GROWTH AND YIELD OF BLACKGRAM AS AFFECTED BY AGRONOMIC MANAGEMENTS

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CERTIFICATE

This is to certify that the thesis entitled ‘‘**GROWTH AND YIELD OF BLACKGRAM AS AFFECTED BY AGRONOMIC MANAGEMENTS”** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **AGRONOMY**, embodies the result of a piece of *bona fide* research work carried out by **MD. HASIBUL HASAN**, Registration number: **18-09195** under my supervision and guidance. No part of the 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. Parimal Kanti Biswas)

Supervisor

DEDICATED TO MY BELOVED PARENTS

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ABSTRACT

A field experiment was carried out at the research field of Sher-e-Bangla Agricultural University, Dhaka during the period of March to June 2019 to study the growth and yield of two blackgram varieties under different agronomic managements. The experiment comprised of two factors; Factor A: Variety (2) viz. BARI mash-1 (V_1), BARI mash-3 (V_2) and Factor B: Agronomic Managements (7) viz. Control (No management) (M_1), No fertilizer but all other managements (M_2), No weeding but all other managements (M_3), No irrigation but all other managements (M_4), No insecticide but all other managements (M_5), No fungicide/bacteriocide but all other managements (M_6), Complete management (recommended) (M_7). The experiment was laid out in split-plot design with three replications. Data on different growth parameters, yield attributes and yield of blackgram were significantly varied for different treatment variables. The maximum germination percentage (99.62%), plant height (49.64 cm), number of leaves plant^{-1} (8.37), plant dry weight (0.78 g), days required to flowering (33.48), number of seeds pod^{-1} (6.01), weight of 1000 grain (37.90 g), shelling percentage (67.86%), total grain yield (763.99 kg ha^{-1}), total shell yield (372.21 kg ha^{-1}), biological yield (4508.46 kg ha^{-1}) and harvest index (17.69%) was recorded from BARI mash-3 (V_2). The complete management (M_7) resulted maximum germination percentage (100%), plant height (25.11 cm), number of leaves plant^{-1} (8.47), number of total pods plant^{-1} (47.40), total grain yield (1072.53 kg ha^{-1}), total shell yield (547.39 kg ha^{-1}) and harvest index (22.87%). The maximum germination percentage (100%), plant dry weight (0.93 g), total grain yield (1044.59 kg ha^{-1}) and harvest index (19.55%) was recorded from V_2M_7. The overall result showed that BARI mash-3 (V_2) along with complete management (M_7) gave better growth and yield of blackgram**.** Compared to that of complete management, the highest yield reduction was observed in no management (77.08%) that followed by no weeding (73.04%), no insecticides (29.19%), no irrigation (25.50%), no fungicides (15.36%) and no fertilizer (12.93%).

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LIST OF ACRONYMS

AEZ	Agro-Ecological Zone
BARI	Bangladesh Agriculture Research Institute
BBS	Bangladesh Bureau of Statistics
cm	Centimeter
CV%	Percentage of coefficient of variance
DAE	Department of Agricultural Extension
DAS	Days after sowing
^0C	Degree Celsius
et al.	And others
g	Gram
ha^{-1}	Per hectare
HI	Harvest Index
kg	Kilogram
kg ha^{-1}	Kilogram per hectare
LSD	Least significant difference
m^2	Square meter
MoP	Muriate of Potash
N	Nitrogen
NPK	Nitrogen, Phosphorus and Potassium
NS	Non-significant
%	Percent
$Plant^{-1}$ q	Plant per quintal
SAU	Sher-e-Bangla Agricultural University
Seeds pod^{-1}	Seeds per pod
TSP	Triple Super Phosphate
viz.	Videlicet (namely)

CHAPTER I

INTRODUCTION

Pulse crops belong to grain legumes which are a vital source of protein, calories, minerals and some vitamins. The cheapest source of protein are the pulses that can be considered as the peasant's meat. It is important component of food grains crops because of their high nutritive value (Protein content ranging from 17 to 27%) and adaptability to wide range of agro ecological and management variable). It also contains amino acid lysine, which is generally deficit in food grains (Elias *et al.,* 1986). The minimum intake of pulse by a human should be 45 g per day whereas, it is only 14.30 g in Bangladesh (BBS, 2013). Most of the health organizations suggested to consume pulse frequently as they appear to help reducing the risks for coronary heart disease, diabetes, obesity and significantly lower serum cholesterol concentrations (Geil and Anderson, 1994). Pulse crops are used as valuable animal feeds and residues as manure. Addition of pulses in intensive cereal based cropping system acts as a component of integrated nutrient supply. Pulses maintain soil fertility through biological nitrogen fixation and thus play a vital role in furthering sustainable agriculture (Kannaiyan, 1999).

A large number of pulse crops are grown in Bangladesh in respect of area and production (BBS, 2016). The major pulses grown in Bangladesh *are:* Khesari *(Lathyrus sativus* L.), Lentil *(Lens culinaris* Medic), Chickpea *(Cicer arietinum* L.), Blackgram *(Vigna mungo* L.), Mungbean *(Vigna radiata* L.) and Fieldpea *(Pisum sativum).* Blackgram (*Vigna mungo*) is a widely grown grain legume and belongs to the family fabaceae and assumes considerable importance from the point of food and nutritional security in the world. It is an important pulse crop in Bangladesh and locally known as "Mashkalai". Blackgram reported to be originated in India. It is a self-pollinated deep rooted drought hardy crop, source of food, fodder and green manure. It has good digestibility, flavor and high protein content. It ranks the fourth position considering both acreage and production (MoA, 2019). Blackgram seeds are highly nutritious containing higher amount of protein (24-26 %) and are reported to be rich in potassium, phosphorus and calcium with good amount of sodium. It is also reported to be rich in vitamin A, B1, B3 besides nutritionally rich proteins, important mineral and vitamins (Selvakumar *et al.,* 2012). It being a short duration crop suits well in the cropping system, as it vacates field well in time giving the space to many winter crops like mustard, lentil etc grown in limited and rainfed situation. It is also grown as a cover crop as well as catch crop.

As an excellent source of plant protein blackgram is cultivated extensively in the tropics and subtropics. Blackgram is well adapted to semi arid and sub-humid zones with annual rainfall between 600-1000 mm. requiring an optimum mean temperature of 30°C. It grows successfully on sandy loam to clay loam soil. Usually grown on low to medium elevations in the tropics as a rain-feed crop (Ardeshna *et al.*, 1993). In Bangladesh, it can be grown in late winter and summer season. Blackgram, especially contains higher percentage of methionine (sulphur containing amino acid) compared to other food legumes (Tsou and Hsu, 1978). Seeds of blackgram are used for human consumption as pulse soup. It contributes in the reinforcement and prevention of soil erosion through its deeper root growth.

In Bangladesh, blackgram is cultivated in the area of 0.0687 million hectares contributing 9.5% of total pulse production (0.0631 million ton) (DAE, 2016). In spite of its various uses, its cultivation is decreasing day by day both in acreage and yield. The average yield of blackgram is 1.01 t ha^{-1} (BBS, 2019), which is much lower than those of blackgram growing countries of the world. There are many reasons of such lower yield of blackgram. In farmers field blackgram is cultivated with less care compared to cereal cultivation thus the yield is very low. Basically it is cultivated with minimum tillage, local varieties with no or minimum fertilizers, no pesticides, no weed management and very early or very late sowing, no practicing of irrigation and drainage facilities etc., which are responsible for low yield of blackgram. The low yield of blackgram besides other factors may partially be due to lack of knowledge regards to suitable production technology of this crop (Hossain *et al*., 2008).

Proper fertilization is essential to improve the productivity of blackgram. It can meet its nitrogen requirements by symbiotic fixation of atmospheric nitrogen. The nutrients which need attention are phosphorus and sulphur (Thakur and Negi, 1985; Nandal *et al.*, 1987). Blackgram is very much responsive to sulphur application (Aulakh and Pasricha, 1978). The growth and yield potential of blackgram can be improved by optimum dose of sulphur.

Weed is one of the most important factors responsible for low yield of blackgram. Blackgram is not very competitive against weed and therefore weed control is essential for it's production (Moody, 1978). Blackgram is usually accompanied by luxuriant weed growth during the rainy (kharif) season owing to abundant rainfall received during monsoons leading to serious crop weeds (Choudhary *et al*., 2012). The most sensitive period of weed competition is between 3 and 6 weeks after sowing and weeding onward this period decreased crop yield (Meylemans *et al.*, 1994). 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). Several growth stages of blackgram such as emergence, flowering and pod setting are greatly hampered by weed population thus significantly reduced crop yield and quality. Weeds are controlled by various methods like cultural, manual, mechanical, biological and chemical. Use of natural or organic source of herbicides has also been found to control weeds through utilizing the allelopathic potentials (Anon, 2014). Thus, proper weed management at the right time is essential for maximum yield of blackgram.

Increasing in seed yield of pulses from 40 to 50% due to proper management for application of irrigation and fertilizer had been reported by various researches (Hussain *et al*., 2011). Blackgram responses favorably to added water resulting in higher yields, especially when irrigation is given at the time of flowering (Lawn, 1978; Miah and Carangal, 1981). In summer cultivation when temperature is high, relative humidity is low and evapo-transpiration is greater, then 3-4 irrigations may be needed to obtain higher yields of blackgram (Sing and Sing, 1979; Lal and Yadav, 1981). Irrigation during flowering stage helps for retention of flowers and pod development.

Depending on the nature and period of occurrence, insect and fungus can cause losses of grain yield of blackgram. The worldwide yield of black gram is very low because mostly indigenous land contests are cultivated and also because the crop is often grown on a poor fertile land with insufficient water. Plant can easily be attacked by disease due to thick plant population. On the contrary, in lower plant population, individual plant performance is better than that of higher plant population but within tolerable limit higher plant population produces higher yield per unit area (Shukla and Dixit, 1996). Management of insect and fungus at the right time is essential for maximum yield of blackgram. Other hand, variety is one of the important factors which ultimately affect growth and yields of plant. Therefore, keeping the above facts in view the experiment entitled "Growth and yield of blackgram as affected by agronomic managements" was carried out with following objectives:-

1. To find out the best performing variety of blackgram under the agronomic management selected
2. To compare the role of agronomic managements on yield reduction of blackgram
3. To determine the interaction of variety and agronomic managements on growth and yield of blackgram

CHAPTER II

REVIEW OF LITERATURE

Blackgram is one of the important pulse crops having global economic importance. Research on this crop on various aspects including varieties and agronomic managements increase its growth and yield. But the research works done on this crop with respect to varieties and agronomic managements are inadequate in the context of Bangladesh. Review of literature provides a theoretical framework, previous work and the basic interpretation of findings to the study. An attempt is made to review the available literature those are related to this study as below under the following headings-

2.1 Effect of variety on growth parameters of blackgram

Yadahalli *et al*. (2006) conducted an experiment to study on the growth and yield of the blackgram genotypes TAU-1, Manikya and K-3. Among those, the highest values for most growth attributes was observed in K-3.

Reddy *et al.* (2003) destined 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). Among those the tallest plants (37.9 cm) was found in LBG 703.

Patel and Munda (2001) conducted a experiment on the growth pattern and yield potential of five cultivars (T-9, PU-19, PDU-1, DPU-88-1 and DPU-88-31) of blackgram. The highest plant height (42.2 and 41.6 cm) and days to flowering (42.7 and 41.3) were found in DPU88-1 for 1998 and 1999, respectively, while DPU-88-31 showed the lowest plant height (25.7 and 24.7 cm) and days to 50% flowering (38.3 and 36.3) respectively.

Chaudhary *et al.* (1994) studied that maximum height, number of leaves as well as dry matter accumulation per plant were found in early (6th July) planted crop. Maximum height; trifoliate leaves and dry matter per plant were recorded in variety WG 218 which associated with variety Type 9.

An experiment was carried out by Vijayalakshmi *et al.* (1993) to study plant growth and leaf production in 12 high, medium and low seed yielding blackgram (*Vigna mungo*) cultivars. Dry matter yield was obtained in 45 days after sowing. Singh and Rana (1992) showed that the higher dry matter accumulation per plant was found in Pant U-30 being at par with Pant U-19 than T-9. Chaudhary *et al.* (1988) reported that variety T-9 contributed higher dry matter/plant was 5.0, 4.0 and 11.2% than UG218, Pant U-19 and UPU9-40-4 respectively.

2.2 Effect of variety on yield parameters of blackgram

Gupta *et al.* (2006) observed that the higher pods/plant, 1000 seed weight, seed yield as well as straw yield were recorded in UG-218 urdbean variety than two varieties (Type-9 & Pant-U19). Manivannan *et al.* (2005) showed that VBG 55 is a blackgram genotype which is hybrid derivative of CO 4 x PDU 102. An average seed yield of 782, 737 and 793 kg ha^{-1} were observed during kharif, rabi and summer seasons respectively.

Ihsanullah *et al.* (2002) declared that different mash bean varieties were shown significant differences in pods $plant^{-1}$, seeds pod^{-1}, grain yield and biological yield. The maximum number of pods $plant^{-1}$ (20.6) was recorded in NARC Mash-1, maximum number of seeds pod^{-1} (4.9) was recorded in NARC Mash-3, highest grain yield (557.1 kg ha^{-1}) was obtained in NARC Mash-1 and highest biological yield (4400 kg ha^{-1}) was obtained in NARC Mash-4.

Biswas *et al.* (2002) researched that pooled analysis shows a significant difference among the varieties in respect of seed yield. The maximum seed yield (977 kg ha^{-1}) was obtained in Barimash-3 which was similar to Binamash-1 (960 kg ha^{-1}). The minimum seed yield (866 kg ha^{-1}) was found in Barimash-2.

An experiment was conducted by Ghafoor *et al.* (2002) to determine the suitable and economically viable cultivation method of blackgram. The highest grain yield (1044 kg ha^{-1}) was observed from BARI Mash-2 where the lowest grain yield (475 kg ha^{-1}) was recorded in BARI Mash-1.

Patel and Munda (2001) conducted an experiment to evaluate the growth pattern and yield potential of five cultivars (T-9, PU-19, PDU-1, DPU-88-1 and DPU-88-31) of blackgram. T-9 cultivar produced maximum number of pods plant^{-1} (47.6) and PU-19 cultivar produced minimum number of pods plant^{-1} (33.3). The maximum number of seeds pod^{-1}, 1000-seed weight and seed yield plant^{-1} were observed from PDU-1 cultivar.

An experiment was conducted by Nag *et al.* (2000) to evaluate the yield and yield attributes of three blackgram (*Vigna mungo*) cultivars (Barimash-1, Barimash-2 and Barimash-3). The highest seed yield (1601.4 kg ha^{-1}) was obtained in Barimash-1 and lowest seed yield (1455.0 kg ha^{-1}) was found in Barimash-3 respectively.

Mishra (1993) was carried out an experiment in farmer's field on sandy loam soil during the rainy seasons of 1986-87 at Sidhi, Madhya Pradesh. Three blackgram cultivar were produced seed yields of 0, 20, 40 and 60 kg P_2O_5 ha^{-1}. Those cultivar were also produced 592, 655, 751 and 846 kg ha^{-1} seed yield, respectively. RU-2, BP-1 and Local cultivar were produced 765, 739 and 635 kg ha^{-1} seed yield, respectively.

2.3 Effect of agronomic managements on growth parameters of blackgram

Marko *et al.* (2013) conducted a field experiment to study the effect of sulphur and biofertilizers on growth, yield and quality of blackgram. Rhizobium + PSB (phosphate solubilizing bacteria) combination showed the best performance with respect to all the parameters. The treatment combinations were significant in case of plant height. Rhizobium + PSB combination produced the highest plant height (25.01 cm).

Masud (2003) conducted a pot experiment at Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. He reported that the highest plant height was obtained from 30 kg N ha^{-1} while Ghosh (2007) observed the highest plant height in 25 kg N ha^{-1}. A field experiment was carried out by Yein *et al.* (1981) on nitrogen in combination with phosphorus fertilizer to blackgram. They founded that plant height was increased by the application of 40 kg N h^{-1}.

A field experiment was conducted by Tomar and Kumar (2013) to study the effect of plant densities, nitrogen and phosphorus on blackgram. Interaction effect revealed that decreasing plant density and increasing levels of nitrogen and phosphorus increased dry matter accumulation and grain yield significantly. The maximum dry matter (34.4 g plant^{-1}) and grain yield (2.07 t ha^{-1}) were observed in 333 × 103 plants ha^{-1} plant density with 20 kg N and 60 kg P_2O_5 ha^{-1}.

Marko *et al.* (2013) conducted a field experiment to study the effect of sulphur and biofertilizers on growth, yield and quality of blackgram. Rhizobium + PSB combination performed the best with respect to all these parameters. The treatment combinations were observed to be significant in case of dry matter production plant^{-1}. Rhizobium + PSB combination produced the highest dry matter production plant^{-1} (39.84 g).

Leelavathi *et al.* (1991) observed that different levels of nitrogen showed significant difference in dry matter production of blackgram up to a certain level of 60 kg N ha^{-1}. A field experiment was conducted by Khan and Prakash (2014) to study the effect of rhizobial inoculation on growth, yield, nutrient uptake and economics of summer blackgram in relation to zinc and molybdenum. Result data found that number of nodules plant^{-1} was increased significantly by the seed inoculation with Rhizobium culture.

Sadasivam *et al.* (1988) stated that water stress during vegetative phase reduce plant size and limiting root growth in mungbean. Pandey *et al.* (1984) found that canopy development and overall growth process were affected by water stress in mungbean. But stress tolerance showed varietals differences.

Jakhar *et al.* (2015) carried out a field Investigation to evaluate the effect of hand weedings and herbicides on the weed flora, growth and yield of urdbean (*Vigna mungo*). The highest plant height was obtained from weed free treatment at all the growth stages and the maximum dry matter accumulation of 108.88 and 159.31 g per meter row length at 50 DAS and harvest stages was recorded in imazethapyr at 0.10 kg ha^{-1} + HW at 30 DAS treatment.

Aggarwal *et al.* (2015) conducted a field experiment during the rainy (kharif) season of 2008 and 2009 at Ludhiana, Punjab to study tolerance of different blackgram [*Vigna* *mungo* (L.) Hepper] cultivars to post-emergence application of imazethapyr and its efficiancy on weeds. The maximum number of nodules, dry weight of nodules and leghaemoglobin content were found in imazethapyr 100 g ha^{-1} sprayed at 15 DAS, being statistically at par with 2 hand-weedings (20 and 40 DAS).

A field experiment was conducted by Das *et al.* (2014) to study the integrated weed management in blackgram (*Vigna mungo* L.) and its effect on soil microflora under sandy loam soil of West Bengal. Result showed that 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}) were obtained in T5 (Two hand weeding at 15 and 25 DAS) which was significantly superior than rest of the treatments.

Khot *et al.* (2012) carried out a field experiment during summer season of 2010 on medium black clayey soils to study the weed management in summer blackgram (*Vigna mungo* L.). They reported that the highest value of plant growth characters viz., plant height (42.65 cm) was found at harvest under weed free conditions.

An experiment was conducted by Mahla *et al.* (1999) on weeding effect at 20, 30, 40 days after sowing and no weeding. Plant height and dry matter production $plant^{-1}$ of blackgram increased with increasing weeding. Plant height and dry matter production $plant^{-1}$ were showed the best result on three times of weeding.

2.4 Effect of agronomic managements on yield parameters of blackgram

Marko *et al.* (2013) carried out a field experiment to study the effect of sulphur and biofertilizers on growth, yield and quality of blackgram. Rhizobium + PSB combination showed the best result with respect to all these parameters. The treatment combinations were recorded to be significant in case of branches $plant^{-1}$, pods $plant^{-1}$, seeds pod^{-1}, weight of 1000 seed, grain yield per hectare and harvest index. Rhizobium + PSB combination produced the maximum branches $plant^{-1}$ (10.43), maximum number of pods $plant^{-1}$ (39.02), maximum number of seeds pod^{-1} (8.95) and highest 1000 seed weight (56.40 g). The highest harvest index (39.24) was obtained in *Rhizobium* application. The findings also elude that maximum productivity may be achieve by the application of 60 kg S ha^{-1} with dual biofertilizers from blackgram cv. JU-2.

An investigation was initiated by Sheikh *et al.* (2012) to work out the effect of Rhizobium culture and phosphate solubilizing bacteria (PSB) with nitrogen and phosphorus applications on the performance of blackgram Cv-T9. The results stated that the number of seeds pod^{-1} and yield of blackgram were increased by the application of Rhizobium and Phosphate Solubilizing Bacteria (PSB) along with nitrogen and phosphorus @10 kg/ha and 25 kg/ha, respectively.

Athokpam *et al.* (2009) conducted an experiment to assess the effect of N, P and K application on seed yield and nutrient uptake by blackgram during kharif seasons of 2004-05. Three nutrients applied in combination did increase the seed yield significantly over control. Application of 15:60:20 kg $N:P_2O_5:K_2O$ ha^{-1} produced the maximum seed yield. Application of 30 kg N ha^{-1} alone reduced the seed yield than 15 kg N ha^{-1} alone indicating inefficiency of higher N level to legume. The increase in seed yield seems to be due to the effect of P as revealed by the relative higher yields with the treatments having P than those without P or lower P treatments.

Kulsum (2003) found that different level of nitrogen showed significantly increased pods /plant of blackgram up to N 60 kg/ha. Saini and Thakur (1996) revealed that grain yield plant^{-1} of blackgram significantly increased with the application of 30 kg N ha^{-1}. Bhalu (1995) reported that application of 20 kg N and 40 kg P_2O_5 increased seed yield of blackgram.

Yadav *et al.* (1994) observed that seed yield of blackgram was recorded highest with the application of 20 kg/ha N, 40 kg/ha P and 40 kg K/ha. Patel *et al.* (1991) reported that 1000 seed weight of blackgram was increased significantly with the application of nitrogen, phosphorus and potassium fertilizers.

A field experiment was conducted by Khan and Prakash (2014) to study the effect of rhizobial inoculation on growth, yield, nutrient uptake and economics of summer blackgram in relation to zinc and molybdenum. Result data showed that stover yield increased significantly at the Rhizobium culture than without inoculation. Nandan and Prasad (1998) found that grain yield and net returns were higher with 3 irrigation than with 1 and 2 irrigation in blackgram. Tripurari and Yadav (1990) observed that grain yield was decreased due to water stress in green grain and blackgram.

A field investigation was conducted by Jakhar *et al*. (2015) to evaluate the effect of hand weedings and herbicides on the weed flora, growth and yield of uradbean (*Vigna mungo*). Results revealed that the maximum pods plant^{-1} (27.73) were observed under pre-emergent imazethapyr at 0.10 kg ha^{-1} + HW at 30 DAS treatment.

Kumar *et al.* (2015) carried out a field experiment to refining the weed management practices to increase the yield of blackgram (*Vigna mungo* L.). Different weed management practices significantly affected the growth and yield attributes of blackgram. Among different methods of weed control, hand weeding at 20 and 40 DAS proved its superiority in respect of all the growth characters and yield attributes as well as grain and straw yield of blackgram 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. Pre-emergence application of pendimethalin either at lower dosage (0.75 kg/ha) along with one hand weeding at 40 days after sowing or at higher dosage (1.0 kg/ha) without any integration with hand weeding proved to obtain higher seed yield (1.09 and1.03 t/ha), respectively. Season-long weed competition caused an average yield reduction of 26.4% as compared to IWM in blackgram.

An experiment was conducted by Aggarwal and Singh (2014) on blackgram and found that highest pod length was obtained 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. Khot *et al*. (2012) carried out an experiment at Agronomy Instructional Farm, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat on blackgram and revealed that among the treatments, two hand weeding showed maximum number of pods plant^{-1} (23.20) and number of grains pod^{-1} (5.92) While minimum number of pods plant^{-1} & seeds pod^{-1} was obtained under treatment unweeded check.

An experiment was conducted by Hemlata (2012) on blackgram and reported that the maximum number of pod plant^{-1}, number of seed pod^{-1}, seed yield, stover yield and harvest index were observed under two hand weeding (20 and 40 DAS), while the minimum number of pod plant^{-1}, number of seed pod^{-1}, seed yield, stover yield and harvest index were found under unweeded check. Singh (2011) carried out a field experiment during the rainy (kharif) season of 2008 and 2009 at Ludhiana, Punjab to study tolerance of different blackgram [*Vigna mungo* (L.) Hepper] cultivars to post-emergence application of imazethapyr and its efficacy on weeds. Result revealed that application of imazethapyr at 100 g ha^{-1} at 15 DAS produced in 62.0% higher grain yield over the unweeded control.

An experiment was conducted by Asaduzzaman *et al*. (2010) to evaluate the impact of weeding and plant spacing on the growth and yield performance of blackgram. Number of pods $plant^{-1}$, number of seeds pod^{-1}, seed weight and seed yield were increased significantly with two weeding (25 and 40 DAS). Two weeding at 25 and 40 DAS contributed 56.18% and 25.23% higher seed yield compared to no weeding and single weeding, respectively.

Asaduzzaman *et al*. (2005) carried out an experiment at the Agronomy Field Laboratory of Sher-e-Bangla Agricultural University, Dhaka to assess the effect of weeding on growth, yield and yield contributing characters of blackgram. Result revealed that the maximum number of branches $plant^{-1}$ and highest 1000-seeds weight (49.09 g) were obtained under two hand weeding (20 DAS and 40 DAS). An experiment was conducted by Malik *et al*. (2003) to determine the effect of varying levels of weeding (0, 1 and 2 weeding) on the yield and quality of blackgram. They found that twice weeding contributed significantly higher pods $plant^{-1}$.

Kalita *et al*. (1995) revealed that the times of weeding (2 or 3 times) on blackgram resulted the highest seed yield and harvest index which were found to be associated with a higher number of pods/plant and seeds/pod. Pongkao and Inthong (1988) stated that proper weeding on blackgram was recorded to be superior giving 23 % greater biological yield over the control. Vasudevan *et al.* (2008) carried out research on the performance of various insecticides on seed yield and quality of blackgram cv. TAU-1. Insecticides viz., fenvalarate 20EC, fenvalarate dust, malathion 25 EC, malathion dust, quinolphos 25 EC, quinolphos dust, neem seed kernel extract (NSKE) and commercial neem seed pesticide (SPIC). Among the various organic and inorganic chemicals used, the highest seed yield (9.8 q h^{-1}) was observed in quinolphos 25EC.

CHAPTER III

MATERIALS AND METHODS

The experiment was accompanied to find out the effect of variety and agronomic managements of blackgram on the growth and yield. The materials and methods for this experiment comprises a short description of the location of experimental site, soil and climatic condition of the experimental area, materials used for the experiment, design of the experiment, data collection and data analysis procedure. The details report of the materials and methods for this experiment have been presented below under the following headings-

3.1 Description of the experimental site

3.1.1 Experimental period

The experiment was conducted during the period from March to June, 2019.

3.1.2 Experimental location

The experiment was conducted at the Research Farm of Sher-e-Bangla Agricultural University (SAU), Dhaka and it was located in 23° 77' N latitude and 90^0 35' E longitudes. As per the Bangladesh Meteorological Department, Agargaon, Dhaka-1207 the altitude of the location was 8 m from the sea level.

3.1.3 Characteristics of soil

The general soil type of the experimental field is Deep Red Brown Terrace soil and the soil belongs to the Tejgaon series under the Agro-ecological Zone, Madhupur Tract (AEZ-28). The soil was consuming a texture of silty clay with pH and organic matter 5.7 and 1.13%, respectively. The experimental area was flat having available irrigation and drainage system and above flood level. The selected plot was medium high land. The experimental site has been presented in Appendix I.

3.1.4 Climate

The geographical location of the experimental site was under the subtropical climate, characterized by three 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 (Edris *et al*., 1979).

3.2 Experimental details

3.2.1 Treatments of the experiment

The experiment comprised of two factors

Factor A: Variety-2:

i) V_1: BARI mash-1

ii) V_2: BARI mash-3

Factor B: Agronomic Managements-7:

i. Control (No management) -M_1

ii. No fertilizer but all other managements –M_2

iii. No weeding but all other managements –M_3

iv. No irrigation but all other managements - M_4

v. No insecticide but all other managements - M_5

vi. No fungicide/bacteriocide but all other managements - M_6

vii. Complete management (recommended) - M_7

As such there were 14 (2 × 7) treatment combinations viz. V_1M_1, V_1M_2, V_1M_3, V_1M_4, V_1M_5, V_1M_6, V_1M_7, V_2M_1, V_2M_2, V_2M_3, V_2M_4, V_2M_5, V_2M_6 and V_2M_7.

3.2.2 Planting material

Blackgram varieties BARI mash-1, BARI mash-3 were used as planting material for the study. The seeds of BARI mash-1 and BARI mash-3 were collected from the Pulse Seed Division of Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. BARI mash-1 was developed by BARI and released in 1990. The yellow mosaic virus resistant BARI mash-3 variety was released by BARI in 1996 in farmers level and it was developed through hybridization between line BMA-2140 and BMA-2038.

3.2.3 Land preparation

The land selected for the experiment was opened in the first week of March 2019 with the tractor drawn disc plough, and then ploughed soil again and again to brought into desirable tilth by cross-ploughing, harrowing and laddering. All weeds and other plant residues of previous crop were removed from the tilth soil. Experimental land was allocated into unit plots following the experimental design of this experiment.

3.2.4 Fertilizer application

The fertilizers N, P, K, S and B in the form of urea, Triple super phosphate (TSP), Muriate of Potash (MoP), Gypsum and Boric acid, respectively were applied in all plots except control (no management) and no fertilizer application. Urea, TSP, MoP, Gypsum and Boric acid were applied at the rate of 45, 90, 40, 55 and 10 kg ha^{-1} in the soil as per treatment. All of the fertilizers were applied in final land preparation as basal dose as per treatment.

3.2.5 Experimental design and layout

The two factors experiment was laid out in a split-plot design with three replications. Each replication had fourteen plots to which different varieties were assigned in the main plot and managements in sub-plot. The total numbers of unit plots were 42. The size of the each unit plot was 6.3 m^2 (3.0 m × 2.1 m). The distances between replication to replication and plot to plot were 1.0 m and 0.75 m, respectively. The layout of the experiment is shown in Appendix II.

3.3 Growing of crops

3.3.1 Sowing of seeds in the field

The seeds were sown by hand in 30 cm row spacing at about 3 cm depth at the rate of 30 kg seed ha^{-1} on 15 March, 2019.

3.3.2 Intercultural operations

3.3.2.1 Gap filling and Thinning

Gap filling was done at 10 days after sowing (DAS) by Sowing of seeds. Thinning was done in all the unit plots with care to maintain optimum plant population on each row. Finally plants were kept at 10 cm distance in rows.

3.3.2.2 Irrigation, drainage and weeding

Irrigation was delivered to the all plots except no management and no irrigation at 7, 37 and 42 DAS, respectively. Drainage channels were properly prepared to easy and quick drained out of excess water from irrigation and also rainfall from the experimental plot. Weeding was done all plots except no management and no weeding at 26 and 45 DAS.

3.3.2.3 Plant protection measures

The crop was infested by insects and diseases. The insecticide Ripcord 10 EC was sprayed at the rate of 1 ml with 1 liter water to 5 decimal lands for two times at 15 days interval after seedlings germination to the all plots except no management and no insecticide to control few worms (*Agrotis ipsilon*) and pod borer (*Maruca testulalis*) insects. The fungicide Autostin 50 WP @ 2 gm/1L water was sprayed to the all plots except no management and no fungicide/bacteriocide during the later stage of crop to control cercospora leaf spot.

3.4 Crop sampling and data collection

Five plants were randomly selected from each plot and marked with sample thread. Plant height, number of leaves plant^{-1}, number of branches plant^{-1}, number of nodules plant^{-1} and Plant dry weight (g) were recorded at different DAS. All of the yield parameters were recorded in 2 times and total or average was estimated as per the nature of yield parameters.

