was found from the treatment, T_3 (Panida - 4 ml liter^{-1}) where the highest number of leaflet plant^{-1} (8.99, 12.60 and 16.00 at 30, 45 and at harvest respectively) and leaf area plant^{-1} (32.55, 39.05 and 41.60 at 30, 45 and at harvest respectively) were found from the treatment, T_2 (Gramaxon - 3 ml liter^{-1}). But the highest number of branches plant^{-1} (1.60, 2.58 and 3.37 at 30, 45 and at harvest respectively), dry weight plant^{-1} (2.38, 6.07 and 6.96 g at 30, 45 and at harvest respectively) were found from the treatment, T_4 (Whip Super – 1.5 ml liter^{-1}). On the other hand, the lowest plant height (21.02, 29.60 and 37.29 cm at 30, 45 and at harvest respectively), number of leaflets plant^{-1} (7.04, 10.72 and 14.09 at 30, 45 and at harvest respectively) and number of branches plant^{-1} (0.99, 1.66 and 2.72 at 30, 45 and at harvest respectively) were recorded from the treatment, T_1 (Hammer 24 EC - 2 ml liter^{-1}) but the lowest leaf area plant^{-1} (27.53, 33.73 and 36.90 at 30, 45 and at harvest respectively) and dry weight plant^{-1} (2.31, 5.93 and 6.88 g at 30, 45 and at harvest respectively) were recorded from the treatment, T_3 (Panida - 4 ml liter^{-1}).

Regarding yield and yield contributing parameters, influenced by herbicide application, the highest number of pods plant^{-1} (10.96), number of seeds pod^{-1} (5.99), pod length (4.08 cm), grain yield (1237.23 kg ha^{-1}) and harvest index (21.53%) were found from the treatment, T_4 (Whip super – 1.5 ml liter^{-1}) where the highest 1000 seed weight (14.25 g), stover yield (6039.33 kg ha^{-1}) and biological yield (7252.93 kg ha^{-1}) were found from the treatment, T_2 (Gramaxon - 3 ml liter^{-1}). Again, the lowest number of pods plant^{-1} (8.32), number of seeds pod^{-1} (5.90) and grain yield (1147.10 kg ha^{-1}) were recorded from the treatment, T_3 (Panida - 4 ml liter^{-1}) but the lowest pod length (3.84 cm) and harvest index (16.69%) were recorded from the treatment, T_2 (Gramaxon - 3 ml liter^{-1}) where the lowest 1000 seed weight (10.57) and lowest biological yield (5699.87 kg ha^{-1}) were recorded from the treatment, T_1 (Hammer 24 EC- 2 ml liter^{-1}) and the lowest stover yield was (4492.67 kg ha^{-1}) recorded from the treatment, T_4 (Whip Super – 1.5 ml liter^{-1}).

In terms of combined effect of variety and herbicide application, regarding growth parameters, the highest plant height (25.39, 39.00 and 44.78 cm at 30, 45 and at harvest respectively) was obtained from the treatment combination of V_1T_3 where the highest number of leaflets plant^{-1} (10.97, 15.47 and 18.81 at 30, 45 and at harvest respectively) and highest leaf area plant^{-1} (39.73, 41.72 and 47.68 at 30, 45 and at harvest respectively) were obtained from the treatment combination of V_3T_2 but the highest number of branches plant^{-1} (2.60, 4.10 and 4.78 at 30, 45 and at harvest respectively) and dry weight plant^{-1} (2.46, 6.29 and 7.18 g at 30, 45 and at harvest respectively) were obtained from the treatment combination of V_1T_1 and V_3T_4 respectively. Similarly, the lowest plant height (19.59, 24.89 and 31.15 cm at 30, 45 and at harvest respectively) and number of leaflets plant^{-1} (5.80, 9.17 and 13.10 at 30, 45 and at harvest respectively) were recorded from the treatment combination of V_2T_1 where the lowest number of branches plant^{-1} (0.50, 1.17 and 2.23 at 30, 45 and at harvest respectively), leaf area plant^{-1} (18.75, 27.26 and 32.37 at 30, 45 and at harvest respectively) and dry weight plant^{-1} (2.24, 5.70 and 6.61 g at 30, 45 and at harvest respectively) were recorded from the treatment combination of V_3T_4, V_2T_3 and V_1T_3 respectively.

Regarding yield and yield contributing parameters influenced by combined effect of variety and herbicide application, the highest number of pods plant^{-1} (16.30), number of seeds pod^{-1} (6.64), pod length (4.26 cm) and grain yield (1434.40 kg ha^{-1}) were obtained from the treatment combination of V_3T_4 but the highest 1000 seed weight (20.20), stover yield (6892.00 kg ha^{-1}) and biological yield (8283.10 kg ha^{-1}) were obtained from the treatment combination of V_3T_2 where the highest harvest index (23.89%) was obtained from the treatment combination of V_2T_1. Similarly the lowest number of pods plant^{-1} (3.90), number of seeds pod^{-1} (5.57) and grain yield (886.60 kg ha^{-1}) were recorded from the treatment combination of V_1T_3 where the lowest 1000 seed weight (5.13), stover yield (3362.60 kg ha^{-1}) and biological yield (4310.80 kg ha^{-1}) were recorded from the treatment combination of V_1T_1 but the lowest pod length (3.73 cm) and harvest index (15.59%) were recorded from the treatment combination of V_1T_2.

From the above findings it can be concluded that the variety, V_3 (BARI mash-3) with herbicide, T_4 (Whip super – 1.5 ml liter^{-1}) application gave the best performance in respect of yield and yield contributing parameters. So, this treatment combination (V_3T_4) can be considered as best compared to other treatment combination though the treatment combination of V_3T_3 also gave comparatively better result on yield.

This type of experiment could be taken further at different AEZ with some other herbicide and variety to reach a definite recommendation.

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APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location