3.5 Harvest and post-harvest operations

Maturity of crop was determined when 80-90% of the pods become brown to black in color. Two harvesting was done while the first harvesting was done on 24 May to 27 May, 2019 and the final harvesting was done on 12 to 13 June, 2019. The harvesting was done by picking pods from central three lines of each plot for avoiding the boarder effects. The collected pods were sun dried, threshed and weighted to a control moisture level. The seeds were separated, cleaned and dried in the sun for 3 to 5 consecutive days for achieving safe moisture of seed.

3.6 Threshing

The pod was sun dried properly by spreading them on the open threshing floor and seeds were separated from the pods by beating the bundles with the help of bamboo sticks.

3.7 Drying, cleaning and weighing

The seeds thus collected were dried in the sun for reducing the moisture in the seeds to a constant level. The dried seeds and straw were cleaned and weighed.

3.8 Data collection

The data were collected on the following parameters during the experimentation.

A. Crop growth characters

a. Germination percentage
b. Plant height
c. Number of leaves plant^{-1}
d. Plant dry weight
e. Number of nodules plant^{-1}
f. SPAD value
g. Days required to flowering

B. Yield and other crop characters

a. Number of branches plant^{-1}
b. Number of pods plant^{-1} at 1st harvest
c. Number of pods plant^{-1} at final harvest
d. Number of total pods plant^{-1}
e. Pod length
f. Number of seeds pod^{-1}
g. 1000-grain weight
h. Shelling percentage
i. Grain yield at 1st harvest
j. Grain yield at final harvest
k. Total grain yield
l. Shell yield at 1st harvest
m. Shell yield at final harvest
n. Total shell yield
o. Straw yield
p. Biological yield
q. Harvest index

C. Weed characters

a. Number of weeds m^{-2}

b. Dry weight of weeds m^{-2}

3.9 Procedure of data collection

A brief outline of the data collection procedure followed during the study given below:

3.9.1 Crop growth characters

i. Germination percentage

An area of 1 m^2 was selected from each plot where germinated seeds were counted avoiding boarder effect at 4, 5, 6, 7 and 8 DAS.

ii. Plant height

The plant height was recorded in centimeter (cm) at 15, 30, 45 and 60 DAS. Data were recorded from randomly selected 5 plants from each plot by binding thread avoiding boarder effect and average height plant^{-1} was documented. The height was determined by measuring the distance from the ground level to the tip of the leaf or pod of main shoot.

iii. Number of leaves plant^{-1}

Number of leaves of five randomly selected plants from each plot was counted at 15, 30, 45 and 60 DAS. The number of leaves plant^{-1} was done by counting total number of leaves of all sampled plants then the average data were recorded.

iv. **Plant dry weight**

Ten randomly selected plants were collected from the outer rows of each plot leaving the boarder line at 20, 40 and 60 DAS. The sample was put into separate envelop then placed in oven maintained at 70^0C for 48 hours. Then dry weight of plant was taken separately with an electric balance and mean values were determined.

v. Number of nodules plant^{-1}

Ten randomly selected plants from second line of each plot was uprooted carefully using Nirani along with sufficient surrounding soils at 20 & 40 DAS then washed in water. The total number of nodules plant^{-1} were counted and the mean value was recorded.

vi. SPAD value

SPAD value was taken from five randomly selected leaf of each plot using spade meter avoiding boarder effect. Then the average data were recorded.

vii. Days required to flowering

The days required to 1% flowering, 50% and 100% flowering were recorded and calculated as the number of days required from sowing to 1%, 50% and 100% flower initiation of blackgram plants in each plot.

3.9.2 Yield and other crop characters

i. Number of branches plant^{-1}

The number of branches was counted at 30, 45 and 60 DAS. The number of branches plant^{-1} from five randomly sampled plants of each plot were counted and average values were recorded.

ii. Number of pods plant^{-1} at 1st and final harvest

The number of pods plant^{-1} was counted from the 5 randomly selected plant sample at 1st harvest and then the average pod number was calculated. Similar procedure was followed for counting number of pods plant^{-1} at final harvest.

iii. Number of total pods plant^{-1}

The total numbers of pods of five randomly selected plants plot^{-1} at 1st and final harvest were counted and the average values were recorded.

iv. Pod length

The length of pods were measured by meter scale from ten randomly selected pods, collected from five randomly selected plants of each plot. Then the average values were recorded.

v. Number of seeds pod^{-1}

The pods from each of five randomly selected plants plot^{-1} were separated from which ten pods were selected randomly. The number of seeds pod^{-1} was counted and average number of seeds pod^{-1} was calculated.

vi. 1000-grain weight

1000 cleaned, dried grains were taken from the seeds sample of each plot and counted manually. Then kept in oven at 48°C with 24 hours and weighed in an electrical balance after removing heat. Finally data were recorded in gram.

vii. Shelling percentage

The weight of grains and shells were taken from middle three line of each plot and the mean results were recorded. Shelling percentage was calculated by the following formulae:

$$\text{Shelling percentage (\%)} = \frac{\text{Grain weight (g)}}{\text{Grain weight (g)} + \text{Shell weight (g)}} \times 100$$

viii. Grain yield at 1st and final harvest

The pods from harvested area (middle three lines, 3.15 m^2) of each plot were harvested and threshed during 1st harvest. Grains were cleaned and properly dried under sun. Then grain yield $plot^{-1}$ was recorded at 12% moisture level & expressed as kg ha^{-1}. Similar procedure was followed for measuring grain yield (kg ha^{-1}) at final harvest.

ix. Total grain yield

Total grain yield was recorded on the basis of total harvested grains $plot^{-1}$ (at 1st harvest + final harvest) and was expressed as kg ha^{-1}.

x. Shell yield at 1st and final harvest

The shell yield was determined from harvested area (middle three lines, 3.15 m^2) of each plot during 1st harvest. After separation of seeds from pod, the shells were dried to a constant weight and finally converted to kg ha^{-1}. Similar procedure was followed for measuring shell yield (kg ha^{-1}) at final harvest.

xi. Total shell yield

Total shell yield was recorded on the basis of total harvested shells $plot^{-1}$ (at 1st harvest + final harvest) and was expressed as kg ha^{-1}.

xii. Straw yield

After separation of pods from plant, the straw of harvested area from each plot was sun dried and the weight of straw was taken and converted the yield in kg ha^{-1}.

xiii. Biological yield

The summation of grain yield, shell yield and straw yield was regarded as biological yield. The biological yield was calculated with the following formulae:

Biological yield = Grain yield + Shell yield + Straw yield.

xiv. Harvest index

The harvest index was calculated by the ratio of grain yield to biological yield of blackgram for each plot and expressed in percentage.

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

Here, Biological yield = Grain yield + Shell yield + Straw yield.

3.9.3 Weed characters

i. Number of weeds m^{-2}

A square shaped spot was randomly selected in each plot using quadrate of $1m^2$ to collect uprooted weeds at 20 and 40 DAS and counted values were recorded.

ii. Dry weight of weeds m^{-2}

The fresh weeds were randomly collected from $1m^2$ area of each plot. Weeds were oven dried for 48 hours at 70°C temperature and then weighed by using a digital electrical balance at 20 and 40 DAS and counted values were recorded.

3.10 Analysis of data

The data collected on different parameters were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program CropStat and the mean differences were estimated by Least Significance Difference (LSD) test at 5% level of significance (Gomez and Gomez, 1984).

CHAPTER IV

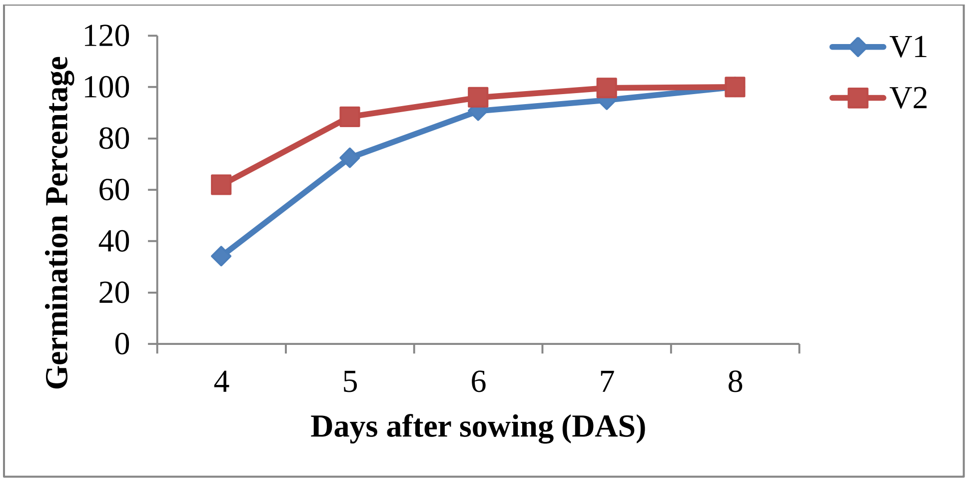
RESULTS AND DISCUSSION

The experiment was conducted to determine the effect of different varieties and agronomic managements on the growth and yield of blackgram. The analyses of variance (ANOVA) of the data on different parameters are also given in the appendices. The results have been presented and discussed and possible interpretations have been given under the following headings:

4.1 Germination percentage

4.1.1 Effect of variety

Germination percentage of blackgram varieties were counted at different days and marked as individual from where the date wise germination was calculated. Germination percentage of blackgram was significantly influenced by varieties at 4, 5, 6 and 7 DAS (Fig. 1 and Appendix III). At 4 DAS, germination percentage was highest in V_2 (61.91%) and the lowest result in V_1 (34.12%). At 5 DAS, germination percentage was maximum in V_2 (88.43%) and the minimum in V_1 (72.47%). At 6 DAS, germination percentage was highest in V_2 (95.98%) and the lowest result in V_1 (90.70%). At 7 DAS, germination percentage was maximum in V_2 (99.62%) and the minimum result in V_1 (94.97%). At 8 DAS, germination percentage was same (100%) for both variety. Rahman *et al.* (2012) and Ghosh (2007) reported the similar finding. They found that germination percentage was significantly influenced by varieties.

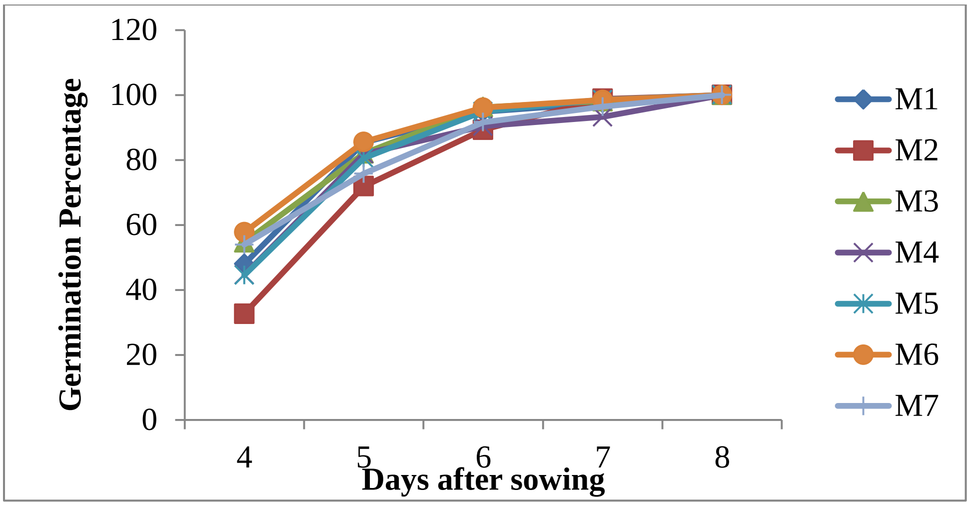


V_1 = BARI mash-1, V_2 = BARI mash-3

Figure 1. Germination percentage of blackgram as influenced by variety.

4.1.2 Effect of Agronomic managements

Agronomic managements showed significant effect on germination percentage of blackgram at 4, 5, 6 and 7 DAS (Fig. 2 and Appendix III). At 4 DAS, the maximum germination percentage (57.75%) was observed in M_6 treatment but the result was statistically similar with M_3 treatment (54.61%), M_7 treatment (53.94%), M_1 treatment (47.97%), M_4 treatment (44.64%) and M_5 treatment (44.54%). The minimum (32.64%) germination percentage was found in M_2 treatment but the result was statistically similar with M_4 treatment (44.64%) and M_5 treatment (44.54%). At 5 DAS, the highest germination percentage (85.55%) was recorded in M_6 treatment but the result was statistically similar with M_1 (85.38%) treatment, M_3 (82.01%) treatment, M_4 (81.89%) treatment, M_5 (80.59%) treatment and M_7 (75.79%) treatment. Germination percentage was lowest (71.93%) in M_2 treatment but the result was statistically similar with M_7 (75.79%) treatment, M_5 (80.59%) treatment, M_4 (81.89%) treatment and M_3 (82.01%) treatment. At 6 DAS, the germination percentage was maximum (96.25%) in M_3 treatment but the result was statistically similar with M_6 treatment (96.10%), M_5 treatment (94.90%), M_1 treatment (94.86%) and M_7 treatment (91.61%). The minimum (89.31%) germination percentage was found in M_2 treatment but the result was statistically similar with M_4 treatment (90.37%), M_7 treatment (91.61%), M_1 treatment (94.86%) and M_5 treatment (94.90%). At 7 DAS, the highest germination percentage (98.81%) was observed in M_2 treatment but the result was statistically similar with M_5 treatment (98.55%), M_6 treatment (98.45%), M_3 treatment (98.07%), M_1 treatment (97.51%) and M_7 treatment (96.42%). The lowest (93.26%) germination percentage was found in M_4 treatment but the result was statistically similar with M_7 treatment (96.42%), M_1 treatment (97.51%), M_3 treatment (98.07%) and M_6 treatment (98.45%). At 8 DAS, germination percentage was same (100%) for all management.



M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

Figure 2. Germination percentage of blackgram as influenced by agronomic managements ($LSD_{(0.05)}$ at 4, 5, 6 and 7 DAS = 14.644, 11.737, 5.871 and 5.201, respectively).

4.1.3 Interaction effect of variety and agronomic managements

There was significant effect on germination percentage of blackgram observed due to interaction between variety and agronomic managements at 4, 5, 6 and 7 DAS (Table 1 and Appendix III). At 4 DAS, the highest germination percentage (83.32%) was observed in V_2M_7 treatment that statistically similar to V_2M_6 (70.39%), V_2M_4 (66.69%) and V_2M_3 (65.73%) treatments. The lowest germination percentage (18.64%) was in V_1M_2 which was statistically similar with V_1M_4 (22.60%) and V_1M_7 (24.55%) treatments. At 5 DAS, the highest germination percentage (91.10%) was recorded in V_2M_4 which was statistically similar with all treatment except V_1M_3 (73.22%), V_1M_4 (71.77%), V_1M_7 (61.49%), V_1M_2 (58.45%) and the germination percentage was lowest (58.45%) in V_1M_2 which was statistically similar with V_1M_7 (61.49%), V_1M_4 (71.77%), V_1M_3 (73.22%) treatments. At 6 DAS the highest germination percentage (97.42%) was observed in V_2M_3 which was statistically similar with all treatment except V_1M_2 (86.68%), V_1M_7 (85.86%), V_1M_4 (84.76%) and the lowest germination percentage (84.76%) was in V_1M_4 that statistically similar to V_1M_7 (85.86%), V_1M_2 (86.68%), V_2M_2 (91.94%), V_1M_5 (92.62%) and V_1M_1 (92.99%) treatments. At 7 DAS, the highest germination percentage was recorded in V_2M_1 - V_2M_6 (100%) which was statistically similar with all treatment except V_1M_4 (86.51%) and the germination percentage was lowest in V_1M_4 (86.51%). At 8 DAS, germination percentage was same (100%) for all interaction between variety and agronomic managements.

Table 1. Interaction effect of variety and agronomic managements on germination percentage of blackgram at different days after sowing

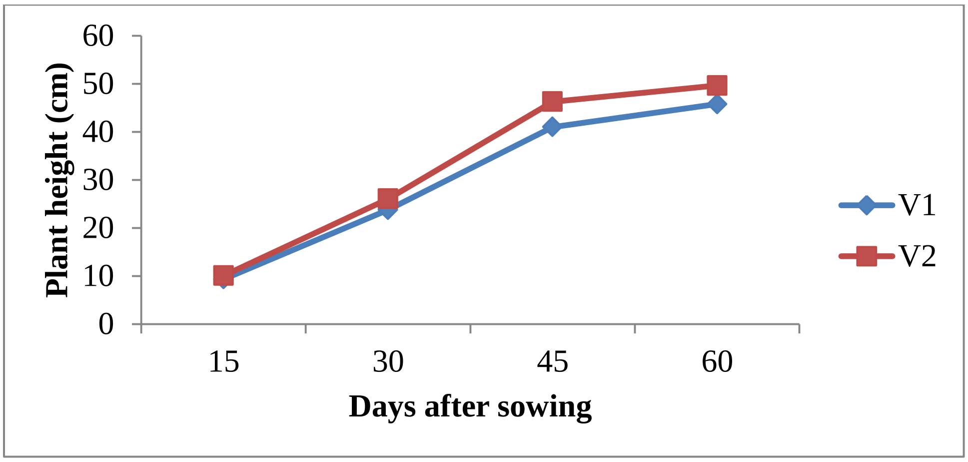
Treatment combination	Germination percentage at				
	4 DAS	5 DAS	6 DAS	7 DAS	8 DAS
V_1M_1	43.91 ef	82.06 a-c	92.99 ab	95.01 a	100
V_1M_2	18.64 h	58.45 e	86.68 b	97.62 a	100
V_1M_3	43.48 ef	73.22 b-e	95.07 a	96.15 a	100
V_1M_4	22.6 gh	71.77 c-e	84.76 b	86.51 b	100
V_1M_5	40.54 e-g	77.62 a-d	92.62 ab	97.10 a	100
V_1M_6	45.11 d-f	82.68 a-c	96.90 a	96.90 a	100
V_1M_7	24.55 f-h	61.49 de	85.86 b	95. 48 a	100
V_2M_1	52.03 b-e	88.71 ab	96.72 a	100 a	100
V_2M_2	46.64 c-e	85.41 a-c	91.94 ab	100 a	100
V_2M_3	65.73 a-d	90.79 a	97.42 a	100 a	100
V_2M_4	66.69 a-c	91.10 a	95.97 a	100 a	100
V_2M_5	48.55 c-e	83.56 a-c	97.18 a	100 a	100
V_2M_6	70.39 ab	88.41 ab	95.31 a	100 a	100
V_2M_7	83.32 a	90.10 a	97.35 a	97.35 a	100
$LSD_{(0.05)}$	20.710	16.599	8.302	7.355	0
CV (%)	25.6	12.24	5.28	4.49	0

In a column mean values having similar letter(s) are statistically similar
NS = Not significant, CV = Coefficient of variation, $LSD_{(0.05)}$ = Least significant difference at 5% level,
DAS = Days after sowing,
V_1 = BARI mash-1, V_2 = BARI mash-3,
M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

4.2 Plant height

4.2.1 Effect of variety

The plant height of blackgram was significantly influenced by varieties at 15, 30, 45 and 60 days after sowing (DAS) (Fig. 3 and Appendix IV). At 15 DAS, the tallest plant (10.06 cm) was recorded from BARI mash-3 (V_2) and the shortest plant recorded from (9.31 cm) at BARI mash-1 (V_1). At 30 DAS, the tallest plant (26.07 cm) was obtained from BARI mash-3 (V_2) and the shortest plant obtained from (23.75 cm) BARI mash-1 (V_1). At 45 DAS, the tallest plant (46.28 cm) was recorded from BARI mash-3 (V_2) and the shortest plant recorded from (41.01 cm) BARI mash-1 (V_1). At 60 DAS, the tallest plant (49.64 cm) was found from BARI mash-3 (V_2) and shortest (45.77 cm) from BARI mash-1 (V_1). These results were similar with the findings of Nag *et al.* (2000) who reported that among the three cultivars of blackgram (*Vigna mungo*), Barimash-1 cultivar had the highest plant height.



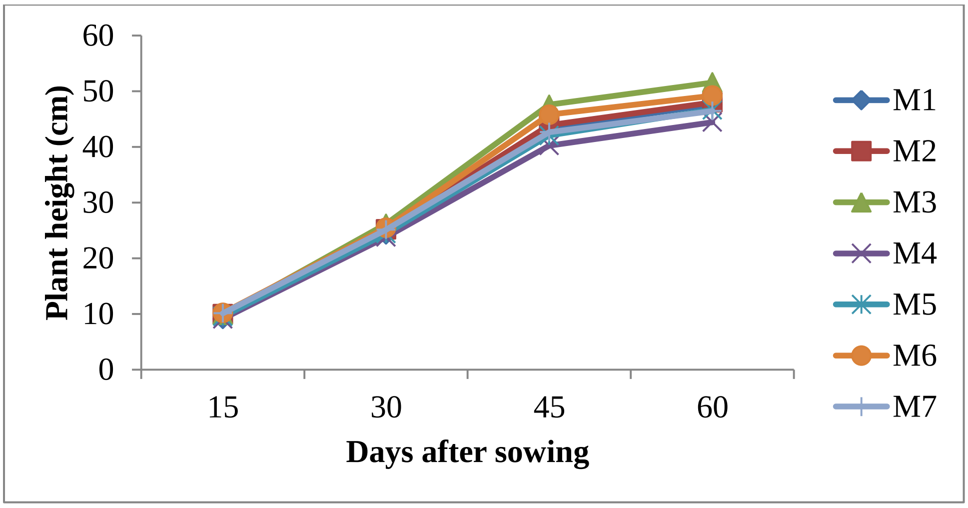
V_1 = BARI mash-1, V_2 = BARI mash-3

Figure 3. Plant height of blackgram as influenced by variety ($LSD_{(0.05)}$ at 15, 30, 45 and 60 DAS = 0.340, 1.380, 2.910 and 2.610, respectively).

4.2.2 Effect of agronomic managements

The results showed that the effect of agronomic managements on plant height was significant at 45 DAS and 60 DAS but insignificant at 15 DAS and 30 DAS (Appendix IV and Fig. 4). At 15 DAS, the tallest plant (10.16 cm) was obtained from M_6 and the shortest plant (9.11 cm) was obtained from M_1. At 30 DAS, the tallest plant (26.14 cm) was recorded from M_3 and the shortest plant (23.79 cm) was recorded from M_4. At 45 DAS, the tallest plant (47.57 cm) was obtained from M_3, which was statistically similar with the height of M_6 (45.80 cm) and M_2 (43.88 cm). The shortest plant (40.25 cm) was obtained from M_4, which was statistically similar with the height of M_5 (42.04 cm), M_7 (42.65 cm), M_1 (43.35 cm) and M_2 (43.88 cm). At 60 DAS, the tallest plant (51.57 cm) was found from M_3, which was statistically similar with the height of M_6 (49.20 cm). The shortest plant (44.43 cm) was found from M_4, which was statistically similar with the height of M_7 (46.45 cm), M_5 (46.66 cm) and M_1 (47.62 cm). This result similar with the findings of

Rajput (1994) who reported that fertilizing with P_2O_5 @ 50 kg/ha improved the leaves per plant significantly as compared to 0 kg P_2O_5 ha^{-1}.



M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

Figure 4. Plant height of blackgram as influenced by agronomic managements ($LSD_{(0.05)}$ at 45 DAS and 60 DAS = 3.947 and 3.514, respectively).

4.2.3 Interaction effect

Interaction effect of variety and agronomic managements showed statistically significant effect on plant height at 15, 30, 45 and 60 DAS (Appendix IV and Table 2). At 15 DAS, the tallest plant (11.00 cm) was found in V_2M_6 which was statistically similar with all treatment except V_1M_1 (8.49 cm) and V_1M_4 (7.87 cm). The shortest plant (7.87 cm) was found in V_1M_4 which was statistically similar with V_1M_1 (8.49 cm), V_2M_5 (9.09 cm), V_1M_6 (9.32 cm), V_1M_3 (9.41 cm), V_2M_1 (9.73 cm), V_1M_2 (9.77 cm) and V_2M_7 (9.88 cm). At 30 DAS, the tallest plant (28.07 cm) was observed in V_2M_3 which was statistically similar with all treatment except V_1M_3 (24.22 cm), V_1M_1 (24.04 cm), V_1M_6 (23.75 cm), V_1M_5 (23.67 cm), V_1M_4 (20.89 cm). The shortest plant (20.89 cm) was observed in V_1M_4 which was statistically similar with V_1M_5 (23.67 cm), V_1M_6 (23.75 cm), V_1M_1 (24.04 cm), V_1M_3 (24.22 cm) and V_2M_1 (24.45 cm). At 45 DAS, plant was tallest (51.07 cm) in V_2M_3 which was statistically similar with V_2M_6 (48.92 cm) and V_2M_2 (47.35 cm). The shortest plant (36.05 cm) was recorded in V_1M_4 which was statistically similar with V_1M_2 (40.40 cm), V_1M_5 (40.55 cm) and V_1M_7 (40.93 cm). At 60 DAS, the tallest plant (53.20 cm) was obtained in V_2M_3 which was statistically similar with V_2M_6 (53.13 cm), V_1M_3 (49.94 cm),

V_2M_2 (49.33 cm) and V_2M_1 (49.00 cm). The shortest plant (41.53 cm) was obtained in V_1M_4 which was statistically similar with V_1M_5 (45.21 cm), V_1M_6 (45.27 cm), V_1M_7 (45.55 cm) and V_1M_1 (46.24 cm).

Table 2. Interaction effect of variety and agronomic managements on plant height of blackgram at different days after sowing

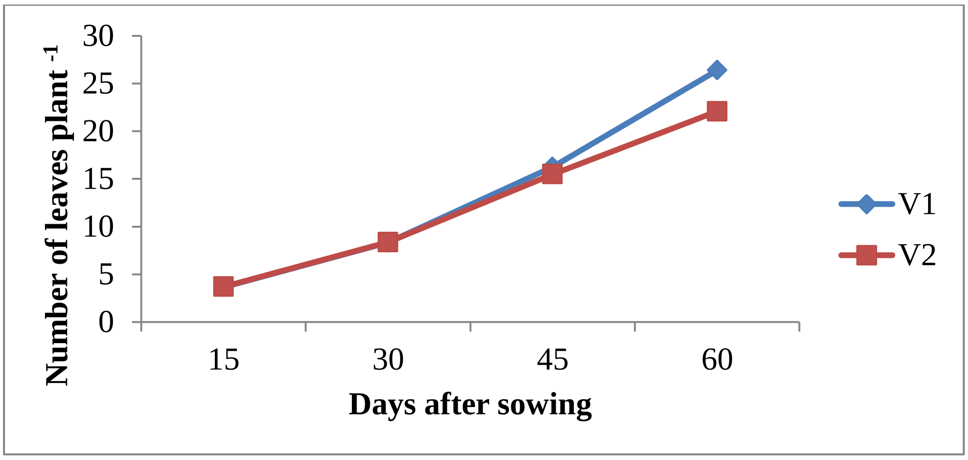
Treatment combination	Plant height (cm) at			
	15 DAS	30 DAS	45 DAS	60 DAS
V_1M_1	8.49 bc	24.04 bc	42.43 cd	46.24 bc
V_1M_2	9.77 a-c	24.72 ab	40.40 de	46.68 b
V_1M_3	9.41 a-c	24.22 bc	44.07 b-d	49.94 ab
V_1M_4	7.87 c	20.89 c	36.05 e	41.53 c
V_1M_5	10.01 ab	23.67 bc	40.55 de	45.21 bc
V_1M_6	9.32 a-c	23.75 bc	42.67 cd	45.27 bc
V_1M_7	10.32 ab	24.93 ab	40.93 de	45.55 bc
V_2M_1	9.73 a-c	24.45 a-c	44.27 b-d	49.00 ab
V_2M_2	10.11 ab	25.62 ab	47.35 a-c	49.33 ab
V_2M_3	10.25 ab	28.07 a	51.07 a	53.20 a
V_2M_4	10.37 ab	26.70 ab	44.45 b-d	47.33 b
V_2M_5	9.09 a-c	25.18 ab	43.53 b-d	48.11 b
V_2M_6	11.00 a	27.18 ab	48.92 ab	53.13 a
V_2M_7	9.88 a-c	25.30 ab	44.37 b-d	47.35 b
$LSD_{(0.05)}$	2.103	3.779	5.582	4.969
CV (%)	12.88	9	7.59	6.18

In a column mean values having similar letter(s) are statistically similar
S = Significant, CV = Coefficient of variation, $LSD_{(0.05)}$ = Least significant difference at 5% level,
DAS = Days after sowing,
V_1 = BARI mash-1, V_2 = BARI mash-3,
M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

4.3 Number of leaves plant $^{-1}$

4.3.1 Effect of variety

Number of leaves plant^{-1} of blackgram was significantly influenced by varieties at 60 days after sowing (DAS) but at 15, 30 and 45 DAS, varieties had no significant effect because number of leaves plant^{-1} of BARI mash-1 and BARI mash-3 were statistically similar (Appendix V and Fig. 5). At 15 DAS, the maximum number of leaves (3.70) was found in BARI mash-3 (V_2) compared to BARI mash-1 (V_1). At 30 DAS, the maximum number of leaves (8.37) was found in BARI mash-3 (V_2) and minimum number of leaves (8.34) was recorded in BARI mash-1 (V_1). At 45 DAS and 60 DAS, number of leaves plant^{-1} was maximum (16.25 and 26.39 respectively) in BARI mash-1 (V_1) and number of leaves plant^{-1} was minimum (15.50 and 22.08 respectively) in BARI mash-3 (V_2). Ansary (2007) reported the similar finding.

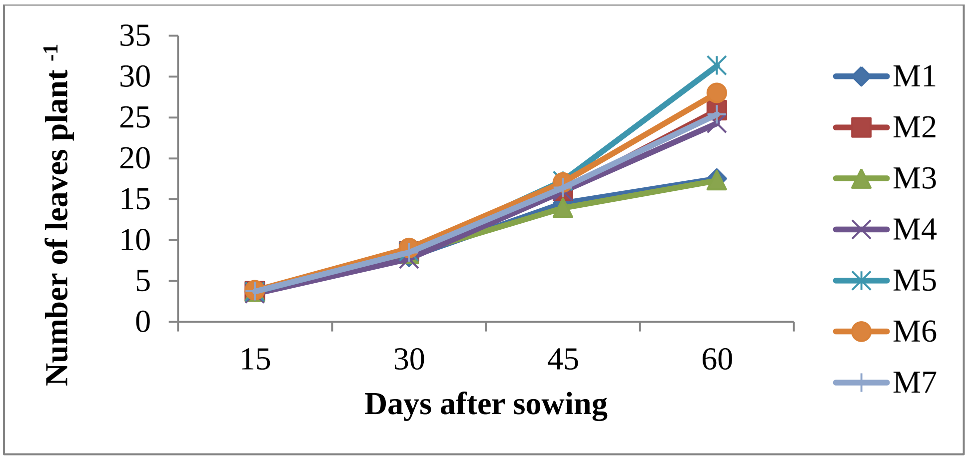


V_1 = BARI mash-1, V_2 = BARI mash-3

Figure 5. Number of leaves plant^{-1} of blackgram as influenced by variety ($LSD_{(0.05)}$ at 60 DAS = 3.990, respectively).

4.3.2 Effect of agronomic managements

The number of leaves plant^{-1} of blackgram had significantly influenced by agronomic managements at 15, 45 and 60 DAS but insignificant at 30 DAS (Appendix V and Figure 6). At 15 DAS, the maximum number of leaves plant^{-1} (3.83) was recorded in M_6 which was statistically similar with all treatment except M_4 (3.43). The minimum number of leaves plant^{-1} (3.43) was found in M_4 which was statistically similar with M_1 (3.67), M_3 (3.67) and M_5 (3.67). At 30 DAS, the maximum number of leaves plant^{-1} (9.00) was observed in M_6 and the minimum number of leaves plant^{-1} (7.70) was found in M_4. At 45 DAS, the maximum number of leaves plant^{-1} (17.23) was recorded in M_5 which was statistically similar with all treatment except M_3 (13.93). The minimum number of leaves plant^{-1} (13.93) was found in M_3 which was statistically similar with all treatment except M_6 (17.03) and M_5 (17.23). At 60 DAS, the maximum number of leaves plant^{-1} (31.33) was observed in M_5 which was statistically similar with M_6 (28.00). The minimum number of leaves plant^{-1} (17.30) was found in M_3 which was statistically similar with M_1 (17.50). Similar result was showed by Rajput (1994) who reported that fertilizing with P_2O_5 @ 50 kg/ha improved the leaves per plant significantly as compared to 0 kg P_2O_5 /ha.



M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

Figure 6. Number of leaves plant^{-1} of blackgram as influenced by agronomic managements at different days after sowing ($LSD_{(0.05)}$ = 0.282, 1.354, 2.805 and 4.518 at 15, 30, 45 and 60 DAS, respectively).

4.3.3 Interaction effect of variety and agronomic managements

Interaction effect of variety and agronomic managements had significant effect on number of leaves plant^{-1} observed at 15, 45 and 60 DAS but there was no significant variation observed on the number of leaves plant^{-1} at 30 DAS ((Appendix V and Table 3). At 15 DAS, the maximum number of leaves plant^{-1} (3.87) was observed in V_1M_6 treatment which was statistically similar with all treatment except V_1M_4 (3.13). The minimum number of leaves plant^{-1} (3.13) observed in V_1M_4 treatment which was statistically similar with V_1M_1 (3.53) and V_2M_5 (3.53) treatment. At 30 DAS, the maximum number of leaves plant^{-1} (9.20) was recorded in V_1M_6 treatment which was statistically similar with all treatment. At 45 DAS, the maximum number of leaves plant^{-1} (18.07) was observed in V_1M_5 treatment which was statistically similar with all treatment except V_2M_3 (13.00).

Number of leaves plant^{-1} was minimum in V_2M_3 (13.00) treatment which was statistically similar with all treatment except V_1M_6 (17.87) and V_1M_5 (18.07). At 60 DAS, number of leaves plant^{-1} was maximum in V_1M_5 (33.40) treatment which was statistically similar with V_1M_6 (31.40), V_2M_5 (29.27), V_1M_2 (28.73), V_1M_7 (27.80) and V_1M_4 (27.47) treatment. Number of leaves plant^{-1} was minimum in V_2M_3 (16.13) treatment which was statistically similar with V_1M_1 (17.47), V_2M_1 (17.53), V_1M_3 (18.47) and V_2M_4 (21.07) treatment.

Table 3. Interaction effect of variety and agronomic managements on number of leaves plant^{-1} of blackgram at different days after sowing

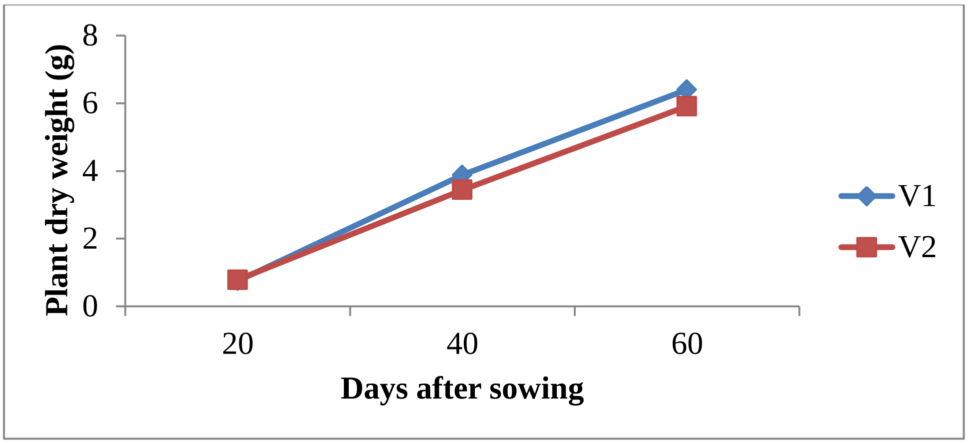
Treatment combination	Number of leaves plant^{-1} at			
	15 DAS	30 DAS	45 DAS	60 DAS
V_1M_1	3.53 ab	7.80 a	14.87 ab	17.47 ef
V_1M_2	3.73 a	8.73 a	15.87 ab	28.73 a-c
V_1M_3	3.73 a	8.07 a	14.87 ab	18.47 d-f
V_1M_4	3.13 b	7.60 a	15.67 ab	27.47 a-c
V_1M_5	3.80 a	8.67 a	18.07 a	33.40 a
V_1M_6	3.87 a	9.20 a	17.87 a	31.40 ab
V_1M_7	3.80 a	8.33 a	16.53 ab	27.80 a-c
V_2M_1	3.80 a	8.00 a	14.13 ab	17.53 ef
V_2M_2	3.73 a	8.40 a	16.20 ab	23.00 c-e
V_2M_3	3.60 a	8.47 a	13.00 b	16.13 f
V_2M_4	3.73 a	7.80 a	16.27 ab	21.07 d-f
V_2M_5	3.53 ab	8.53 a	16.40 ab	29.27 a-c
V_2M_6	3.80 a	8.80 a	16.20 ab	24.60 cd
V_2M_7	3.67 a	8.60 a	16.27 ab	22.93 c-e
$LSD_{(0.05)}$	0.399	1.915	3.967	6.389
CV (%)	6.44	13.6	14.83	15.65

In a column mean values having similar letter(s) are statistically similar
NS = Not significant, CV = Coefficient of variation, $LSD_{(0.05)}$ = Least significant difference at 5% level, DAS = Days after sowing, V_1 = BARI mash-1, V_2 = BARI mash-3,
M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

4.4 Plant dry weight

4.4.1 Effect of variety

Blackgram varieties showed non-significant values of plant dry weight at 20, 40 and 60 DAS (Fig. 7 and Appendix VI). At 20 DAS, the higher plant dry weight (0.78 g) was observed in BARI mash-3 (V_2) and the lower plant dry weight (0.75 g) was observed in BARI mash-1 (V_1). At 40 and 60 DAS, the higher plant dry weight found in BARI mash-1 (V_1) and the lower plant dry weight found in BARI mash-3 (V_2). Rahman *et al.* (2012) reported the similar finding.

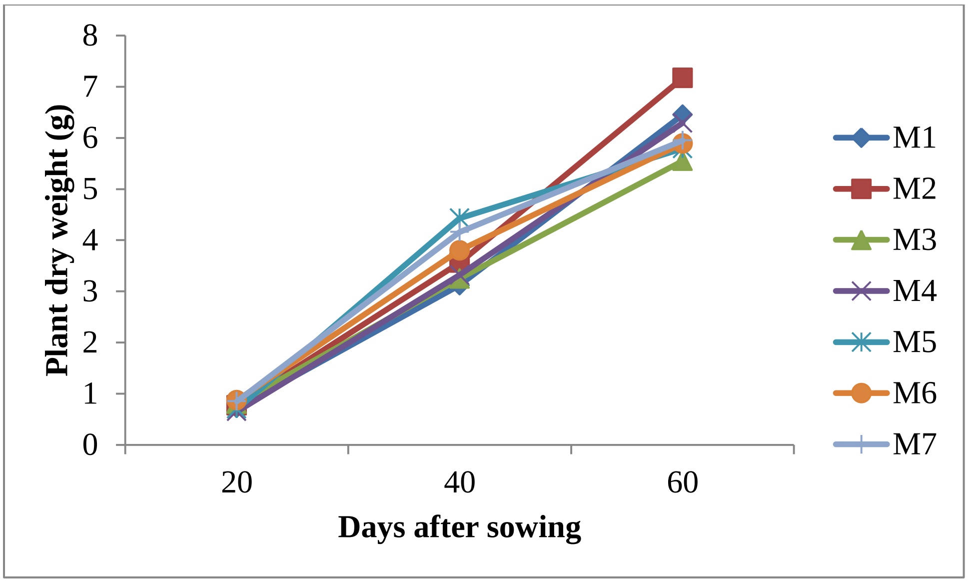


V_1 = BARI mash-1, V_2 = BARI mash-3

Figure 7. Plant dry weight of blackgram as influenced by variety at different days after sowing ($LSD_{(0.05)}$ = 0.240, 1.150 and 1.470 at 20, 40 and 60 DAS and at harvest, respectively).

4.4.2 Effect of agronomic managements

Plant dry weight was significantly influenced by agronomic managements at 20 and 40 DAS but insignificant at 60 DAS (Appendix VI and Fig. 8). At 20 DAS, the highest plant dry weight (0.87g) was obtained in M_6 treatment which was statistically similar with all treatment except M_4 (0.65 g). The lowest plant dry weight (0.65 g) was obtained in M_4 treatment which was statistically similar with all treatment except M_7 (0.85 g) and M_6 (0.87 g). At 40 DAS, the treatment M_5 produced the highest plant dry weight (4.43 g) which was statistically similar with M_7 (4.16 g), M_6 (3.80 g) and M_2 (3.56 g). The lowest plant dry weight (3.12 g) was found from the M_1 treatment which was statistically similar with all treatment except M_2 (3.56 g) and M_5 (4.43 g). At 60 DAS, the highest plant dry weight (7.17 g) was recorded in M_2 treatment, while the lowest (5.55 g) was recorded in M_3 treatment. Singh and Jain (1996) noticed significant increase in plant growth of cowpea by increased levels of phosphorus application.



M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

Figure 8. Plant dry weight of blackgram as influenced by agronomic managements at different days after sowing ($LSD_{(0.05)}$ = 0.187, 1.038 and 2.459 at 20, 40 and 60 DAS, respectively).

4.4.3 Interaction effect of variety and agronomic managements

Interaction effect of variety and agronomic managements showed significant effect on plant dry weight at 20, 40 and 60 DAS (Appendix VI and Table 4). At 20 DAS, the highest plant dry weight (0.93 g) was recorded in the V_2M_6 and V_2M_7 interaction. The lowest plant dry weight (0.53 g) was recorded in the V_2M_4 interaction which was statistically similar to the interactions of V_1M_5 (0.57), V_2M_1 (0.67), V_1M_2 (0.73), V_1M_1 (0.77), V_1M_4 (0.77), V_1M_7 (0.77) and V_2M_3 (0.77). At 40 DAS, the highest plant dry weight (4.96 g) was observed from the V_1M_5 interaction which was statistically similar to the interactions of V_1M_7 (4.76), V_1M_6 (4.38), V_2M_2 (3.92), V_2M_5 (3.90), V_1M_4 (3.83) and V_2M_7 (3.56). The lowest (2.81 g) was observed in the V_2M_4 interaction which shown similarity with all combinations except V_1M_6 (4.38), V_1M_7 (4.76) & V_1M_5 (4.96). At 60 DAS, the highest plant dry weight (8.31 g) was produced by the V_1M_2 which was statistically similar to all treatment except V_2M_3 (4.54) and the lowest plant dry weight (4.54 g) was found in the V_2M_3 interaction which shown similarity with all treatment except V_1M_2 (8.31).

Table 4. Interaction effect of variety and agronomic managements on plant dry weight of blackgram at different days after sowing

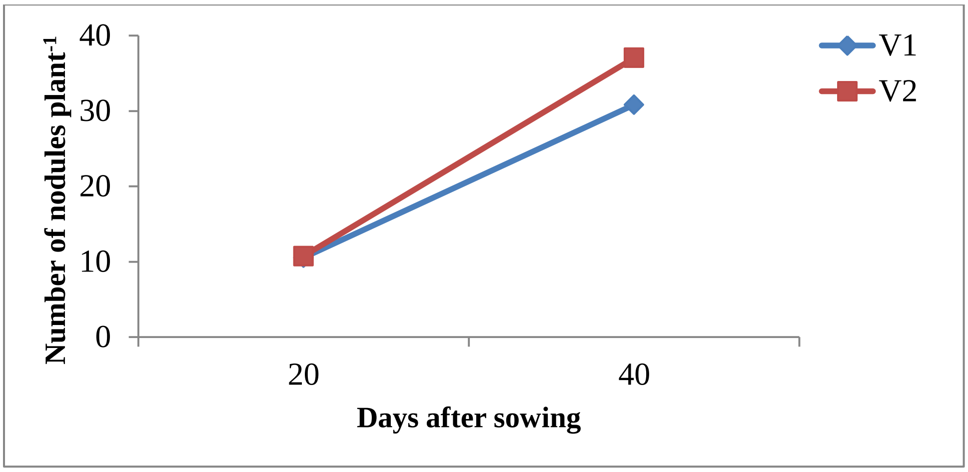
Treatment combination	Plant dry weight (g) at		
	20 DAS	40 DAS	60DAS
V_1M_1	0.77 a-c	2.88 d	6.39 ab
V_1M_2	0.73 a-c	3.19 cd	8.31 a
V_1M_3	0.83 ab	3.19 cd	6.55 ab
V_1M_4	0.77 a-c	3.83 a-d	5.70 ab
V_1M_5	0.57 bc	4.96 a	6.38 ab
V_1M_6	0.80 ab	4.38 a-c	5.54 ab
V_1M_7	0.77 a-c	4.76 ab	5.91 ab
V_2M_1	0.67 a-c	3.37 b-d	6.50 ab
V_2M_2	0.80 ab	3.92 a-d	6.03 ab
V_2M_3	0.77 a-c	3.31 b-d	4.54 b
V_2M_4	0.53 c	2.81 d	6.88 ab
V_2M_5	0.83 ab	3.90 a-d	5.19 ab
V_2M_6	0.93 a	3.22 cd	6.23 ab
V_2M_7	0.93 a	3.56 a-d	5.98 ab
$LSD_{(0.05)}$	0.265	1.467	3.478
CV (%)	20.56	23.78	33.54

In a column mean values having similar letter(s) are statistically similar
S = Significant, CV = Coefficient of variation, $LSD_{(0.05)}$ = Least significant difference at 5% level,
DAS = Days after sowing, V_1 = BARI mash-1, V_2 = BARI mash-3,
M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

4.5 Number of nodules plant^{-1}

4.5.1 Effect of variety

Blackgram varieties showed non-significant values of number of nodules plant^{-1} at 20 and 40 DAS (Appendix VII and Fig. 9). At 20 DAS, the maximum number of nodules plant^{-1} (10.73) was recorded in V_2 variety and minimum number of nodules plant^{-1} (10.53) was found in V_1 variety. At 40 DAS, the maximum number of nodules plant^{-1} (37.03) was recorded in V_2 variety and minimum number of nodules plant^{-1} (30.81) was found in V_1 variety. Uddin *et al.* (2009) reported the similar result.

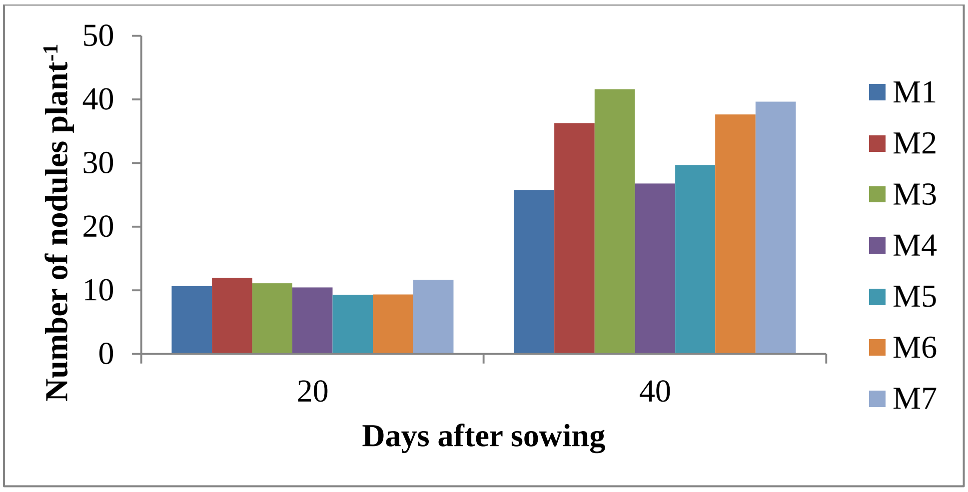


V_1 = BARI mash-1, V_2 = BARI mash-3

Figure 9. Effect of variety on the number of nodules plant^{-1} of blackgram at different days after sowing.

4.5.2 Effect of agronomic managements

The agronomic managements showed non-significant effect on number of nodules plant^{-1} of blackgram at 20 and 40 DAS (Appendix VII and Fig. 10). At 20 DAS, the maximum number of nodules plant^{-1} (11.95) was found from M_2, while the minimum number of nodules plant^{-1} (9.27) was recorded from M_5. At 40 DAS, the maximum number of nodules plant^{-1} (41.60) was found from M_3, while the minimum number of nodules plant^{-1} (25.80) was recorded from M_1. Perez-Fernandez *et al.* (2006) reported the similar finding



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M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

Figure 10. Effect of agronomic managements on the number of nodules plant^{-1} of blackgram at different days after sowing ($LSD_{(0.05)}$ = 3.940 and 17.313 at 20 and 40 DAS, respectively).

4.5.3 Interaction effect of variety and agronomic managements

Significant interaction effect between the variety and agronomic managements was observed at 20 and 40 DAS on the number of nodules plant^{-1} (Appendix VII and Table 5). At 20 DAS, the maximum number of nodules plant^{-1} was recorded in V_2M_3 (13.27) combination which was statistically similar with all interactions except V_2M_5 (7.20) and the minimum number of nodules plant^{-1} was found in V_2M_5 (7.20) combination which was statistically similar with all interaction except V_1M_1 (12.87), V_2M_2 (13.10) and V_2M_3 (13.27). At 40 DAS, the maximum number of nodules plant^{-1} was recorded in V_2M_3 (50.13) interaction which shown similarity with all combinations except V_2M_1 (24.20) and V_1M_4 (22.67), while the minimum number of nodules plant^{-1} was found in V_1M_4 (22.67) interaction which shown similarity with all combination except V_2M_3 (50.13).

Table 5. Interaction effect of variety and agronomic managements on number of nodules plant^{-1} of blackgram at different days after sowing

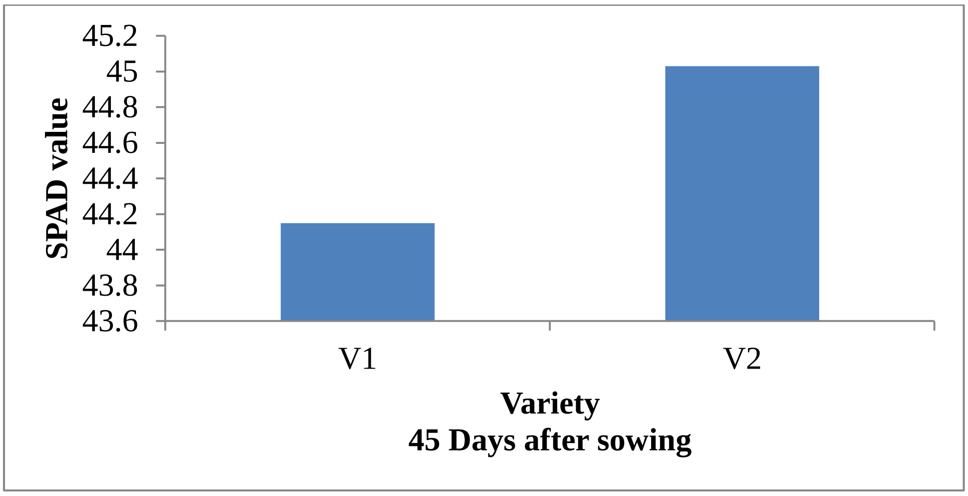
Treatment combination	Number of nodules plant^{-1} at	
	20 DAS	40 DAS
V_1M_1	12.87 a	27.40 ab
V_1M_2	10.80 ab	27.20 ab
V_1M_3	8.90 ab	33.07 ab
V_1M_4	10.27 ab	22.67 b
V_1M_5	11.33 ab	30.27 ab
V_1M_6	8.03 ab	36.07 ab
V_1M_7	11.50 ab	39.00 ab
V_2M_1	8.40 ab	24.20 b
V_2M_2	13.10 a	45.33 ab
V_2M_3	13.27 a	50.13 a
V_2M_4	10.60 ab	30.93 ab
V_2M_5	7.20 b	29.13 ab
V_2M_6	10.67 ab	39.20 ab
V_2M_7	11.87 ab	40.27 ab
$LSD_{(0.05)}$	5.572	24.484
CV (%)	31.11	42.84

In a column mean values having similar letter(s) are statistically similar
S = Significant, CV = Coefficient of variation, $LSD_{(0.05)}$ = Least significant difference at 5% level,
DAS = Days after sowing, V_1 = BARI mash-1, V_2 = BARI mash-3,
M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

4.6 SPAD value

4.6.1 Effect of variety

The SPAD value was not significantly influenced by the variety of blackgram at 45 Days after sowing (Appendix VII and Fig. 11). Though having the non-significant effect, the higher SPAD value (45.03) was found in V_2 variety and lower (44.15) was recorded in V_1 variety.

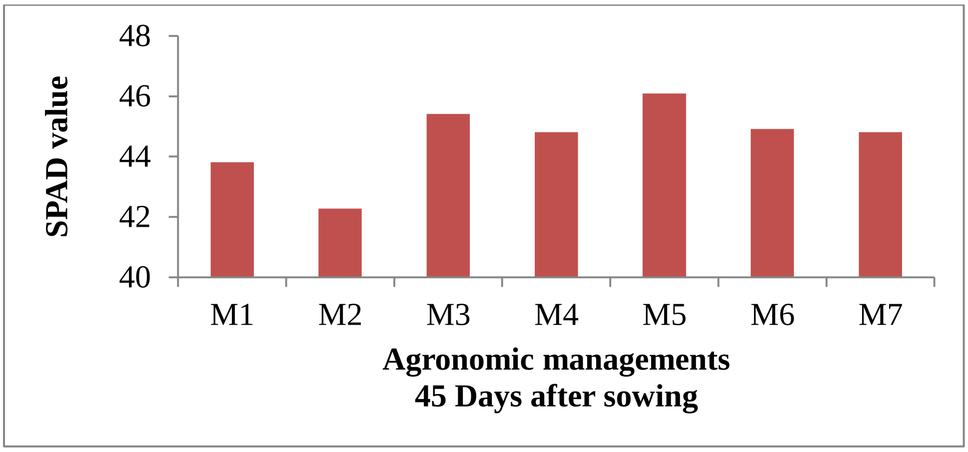


V_1 = BARI mash-1, V_2 = BARI mash-3

Figure 11. SPAD value of blackgram as influenced by variety at 45 Days after sowing.

4.6.2 Effect of agronomic managements

Agronomic managements had significant effect on SPAD value of blackgram at 45 Days after sowing (Appendix VII and Fig. 12).



M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

Figure 12. SPAD value of blackgram as influenced by agronomic managements at 45 Days after sowing.

The highest SPAD value (46.09) was produced by M_5 which was statistically similar with all treatments except M_2 (42.28) and the lowest (42.28) was produced by M_2 which was statistically similar with all treatments except M_3 (45.41) and M_5 (46.09).

4.6.3 Interaction effect of variety and agronomic managements

Interaction effect between variety and agronomic managements was found significant in SPAD value of blackgram at 45 Days after sowing (Appendix VII and Table 6). The highest SPAD value (47.99) was recorded in V_2M_5 which was statistically similar with all treatments except V_1M_2 (42.95), V_1M_1 (41.90) and V_2M_2 (41.62). The lowest SPAD value (41.62) was found in V_2M_2 which was statistically similar with all treatments except V_2M_5 (47.99).

Table 6. Interaction effect of variety and agronomic managements on SPAD value of blackgram at 45 Days after sowing

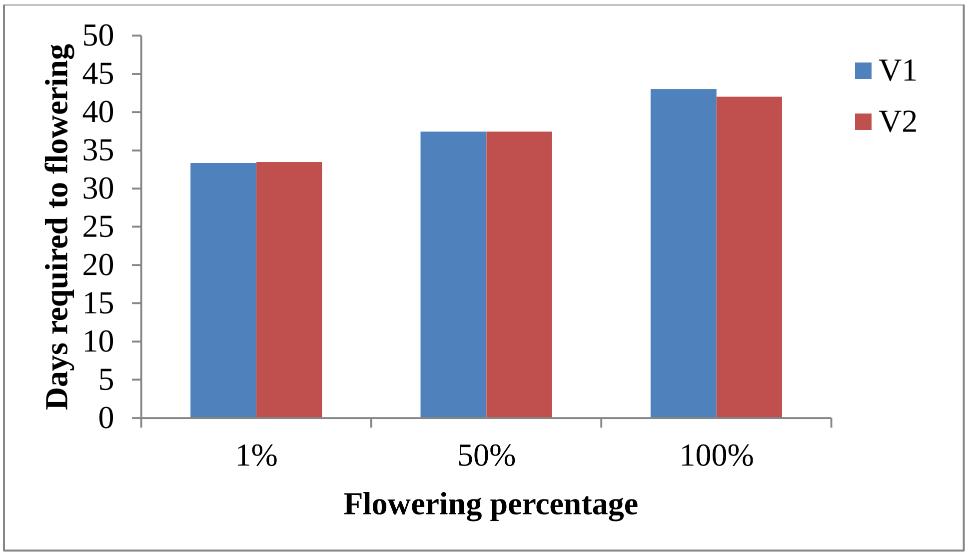
Treatment combination	SPAD value at 45 Days after sowing
V_1M_1	41.90 b
V_1M_2	42.95 b
V_1M_3	45.01 ab
V_1M_4	45.08 ab
V_1M_5	44.20 ab
V_1M_6	45.05 ab
V_1M_7	44.87 ab
V_2M_1	45.73 ab
V_2M_2	41.62 b
V_2M_3	45.81 ab
V_2M_4	44.55 ab
V_2M_5	47.99 a
V_2M_6	44.79 ab
V_2M_7	44.75 ab
$LSD_{(0.05)}$	4.267
CV (%)	5.68

In a column mean values having similar letter(s) are statistically similar
S = Significant, CV = Coefficient of variation, $LSD_{(0.05)}$ = Least significant difference at 5% level,
V_1 = BARI mash-1, V_2 = BARI mash-3, M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

4.7 Days required to flowering

4.7.1 Effect of variety

Days required to flowering of blackgram was not significantly influenced by varieties at 1% flowering & 50% flowering but significantly influenced at 100% flowering (Appendix VIII and Fig. 13). The maximum days required to 1% flowering (33.48) was in V_2 and the minimum days required to 1% flowering (33.33) in V_1. The maximum days required to 100% flowering (43.00) was in V_1 and the minimum days required to 100% flowering (42.00) in V_2.

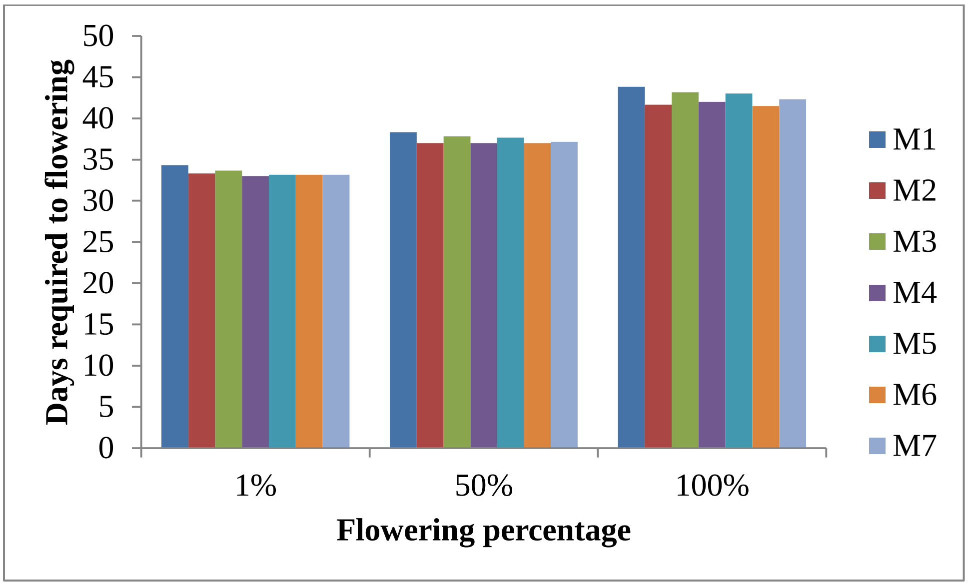


V_1 = BARI mash-1, V_2 = BARI mash-3

Figure 13. Effect of variety on the days required to flowering of blackgram.

4.7.2 Effect of agronomic managements

Agronomic managements showed significant effect on days required to flowering of blackgram at 1% flowering, 50% flowering and 100% flowering (Appendix VIII and Fig. 14). The maximum days required to 1% flowering (34.33) was by M_1 which was statistically similar to the treatment of M_3 (33.67) and the minimum days required to 1% flowering (33.00) was in M_4 which was statistically similar with all treatments except M_1 (34.33). The maximum days required to 50% flowering (38.33) was by M_1 which was statistically similar to the treatment of M_3 (37.83) and the minimum days required to 50% flowering (37.00) was in M_2, M_4 & M_6 which was statistically similar to the treatment of M_7 (37.17). The maximum days required to 100% flowering (43.83) was by M_1 which was statistically similar with all treatments except M_2 (41.67) & M_6 (41.50) and the minimum days required to 100% flowering (41.50) was in M_6 which was statistically similar with all treatments except M_1 (43.83).



M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

Figure 14. Effect of agronomic managements on the days required to flowering of blackgram.

4.7.3 Interaction effect of variety and agronomic managements

Significant interaction effect between the variety and agronomic managements was observed for days required to 1% flowering, 50% flowering and 100% flowering (Appendix VIII and Table 7). The maximum days required to 1% flowering (35.00) was obtained from the V_2M_1 interaction and the minimum days required to 1% flowering (33.00) was in V_2M_2 which was statistically similar with all the interactions except of V_2M_1 (35.00). The maximum days required to 50% flowering (38.67) was obtained from the V_1M_1 interaction which was statistically similar with V_2M_5 (38.33), V_2M_1 (38.00) & V_1M_3 (38.00) but the minimum days required to 50% flowering (37.00) was in V_1M_2, V_1M_4, V_1M_5, V_1M_6, V_2M_2, V_2M_4, V_2M_6 & V_2M_7 interactions which was statistically similar with V_1M_7 (37.33) & V_2M_3 (37.67). The maximum days required to 100% flowering (44.67) was obtained from the V_1M_7 interaction which was statistically similar with all the interactions except of V_1M_2 (41.33), V_2M_4 (41.33), V_2M_6 (40.33) and V_2M_7 (40.00) but the minimum days required to 100% flowering (40.00) was in V_2M_7 interaction which was statistically similar with V_2M_6 (40.33), V_2M_4 (41.33), V_1M_2 (41.33), V_2M_2 (42.00), V_1M_5 (42.33), V_1M_6 (42.67) & V_1M_4 (42.67).