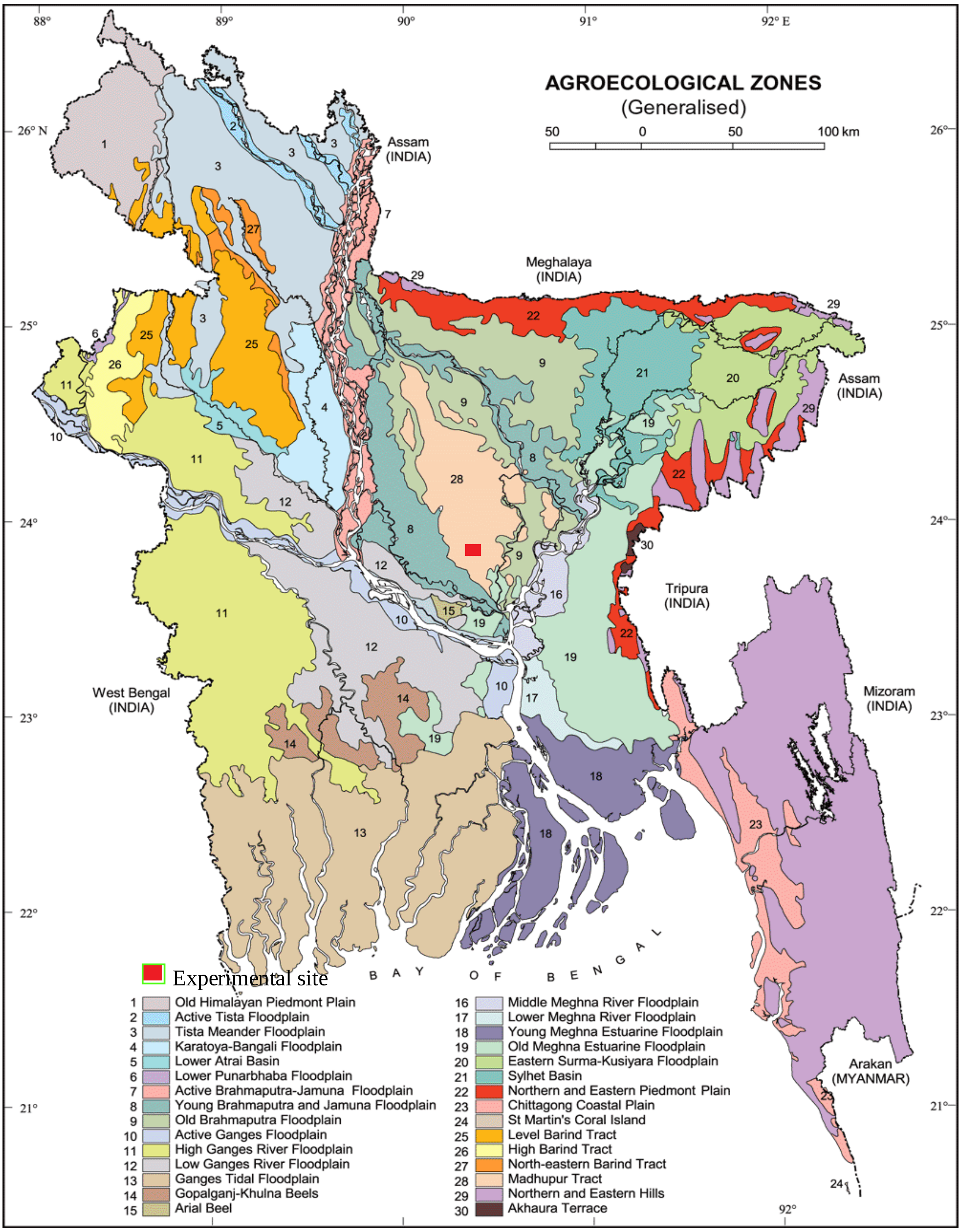

Fig. 9. Experimental site

Appendix II. Monthly records of air temperature, relative humidity, rainfall and sunshine hours during the period from March to June, 2017

Month	RH (%)	Air temperature (C)			Rainfall (mm)
		Max.	*Min.*	*Mean*	
March	64	32.5	20.4	28.03	65.8
April	70	38.9	23.6	26.30	76.4
May	75	40.5	24.5	23.33	80.6
June	80	41.6	29.5	18.56	85.4

Source: Sher-e-Bangla Agricultural University Weather Station and Bangladesh Meteorological Department

Appendix III. Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Agronomy Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not Applicable

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

Characteristics	**Value**
Partical size analysis % Sand	27
%Silt	43
% Clay	30
Textural class	Silty Clay Loam (ISSS)
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.1
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI).

Appendix IV. Layout of the experiment field

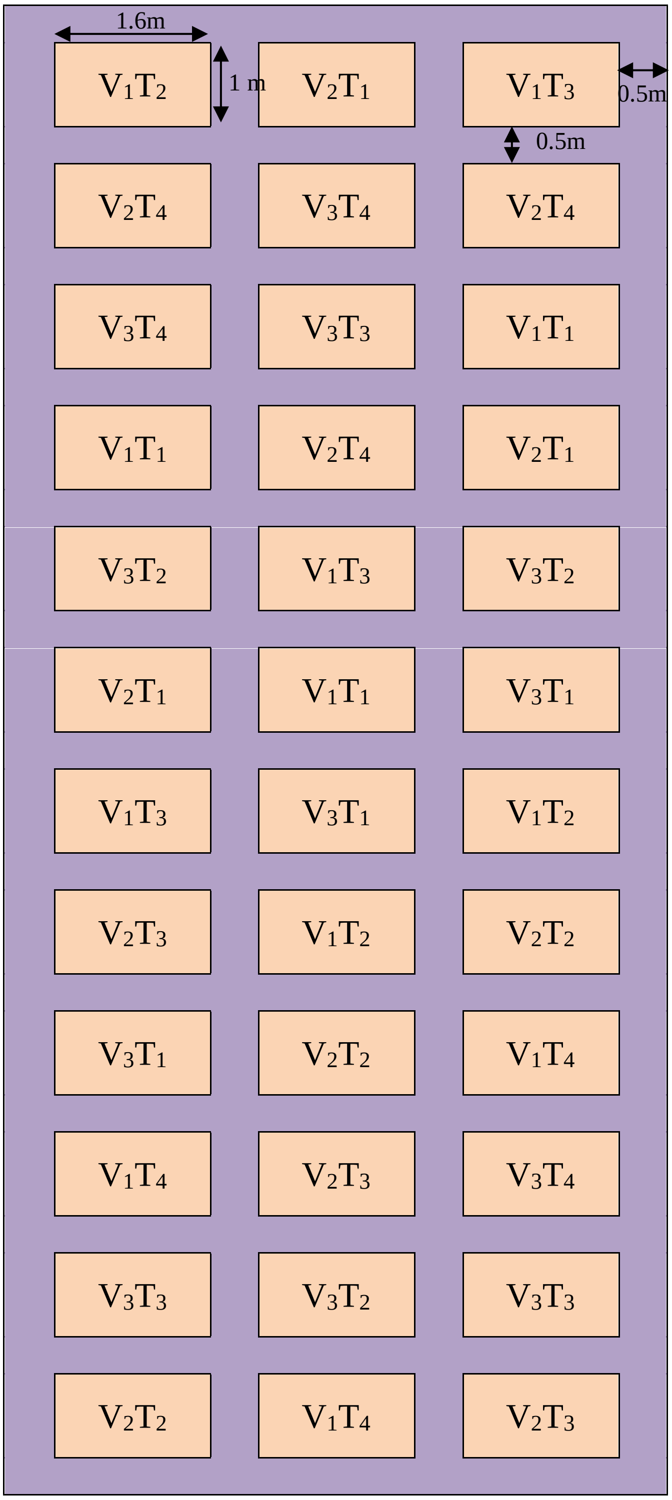

Fig. 9. Layout of the experimental plot

Appendix V. Effect on plant height of blackgram influenced by different variety and herbicide application