Table 7. Interaction effect of variety and agronomic managements on the days required to flowering of blackgram

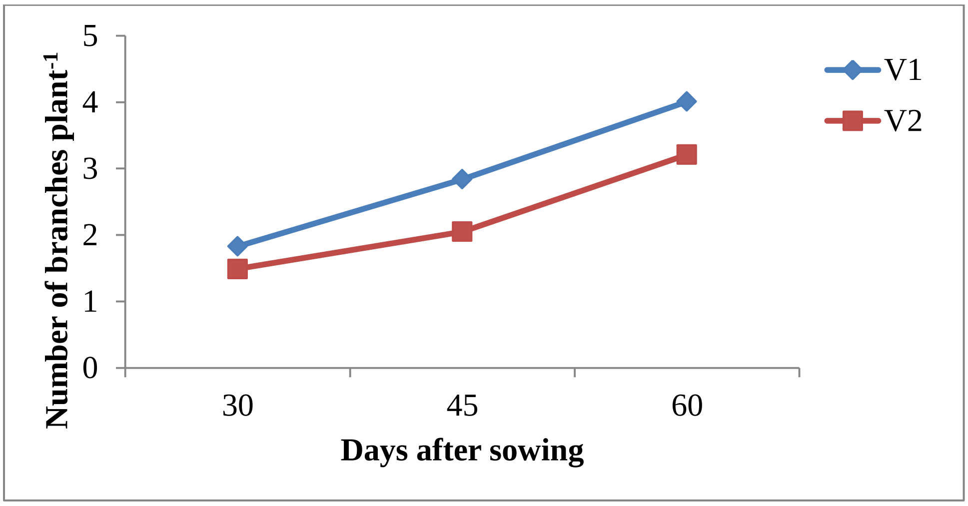
Treatment combination	Days required to flowering		
	1% Flowering	50% Flowering	100% Flowering
V_1M_1	33.67 b	38.67 a	44.33 a
V_1M_2	33.67 b	37.00 d	41.33 b-d
V_1M_3	33.67 b	38.00 a-c	43.00 a-c
V_1M_4	33.00 b	37.00 d	42.67 a-d
V_1M_5	33.00 b	37.00 d	42.33 a-d
V_1M_6	33.33 b	37.00 d	42.67 a-d
V_1M_7	33.00 b	37.33 cd	44.67 a
V_2M_1	35.00 a	38.00 a-c	43.33 ab
V_2M_2	33.00 b	37.00 d	42.00 a-d
V_2M_3	33.67 b	37.67 b-d	43.33 ab
V_2M_4	33.00 b	37.00 d	41.33 b-d
V_2M_5	33.33 b	38.33 ab	43.67 ab
V_2M_6	33.00 b	37.00 d	40.33 cd
V_2M_7	33.33 b	37.00 d	40.00 d
$LSD_{(0.05)}$	0.984	0.907	2.934
CV (%)	1.75	1.48	4.1

In a column mean values having similar letter(s) are statistically similar
S = Significant, CV = Coefficient of variation, $LSD_{(0.05)}$ = Least significant difference at 5% level,
V_1 = BARI mash-1, V_2 = BARI mash-3,
M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

4.8 Number of branches plant^{-1}

4.8.1 Effect of variety

Number of branches plant^{-1} of blackgram variety showed significant variation at 60 DAS but non-significant variation at 30 and 45 DAS (Appendix IX and Fig. 15). At 30 DAS, maximum number of branches plant^{-1} (1.83) was recorded in V_1 (BARI mash-1) and the minimum number of branches plant^{-1} (1.49) was found in V_2 (BARI mash-3). At 45 DAS, maximum number of branches plant^{-1} (2.84) was observed in V_1 (BARI mash-1) and the minimum number of branches plant^{-1} (2.05) was found in V_2 (BARI mash-3). At 60 DAS, maximum number of branches plant^{-1} (4.01) was recorded in V_1 (BARI mash-1) and the minimum number of branches plant^{-1} (3.21) was found in V_2 (BARI mash-3). The variation in the production of branches plant^{-1} might be due to genetic constituents of the crop. The result has conformity with the findings of Ghosh (2007) who observed varieties differ significantly in respect of number of branches plant^{-1}. He found the higher number of branches plant^{-1} in Sona mung and the lower in BARI Mung-6.

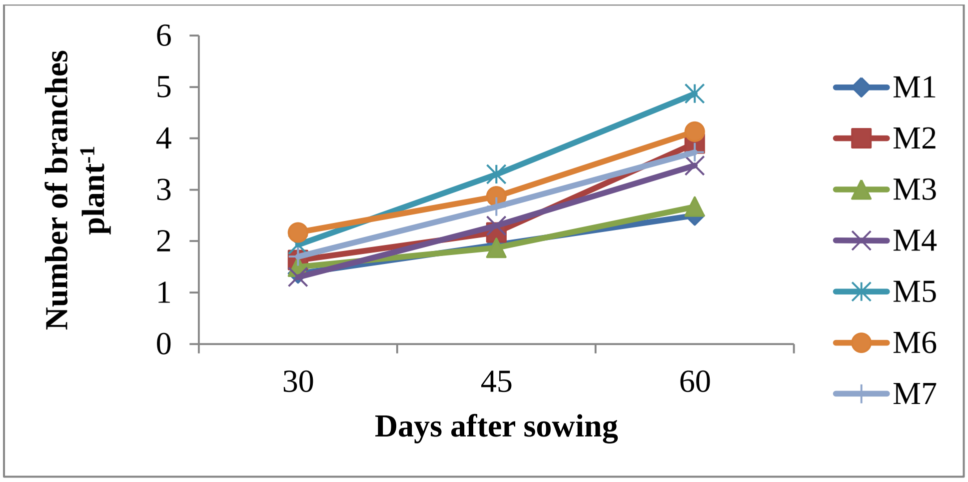


V_1 = BARI mash-1, V_2 = BARI mash-3

Figure 15. Effect of variety on number of branches plant^{-1} of blackgram ($LSD_{(0.05)}$ at 60 DAS = 0.620).

4.8.2 Effect of agronomic managements

Agronomic managements showed significant variation for number of branches plant^{-1} at 30, 45 and 60 DAS (Appendix IX and Fig. 16). At 30 DAS, the maximum number of branches plant^{-1} (2.17) was obtained from M_6 which was statistically similar with M_5 (1.93), M_7 (1.70) and M_2 (1.63) treatment, while the minimum number (1.30) was recorded from M_4 which was statistically similar with all treatment except M_5 (1.93) and M_6 (2.17). At 45 DAS, the maximum number of branches plant^{-1} (3.30) was recorded from M_5 which was statistically similar with M_6 (2.87) and M_7 (2.67) treatment, while the minimum number (1.87) was found from M_3 which was statistically similar with M_1 (1.93), M_2 (2.17) and M_4 (2.30) treatment. At 60 DAS, the maximum number of branches plant^{-1} (4.87) was obtained from M_5 which was statistically similar with M_6 (4.13) treatment, while the minimum number (2.50) was recorded from M_1 which was statistically similar with M_3 (2.67) treatment. Hossain *et al.* (2014) and Malik *et al.* (2014) reported the similar finding.



M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

Figure 16. Effect of agronomic managements on number of branches plant^{-1} of blackgram at different days after sowing ($LSD_{(0.05)}$ = 0.585, 0.792 and 0.851 at 30, 45 and 60 DAS, respectively).

4.8.3 Interaction effect of variety and agronomic managements

Interaction effect of variety and agronomic managements showed significant effect on number of branches plant^{-1} of blackgram at 30, 45 and 60 DAS (Appendix IX and Table 8). At 30 DAS, the maximum number of branches plant^{-1} (2.47) was recorded in V_1M_6 which was statistically similar with all interaction except V_2M_4 (1.40), V_2M_3 (1.33), V_2M_2 (1.33), V_1M_4 (1.20) & V_2M_1 (1.07) and the minimum number of branches (1.07) recorded in V_2M_1 which was statistically similar with all interaction except V_1M_2 (1.93), V_1M_5 (1.93), V_2M_5 (1.93) & V_1M_6 (2.47). At 45 DAS, the maximum number of branches plant^{-1} (3.93) was obtained from V_1M_5 which was statistically similar with the interaction of V_1M_6 (3.27) & V_1M_7 (2.93), whereas the minimum number of branches plant^{-1} (1.27) from V_2M_3 which was statistically similar with the interaction of V_2M_1 (1.60), V_2M_4 (1.93), V_2M_2 (2.00), V_1M_1 (2.27) & V_1M_2 (2.33). At 60 DAS, the maximum number of branches plant^{-1} (5.33) was attained from V_1M_5 which was statistically similar with the interaction of V_1M_6 (4.47), V_1M_2 (4.40) & V_2M_5 (4.40), whereas the minimum number of branches plant^{-1} (2.13) from V_2M_1 which was statistically similar with the interaction of V_2M_3 (2.20), V_1M_1 (2.87), V_1M_3 (3.13) & V_2M_4 (3.13). Shah *et al.* (1994) noted that the plant height at 45 days after sowing and at harvest number of primary branches per plant in blackgram showed significant response to application of 30 kg and 60 kg P_2O_5 per ha as compared to the control.

Table 8. Interaction effect of variety and agronomic managements on number of branches plant^{-1} of blackgram at different days after sowing

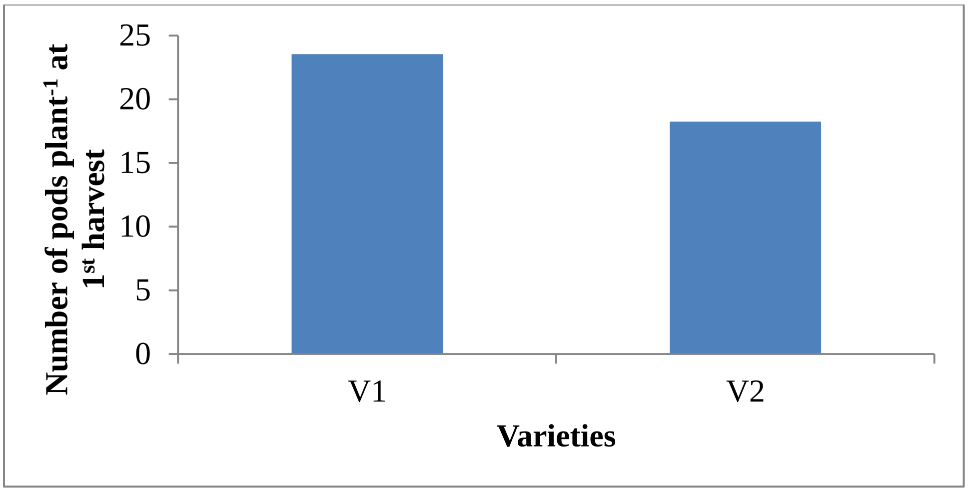
Treatment combination	Number of branches plant^{-1} at		
	30 DAS	45 DAS	60 DAS
V_1M_1	1.67 a-c	2.27 b-e	2.87 c-e
V_1M_2	1.93 ab	2.33 b-e	4.40 a
V_1M_3	1.87 a-c	2.47 b-d	3.13 c-e
V_1M_4	1.20 bc	2.67 b-d	3.80 bc
V_1M_5	1.93 ab	3.93 a	5.33 a
V_1M_6	2.47 a	3.27 ab	4.47 ab
V_1M_7	1.73 a-c	2.93 a-c	4.07 bc
V_2M_1	1.07 c	1.60 de	2.13 e
V_2M_2	1.33 bc	2.00 c-e	3.40 b-d
V_2M_3	1.33 bc	1.27 e	2.20 de
V_2M_4	1.40 bc	1.93 c-e	3.13 c-e
V_2M_5	1.93 ab	2.67 b-d	4.40 ab
V_2M_6	1.87 a-c	2.47 b-d	3.80 bc
V_2M_7	1.67 a-c	2.40 b-d	3.40 b-d
$LSD_{(0.05)}$	0.827	1.110	1.204
CV (%)	29.62	27.2	19.79

In a column mean values having similar letter(s) are statistically similar
S = Significant, CV = Coefficient of variation, $LSD_{(0.05)}$ = Least significant difference at 5% level,
DAS = Days after sowing, V_1 = BARI mash-1, V_2 = BARI mash-3, M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

4.9 Number of pods plant^{-1} at 1st harvest

4.9.1 Effect of variety

The number of pods plant^{-1} at 1st harvest was significantly influenced by variety (Appendix X and Fig. 17). Results showed that, the V_1 produced highest number of pods plant^{-1} at 1st harvest (23.55) whereas the lowest number of pods plant^{-1} at 1st harvest was obtained from V_2 (18.23). Ghosh (2007) reported the similar finding.

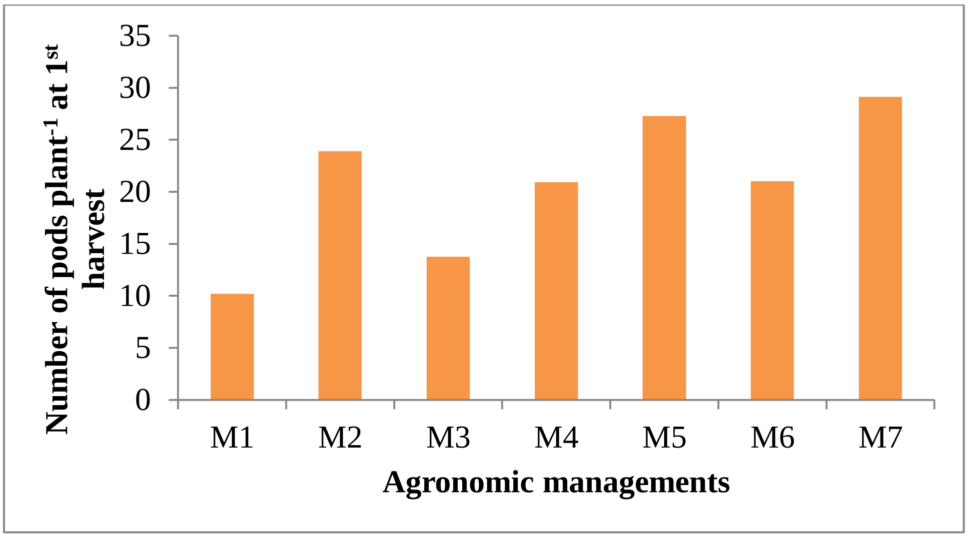


V_1 = BARI mash-1, V_2 = BARI mash-3

Figure 17. Effect of variety on number of pods plant^{-1} at 1st harvest of blackgram ($LSD_{(0.05)}$ = 3.860).

4.9.2 Effect of agronomic managements

The number of pods plant^{-1} at 1st harvest was significantly influenced by agronomic managements (Appendix X and Fig. 18). The highest number of pods plant^{-1} at 1st harvest (29.13) was obtained from the M_7 treatment which was statistically similar with M_5 (27.30) & M_2 (23.90) while the lowest number of pods plant^{-1} at 1st harvest (10.20) was found from the M_1 treatment which was statistically similar with M_3 (13.77). Sultana *et al.* (2009) reported the similar finding.



M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

Figure 18. Effect of agronomic managements on number of pods plant^{-1} at 1st harvest of blackgram ($LSD_{(0.05)}$ = 8.084).

4.9.3 Interaction effect of variety and agronomic managements

The interaction of variety and agronomic managements had significant effect on the number of pods plant^{-1} at 1st harvest (Appendix X and Table 9). The highest number of pods plant^{-1} at 1st harvest (29.73) was found from the V_1M_5 which shown similarity with all interaction except V_2M_6 (17.33), V_2M_4 (15.80), V_2M_1 (11.67), V_2M_3 (9.20) and V_1M_1 (8.73). The lowest number of pods plant^{-1} at 1st harvest (8.73) was obtained from V_1M_1 which shown similarity with the interaction of V_2M_3 (9.20), V_2M_1 (11.67), V_2M_4 (15.80), V_2M_6 (17.33), V_1M_3 (18.33), V_2M_2 (19.60).

Table 9. Interaction effect of variety and agronomic managements on number of pods plant^{-1} at 1st harvest of blackgram

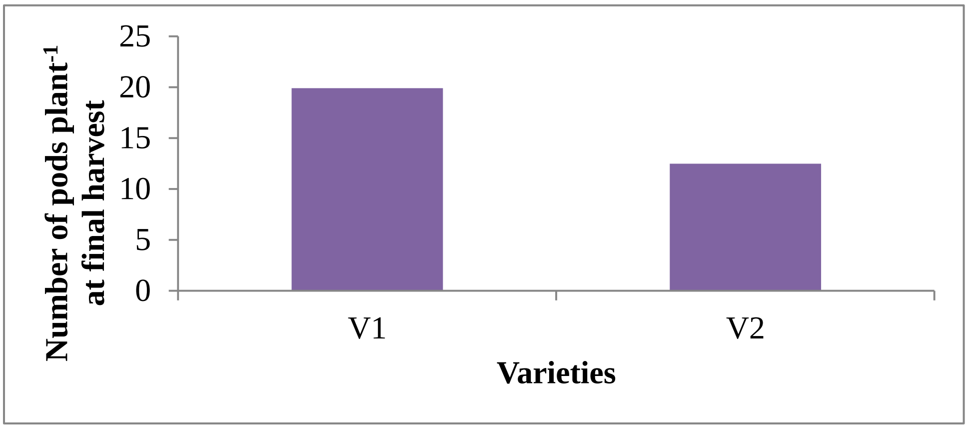
Treatment combination	Number of pods plant^{-1} at 1st harvest
V_1M_1	8.73 d
V_1M_2	28.20 ab
V_1M_3	18.33 a-d
V_1M_4	26.07 a-c
V_1M_5	29.73 a
V_1M_6	24.67 a-c
V_1M_7	29.13 a
V_2M_1	11.67 d
V_2M_2	19.60 a-d
V_2M_3	9.20 d
V_2M_4	15.80 cd
V_2M_5	24.87 a-c
V_2M_6	17.33 b-d
V_2M_7	29.13 a
$LSD_{(0.05)}$	11.433
CV (%)	32.48

In a column mean values having similar letter(s) are statistically similar
S = Significant, CV = Coefficient of variation, $LSD_{(0.05)}$ = Least significant difference at 5% level,
V_1 = BARI mash-1, V_2 = BARI mash-3,
M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

4.10 Number of pods plant^{-1} at final harvest

4.10.1 Effect of variety

The number of pods plant^{-1} at final harvest was not significantly influenced by variety (Appendix X and Fig. 19). The V_1 produced highest number of pods plant^{-1} at final harvest (19.92) whereas the lowest number of pods plant^{-1} at final harvest was found from V_2 (12.48).

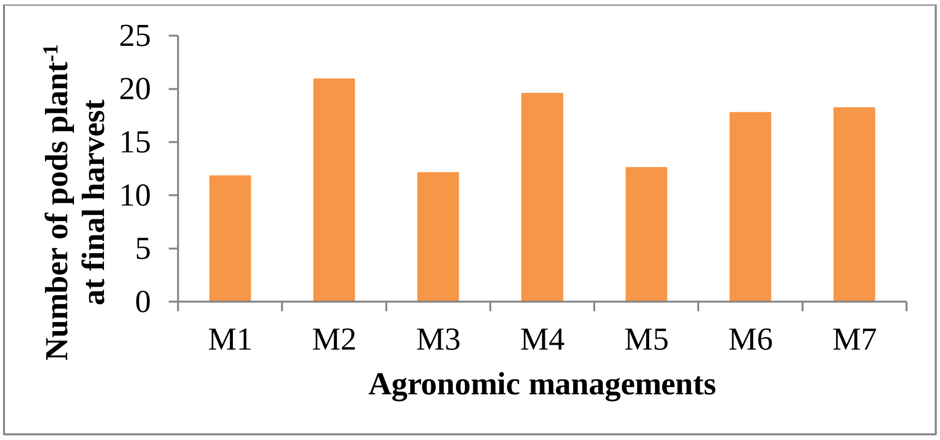


V_1 = BARI mash-1, V_2 = BARI mash-3

Figure 19. Effect of variety on number of pods plant^{-1} at final harvest of blackgram ($LSD_{(0.05)}$ = 12.930).

4.10.2 Effect of agronomic managements

The number of pods plant^{-1} at final harvest was significantly influenced by agronomic managements (Appendix X and Fig. 20).



M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

Figure 20. Effect of agronomic managements on number of pods plant^{-1} at final harvest of blackgram ($LSD_{(0.05)}$ = 7.097).

The highest number of pods plant^{-1} at final harvest (20.97) was found from the M_2 treatment which was statistically similar with M_4 (19.63), M_7 (18.27) & M_6 (17.83), while the lowest number of pods plant^{-1} at final harvest (11.87) was obtained from the M_1 treatment which was statistically similar with all treatment except M_4 (19.63) & M_2 (20.97). Yaqub *et al.* (2010) reported the similar finding.

4.10.3 Interaction effect of variety and agronomic managements

The interaction of variety and agronomic managements had significant effect on the number of pods plant^{-1} at final harvest (Appendix X and Table 10).

Table 10. Interaction effect of variety and agronomic managements on number of pods plant^{-1} at final harvest of blackgram

Treatment combination	Number of pods plant^{-1} at final harvest
V_1M_1	13.93 bc
V_1M_2	21.27 ab
V_1M_3	15.13 bc
V_1M_4	23.47 ab
V_1M_5	17.47 a-c
V_1M_6	25.27 a
V_1M_7	22.93 ab
V_2M_1	9.80 c
V_2M_2	20.67 ab
V_2M_3	9.20 c
V_2M_4	15.80 a-c
V_2M_5	7.87 c
V_2M_6	10.40 c
V_2M_7	13.60 bc
$LSD_{(0.05)}$	10.036
CV (%)	36.76

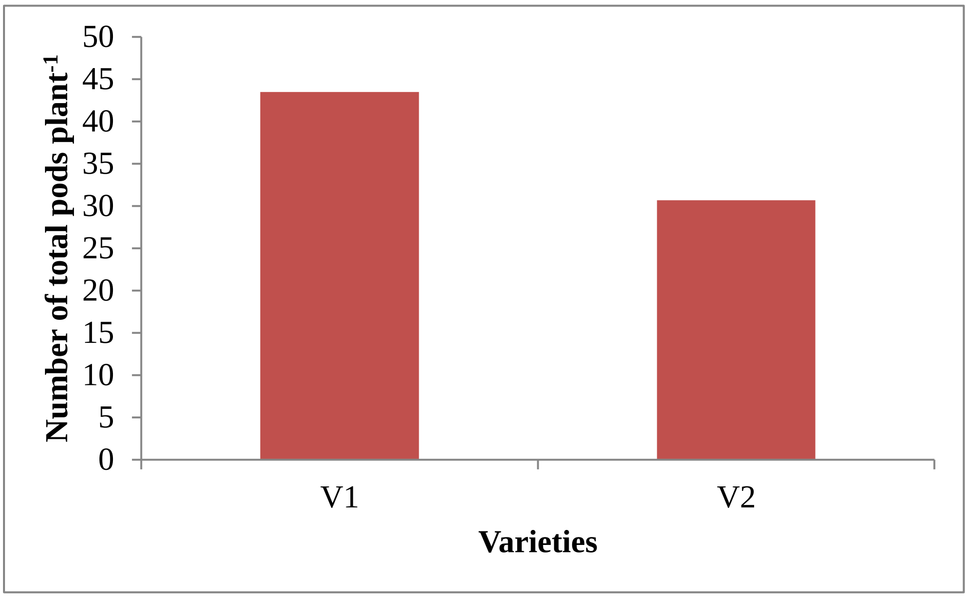
In a column mean values having similar letter(s) are statistically similar
S = Significant, CV = Coefficient of variation, $LSD_{(0.05)}$ = Least significant difference at 5% level,
V_1 = BARI mash-1, V_2 = BARI mash-3,
M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

The highest number of pods plant^{-1} at final harvest (25.27) was obtained from the V_1M_6 which shown similarity with the interaction of V_1M_4 (23.47), V_1M_7 (22.93), V_1M_2 (21.27), V_2M_2 (20.67), V_1M_5 (17.47) and V_2M_4 (15.80). The lowest number of pods plant^{-1} at final harvest (7.87) was found from V_2M_5 which was statistically similar with all interaction except V_2M_2 (20.67), V_1M_2 (21.27), V_1M_7 (22.93), V_1M_4 (23.47) and V_1M_6 (25.27).

4.11 Number of total pods plant^{-1}

4.11.1 Effect of variety

The number of total pods plant^{-1} was significantly influenced by variety (Appendix X and Fig. 21). The highest number of total pods plant^{-1} (43.48) was found in V_1 and the lowest number of total pods plant^{-1} (30.70) was recorded in V_2. Masood and Meena (1986) reported that number of pods plant^{-1} varied significantly with genotypes. Islam (1983), Haque *et al*. (2002) also opined that pods plant^{-1} as a useful agronomic character contributing to higher yield of mungbean and there was a significant positive correlation between the number of pods plant^{-1} and yield plant^{-1}.

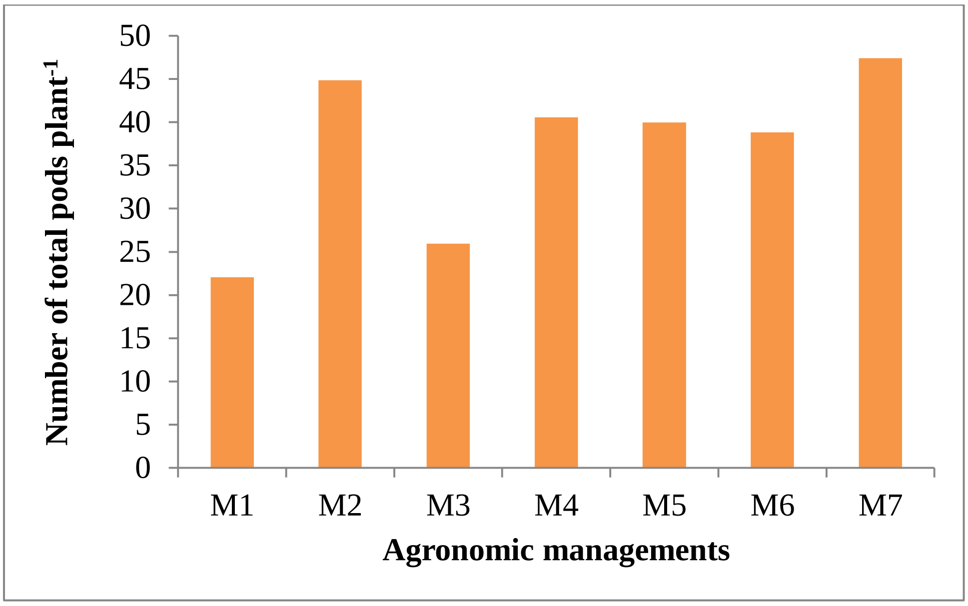


V_1 = BARI mash-1, V_2 = BARI mash-3

Figure 21. Effect of variety on number of total pods plant^{-1} of blackgram ($LSD_{(0.05)}$ = 9.390).

4.11.2 Effect of agronomic managements

The number of total pods plant^{-1} was significantly influenced by agronomic managements (Appendix X and Fig. 22). The highest number of total pods plant^{-1} (47.40) was obtained from the M_7 treatment which was statistically similar with all treatment except M_3 (25.93) & M_1 (22.07), while the lowest number of total pods plant^{-1} (22.07) was found from the M_1 treatment which was statistically similar with M_3 (25.93).



M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

Figure 22. Effect of agronomic managements on number of total pods plant^{-1} of blackgram ($LSD_{(0.05)}$ = 11.834).

4.11.3 Interaction effect of variety and agronomic managements

The interaction of variety and agronomic managements had significant effect on the number of total pods plant^{-1} (Appendix X and Table 11). The highest number of total pods plant^{-1} (52.07) was found from the V_1M_7 which shown similarity with the interaction of V_1M_6 (49.93), V_1M_4 (49.53), V_1M_2 (49.47), V_1M_5 (47.20), V_2M_7 (42.73) and V_2M_2 (40.27). The lowest number of total pods plant^{-1} (18.40) was obtained from V_2M_3 which was statistically similar with the interaction of V_2M_1 (21.47), V_1M_1 (22.67), V_2M_6 (27.73), V_2M_4 (31.60), V_2M_5 (32.73) and V_1M_3 (33.47). Kudikeri *et al*. (1973) revealed that phosphorus has also been reported to increase the number of leaves and fruits per plant as well as earliness in flowering and yield.

Table 11. Interaction effect of variety and agronomic managements on number of total pods $plant^{-1}$ of blackgram

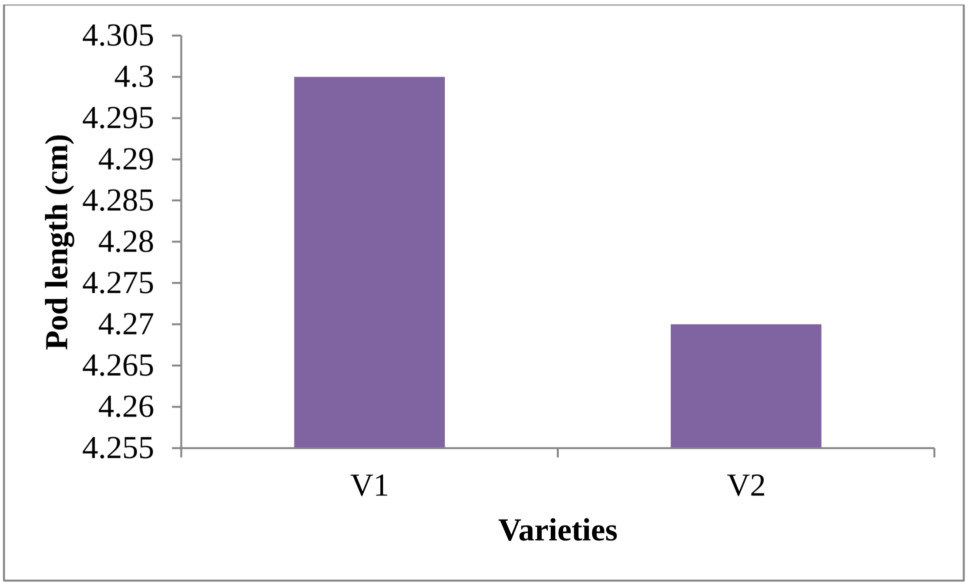
Treatment combination	Number of total pods $plant^{-1}$
V_1M_1	22.67 f
V_1M_2	49.47 a-c
V_1M_3	33.47 b-f
V_1M_4	49.53 ab
V_1M_5	47.20 a-d
V_1M_6	49.93 ab
V_1M_7	52.07 a
V_2M_1	21.47 f
V_2M_2	40.27 a-e
V_2M_3	18.40 f
V_2M_4	31.60 d-f
V_2M_5	32.73 c-f
V_2M_6	27.73 ef
V_2M_7	42.73 a-e
$LSD_{(0.05)}$	16.735
CV (%)	26.23

In a column mean values having similar letter(s) are statistically similar
S = Significant, CV = Coefficient of variation, $LSD_{(0.05)}$ = Least significant difference at 5% level,
V_1 = BARI mash-1, V_2 = BARI mash-3,
M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

4.12 Pod length

4.12.1 Effect of variety

Variety did not affect significantly on the pod length (cm) (Appendix XI and Fig. 23). The longest pod length (4.30 cm) was observed from V_1 and the shortest pod length (4.27 cm) was found in V_2. Sarkar *et al.* (2004) reported the similar finding.

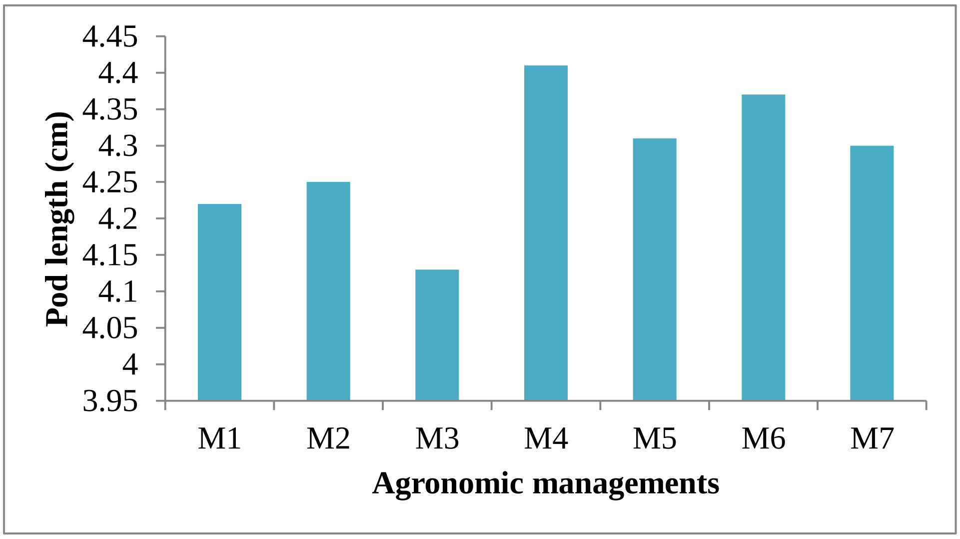


V_1 = BARI mash-1, V_2 = BARI mash-3

Figure 23. Effect of variety on pod length of blackgram ($LSD_{(0.05)}$ = 0.280).

4.12.2 Effect of agronomic managements

There was significant difference observed in pod length (cm) due to different agronomic managements (Appendix XI and Fig. 24).



M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

Figure 24. Effect of agronomic managements on pod length of blackgram ($LSD_{(0.05)}$ = 0.258).

Result revealed that, the longest pod (4.41 cm) was produced by M_4 treatment which was statistically similar with all treatment except M_3 (4.13 cm) while the shortest pod (4.13 cm) was produced by treatment M_3 which was statistically similar with all treatment except M_4 (4.41 cm).

4.12.3 Interaction effect of variety and agronomic managements

Interaction effect of variety and agronomic managements showed significant differences on pod length (Appendix XI and Table 12). The longest pod (4.44 cm) was obtained from the V_2M_4 interaction which was statistically similar with all interaction except V_2M_3 (4.02), while the shortest pod (4.02 cm) was attained from the V_2M_3 interaction which shown similarity with all interaction except V_2M_6 (4.39), V_2M_7 (4.40) and V_2M_4 (4.44).

Table 12. Interaction effect of variety and agronomic managements on pod length of blackgram

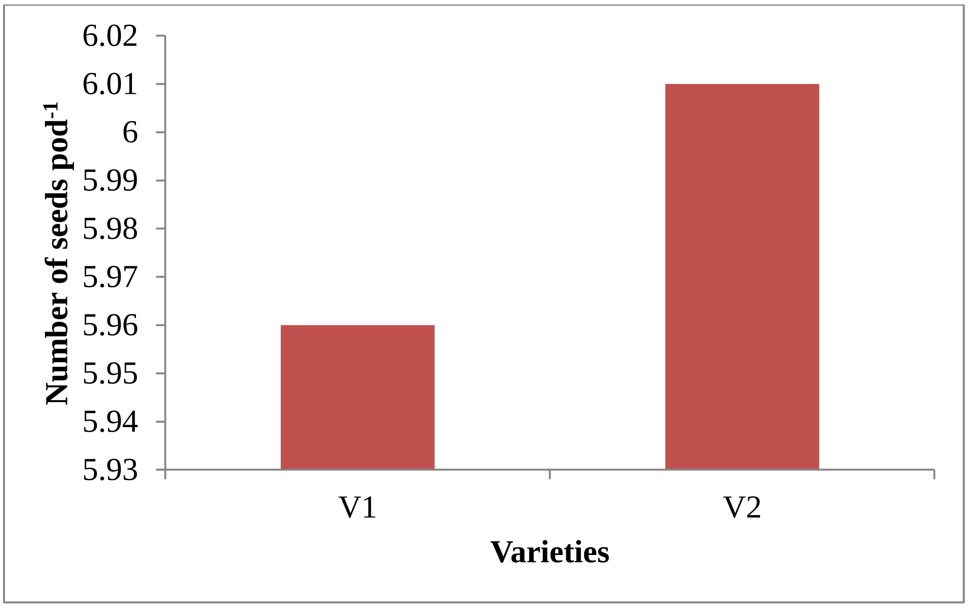
Treatment combination	Pod length (cm)
V_1M_1	4.29 ab
V_1M_2	4.34 ab
V_1M_3	4.24 ab
V_1M_4	4.38 ab
V_1M_5	4.28 ab
V_1M_6	4.36 ab
V_1M_7	4.20 ab
V_2M_1	4.16 ab
V_2M_2	4.16 ab
V_2M_3	4.02 b
V_2M_4	4.44 a
V_2M_5	4.34 ab
V_2M_6	4.39 a
V_2M_7	4.40 a
$LSD_{(0.05)}$	0.365
CV (%)	5.05

In a column mean values having similar letter(s) are statistically similar
S = Significant, CV = Coefficient of variation, $LSD_{(0.05)}$ = Least significant difference at 5% level,
V_1 = BARI mash-1, V_2 = BARI mash-3,
M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

4.13 Number of seeds pod^{-1}

4.13.1 Effect of variety

The number of seeds pod^{-1} was not significantly influenced by the variety (Appendix XI and Fig. 25). The V_2 produced the higher number of seeds pod^{-1} (6.01) and the V_1 produced the lower number of seeds pod^{-1} (5.96). The result support the findings of Ghosh (2007) who found that number of seeds pod^{-1} did not differ significantly between BARI mung-6 and Sona mung.

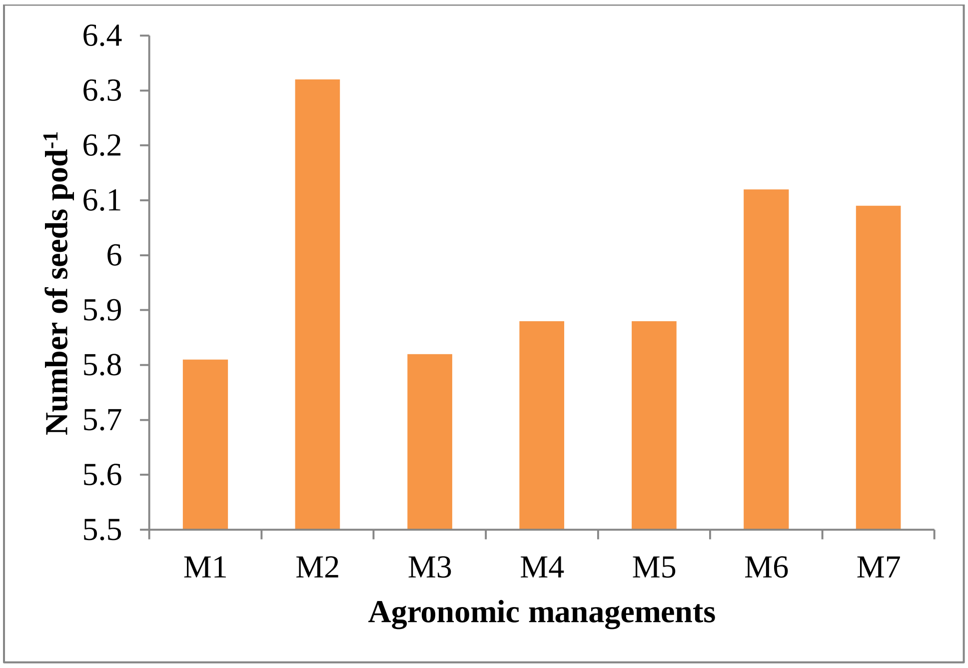


V_1 = BARI mash-1, V_2 = BARI mash-3

Figure 25. Effect of variety on number of seeds pod^{-1} of blackgram ($LSD_{(0.05)}$ = 1.070).

4.13.2 Effect of agronomic managements

Agronomic managements showed significant effect on number of seeds pod^{-1} (Appendix XI and Fig. 26). The highest number of seeds pod^{-1} (6.32) was obtained from the M_2 treatment which was statistically similar with all interaction except M_3 (5.82) & M_1 (5.81). The lowest number of seeds pod^{-1} (5.81) was recorded from the M_1 which was statistically similar with all interaction except M_2 (6.32).



M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

Figure 26. Effect of agronomic managements on number of seeds pod^{-1} of blackgram ($LSD_{(0.05)}$ = 0.464).

4.13.3 Interaction effect of variety and agronomic managements

The number of seeds pod^{-1} was not significantly influenced by the interaction effect of variety and agronomic managements (Appendix XI and Table 13). The highest number of seeds pod^{-1} (6.33) was observed from the V_1M_2 interaction which was statistically similar with all interaction.

Table 13. Interaction effect of variety and agronomic managements on number of seeds pod^{-1} of blackgram

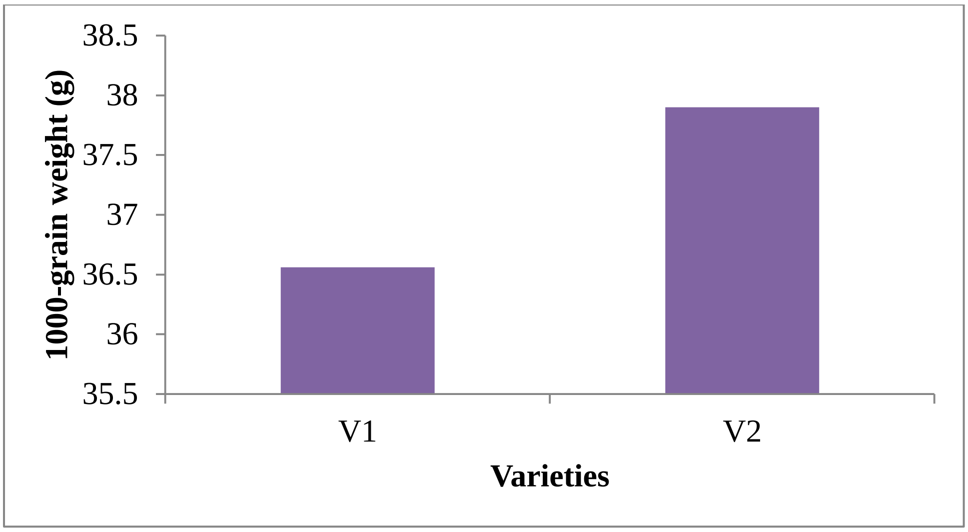
Treatment combination	Number of seeds pod^{-1}
V_1M_1	5.72
V_1M_2	6.33
V_1M_3	5.93
V_1M_4	5.75
V_1M_5	5.97
V_1M_6	5.93
V_1M_7	6.10
V_2M_1	5.90
V_2M_2	6.30
V_2M_3	5.70
V_2M_4	6.02
V_2M_5	5.80
V_2M_6	6.30
V_2M_7	6.08
$LSD_{(0.05)}$	0.657
CV (%)	6.51

In a column mean values having similar letter(s) are statistically similar
NS = Not significant, CV = Coefficient of variation, $LSD_{(0.05)}$ = Least significant difference at 5% level,
V_1 = BARI mash-1, V_2 = BARI mash-3,
M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

4.14 1000-grain weight

4.14.1 Effect of variety

The 1000-grain weight of blackgram was not varied significantly for the varieties (Appendix XI and Figure 27). The highest weight of 1000-grain (37.90 g) was obtained in V_2 and lowest weight of 1000-grain (36.56 g) was found in V_1. Sarkar and Banik (1991); Katial and Shah (1998) and Raj and Tripathi (2005) reported the similar finding.

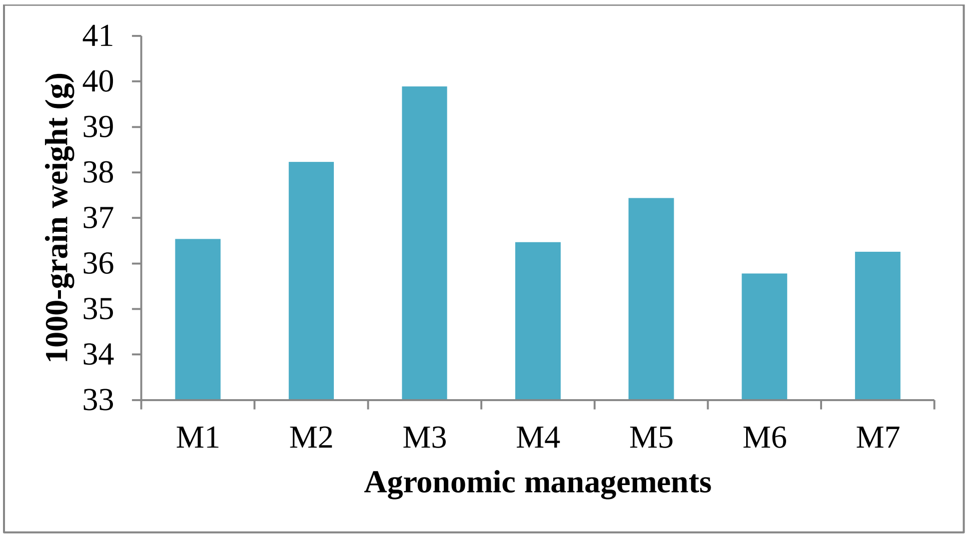


V_1 = BARI mash-1, V_2 = BARI mash-3

Figure 27. Effect of variety on 1000-grain weight of blackgram ($LSD_{(0.05)}$ = 1.920).

4.14.2 Effect of agronomic managements

There was no significant variation was observed on the weight of 1000-grain due to agronomic managements (Appendix XI and Fig. 28). The highest weight of 1000-grain (39.89 g) was observed from M_3, while the lowest weight of 1000-grain (36.47 g) was found from M_4.



M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

Figure 28. Effect of agronomic managements on 1000-grain weight of blackgram ($LSD_{(0.05)}$ = 6.795).

4.14.3 Interaction effect of variety and agronomic managements

Interaction effect between variety and agronomic managements was not found significant in respect of 1000-grain weight (Appendix XI and Table 14). The highest weight of 1000 grain (42.58 g) was produced by V_2M_2 which was statistically similar with all interaction.

Table 14. Interaction effect of variety and agronomic managements on 1000-grain weight of blackgram

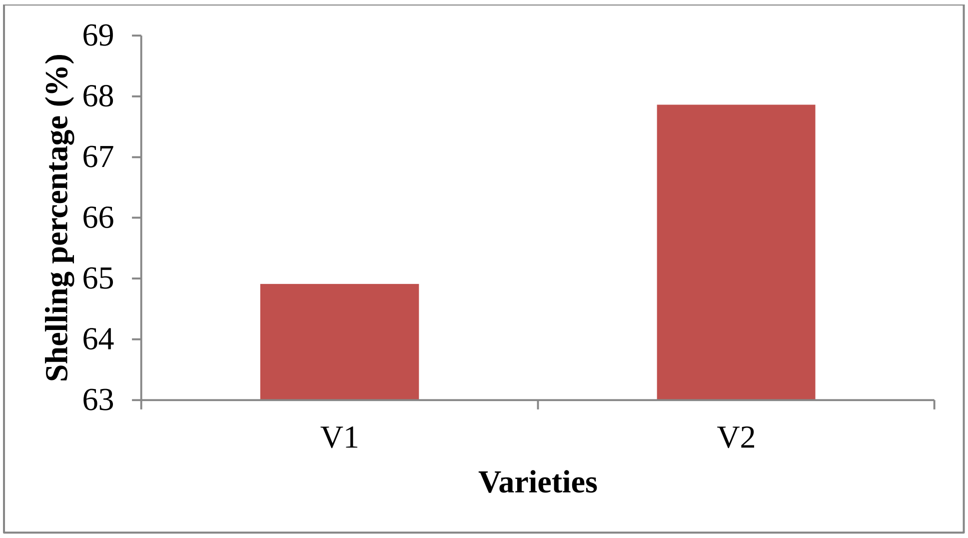
Treatment combination	1000-grain weight (g)
V_1M_1	35.59
V_1M_2	33.88
V_1M_3	39.39
V_1M_4	34.78
V_1M_5	38.39
V_1M_6	35.04
V_1M_7	38.87
V_2M_1	37.49
V_2M_2	42.58
V_2M_3	40.38
V_2M_4	38.15
V_2M_5	36.50
V_2M_6	36.53
V_2M_7	33.65
$LSD_{(0.05)}$	9.609
CV (%)	15.32

In a column mean values having similar letter(s) are statistically similar
NS = Not significant, CV = Coefficient of variation, $LSD_{(0.05)}$ = Least significant difference at 5% level,
V_1 = BARI mash-1, V_2 = BARI mash-3,
M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

4.15 Shelling percentage

4.15.1 Effect of variety

The shelling percentage was not significantly influenced by the variety (Appendix XI and Fig. 29). The highest shelling percentage (67.86%) was observed in the V_2 and the lowest shelling percentage (64.91%) obtained from V_1.

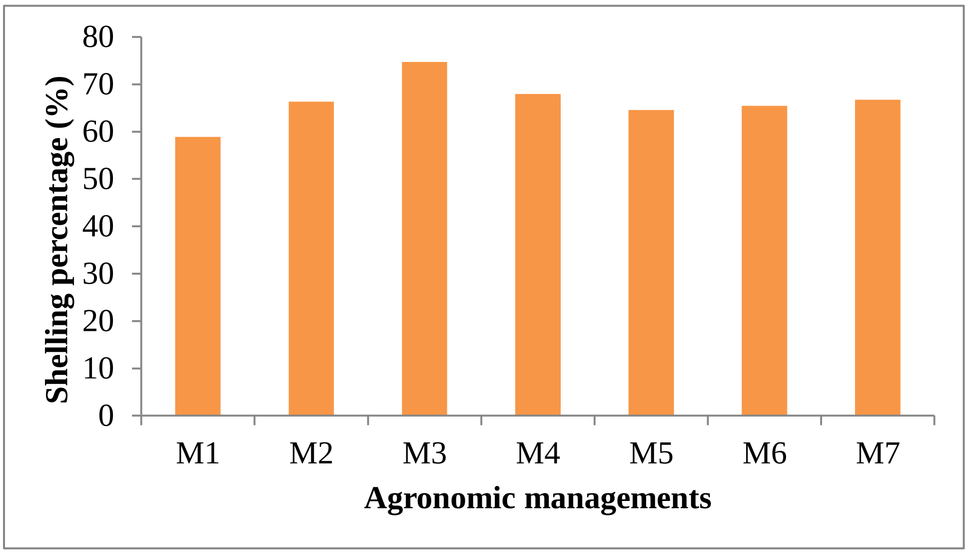


V_1 = BARI mash-1, V_2 = BARI mash-3

Figure 29. Effect of variety on shelling percentage of blackgram ($LSD_{(0.05)}$ = 31.780).

4.15.2 Effect of agronomic managements

Agronomic managements had no significant effect on shelling percentage (Appendix XI and Fig. 30). The numerically highest shelling percentage (74.75%) was recorded in M_3 and the lowest shelling percentage (58.87%) was obtained from M_1.



M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

Figure 30. Effect of agronomic managements on shelling percentage of blackgram ($LSD_{(0.05)}$ = 15.947).

4.15.3 Interaction effect of variety and agronomic managements

Interaction effect between variety and agronomic managements was found significant in respect of shelling percentage (Appendix XI and Table 15). The highest shelling percentage (83.51%) was observed in V_2M_3 which was similar with all the interactions except V_2M_1 (59.34%) and V_1M_1 (58.40%). The lowest shelling percentage (58.40%) was obtained from V_1M_1 which were similar with all the interactions except V_2M_3 (83.51%).

Table 15. Interaction effect of variety and agronomic managements on shelling percentage of blackgram

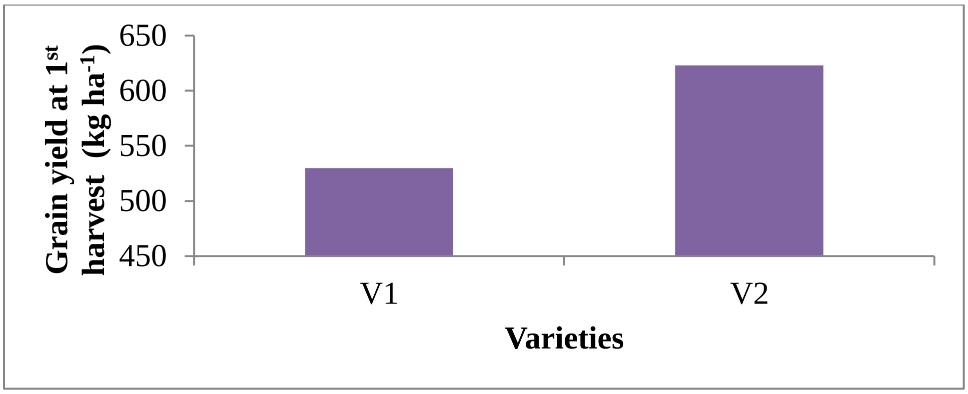
Treatment combination	Shelling percentage (%)
V_1M_1	58.40 b
V_1M_2	65.42 ab
V_1M_3	65.98 ab
V_1M_4	69.50 ab
V_1M_5	63.74 ab
V_1M_6	65.86 ab
V_1M_7	65.46 ab
V_2M_1	59.34 b
V_2M_2	67.21 ab
V_2M_3	83.51 a
V_2M_4	66.38 ab
V_2M_5	65.45 ab
V_2M_6	65.10 ab
V_2M_7	68.05 ab
$LSD_{(0.05)}$	22.552
CV (%)	20.16

In a column mean values having similar letter(s) are statistically similar
S = Significant, CV = Coefficient of variation, $LSD_{(0.05)}$ = Least significant difference at 5% level,
V_1 = BARI mash-1, V_2 = BARI mash-3,
M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

4.16 Grain yield at 1st harvest

4.16.1 Effect of variety

The grain yield at 1st harvest of blackgram was not significantly influenced by the variety (Appendix XII and Fig. 31). Although having non-significant between the varieties, the maximum grain yield at 1st harvest (622.87 kg ha^{-1}) was found in V_2 and minimum (529.89 kg ha^{-1}) was recorded in V_1. Uddin *et al*. (2009) reported the similar finding.

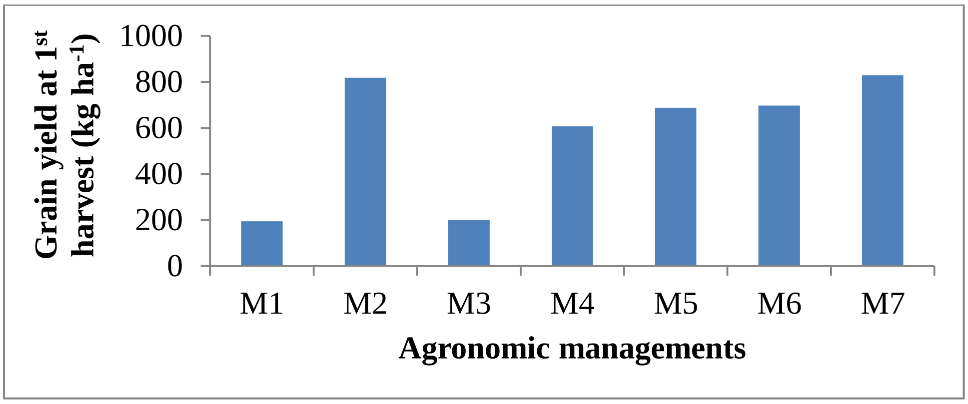


V_1 = BARI mash-1, V_2 = BARI mash-3

Figure 31. Effect of variety on grain yield at 1st harvest of blackgram ($LSD_{(0.05)}$ = 156.930).

4.16.2 Effect of agronomic managements

Agronomic managements had significant effect on the grain yield at 1st harvest of blackgram (Appendix XII and Fig. 32).



M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

Figure 32. Effect of agronomic managements on grain yield at 1st harvest of Blackgram ($LSD_{(0.05)}$ = 184.200).

The M_7 produced significantly highest grain yield at 1st harvest (828.88 kg ha^{-1}) that similar to M_2 (818.51 kg ha^{-1}), M_6 (697.43 kg ha^{-1}) & M_5 (687.46 kg ha^{-1}) and the lowest grain yield at 1st harvest (194.80 kg ha^{-1}) was obtained from M_1 that similar with M_3 (200.57 kg ha^{-1}). Asaduzzaman (2006) reported the similar result.

4.16.3 Interaction effect of variety and agronomic managements

The interaction between variety and agronomic managements significantly affected the grain yield at 1st harvest (Appendix XII and Table 16). The maximum grain yield at 1st harvest (908.79 kg ha^{-1}) was observed from V_2M_2 which was similar to V_2M_7 (885.33 kg ha^{-1}), V_1M_7 (772.43 kg ha^{-1}), V_2M_5 (768.96 kg ha^{-1}), V_1M_6 (749.40 kg ha^{-1}), V_1M_2 (728.24 kg ha^{-1}) & V_2M_4 (656.08 kg ha^{-1}), while the minimum grain yield at 1st harvest (125.42 kg ha^{-1}) was obtained from V_1M_1 which was similar to V_1M_3 (169.88 kg ha^{-1}), V_2M_3 (231.25 kg ha^{-1}) & V_2M_1 (264.19 kg ha^{-1}).

Table 16. Interaction effect of variety and agronomic managements on grain yield at 1st harvest of blackgram

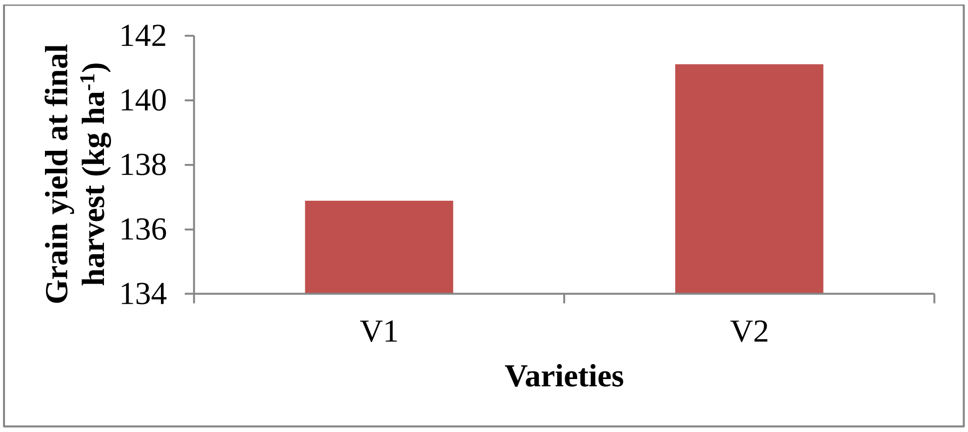
Treatment combination	Grain yield at 1st harvest (kg ha^{-1})
V_1M_1	125.42 d
V_1M_2	728.24 a-c
V_1M_3	169.88 d
V_1M_4	557.90 c
V_1M_5	605.96 c
V_1M_6	749.40 a-c
V_1M_7	772.43 a-c
V_2M_1	264.19 d
V_2M_2	908.79 a
V_2M_3	231.25 d
V_2M_4	656.08 a-c
V_2M_5	768.96 a-c
V_2M_6	645.46 bc
V_2M_7	885.33 ab
$LSD_{(0.05)}$	260.491
CV (%)	26.82

In a column mean values having similar letter(s) are statistically similar
S = Significant, CV = Coefficient of variation, $LSD_{(0.05)}$ = Least significant difference at 5% level,
V_1 = BARI mash-1, V_2 = BARI mash-3, M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

4.17 Grain yield at final harvest

4.17.1 Effect of variety

Grain yield at final harvest was not varied significantly for the variety (Appendix XII and Fig. 33). Numerically the maximum grain yield at final harvest (141.12 kg ha^{-1}) was obtained in V_2 and minimum grain yield at final harvest (136.89 kg ha^{-1}) was found in V_1.

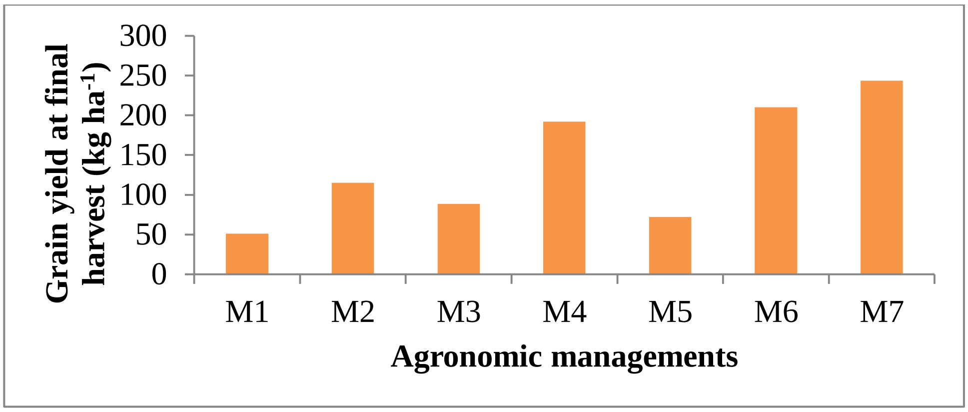


V_1 = BARI mash-1, V_2 = BARI mash-3

Figure 33. Effect of variety on grain yield at final harvest of blackgram ($LSD_{(0.05)}$ = 128.640).

4.17.2 Effect of agronomic managements

Agronomic managements showed significant differences on grain yield at final harvest of blackgram (Appendix XII and Fig. 34).



M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

Figure 34. Effect of agronomic managements on grain yield at final harvest of blackgram ($LSD_{(0.05)}$ = 101.338).

The M_7 produced the maximum grain yield at final harvest (243.65 kg ha^{-1}) that similar to M_6 (210.32 kg ha^{-1}) & M_4 (192.06 kg ha^{-1}) and the minimum grain yield at final harvest (51.06 kg ha^{-1}) was obtained from M_1 which was similar with M_5 (71.96 kg ha^{-1}), M_3 (88.62 kg ha^{-1}) & M_2 (115.34 kg ha^{-1}). Sarkar and Banik (1991) reported the similar finding.

4.17.3 Interaction effect of variety and agronomic managements

Interaction effect of variety and agronomic managements showed significant differences on grain yield at final harvest (Appendix XII and Table 17). The maximum grain yield at final harvest (328.04 kg ha^{-1}) was obtained in V_1M_7 which was similar to V_2M_6 (280.95 kg ha^{-1}) & V_2M_4 (233.33 kg ha^{-1}), while the minimum grain yield at final harvest (43.39 kg ha^{-1}) was observed from V_2M_1 which was similar with all interaction except V_2M_4 (233.33 kg ha^{-1}), V_2M_6 (280.95 kg ha^{-1}) & V_1M_7 (328.04 kg ha^{-1}).