Sources of variation	Degrees of freedom	Mean Square Value		
		30 DAS	45 DAS	60 DAS
Replication	2	0.109	0.414	1.847
Factor A	2	9.593*	34.11*	44.94*
Factor B	3	8.065**	21.67*	26.60*
AB	6	10.50*	36.89*	32.43*
Error	22	4.252	4.695	5.845

Appendix VI. Effect on number of leaflets plant^{-1} of blackgram influenced by different variety and herbicide application

Sources of variation	Degrees of freedom	Mean Square Value		
		30 DAS	45 DAS	60 DAS
Replication	2	1.462	1.673	2.294
Factor A	2	7.916**	4.171*	5.005*
Factor B	3	5.818**	6.950*	6.581**
AB	6	8.992*	10.52*	8.311*
Error	22	2.627	3.251	5.376

Appendix VII. Effect on number of branches plant^{-1} of blackgram influenced by different variety and herbicide application

Sources of variation	Degrees of freedom	Mean Square Value		
		30 DAS	45 DAS	60 DAS
Replication	2	0.678	0.663	0.412
Factor A	2	0.596**	2.576*	0.844*
Factor B	3	0.658*	1.455*	0.945**
AB	6	2.240*	2.249*	2.827*
Error	22	0.625	0.786	0.456

Appendix VIII. Effect on leaf area plant^{-1} of blackgram influenced by different variety and herbicide application

Sources of variation	Degrees of freedom	Mean Square Value		
		30 DAS	45 DAS	60 DAS
Replication	2	2.12	3.980	4.029
Factor A	2	25.74*	25.005*	8.703*
Factor B	3	40.90*	42.808*	34.58*
AB	6	73.41*	88.147*	83.29*
Error	22	5.135	6.413	4.925

Appendix IX. Effect on dry weight plant^{-1} of blackgram influenced by different variety and herbicide application

Sources of variation	Degrees of freedom	Mean Square Value		
		30 DAS	45 DAS	60 DAS
Replication	2	0.060	0.196	0.194
Factor A	2	NS	NS	NS
Factor B	3	NS	NS	NS
AB	6	NS	0.021**	0.021**
Error	22	0.007	0.016	0.036

Appendix X. Effect on yield contributing parameters of blackgram influenced by different variety and herbicide application

Sources of variation	Degrees of freedom	Mean Square Value			
		Number of pods plant^{-1}	Number of seeds pod^{-1}	Pod length (cm)	1000 seed weight (g)
Replication	2	1.886	0.076	0.223	0.008
Factor A	2	8.443*	0.220**	0.128**	9.889*
Factor B	3	11.476*	NS	0.100**	5.429*
AB	6	39.728*	0.329**	0.097**	3.386**
Error	22	0.262	0.097	0.063	2.783

Appendix XI. Effect on yield parameters of blackgram influenced by different variety and herbicide application

Sources of variation	Degrees of freedom	Mean Square Value			
		Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Replication	2	6.226	6.834	7.056	1.032
Factor A	2	122.13*	138.36*	152.63*	19.36*
Factor B	3	226.39*	311.28*	345.12*	25.26*
AB	6	175.26*	188.72*	192.57*	12.28*
Error	22	10.359	12.262	14.381	2.783

Appendix XII. List of some weeds found in experimental field

Sl. No.	Common name	English name	Scientific name
1	Chotoshama	Jungle rice	*Echinochloa colonum*
2	Durba	Bermuda grass	*Cynodon dactylon*
3	Mutha	Purple nutsedge	*Cyperus rotundus*
4	Holdemutha	Yellow nutsedge	*Cyperus esculentus*
5	Hatishur	Indian helitrop	*Helitropun indicum*
6	Helencha	Marsk herb	*Enhydra fluctuans*
7	Malancha	Alligator weed	*Alternanthera philoxeroides*