Table 17. Interaction effect of variety and agronomic managements on grain yield at final harvest of blackgram

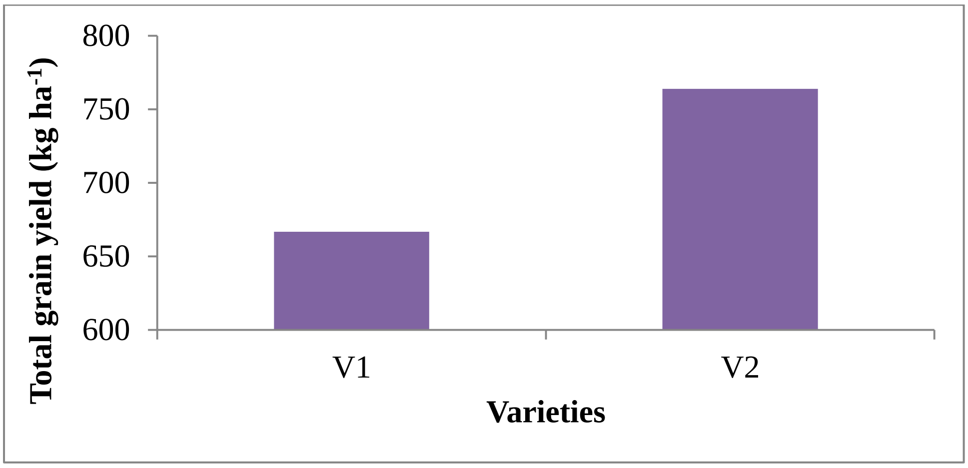
Treatment combination	Grain yield at final harvest (kg ha^{-1})
V_1M_1	58.73 d
V_1M_2	110.58 cd
V_1M_3	81.48 d
V_1M_4	150.79 b-d
V_1M_5	88.89 d
V_1M_6	139.68 b-d
V_1M_7	328.04 a
V_2M_1	43.39 d
V_2M_2	120.11 cd
V_2M_3	95.77 cd
V_2M_4	233.33 a-c
V_2M_5	55.03 d
V_2M_6	280.95 ab
V_2M_7	159.26 b-d
$LSD_{(0.05)}$	143.314
CV (%)	61.18

In a column mean values having similar letter(s) are statistically similar
S = Significant, CV = Coefficient of variation, $LSD_{(0.05)}$ = Least significant difference at 5% level,
V_1 = BARI mash-1, V_2 = BARI mash-3,
M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

4.18 Total grain yield

4.18.1 Effect of variety

The total grain yield of blackgram was not significantly influenced by the variety (Appendix XII and Fig. 35). Although having non-significant between the varieties, the maximum total grain yield (763.99 kg ha^{-1}) was recorded in V_2 and minimum total grain yield (666.78 kg ha^{-1}) was found in V_1.

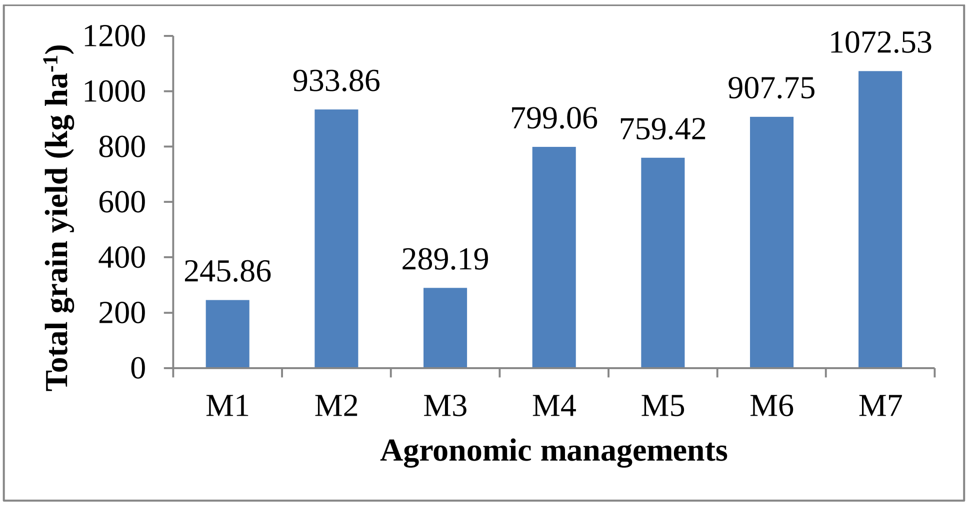


V_1 = BARI mash-1, V_2 = BARI mash-3

Figure 35. Effect of variety on total grain yield of blackgram ($LSD_{(0.05)}$ = 283.71).

4.18.2 Effect of agronomic managements

Agronomic managements showed significant differences on total grain yield of blackgram (Appendix XII and Fig. 36).



M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

Figure 36. Effect of agronomic managements on total grain yield of blackgram ($LSD_{(0.05)}$ = 231.580).

The M_7 produced the maximum total grain yield (1072.53 kg ha^{-1}) which was similar with M_2 (933.86 kg ha^{-1}) & M_6 (907.75 kg ha^{-1}) and the minimum total grain yield (245.86 kg ha^{-1}) was recorded from M_1 which was similar with M_3 (289.19 kg ha^{-1}).

4.18.3 Interaction effect of variety and agronomic managements

The interaction between variety and agronomic managements significantly affected the total grain yield (Appendix XII and Table 18). The maximum total grain yield (1100.47 kg ha^{-1}) was obtained from V_1M_7 which was similar to V_2M_7 (1044.59 kg ha^{-1}), V_2M_2 (1028.89 kg ha^{-1}), V_2M_6 (926.42 kg ha^{-1}), V_2M_4 (889.42 kg ha^{-1}), V_1M_6 (889.08 kg ha^{-1}) & V_1M_2 (838.82 kg ha^{-1}) & V_2M_5 (823.99 kg ha^{-1}), while the minimum total grain yield (184.15 kg ha^{-1}) was observed from V_1M_1 which was similar to V_1M_3 (251.37 kg ha^{-1}), V_2M_1 (307.58 kg ha^{-1}) & V_2M_3 (327.02 kg ha^{-1}).

Table 18. Interaction effect of variety and agronomic managements on total grain yield of blackgram

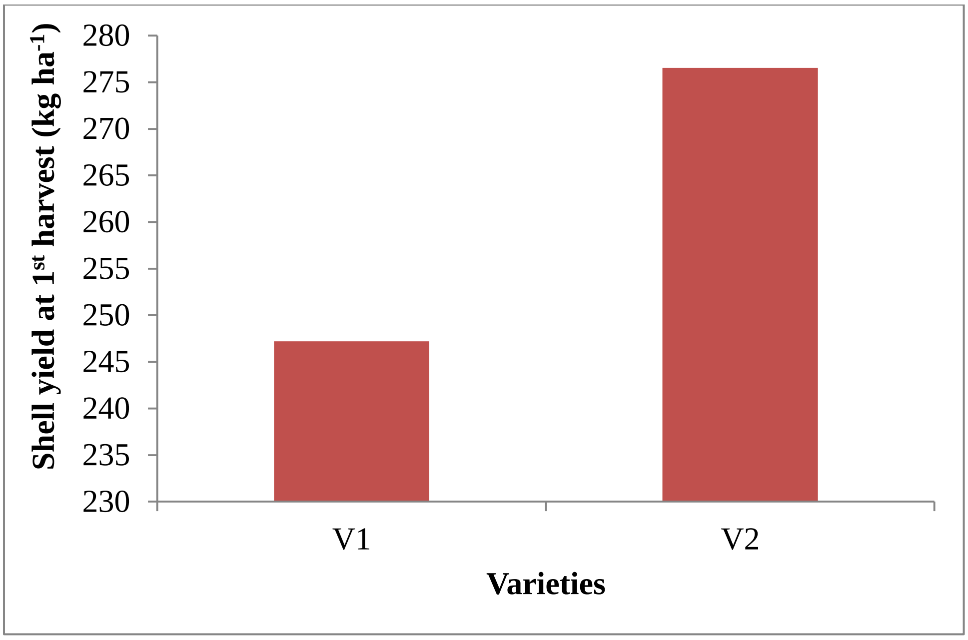
Treatment combination	Total grain yield (kg ha^{-1})
V_1M_1	184.15 d
V_1M_2	838.82 a-c
V_1M_3	251.37 d
V_1M_4	708.70 bc
V_1M_5	694.85 c
V_1M_6	889.08 a-c
V_1M_7	1100.47 a
V_2M_1	307.58 d
V_2M_2	1028.89 ab
V_2M_3	327.02 d
V_2M_4	889.42 a-c
V_2M_5	823.99 a-c
V_2M_6	926.42 a-c
V_2M_7	1044.59 a
$LSD_{(0.05)}$	327.496
CV (%)	27.17

In a column mean values having similar letter(s) are statistically similar
S = Significant, CV = Coefficient of variation, $LSD_{(0.05)}$ = Least significant difference at 5% level,
V_1 = BARI mash-1, V_2 = BARI mash-3,
M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

4.19 Shell yield at 1st harvest

4.19.1 Effect of variety

Statistically significant variation was recorded for shell yield at 1st harvest by the variety (Appendix XIII and Fig. 37). The numerically maximum shell yield at 1st harvest (276.52 kg ha^{-1}) was obtained from the V_2 and minimum shell yield at 1st harvest (247.21 kg ha^{-1}) was recorded in V_1 variety.

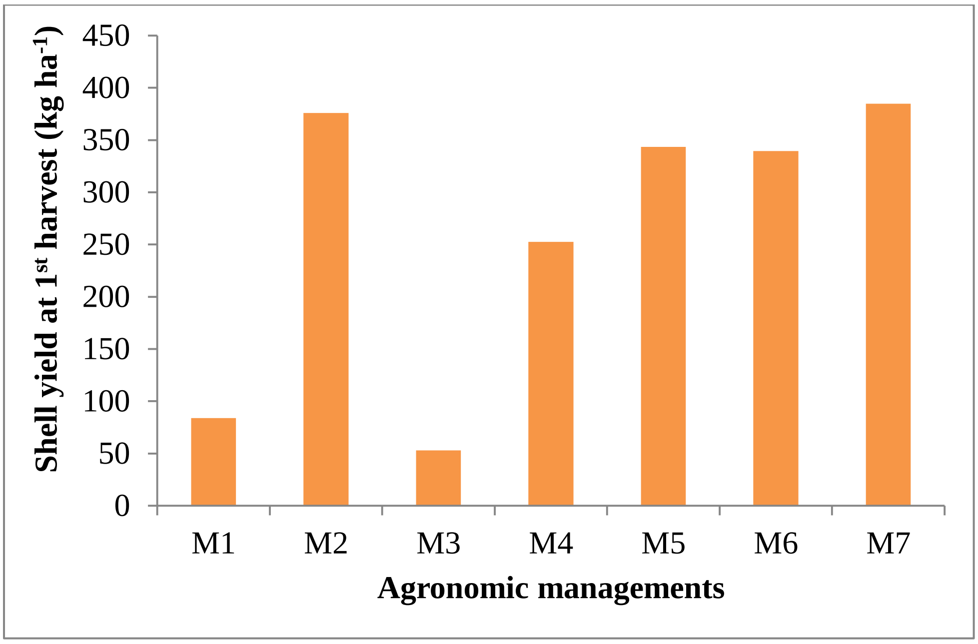


V_1 = BARI mash-1, V_2 = BARI mash-3

Figure 37. Effect of variety on shell yield at 1st harvest of blackgram ($LSD_{(0.05)}$ = 29.020).

4.19.2 Effect of agronomic managements

Agronomic managements had significant effect on shell yield at 1st harvest of blackgram (Appendix XIII and Fig. 38). The M_7 produced significantly the maximum shell yield at 1st harvest (384.69 kg ha^{-1}) which was similar to M_2 (375.82 kg ha^{-1}), M_5 (343.61 kg ha^{-1}) & M_6 (339.54 kg ha^{-1}) and the minimum shell yield at 1st harvest (52.84 kg ha^{-1}) was observed from the M_3 treatment which was similar to M_1 (83.92 kg ha^{-1}). Perez-Fernandez *et al.* (2006) reported the similar finding.



M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

Figure 38. Effect of agronomic managements on shell yield at 1st harvest of blackgram ($LSD_{(0.05)}$ = 107.335).

4.19.3 Interaction effect of variety and agronomic managements

Interaction effect of variety and agronomic managements showed significant differences on shell yield at 1st harvest (Appendix XIII and Table 19). The maximum shell yield at 1st harvest (402.37 kg ha^{-1}) was observed from V_2M_2 which was similar with all interaction except V_1M_4 (217.50 kg ha^{-1}), V_2M_1 (117.45 kg ha^{-1}), V_1M_3 (64.02 kg ha^{-1}), V_1M_1 (50.39 kg ha^{-1}) & V_2M_3 (41.66 kg ha^{-1}), while the minimum shell yield at 1st harvest (41.66 kg ha^{-1}) was found from V_2M_3 which was similar to V_1M_1 (50.39 kg ha^{-1}), V_1M_3 (64.02 kg ha^{-1}) & V_2M_1 (117.45 kg ha^{-1}).

Table 19. Interaction effect of variety and agronomic managements on shell yield at 1st harvest of blackgram

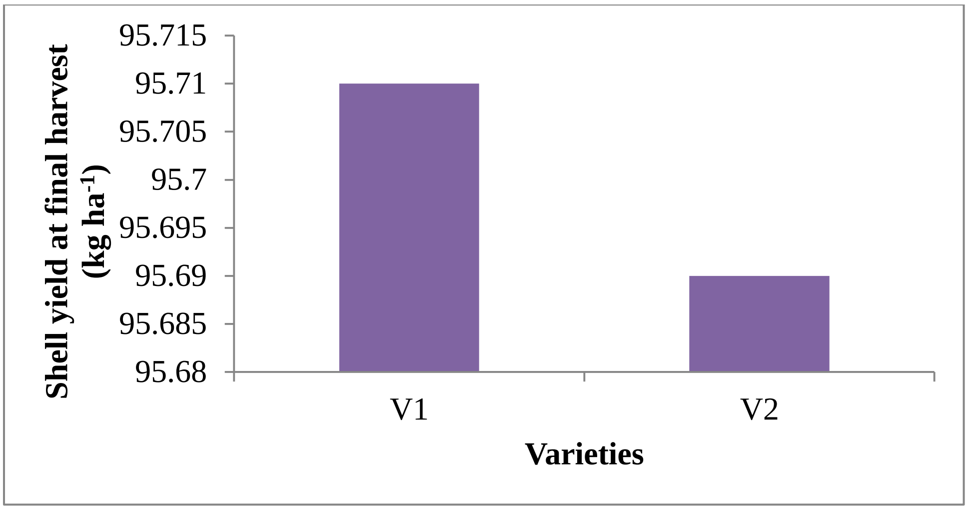
Treatment combination	Shell yield at 1st harvest (kg ha^{-1})
V_1M_1	50.39 d
V_1M_2	349.26 ab
V_1M_3	64.02 d
V_1M_4	217.50 bc
V_1M_5	319.63 ab
V_1M_6	351.07 ab
V_1M_7	378.60 a
V_2M_1	117.45 cd
V_2M_2	402.37 a
V_2M_3	41.66 d
V_2M_4	287.78 ab
V_2M_5	367.59 ab
V_2M_6	328.01 ab
V_2M_7	390.77 a
$LSD_{(0.05)}$	151.794
CV (%)	34.4

In a column mean values having similar letter(s) are statistically similar
S = Significant, CV = Coefficient of variation, $LSD_{(0.05)}$ = Least significant difference at 5% level,
V_1 = BARI mash-1, V_2 = BARI mash-3,
M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

4.20 Shell yield at final harvest

4.20.1 Effect of variety

Shell yield at final harvest of blackgram did not show the statistically significant variation (Appendix XIII and Fig. 39). The maximum shell yield at final harvest (95.71 kg ha^{-1}) was recorded from the V_1 and minimum shell yield at final harvest (95.69 kg ha^{-1}) was obtained in V_2 variety.

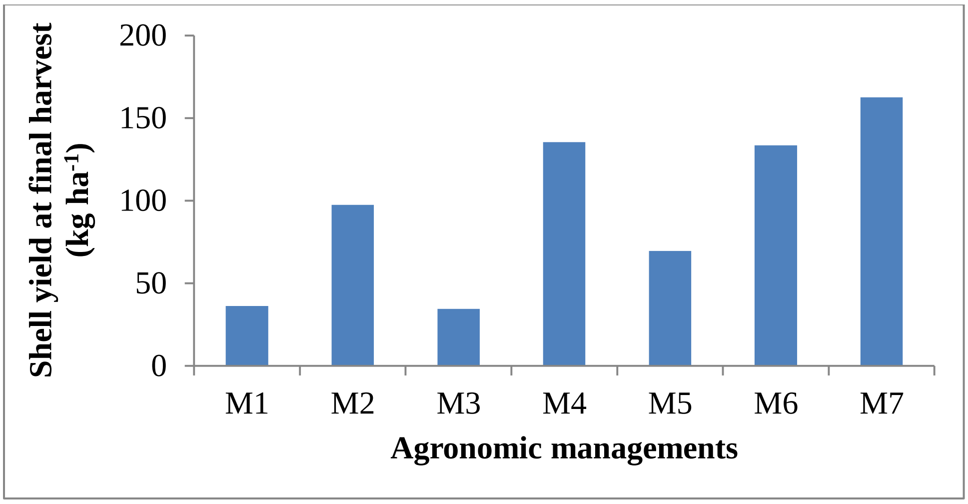


V_1 = BARI mash-1, V_2 = BARI mash-3

Figure 39. Effect of variety on shell yield at final harvest of blackgram ($LSD_{(0.05)}$ = 57.290).

4.20.2 Effect of agronomic managements

Agronomic managements had significant effect on shell yield at final harvest of blackgram (Appendix XIII and Fig. 40). The maximum shell yield at final harvest (162.70 kg ha^{-1}) was obtained from M_7 which was similar to M_4 (135.45 kg ha^{-1}) & M_6 (133.65 kg ha^{-1}) and the minimum shell yield at final harvest (34.65 kg ha^{-1}) was observed from the M_3 treatment which was similar to M_1 (36.25 kg ha^{-1}) & M_5 (69.58 kg ha^{-1}).



M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

Figure 40. Effect of agronomic managements on shell yield at final harvest of blackgram ($LSD_{(0.05)}$ = 49.976).

4.20.3 Interaction effect of variety and agronomic managements

The interaction between variety and agronomic managements significantly affected the shell yield at final harvest (Appendix XIII and Table 20). The maximum shell yield at final harvest (211.64 kg ha^{-1}) was obtained from V_1M_7 which was similar to V_2M_4 (167.19 kg ha^{-1}) & V_2M_6 (154.50 kg ha^{-1}), while the minimum shell yield at final harvest (27.51 kg ha^{-1}) was found from V_2M_3 which was similar to V_1M_1 (28.04 kg ha^{-1}), V_1M_3 (41.80 kg ha^{-1}), V_2M_1 (44.45 kg ha^{-1}), V_2M_5 (61.91 kg ha^{-1}), V_1M_5 (77.25 kg ha^{-1}) & V_1M_2 (94.71 kg ha^{-1}).

Table 20. Interaction effect of variety and agronomic managements on shell yield at final harvest of blackgram

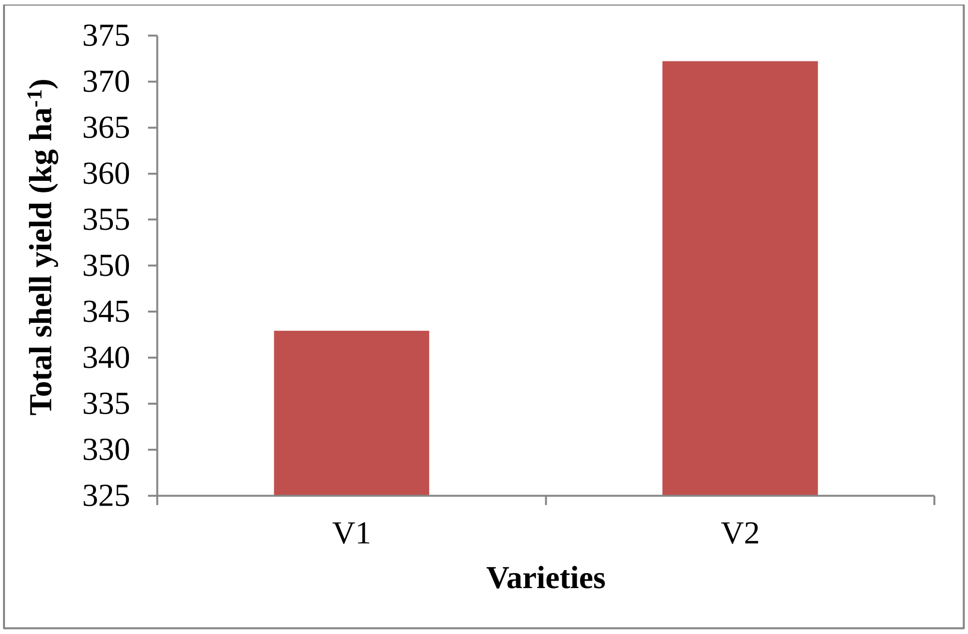
Treatment combination	Shell yield at final harvest (kg ha^{-1})
V_1M_1	28.04 f
V_1M_2	94.71 c-f
V_1M_3	41.80 ef
V_1M_4	103.70 b-e
V_1M_5	77.25 d-f
V_1M_6	112.81 b-d
V_1M_7	211.64 a
V_2M_1	44.45 d-f
V_2M_2	100.53 b-e
V_2M_3	27.51 f
V_2M_4	167.19 ab
V_2M_5	61.91 d-f
V_2M_6	154.50 a-c
V_2M_7	113.76 b-d
$LSD_{(0.05)}$	70.677
CV (%)	43.83

In a column mean values having similar letter(s) are statistically similar
S = Significant, CV = Coefficient of variation, $LSD_{(0.05)}$ = Least significant difference at 5% level,
V_1 = BARI mash-1, V_2 = BARI mash-3,
M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

4.21 Total shell yield

4.21.1 Effect of variety

Statistically significant variation was recorded for total shell yield by the variety (Appendix XIII and Fig. 41). The numerically maximum total shell yield (372.21 kg ha^{-1}) was recorded from the V_2 and minimum total shell yield (342.92 kg ha^{-1}) was obtained in V_1 variety.

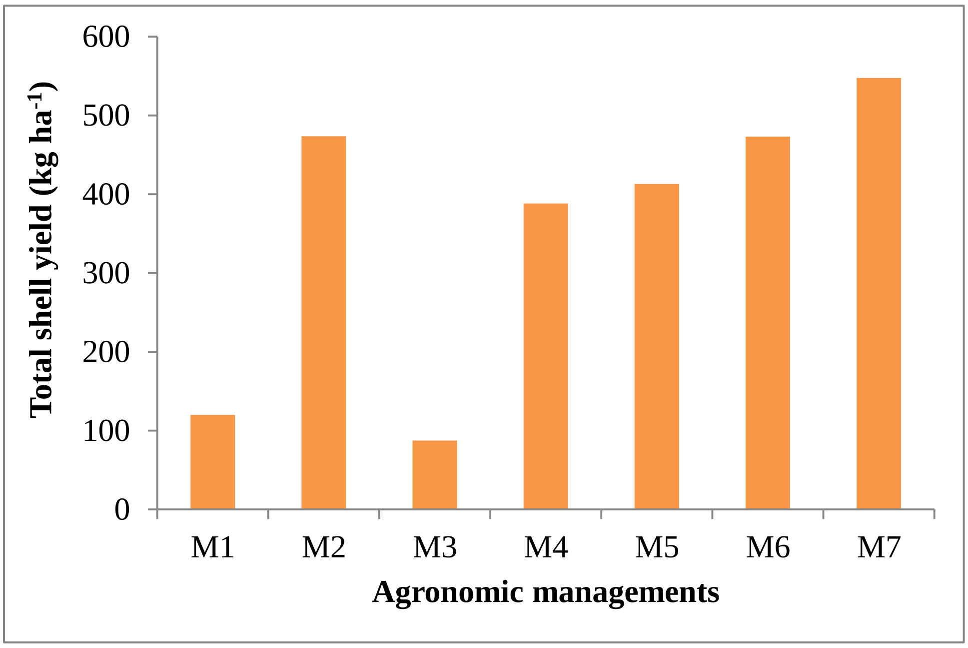


V_1 = BARI mash-1, V_2 = BARI mash-3

Figure 41. Effect of variety on total shell yield of blackgram ($LSD_{(0.05)}$ = 28.800).

4.21.2 Effect of agronomic managements

Agronomic managements had significant effect on total shell yield of blackgram (Appendix XIII and Fig. 42). The M_7 produced significantly the maximum total shell yield (547.39 kg ha^{-1}) which was similar to M_2 (473.44 kg ha^{-1}) & M_6 (473.19 kg ha^{-1}) and the minimum total shell yield (87.50 kg ha^{-1}) was obtained from the M_3 treatment which was similar to M_1 (120.16 kg ha^{-1}).



M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

Figure 42. Effect of agronomic managements on total shell yield of blackgram ($LSD_{(0.05)}$ = 134.060).

4.21.3 Interaction effect of variety and agronomic managements

Interaction effect of variety and agronomic managements showed significant differences on total shell yield (Appendix XIII and Table 21). The maximum total shell yield (590.25 kg ha^{-1}) was obtained from V_1M_7 which was similar to V_2M_7 (504.53 kg ha^{-1}), V_2M_2 (502.90 kg ha^{-1}), V_2M_6 (482.51 kg ha^{-1}), V_1M_6 (463.87 kg ha^{-1}), V_2M_4 (454.97 kg ha^{-1}), V_1M_2 (443.97 kg ha^{-1}) & V_2M_5 (429.49 kg ha^{-1}), while the minimum total shell yield (69.18 kg ha^{-1}) was found from V_2M_3 which was similar to V_1M_1 (78.43 kg ha^{-1}), V_1M_3 (105.82 kg ha^{-1}) & V_2M_1 (161.89 kg ha^{-1}).

Table 21. Interaction effect of variety and agronomic managements on total shell yield of blackgram

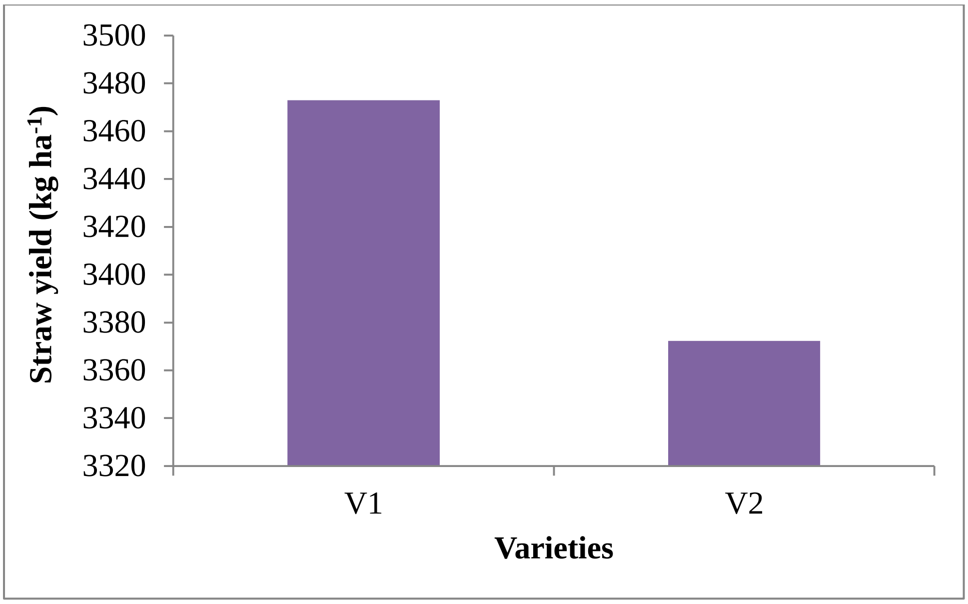
Treatment combination	Total shell yield (kg ha^{-1})
V_1M_1	78.43 d
V_1M_2	443.97 ab
V_1M_3	105.82 d
V_1M_4	321.21 bc
V_1M_5	396.88 b
V_1M_6	463.87 ab
V_1M_7	590.25 a
V_2M_1	161.89 cd
V_2M_2	502.90 ab
V_2M_3	69.18 d
V_2M_4	454.97 ab
V_2M_5	429.49 ab
V_2M_6	482.51 ab
V_2M_7	504.53 ab
$LSD_{(0.05)}$	189.594
CV (%)	31.47

In a column mean values having similar letter(s) are statistically similar
S = Significant, CV = Coefficient of variation, $LSD_{(0.05)}$ = Least significant difference at 5% level,
V_1 = BARI mash-1, V_2 = BARI mash-3,
M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

4.22 Straw yield

4.22.1 Effect of variety

Straw yield was significantly influenced by the variety (Appendix XIV and Fig. 43). The maximum straw yield (3472.93 kg ha^{-1}) was observed from the V_1 and minimum straw yield (3372.26 kg ha^{-1}) was recorded in V_2 variety. Bhati *et al*. (2005) reported that mungbean cv. PDM-54 showed 13.7% higher fodder yield than the local cultivar.

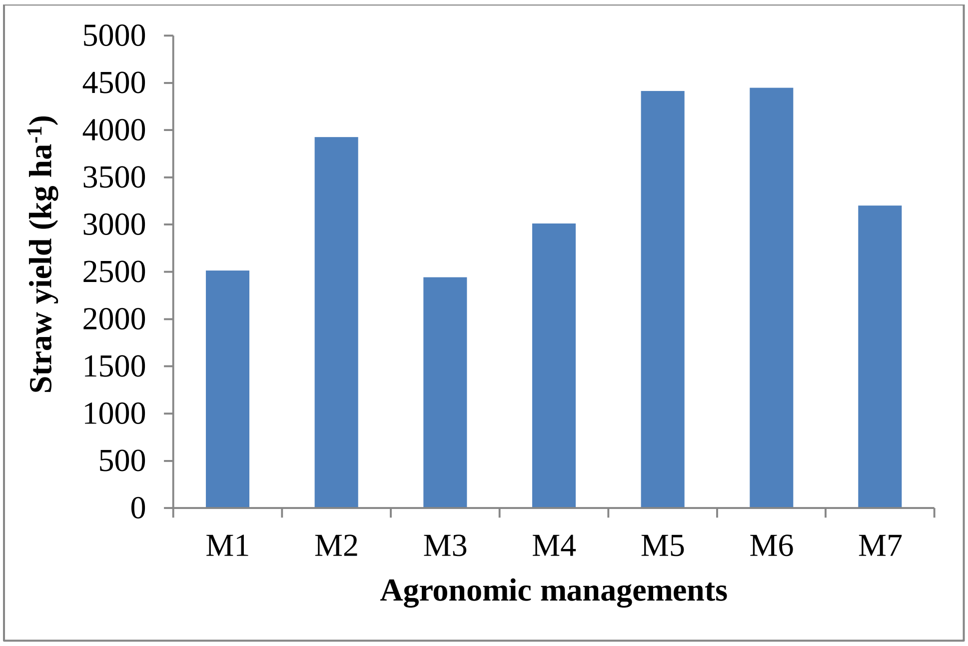


V_1 = BARI mash-1, V_2 = BARI mash-3

Figure 43. Effect of variety on straw yield of blackgram ($LSD_{(0.05)}$ = 0.590).

4.22.2 Effect of agronomic managements

Agronomic managements showed significant effect on straw yield of blackgram (Appendix XIV and Fig. 44).



M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

Figure 44. Effect of agronomic managements on straw yield of blackgram ($LSD_{(0.05)}$ = 1667.140).

The M_6 produced significantly the maximum straw yield (4448.58 kg ha^{-1}) which was similar with all treatment except M_1 (2514.79 kg ha^{-1}) & M_3 (2442.58 kg ha^{-1}) and the minimum straw yield (2442.58 kg ha^{-1}) was obtained from the M_3 treatment which was similar with all treatment except M_5 (4412.61 kg ha^{-1}) & M_6 (4448.58 kg ha^{-1}).

4.22.3 Interaction effect of variety and agronomic managements

The interaction between variety and agronomic managements significantly affected the straw yield (Appendix XIV and Table 22).

Table 22. Interaction effect of variety and agronomic managements on straw yield of blackgram

Treatment combination	Straw yield (kg ha^{-1})
V_1M_1	3875.75 a-c
V_1M_2	3634.41 a-c
V_1M_3	3108.92 a-d
V_1M_4	2962.62 a-d
V_1M_5	4501.16 ab
V_1M_6	3723.24 a-c
V_1M_7	2504.40 b-d
V_2M_1	1153.83 d
V_2M_2	4219.98 ab
V_2M_3	1776.23 cd
V_2M_4	3060.86 a-d
V_2M_5	4324.06 ab
V_2M_6	5173.92 a
V_2M_7	3896.97 a-c
$LSD_{(0.05)}$	2357.690
CV (%)	40.88

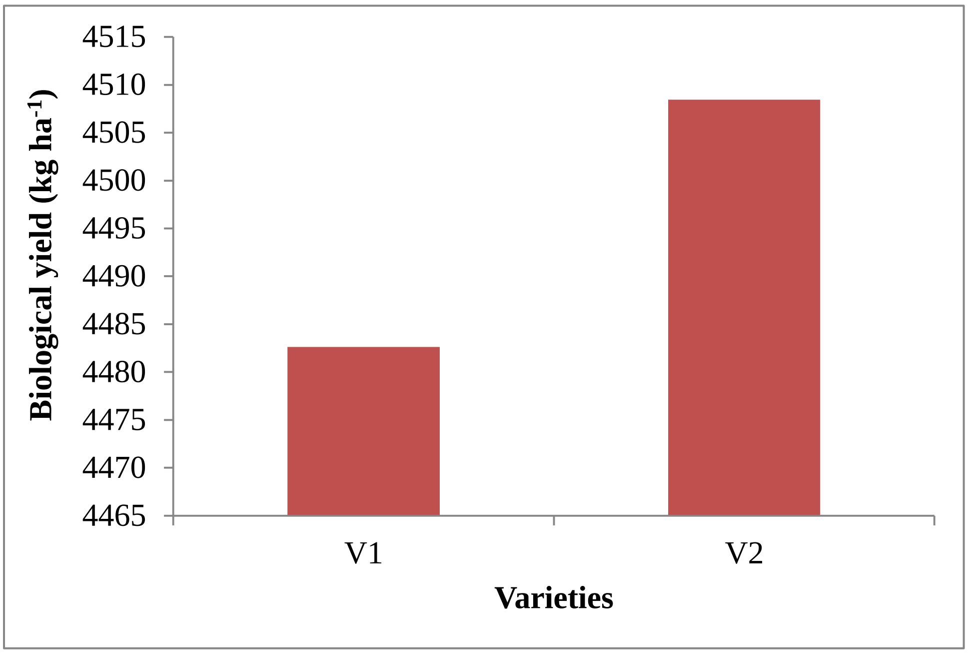
In a column mean values having similar letter(s) are statistically similar
S = Significant, CV = Coefficient of variation, $LSD_{(0.05)}$ = Least significant difference at 5% level,
V_1 = BARI mash-1, V_2 = BARI mash-3,
M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

The maximum straw yield (5173.92 kg ha^{-1}) was recorded from V_2M_6 which was similar with all interaction except V_1M_7 (2504.40 kg ha^{-1}), V_2M_3 (1776.23 kg ha^{-1}) & V_2M_1 (1153.83 kg ha^{-1}), while the minimum straw yield (1153.83 kg ha^{-1}) was found from V_2M_1 which was similar to V_2M_3 (1776.23 kg ha^{-1}), V_1M_7 (2504.40 kg ha^{-1}), V_1M_4 (2962.62 kg ha^{-1}), V_2M_4 (3060.86 kg ha^{-1}) & V_1M_3 (3108.92 kg ha^{-1}).

4.23 Biological yield

4.23.1 Effect of variety

The biological yield of blackgram was not significantly influenced by the variety (Appendix XIV and Fig. 45). The numerically highest biological yield (4508.46 kg ha^{-1}) was obtained from the V_2 whereas the lowest biological yield (4482.62 kg ha^{-1}) was recorded from V_1.

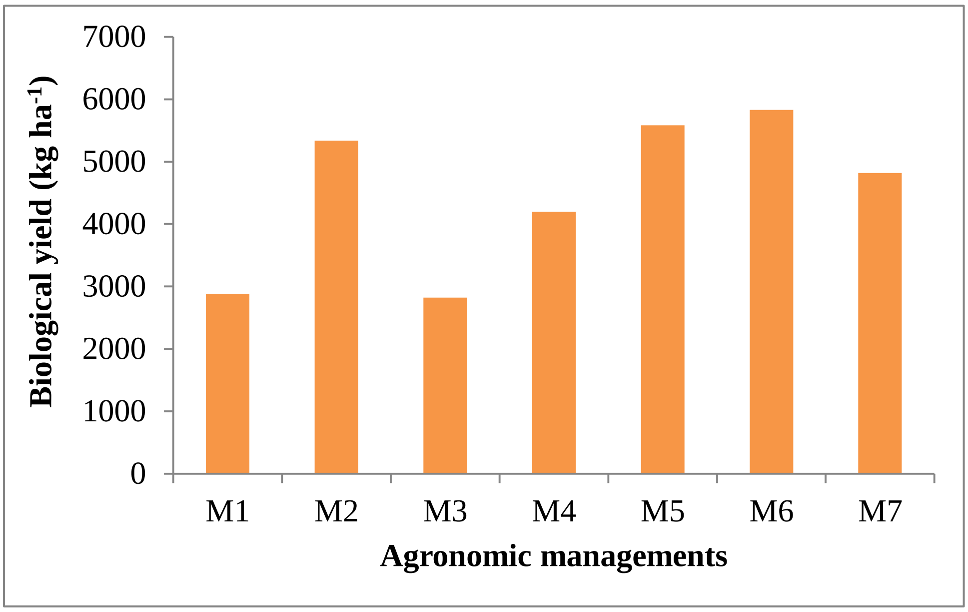


V_1 = BARI mash-1, V_2 = BARI mash-3

Figure 45. Effect of variety on biological yield of blackgram ($LSD_{(0.05)}$ = 285.680).

4.23.2 Effect of agronomic managements

Agronomic managements showed significant differences on biological yield (Appendix XIV and Fig. 46). The highest biological yield (5829.52 kg ha^{-1}) was observed from the M_6 which was similar with all treatment except M_1 (2880.82 kg ha^{-1}) & M_3 (2819.26 kg ha^{-1}) whereas the lowest biological yield (2819.26 kg ha^{-1}) was recorded from M_3 which was similar to M_1 (2880.82 kg ha^{-1}) & M_4 (4198.89 kg ha^{-1}).



M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

Figure 46. Effect of agronomic managements on biological yield of blackgram ($LSD_{(0.05)}$ = 1823.030).

4.23.3 Interaction effect of variety and agronomic managements

Interaction effect between variety and agronomic managements was found significant in respect of biological yield (Appendix XIV and Table 23). The highest biological yield (6582.84 kg ha^{-1}) was obtained from the V_2M_6 which was similar with all treatment except V_1M_4 (3992.53 kg ha^{-1}), V_1M_3 (3466.10 kg ha^{-1}), V_2M_3 (2172.42 kg ha^{-1}) & V_2M_1 (1623.30 kg ha^{-1}) whereas the lowest biological yield (1623.30 kg ha^{-1}) was recorded from V_2M_1 which was similar to V_2M_3 (2172.42 kg ha^{-1}), V_1M_3 (3466.10 kg ha^{-1}), V_1M_4 (3992.53 kg ha^{-1}), V_1M_1 (4138.33 kg ha^{-1}) & V_1M_7 (4195.11 kg ha^{-1}).

Table 23. Interaction effect of variety and agronomic managements on biological yield of blackgram

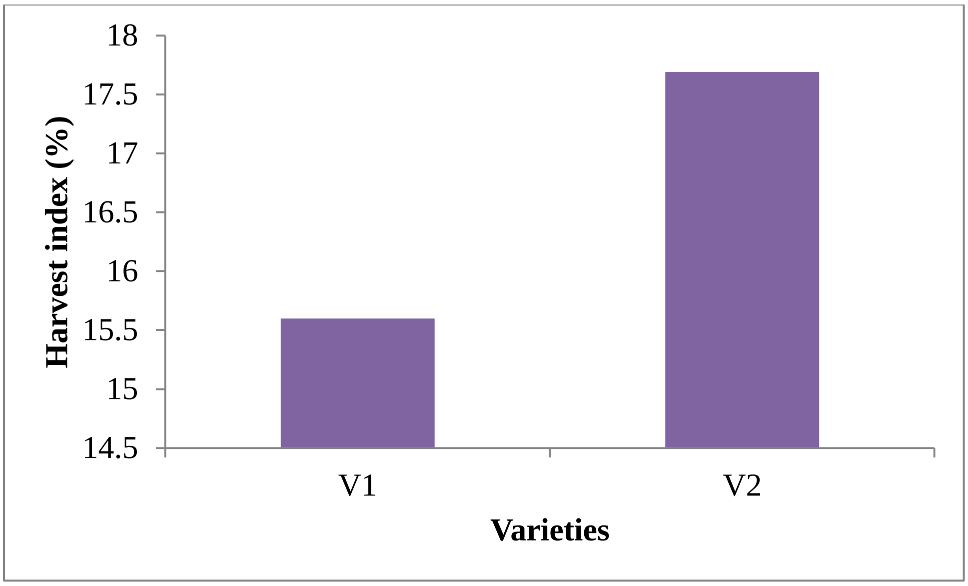
Treatment combination	Biological yield (kg ha^{-1})
V_1M_1	4138.33 a-d
V_1M_2	4917.21 ab
V_1M_3	3466.10 b-d
V_1M_4	3992.53 b-d
V_1M_5	5592.89 ab
V_1M_6	5076.19 ab
V_1M_7	4195.11 a-d
V_2M_1	1623.30 d
V_2M_2	5751.77 ab
V_2M_3	2172.42 cd
V_2M_4	4405.25 a-c
V_2M_5	5577.55 ab
V_2M_6	6582.84 a
V_2M_7	5446.10 ab
$LSD_{(0.05)}$	2578.160
CV (%)	34.03

In a column mean values having similar letter(s) are statistically similar
S = Significant, CV = Coefficient of variation, $LSD_{(0.05)}$ = Least significant difference at 5% level,
V_1 = BARI mash-1, V_2 = BARI mash-3,
M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

4.24 Harvest index

4.24.1 Effect of variety

Harvest index varied non-significantly for the variety (Appendix XIV and Fig. 47). The highest harvest index (17.69%) was observed from V_2, whereas the lowest (15.60%) from V_1. The result was disagreed with the findings of Aguliar and Villarea (1989) who reported that the harvest index of mungbean was significantly influenced by the variety.

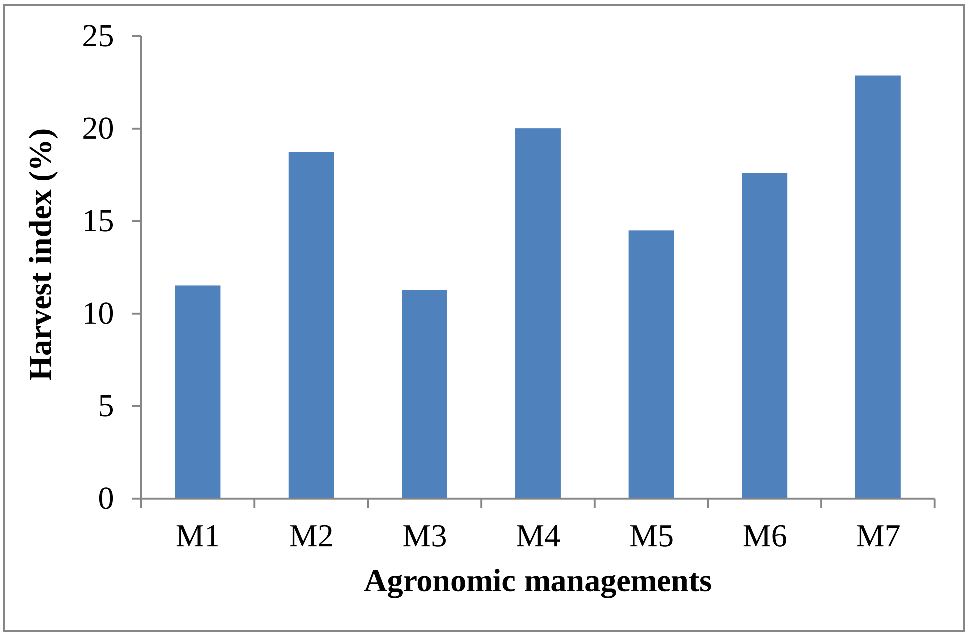


V_1 = BARI mash-1, V_2 = BARI mash-3

Figure 47. Effect of variety on harvest index of blackgram ($LSD_{(0.05)}$ = 9.920).

4.24.2 Effect of agronomic managements

Agronomic managements showed significant differences on harvest index (Appendix XIV and Fig. 48).



M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

Figure 48. Effect of agronomic managements on harvest index of blackgram ($LSD_{(0.05)}$ = 6.757).

The highest harvest index (22.87%) was recorded from M_7 which was similar to M_4 (20.02%), M_2 (18.74%) & M_6 (17.59%), whereas the lowest harvest index (11.28%) was found from M_3 which was similar to M_1 (11.53%), M_5 (14.50%) & M_6 (17.59%).

4.24.3 Interaction effect of variety and agronomic managements

Interaction effect between variety and agronomic managements was found significant in respect of harvest index (Appendix XIV and Table 24). The highest harvest index (26.19%) was observed from the V_1M_7 which was statistically similar to V_2M_4 (21.05%), V_1M_6 (20.43%), V_2M_7 (19.55%), V_2M_2 (19.07%), V_1M_4 (18.99%), V_2M_1 (18.61%) & V_1M_2 (18.42%), whereas the lowest harvest index (4.46%) was obtained from V_1M_1 which was similar to V_1M_3 (6.89%) & V_1M_5 (13.82%).

Table 24. Interaction effect of variety and agronomic managements on harvest index of blackgram

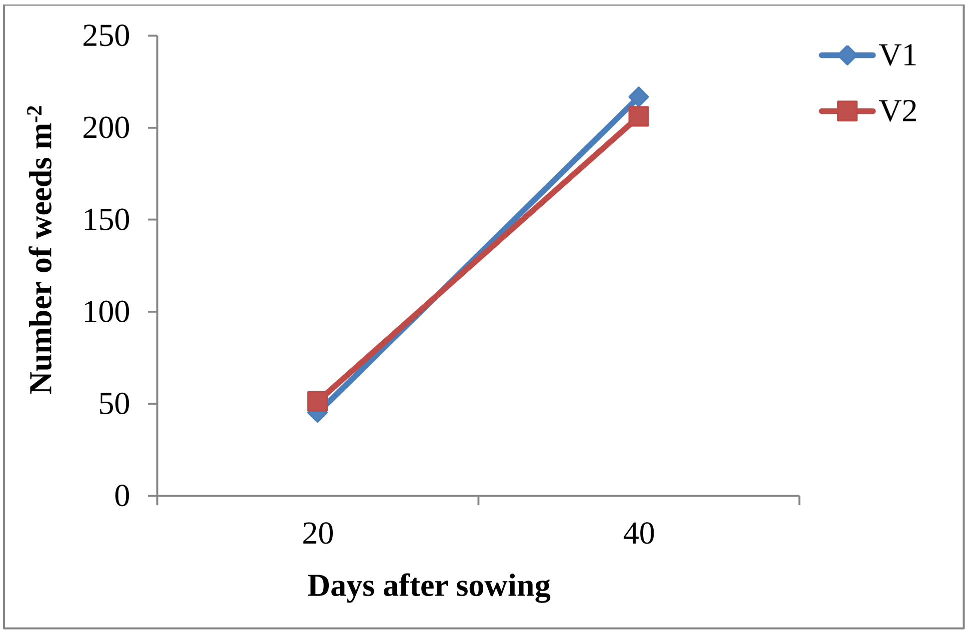
Treatment combination	Harvest index (%)
V_1M_1	4.46 d
V_1M_2	18.42 ab
V_1M_3	6.89 cd
V_1M_4	18.99 ab
V_1M_5	13.82 b-d
V_1M_6	20.43 ab
V_1M_7	26.19 a
V_2M_1	18.61 ab
V_2M_2	19.07 ab
V_2M_3	15.67 bc
V_2M_4	21.05 ab
V_2M_5	15.18 bc
V_2M_6	14.74 bc
V_2M_7	19.55 ab
$LSD_{(0.05)}$	9.556
CV (%)	30.06

In a column mean values having similar letter(s) are statistically similar
S = Significant, CV = Coefficient of variation, $LSD_{(0.05)}$ = Least significant difference at 5% level,
V_1 = BARI mash-1, V_2 = BARI mash-3,
M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

4.25 Number of weeds m^{-2}

4.25.1 Effect of variety

The number of weeds m^{-2} was significantly influenced by the variety at 20 DAS but was insignificant at 40 DAS (Appendix XV and Fig. 49). The maximum number of weeds m^{-2} (51.33) was observed in V_2 and the minimum number of weeds m^{-2} (45.14) was recorded in V_1 at 20 DAS. At 40 DAS, the maximum number of weeds m^{-2} (216.67) was observed in V_1 and the minimum number of weeds m^{-2} (206.10) was recorded in both V_2.

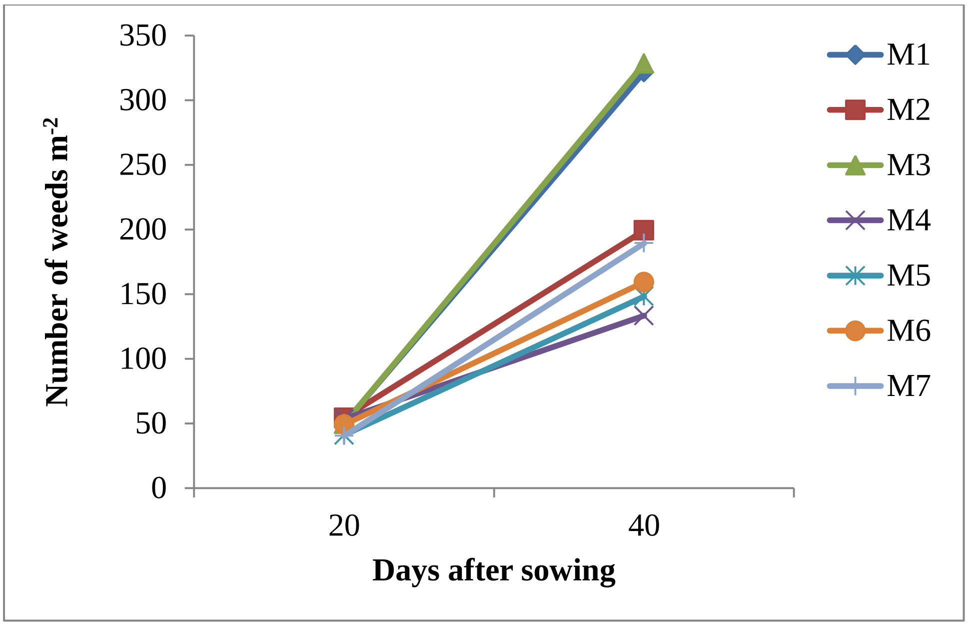


V_1 = BARI mash-1, V_2 = BARI mash-3

Figure 49. Effect of variety on number of weeds m^{-2} of blackgram at different days after sowing ($LSD_{(0.05)}$ = 5.040 & 110.790 at 20 & 40 DAS).

4.25.2 Effect of agronomic managements

Agronomic managements showed significant effect on number of weeds m^{-2} at 40 DAS but was insignificant at 20 DAS (Appendix XV and Fig. 50). The maximum number of weeds m^{-2} (54.33) was recorded in M_2 and the minimum number of weeds m^{-2} (40.33) was found in M_7 at 20 DAS. At 40 DAS, the maximum number of weeds m^{-2} (328.33) was recorded in M_3 which was similar to M_1 (321.67) and the minimum number of weeds m^{-2} (133.33) was found in M_4 which was similar with all treatment except M_1 (321.67) & M_3 (328.33). Shultana *et al.* (2016) reported that weed density was higher in unweeded plots with 140:36:43 kg NPK ha^{-1}.



M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

Figure 50. Effect of agronomic managements on number of weeds m^{-2} of blackgram ($LSD_{(0.05)}$ = 21.182 & 77.546 at 20 & 40 DAS).

4.25.3 Interaction effect of variety and agronomic managements

There was statistically significant effect on number of weeds m^{-2} by the interaction effect of variety and agronomic managements at 20 & 40 DAS (Appendix XV and Table 25). At 20 DAS, The maximum number of weeds m^{-2} (67.33) was observed in V_2M_6 which was statistically similar with all interaction except V_2M_7 (35.33) & V_1M_6 (30.67) and the minimum number of weeds m^{-2} (30.67) was found in V_1M_6 which was statistically similar with all interaction except V_2M_4 (62.00) & V_2M_6 (67.33). At 40 DAS, The maximum number of weeds m^{-2} (346.67) was observed in V_1M_3 which was statistically similar to the interactions of V_1M_1 (336.67), V_2M_3 (310.00) & V_2M_1 (306.67) and the minimum number of weeds m^{-2} (130.00) was found in V_2M_4 which was statistically similar with all interaction except V_2M_1 (306.67), V_2M_3 (310.00), V_1M_1 (336.67) & V_1M_3 (346.67).

Table 25. Interaction effect of variety and agronomic managements on number of weeds m^{-2} of blackgram

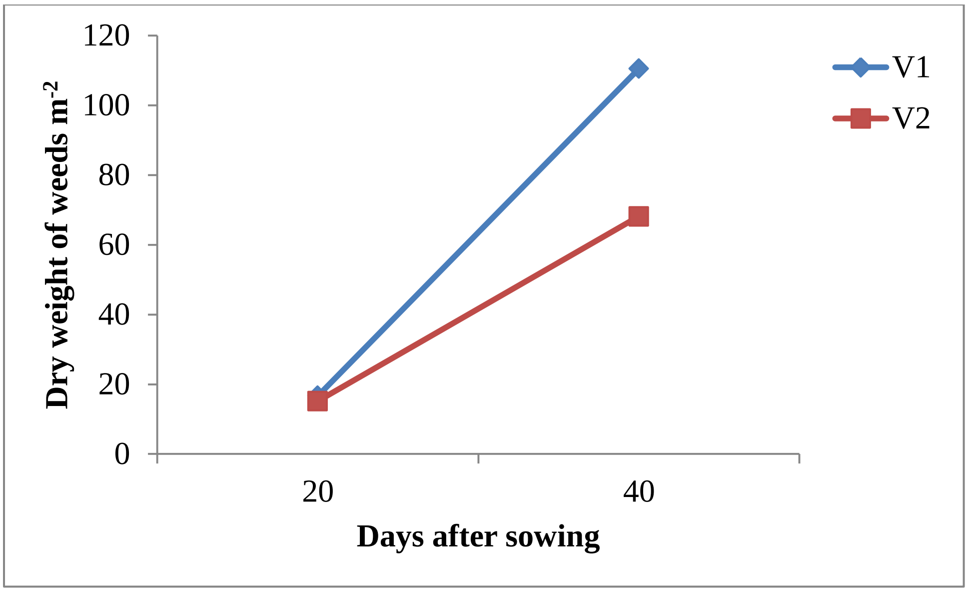
Treatment combination	Number of weeds m^{-2} at	
	20 DAS	40 DAS
V_1M_1	52.67 a-c	336.67 a
V_1M_2	54.00 a-c	222.00 bc
V_1M_3	47.33 a-c	346.67 a
V_1M_4	44.67 a-c	136.67 c
V_1M_5	41.33 a-c	143.33 c
V_1M_6	30.67 c	178.00 c
V_1M_7	45.33 a-c	153.33 c
V_2M_1	47.33 a-c	306.67 ab
V_2M_2	54.67 a-c	176.67 c
V_2M_3	52.00 a-c	310.00 ab
V_2M_4	62.00 ab	130. 00 c
V_2M_5	40.67 a-c	153.33 c
V_2M_6	67.33 a	140.67 c
V_2M_7	35.33 bc	225.33 bc
$LSD_{(0.05)}$	29.956	109.666
CV (%)	36.85	30.79

In a column mean values having similar letter(s) are statistically similar
S = Significant, CV = Coefficient of variation, $LSD_{(0.05)}$ = Least significant difference at 5% level,
V_1 = BARI mash-1, V_2 = BARI mash-3, M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

4.26 Dry weight of weeds m^{-2}

4.26.1 Effect of variety

The dry weight of weeds m^{-2} was significantly influenced by the variety at 40 DAS but was insignificant at 20 DAS (Appendix XV and Fig. 51). At 20 DAS, the maximum dry weight of weeds m^{-2} (16.67 g) was recorded in V_1 and the minimum dry weight of weeds m^{-2} (15.14 g) was found from V_2. At 40 DAS, the maximum dry weight of weeds m^{-2} (110.46 g) was recorded in V_1 and the minimum dry weight of weeds m^{-2} (68.11 g) was found from V_2.

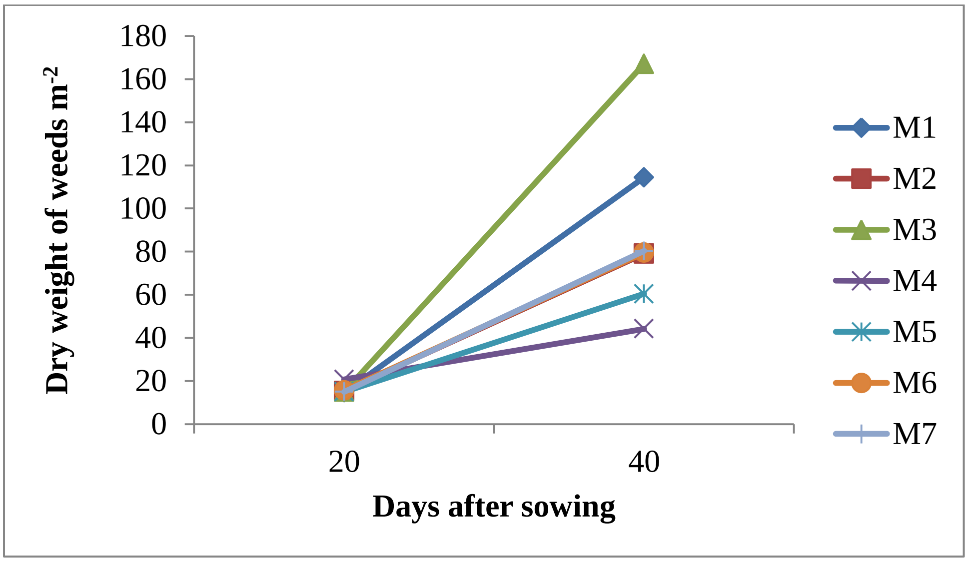


V_1 = BARI mash-1, V_2 = BARI mash-3

Figure 51. Effect of variety on dry weight of weeds m^{-2} of blackgram ($LSD_{(0.05)}$ = 12.780 & 12.790 at 20 & 40 DAS).

4.26.2 Effect of agronomic managements

Dry weight of weeds m^{-2} varied significantly due to agronomic managements at 20 & 40 DAS (Appendix XV and Fig. 52).



M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

Figure 52. Effect of agronomic managements on dry weight of weeds m^{-2} of blackgram ($LSD_{(0.05)}$ = 5.805 & 62.841 at 20 & 40 DAS).

At 20 DAS, the maximum dry weight of weeds m^{-2} (20.67 g) was observed in M_4 which was statistically similar with all treatment except M_1 (14.67 g) and the minimum dry weight of weeds m^{-2} (14.67 g) was found in M_1 which was statistically similar with all treatment except M_4 (20.67 g). At 40 DAS, the maximum dry weight of weeds m^{-2} (167.09 g) was observed in M_3 which was statistically similar with M_1 (114.45 g) and the minimum dry weight of weeds m^{-2} (44.20 g) was found in M_4 which was statistically similar with all treatment except M_1 (114.45 g) & M_3 (167.09 g). Manish *et al.* (2006) recorded maximum weed dry weight were recorded in no management treatment, while the minimum values were obtained with hand weeding at 15 and 30 DAT.

4.26.3 Interaction effect of variety and agronomic managements

Interaction effect between variety and agronomic managements was found significant in respect of dry weight of weeds m^{-2} of blackgram at 20 and 40 DAS (Appendix XV and Table 26).

Table 26. Interaction effect of variety and agronomic managements on dry weight of weeds m^{-2} of blackgram

Treatment combination	Dry weight of weeds m^{-2} at	
	20 DAS	40 DAS
V_1M_1	14.00 b	114.01 b-d
V_1M_2	17.33 ab	114.53 b-d
V_1M_3	18.00 ab	207.19 a
V_1M_4	18.00 ab	58.29 b-d
V_1M_5	16.00 ab	66.90 b-d
V_1M_6	17.33 ab	121.75 a-c
V_1M_7	16.00 ab	90.56 b-d
V_2M_1	15.33 ab	114.89 b-d
V_2M_2	13.33 b	43.60 b-d
V_2M_3	12.00 b	127.00 ab
V_2M_4	23.33 a	30.11 d
V_2M_5	14.00 b	53.95 b-d
V_2M_6	14.00 b	37.20 cd
V_2M_7	14.00 b	70.05 b-d
$LSD_{(0.05)}$	8.209	88.870
CV (%)	30.63	59.07

In a column mean values having similar letter(s) are statistically similar
S = Significant, CV = Coefficient of variation, $LSD_{(0.05)}$ = Least significant difference at 5% level,
V_1 = BARI mash-1, V_2 = BARI mash-3,
M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

At 20 DAS, The maximum dry weight of weeds m^{-2} (23.33 g) was recorded in V_2M_4 which was statistically similar to V_1M_3 (18.00 g), V_1M_4 (18.00 g), V_1M_2 (17.33 g), V_1M_6 (17.33 g), V_1M_5 (16.00 g), V_1M_7 (16.00 g) & V_2M_1 (15.33 g) and the minimum dry weight of weeds m^{-2} (12.00 g) was found in V_2M_3 which was statistically similar with all interaction except V_2M_4 (23.33 g). At 40 DAS, The maximum dry weight of weeds m^{-2} (207.19 g) was recorded in V_1M_3 which was statistically similar to the interactions of V_2M_3 (127.00 g) & V_1M_6 (121.75 g) and the minimum dry weight of weeds m^{-2} (30.11 g) was found in V_2M_4 which was statistically similar with all interaction except V_1M_6 (121.75 g), V_2M_3 (127.00 g), V_1M_3 (207.19 g).

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was carried out in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, during the period from March to June, 2019 to study the growth and yield of blackgram as affected by agronomic managements in Kharif-1 season under the Madhupur Tract (AEZ-28).

The experiment was laid out in a split-plot design with three replications having variety in the main plot and agronomic managements in sub-plots. The experiment consists of two factors; Factor A: Variety-2 viz. BARI mash-1 (V_1) and BARI mash-3 (V_2) and Factor B: Agronomic Managements-7 viz. Control (No management) (M_1), No fertilizer but all other managements (M_2), No weeding but all other managements (M_3), No irrigation but all other managements (M_4), No insecticide but all other managements (M_5), No fungicide/bacteriocide but all other managements (M_6) and Complete management (recommended) (M_7). Significant variation was recorded for data on different growth, yield contributing characters and yield of blackgram from the experimental field. The sowing date was on15 March, 2019.

The data on crop growth parameters viz. germination percentage, plant height, number of leaves plant^{-1}, plant dry weight, number of nodules plant^{-1}, SPAD value and days required to flowering were recorded at different days after sowing (DAS). Germination percentage was recorded upto hundred percent germination from 1m^2 area. Five plants were randomly selected from each unit plot for taking observations on plant height, number of leaves plant^{-1} and number of branches plant^{-1} data with 15 days interval at 15, 30, 45 and 60 days after sowing (DAS). Plant dry weight was recorded from 20, 40 and 60 DAS, while number of nodules plant^{-1} was recorded from 20 and 40 DAS. Yield and other crop characters like number of branches plant^{-1}, number of pods plant^{-1} at 1st harvest, number of pods plant^{-1} at final harvest, number of total pods plant^{-1}, pod length, number of seeds pod^{-1}, 1000-grain weight, shelling percentage, grain yield at 1st harvest, grain yield at final harvest, total grain yield, shell yield at 1st harvest, shell yield at final harvest, total shell yield, straw yield, biological yield and harvest index were recorded. Pods plant^{-1}, pod length and number of seeds pod^{-1} were recorded from the selected plants. Central 3.15 m^2 areas from each plot were harvested for yield determination. Thousand grain weight was measured from sampled seed. Besides weed characters like number of weeds m^{-2} and dry weight of weeds m^{-2} were recorded from 20 and 40 DAS. Data were analyzed using CropStat package. The mean differences among the treatments were compared by least significant difference (LSD) test at 5% level of significance.

Data on different growth parameters, yield attributes and yield were significantly varied for different treatments. In case of variety, at 4, 5, 6 and 7 DAS, maximum germination percentage (61.91, 88.43, 95.98 and 99.62 %, respectively) was counted in V_2 (BARI mash-3) respectively whereas the minimum germination percentage (34.12, 72.47, 90.70 and 94.97 %, respectively) was recorded from V_1 (BARI mash-1). At 15, 30, 45 and 60 DAS, tallest plant (10.06, 26.07, 46.28 and 49.64 cm) was produced by V_2 (BARI mash-3) whereas the shortest plant (9.31, 23.75, 41.01 and 45.77 cm) was found from V_1 (BARI mash-1). At 15, 30, 45 and 60 DAS maximum number of leaves plant^{-1} (3.70, 8.37, 16.25 and 26.39 respectively) was obtained from V_2, V_2, V_1, V_1 and minimum number of leaves plant^{-1} (3.66, 8.34, 15.50 and 22.08 respectively) was found from V_1, V_1, V_2, V_2. At 20, 40 and 60 DAS higher plant dry weight (0.78, 3.88 and 6.40 g) was accumulated by V_2, V_1 and V_1 whereas the lower plant dry weight (0.75, 3.44 and 5.91 g) was accumulated by V_1, V_2 and V_2. At 20 and 40 DAS, maximum number of nodules plant^{-1} (10.73 and 37.03) was produced by V_2 (BARI mash-3) and minimum number of nodules plant^{-1} (10.53 and 30.81) was produced by V_1 (BARI mash-1). The highest SPAD value (45.03) was obtained from V_2 (BARI mash-3) variety and lowest SPAD value (44.15) was found in V_1 (BARI mash-1) variety at 45 DAS. The maximum days required to 1% and 100% flowering (33.48 and 43.00) was in V_2 and V_1 while minimum days required to 1% and 100% flowering (33.33 and 42.00) was in V_1 and V_2. At 20 and 40 DAS, the maximum number of weeds m^{-2} (51.33 and 216.67 respectively) was observed from V_2 and V_1 while the minimum number of weeds m^{-2} (45.14 and 206.10 respectively) was recorded in V_1 and V_2. At 20 and 40 DAS, the maximum dry weight of weeds m^{-2} (16.67 and 110.46 g respectively) was obtained from V_1 (BARI mash-1) whereas the minimum dry weight of weeds m^{-2} (15.14 and 68.11 g respectively) was found in V_2 (BARI mash-3). The maximum number of branches plant^{-1} was observed from V_1 (1.83, 2.84 and 4.01 at 30, 45 and 60 DAS, respectively) while minimum number of branches plant^{-1} was recorded in V_2 (1.49, 2.05 and 3.21 at 30, 45 and 60 DAS, respectively). The highest number of total pods plant^{-1} (43.48) was produced by V_1 (BARI mash-1) and the lowest number of total pods plant^{-1} (30.70) was found in V_2 (BARI mash-3). The highest value of pod length (4.30 cm) was observed from the variety V_1 (BARI mash-1) while the lowest value of pod length (4.27 cm) was recorded in variety V_2 (BARI mash-3). The higher number of seeds pod^{-1} (6.01) and lower number of seeds pod^{-1} (5.96) were recorded in the V_2 and V_1, respectively. The highest weight of 1000-grain (37.90 g) was obtained from V_2 (BARI mash-3), whereas the lowest weight of 1000-grain (36.56 g) was found from V_1 (BARI mash-1). The highest shelling percentage (67.86%) was recorded in V_2 and the lowest shelling percentage (64.91%) was found from V_1. The maximum total grain yield (763.99 kg ha^{-1}) was produced by V_2 (BARI mash-3), while the minimum total grain yield (666.78 kg ha^{-1}) was recorded in V_1 (BARI mash-1). The maximum total shell yield (372.21 kg ha^{-1}) was observed from V_2 and minimum total shell yield (342.92 kg ha^{-1}) was found in V_1 variety. The maximum straw yield (3472.93 kg ha^{-1}) was obtained from V_1 (BARI mash-1), whereas minimum straw yield (3372.26 kg ha^{-1}) was recorded in V_2 (BARI mash-3) variety. The highest biological yield (4508.46 kg ha^{-1}) was produced by V_2 and the lowest biological yield (4482.62 kg ha^{-1}) was found from V_1. The highest harvest index (17.69%) was observed from V_2, while the lowest harvest index (15.60%) from V_1.

For agronomic managements, at 4, 5, 6 and 7 DAS, maximum germination percentage (57.75, 85.55, 96.25 and 98.81 %, respectively) was recorded from M_6, M_6, M_3, M_2 respectively while the minimum germination percentage (32.64, 71.93, 89.31 and 93.26 %, respectively) was counted in M_2, M_2, M_2, M_4. At 15, 30, 45 and 60 DAS, tallest plant (10.16, 26.14, 47.57 and 51.57 cm) was observed from M_6, M_3, M_3, M_3 whereas the shortest plant (9.11, 23.79, 40.25 and 44.43 cm) was recorded from M_1, M_4, M_4, M_4. At 15, 30, 45 and 60 DAS maximum number of leaves plant^{-1} (3.83, 9.00, 17.23 and 31.33 respectively) was counted in M_6, M_6, M_5, M_5 while minimum number of leaves plant^{-1} (3.43, 7.70, 13.93 and 17.30 respectively) was obtained from M_4, M_4, M_3, M_3. At 20, 40 and 60 DAS highest plant dry weight (0.87, 4.43 and 7.17 g) was accumulated by M_6, M_5 and M_2 and the lowest plant dry weight (0.65, 3.12 and 5.55 g) was accumulated by M_4, M_1 and M_3. At 20 and 40 DAS, maximum number of nodules plant^{-1} (11.95 and 41.60) was observed from M_2 and M_3 whereas minimum number of nodules plant^{-1} (9.27 and 25.80) was recorded in M_5 and M_1. The highest SPAD value (46.09) was obtained from M_5 and lowest SPAD value (42.28) was found in M_2 at 45 DAS. The maximum days required to 1%, 50% and 100% flowering (34.33, 38.33 and 43.83) was observed from M_1 while minimum days required to 1%, 50% and 100% flowering (33.00, 37.00 and 41.50) was recorded in M_4, M_4 and M_6. At 20 and 40 DAS, the maximum number of weeds m^{-2}

(54.33 and 328.33 respectively) was recorded from M_2 and M_3 whereas the minimum number of weeds m^{-2} (40.33 and 133.33 respectively) was found in M_7 and M_4. At 20 and 40 DAS, the maximum dry weight of weeds m^{-2} (20.67 and 167.09 g respectively) was accumulated by M_4 and M_3 while the minimum dry weight of weeds m^{-2} (14.67 and 44.20 g respectively) was counted in M_1 and M_4. At 30, 45 and 60 DAS, the maximum number of branches $plant^{-1}$ (2.17, 3.30 and 4.87 respectively) was obtained from M_6, M_5 and M_5 and minimum number of branches $plant^{-1}$ (1.30, 1.87 and 2.50 respectively) was found in M_4, M_3 and M_1. The highest number of total pods $plant^{-1}$ (47.40) was observed from M_7 whereas the lowest number of total pods $plant^{-1}$ (22.07) was counted in M_1. The highest value of pod length (4.41 cm) was recorded from M_4 and the lowest value of pod length (4.13 cm) was found in M_3. The higher number of seeds pod^{-1} (6.32) and lower number of seeds pod^{-1} (5.81) were obtained from M_2 and M_1, respectively. The highest weight of 1000-grain (39.89 g) was observed from M_3 while the lowest weight of 1000-grain (36.47 g) was recorded in M_4. The highest shelling percentage (74.75%) was obtained from M_3 whereas the lowest shelling percentage (58.87%) was recorded in M_1. The maximum total grain yield (1072.53 kg ha^{-1}) was produced by M_7 and the minimum total grain yield (245.86 kg ha^{-1}) was found in M_1. The maximum total shell yield (547.39 kg ha^{-1}) was counted in M_7 while minimum total shell yield (87.50 kg ha^{-1}) was recorded in M_3. The maximum straw yield (4448.58 kg ha^{-1}) was observed from M_6 and minimum straw yield (2442.58 kg ha^{-1}) was found in M_3. The highest biological yield (5829.52 kg ha^{-1}) was produced by M_6 whereas the lowest biological yield (2819.26 kg ha^{-1}) was counted in M_3. The highest harvest index (22.87%) was recorded from M_7 and the lowest harvest index (11.28%) was found in M_3.

Due to interaction effect between variety and agronomic managements, at 4, 5, 6 and 7 DAS, maximum germination percentage (83.32, 91.10, 97.42 and 100 %, respectively) was counted from V_2M_7, V_2M_4, V_2M_3, V_2M_6 respectively whereas the minimum germination percentage (18.64, 58.45, 84.76 and 86.51 %, respectively) was found in V_1M_2, V_1M_2, V_1M_4, V_1M_4. At 15, 30, 45 and 60 DAS, tallest plant (11.00, 28.07, 51.07 and 53.20 cm) was obtained from V_2M_6, V_2M_3, V_2M_3, V_2M_3 and the shortest plant (7.87, 20.89, 36.05 and 41.53 cm) was observed from V_1M_4. At 15, 30, 45 and 60 DAS maximum number of leaves $plant^{-1}$ (3.87, 9.20, 18.07 and 33.40 respectively) was observed from V_1M_6, V_1M_6, V_1M_5, V_1M_5 while minimum number of leaves $plant^{-1}$ (3.13, 7.60, 13.00 and 16.13 respectively) was recorded in V_1M_4, V_1M_4, V_2M_3, V_2M_3. At 20, 40 and 60 DAS highest plant dry weight (0.93, 4.96 and 8.31 g) was accumulated by V_2M_7, V_1M_5 and V_1M_2 whereas the lowest plant dry weight (0.53, 2.81 and 4.54 g) was found in V_2M_4, V_2M_4 and V_2M_3. At 20 and 40 DAS, maximum number of nodules plant^{-1} (13.27 and 50.13) was obtained from V_2M_3 and minimum number of nodules plant^{-1} (7.20 and 22.67) was counted in V_2M_5 and V_1M_4. The highest SPAD value (47.99) was recorded from V_2M_5 while lowest SPAD value (41.62) was found in V_2M_2 at 45 DAS. The maximum days required to 1%, 50% and 100% flowering (35.00, 38.67 and 44.67) was counted from V_2M_1, V_1M_1 and V_1M_7 whereas minimum days required to 1%, 50% and 100% flowering (33.00, 37.00 and 40.00) was found in V_2M_2, V_1M_2 and V_2M_7. At 20 and 40 DAS, the maximum number of weeds m^{-2} (67.33 and 346.67 respectively) was observed from V_2M_6 and V_1M_3 while the minimum number of weeds m^{-2} (30.67 and 130.00 respectively) was recorded from V_1M_6 and V_2M_4. At 20 and 40 DAS, the maximum dry weight of weeds m^{-2} (23.33 and 207.19 g respectively) was accumulated by V_2M_4 and V_1M_3 whereas the minimum dry weight of weeds m^{-2} (12.00 and 30.11 g respectively) was found in V_2M_3 and V_2M_4. At 30, 45 and 60 DAS, the maximum number of branches plant^{-1} (2.47, 3.93 and 5.33 respectively) was recorded from V_1M_6, V_1M_5 and V_1M_5 while minimum number of branches plant^{-1} (1.07, 1.27 and 2.13 respectively) was counted in V_2M_1, V_2M_3 and V_2M_1. The highest number of total pods plant^{-1} (52.07) was obtained from V_1M_7 and the lowest number of total pods plant^{-1} (18.40) was recorded from V_2M_3. The highest value of pod length (4.44 cm) was observed from V_2M_4 whereas the lowest value of pod length (4.02 cm) was counted from V_2M_3. The higher number of seeds pod^{-1} (6.33) and lower number of seeds pod^{-1} (5.70) were recorded from V_1M_2 and V_2M_3, respectively. The highest weight of 1000-grain (42.58 g) was obtained from V_2M_2 while the lowest weight of 1000-grain (33.65 g) was found in V_2M_7. The highest shelling percentage (83.51%) was recorded from V_2M_3 and the lowest shelling percentage (58.40 %) was counted from V_1M_1. The maximum total grain yield (1100.47 kg ha^{-1}) was produced by V_1M_7 whereas the minimum total grain yield (184.15 kg ha^{-1}) was recorded in V_1M_1. The maximum total shell yield (590.25 kg ha^{-1}) was observed from V_1M_7 and minimum total shell yield (69.18 kg ha^{-1}) was found from V_2M_3. The maximum straw yield (5173.92 kg ha^{-1}) was obtained from V_2M_6 while minimum straw yield (1153.83 kg ha^{-1}) was recorded in V_2M_1. The highest biological yield (6582.84 kg ha^{-1}) was observed from V_2M_6 and the lowest biological yield (1623.30 kg ha^{-1}) was found from V_2M_1. The highest harvest index (26.19%) was obtained from V_1M_7 whereas the lowest harvest index (4.46%) was recorded from V_1M_1.

Based on the findings of the present experiment, the conclusion may be drawn as follows:

- The variety BARI mash-3 showed higher yield than BARI mash-1.
- The complete management (recommended) gave higher growth and yield as compared to other agronomic managements in blackgram. No management reduced the highest yield (77.08%) compared to that of complete management that followed by no weeding (73.04%), no insecticides (29.19%), no irrigation (25.50%), no fungicides (15.36%) and no fertilizer (12.93%).
- In interaction effect, the variety BARI mash-3 along with complete management could be the better production package for maximum growth and yield of blackgram. Agronomic managements played an important role for getting maximum return and more emphasis should be given on weeding that reduced highest yield irrespective of blackgram varieties.

However, to reach a specific recommendation, the same experiment is needed to conduct over different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performance.

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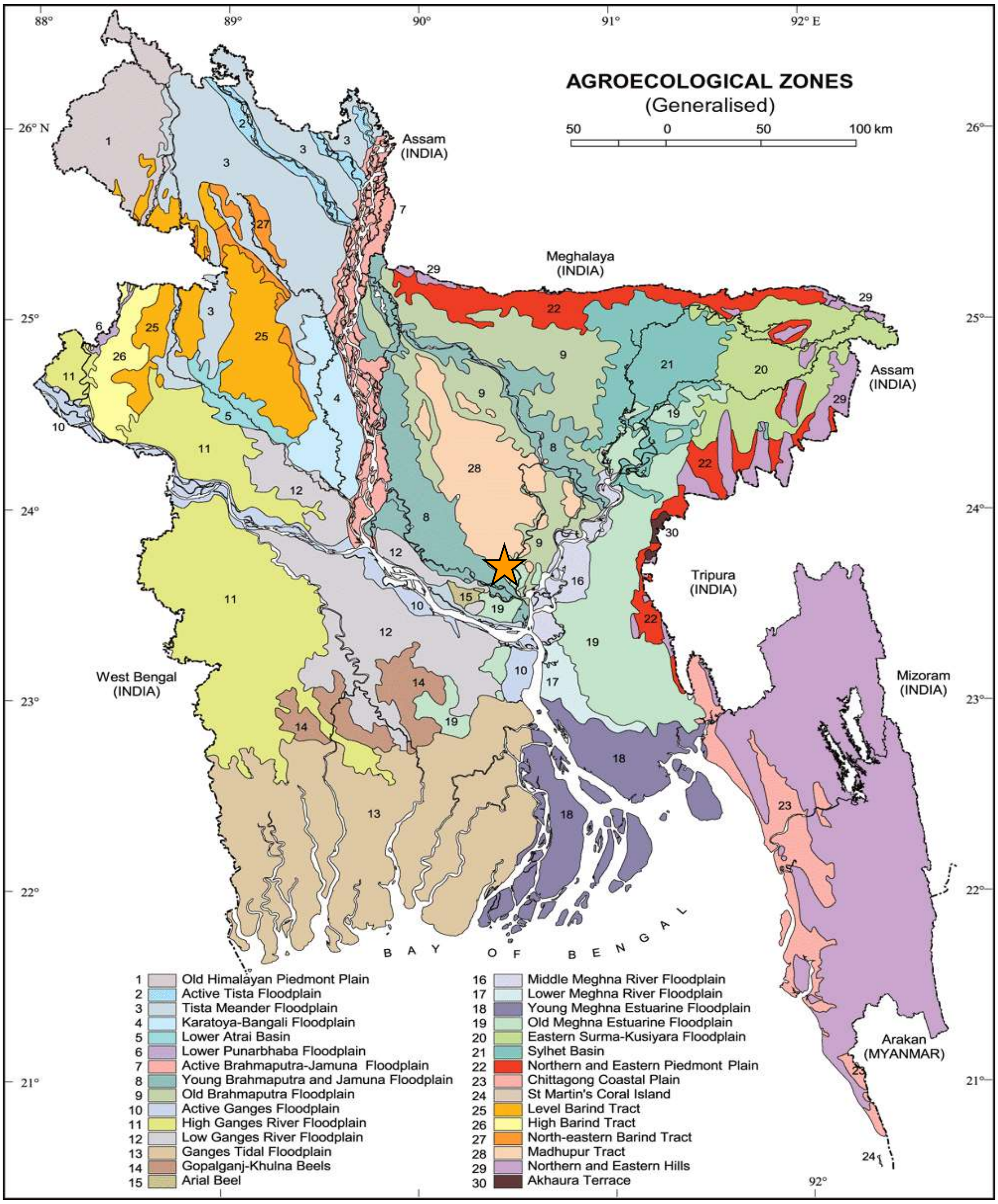
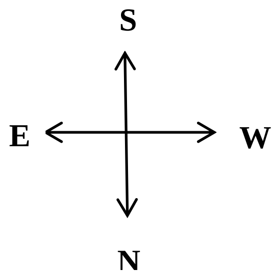
APPENDICES

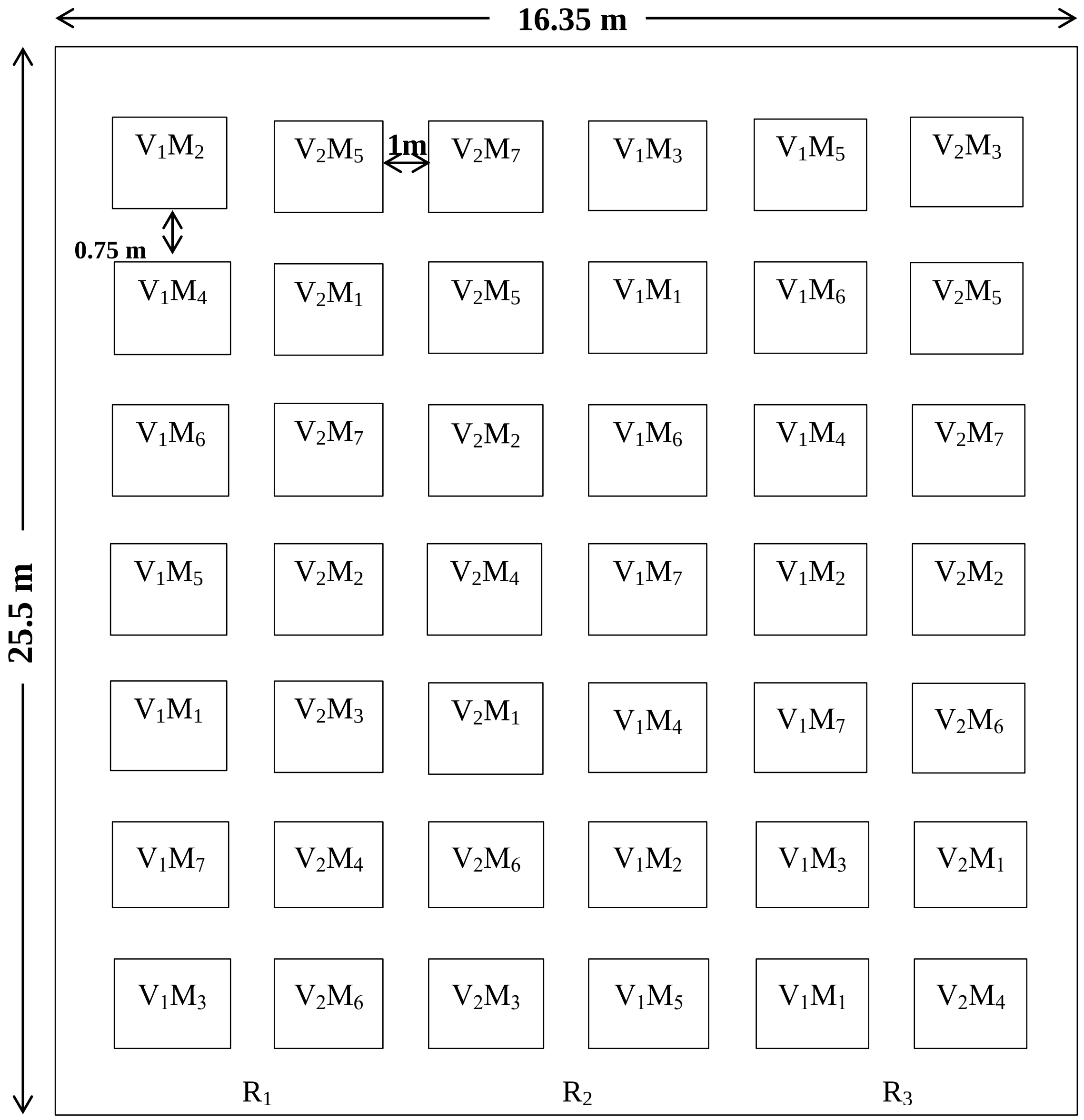
Appendix I. Map showing the experimental sites under study



☆ **The experimental site under study**

Appendix II. Field layout of the experiment





Plot size: 3.0 × 2.1 m, Replication to Replication distance: 1m, Plot to plot distance: 0.75 m

Factor A: Variety: V_1 = BARI mash-1, V_2 = BARI mash-3

Factor B: Agronomic Managements: M_1 = Control (No management), M_2 = No fertilizer but all other managements, M_3 = No weeding but all other managements, M_4 = No irrigation but all other managements, M_5 = No insecticide but all other managements, M_6 = No fungicide/bacteriocide but all other managements, M_7 = Complete management (recommended)

Appendix III. Analysis of variance of the data on germination percentage of blackgram as influenced by variety and agronomic managements

Source of variation	Degrees of freedom	Mean square			
		Germination percentage at			
		4 DAS	5 DAS	6 DAS	7 DAS
Replication	2	249.539	93.5424	10.8993	6.24630
Variety (A)	1	8110.37*	2673.14*	293.569	227.641
Error I	2	62.4917	3.14460	11.7746	4.37887
Agronomic managements (B)	6	433.120*	149.040	48.9087	22.9463
Interaction (A×B)	6	510.036*	148.349	33.1374	24.2986
Error II	24	151.046	97.0314	24.2745	19.0498

* Significant at 5% level

Appendix IV. Analysis of variance of the data on plant height of blackgram as influenced by variety and agronomic managements

Source of variation	Degrees of freedom	Mean square			
		Plant height at			
		15 DAS	30 DAS	45 DAS	60 DAS
Replication	2	12.3244	2.80906	14.0989	0.672799
Variety (A)	1	5.88377	56.7940	291.247*	156.678*
Error I	2	0.0674	1.07626	4.80178	3.85520
Agronomic managements (B)	6	1.15364	3.85815	35.2767*	30.6607*
Interaction (A×B)	6	2.12448	6.47554	9.25764	6.98551
Error II	24	1.55793	5.02946	10.9735	8.69667

* Significant at 5% level

Appendix V. Analysis of variance of the data on number of leaves plant^{-1} of blackgram as influenced by variety and agronomic managements

Source of variation	Degrees of freedom	Mean square			
		Number of leaves plant^{-1} at			
		15 DAS	30 DAS	45 DAS	60 DAS
Replication	2	0.383809	0.560000	3.32572	19.1552
Variety (A)	1	0.015238	.0085718	5.94381	195.437
Error I	2	0.183809	0.148571	5.54667	9.07143
Agronomic managements (B)	6	.0904762	1.17714	9.15651	161.960*
Interaction (A×B)	6	0.133016	0.148571	1.53937	8.99936
Error II	24	.0560317	1.29095	5.54175	14.3744

* Significant at 5% level

Appendix VI. Analysis of variance of the data on plant dry weight of blackgram as influenced by variety and agronomic managements

Source of variation	Degrees of freedom	Mean square		
		Plant dry weight at		
		20 DAS	40 DAS	60 DAS
Replication	2	.000714287	3.90400	10.5876
Variety (A)	1	0.0116667	2.05044	2.53086
Error I	2	0.0330952	0.746302	1.21926
Agronomic managements (B)	6	0.0385714	1.43967	1.75658
Interaction (A×B)	6	0.0455556	1.08529	2.73359
Error II	24	0.0246825	0.758297	4.25906

* Significant at 5% level

Appendix VII. Analysis of variance of the data on number of nodules plant^{-1} and SPAD value of blackgram as influenced by variety and agronomic managements

Source of variation	Degrees of freedom	Mean square		
		Number of nodules plant^{-1} at		SPAD value at 45 DAS
		20 DAS	40 DAS	
Replication	2	15.2379	2322.62	107.969
Variety (A)	1	0.420000	406.104	8.13120
Error I	2	2.87214	167.687	11.9483
Agronomic managements (B)	6	6.59317	245.357	9.06131
Interaction (A×B)	6	17.0733	110.159	6.57973
Error II	24	10.9344	211.111	6.41328

* Significant at 5% level

Appendix VIII. Analysis of variance of the data on days required to flowering of blackgram as influenced by variety and agronomic managements

Source of variation	Degrees of freedom	Mean square		
		Days required to 1% flowering	Days required to 50% flowering	Days required to 100% flowering
Replication	2	2.95238	0.214286	10.5000
Variety (A)	1	0.214286	2.12152×10^{-14}	10.5000
Error I	2	0.285714	0.642857	2.78571
Agronomic managements (B)	6	1.26984*****	1.65873*****	4.44444
Interaction (A×B)	6	0.603175	0.611111	6.33333
Error II	24	0.341270	0.289683	3.03175

* Significant at 5% level

Appendix IX. Analysis of variance of the data on number of branches plant^{-1} of blackgram as influenced by variety and agronomic managements

Source of variation	Degrees of freedom	Mean square		
		Number of branches plant^{-1} at		
		30 DAS	45 DAS	60 DAS
Replication	2	0.0800000	1.32286	1.19238
Variety (A)	1	1.23429	6.56095	6.72000
Error I	2	0.548572	0.926667	0.217143
Agronomic managements (B)	6	0.574921	1.65270*	4.09492*
Interaction (A×B)	6	0.209841	0.172063	0.0333333
Error II	24	0.240952	0.441429	0.510317

*Significant at 5% level of significance

Appendix X. Analysis of variance of the data on number of pods plant^{-1} of blackgram as influenced by variety and agronomic managements

Source of variation	Degrees of freedom	Mean square		
		Number of pods plant^{-1} at		
		1st harvest	Final harvest	Total
Replication	2	16.8267	71.5400	19.4867
Variety (A)	1	297.601	582.404	1712.65*
Error I	2	8.46094	94.8752	50.0257
Agronomic managements (B)	6	283.133*	88.9778*	540.346*
Interaction (A×B)	6	37.6121	30.8616	70.5397
Error II	24	46.0305	35.4721	98.6295

*Significant at 5% level of significance

Appendix XI. Analysis of variance of the data on pod length, number of seeds pod^{-1}, 1000-grain weight and shelling percentage of blackgram as influenced by variety and agronomic managements

Source of variation	Degrees of freedom	Mean square			
		Pod length	Number of seeds pod^{-1}	1000 grain weight	Shelling percentage
Replication	2	.000697035	0.229524	49.4105	95.8757
Variety (A)	1	0.00656248	0.0288095	18.7334	91.6420
Error I	2	0.0444875	0.653095	2.09985	572.719
Agronomic managements (B)	6	0.0530737	0.218869	12.1760	132.923
Interaction (A×B)	6	0.0346653	0.0758929	28.0521	67.6194
Error II	24	0.0468492	0.151935	32.5164	179.109

*Significant at 5% level of significance

Appendix XII. Analysis of variance of the data on grain yield of blackgram as influenced by variety and agronomic managements

Source of variation	Degrees of freedom	Mean square		
		Grain yield at		
		1^{st} harvest	Final harvest	Total
Replication	2	70998.2	3149.57	45994.3
Variety (A)	1	90768.0	188.214	99221.8
Error I	2	13964.8	9384.55	45645.4
Agronomic managements (B)	6	437149.0*	34179.4*	623318.0*
Interaction (A×B)	6	13716.7	14202.1	11196.8
Error II	24	23895.9	7232.92	37770.1

*Significant at 5% level of significance

Appendix XIII. Analysis of variance of the data on shell yield of blackgram as influenced by variety and agronomic managements

Source of variation	Degrees of freedom	Mean square		
		Shell yield at		
		1^{st} harvest	Final harvest	Total
Replication	2	20560.1	300.098	16296.7
Variety (A)	1	9018.54	0.00259232	9009.16
Error I	2	477.538	1861.45	470.224
Agronomic managements (B)	6	116226.0*	15456.7*	196149.0*
Interaction (A×B)	6	2430.79	4023.13	8106.66
Error II	24	8114.20	1759.12	12658.6

*Significant at 5% level of significance

Appendix XIV. Analysis of variance of the data on straw yield, biological yield and harvest index of blackgram as influenced by variety and agronomic managements

Source of variation	Degrees of freedom	Mean square		
		Straw yield	Biological yield	Harvest index
Replication	2	7256070.0	8759330.0	35.6573
Variety (A)	1	106402.0	7009.59	46.1372
Error I	2	200623.0	46280.4	55.7770
Agronomic managements (B)	6	4289990.0	9281620.0*	114.892*
Interaction (A×B)	6	3385390.0	3174080.0	82.3477*
Error II	24	1957540.0	2340750.0	32.1567

*Significant at 5% level of significance

Appendix XV. Analysis of variance of the data on number of weeds m^{-2} and dry weight of weeds m^{-2} of blackgram as influenced by variety and agronomic managements

Source of variation	Degrees of freedom	Mean square			
		Number of weeds m^{-2} at		Dry weight of weeds m^{-2} at	
		20 DAS	40 DAS	20 DAS	40 DAS
Replication	2	16.0952	35613.0	101.238	484.144
Variety (A)	1	402.381	1173.43	24.3810	18830.7
Error I	2	14.3810	6961.14	92.6667	92.7622
Agronomic managements (B)	6	183.714	39247.4*	27.0476	9834.23*
Interaction (A×B)	6	381.937	2559.87	21.2698	1859.86
Error II	24	316.016	4235.27	23.7302	2781.30

*Significant at 5% level of significance

PLATES

Plate 1. Field view of the experiment

Plate 2. Field view of no weeding but all other managements (M_3)

Plate 3. Field view of no fungicide/bacteriocide but all other managements (M_6)

Plate 4. Maximum grain yield at 1st harvest of blackgram

Plate 5. Minimum grain yield at 1st harvest of blackgram

Plate 6. Maximum grain yield at 2^{nd} harvest of blackgram

Plate 7. Minimum grain yield at 2^{nd} harvest of blackgram