INFLUENCE OF NITROGEN AND PHOSPHORUS LEVELS ON YIELD AND SEED QUALITY OF BLACKGRAM

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CERTIFICATE

This is to certify that the thesis entitled **"INFLUENCE OF NITROGEN AND PHOSPHORUS LEVELS ON YIELD AND SEED QUALITY OF BLACKGRAM"** *submitted to the Institute of Seed Technology, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of* ***MASTER OF SCIENCE (M.S.)*** *in* ***SEED TECHNOLOGY,*** *embodies the results of a piece of bona fide research work carried out by* ***HASIBUL AHSAN,*** *Registration No.* ***11-04451*** *under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

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

Dated:

Dhaka, Bangladesh

(Prof. Dr. A. K. M. Ruhul Amin)
Supervisor

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INFLUENCE OF NITROGEN AND PHOSPHORUS LEVELS ON YIELD AND SEED QUALITY OF BLACKGRAM

ABSTRACT

The experiment was conducted at the research farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during March to June 2017 to study the influence of nitrogen and phosphorus levels on yield and seed quality of blackgram. The experiment comprised as two factors, i.e. different fertilizer doses i.e. F_0 = all fertilizer except N & P, F_1 = 50% less N & P, F_2= Recommended dose of N & P with others, F_3= 50% higher N & P; and two varieties V_1= BARI mash2, V_2=BARI mash3. The experiment was conducted following the Randomized Complete Block Design with three replications. Result indicated that the number of pods plant (68.73), number of seeds pod^{-1} (7.21), 1000 seeds weight (40.79 g) attributed to higher seed yield (2014.70 kg ha^{-1}) with fertilizer treatment F_3. Similarly, number of pods plant^{-1} (60.45), number of seeds pod^{-1} (6.57) and 1000 seeds weight (39.56 g) accelerated higher seed yield (1726.90 kg ha^{-1}) of the variety V_2 (BARI mash3). Interaction of F_3V_2 also gave the higher seed yield and other yield attributes. The seed quality parameters i.e. germination (%), shoot length, root length, shoot dry weight and root dry weight was also highest in the fertilizer F_3 (94.66%, 9.85 cm, 16.41 cm, 17.36 g and 70.96 g) and variety V_2 (86.08%, 8.81 cm, 15.11 cm, 15.33 g and 60.35 g). So, BARI mash3 can be cultivated with higher doses of fertilizer (50% higher N & P) to get maximum yield and quality seeds.

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LIST OF ACRONYMS

AEZ	Agro-Ecological Zone
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
CV%	Percentage of coefficient of variance
cv.	Cultivar
DAS	Days after sowing
^{0}C	Degree Celsius
et al	And others
FAO	Food and Agriculture Organization
g	gram(s)
ha^{-1}	Per hectare
HI	Harvest Index
kg	Kilogram
mg	Milligram
MoP	Muriate of Potash
N	Nitrogen
No.	Number
NS	Not significant
%	Percent
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resources and Development Institute
TSP	Triple Super Phosphate
Wt.	Weight

CHAPTER I

INTRODUCTION

Blackgram is one of the main edible pulse crops of Bangladesh. It ranks fourth among the pulses with an area of about 70,000 ha (BBS, 2013). Pulses are the most important crops in Bangladesh because of its low-cost production and high-quality protein. They play a major role in providing a balanced protein component in the diet of the people. Pulses contain a higher level of quality protein, nearly three times as much as cereals; therefore, they are the cheapest and rich source of protein and essential amino acids and thus share a major protein of the vegetarian diet. As an excellent source of plant protein, it is cultivated extensively in the tropics and subtropics. Besides, the crops enrich the soil fertility and health in terms of addition of nitrogen and organic matter. Among pulses, blackgram (*Vigna mungo* L.), occupies a unique place for its use as vegetable, and it is grown both as pure and mixed crop along with maize, cotton, sorghum and other millets. It is a major component of the daily Bangladeshi diet and serves as a rich protein source (23.9%) besides; it also contains 60.4 per cent carbohydrates. As per the World Health Organization every man needs 80 g of pulses per day and every man needs minimum consumption of 47 g of protein per day to meet requirement of the body. But at present, the per capita availability of pulses is only 30~35 g/d. Therefore, there is a need for three-fold increase in pulse production as that of current production.

Blackgram is one of the major pulses crop in Bangladesh and it is the fourth most important food legume grown in the world after lentil, Khesari and Chickpea. It

contributes about 9.5% of total pulses production in Bangladesh (BBS, 2013). The traditional cultivation of blackgram is confined to South-Asia and adjacent region. The production of blackgram globally is around 8.5 million tons from the major producing countries such as India, Myanmar and Thailand. India contributes nearly 70 percent of the world's production followed by Myanmar and Thailand. Blackgram is cultivated about 3.24 million hectares with average productivity of at 700 kg a hectare. But blackgram yield in our country is far below than the other country. The low yield can be improved in various ways. Among them fertilizer management like nitrogen and phosphorus is one of the important aspects. Domestic pulse production satisfies less than half of our countrymen demands. Application of N and P fertilizer was found to increase 1000 grains weight, grain yield and protein contents of various legumes particularly blackgram (Rajendran *et al.* 1974). This finding was further supported by the results reported by Subramanian and Radhkrishnan (1983) who claimed significant increase in yield of blackgram with the use of N and P. Malik *et al*. (1986) reported that N and P combination was essential for having maximum yield of blackgram.

The price of protein rich food higher than other foods. The resulting high prices have led to widespread protein malnutrition especially among vulnerable groups, such as rural children and the aged. Blackgram plays an important role the agro-economy and human health of Bangladesh. This is a good source of proteins, vitamins and minerals. Since animals' proteins are costly and scarce in the developing countries cultivation of food legumes is the best and quickest way to

augment the production of food proteins. The response to applied phosphorus with respect to protein content in blackgram attributed to more nitrogen fixation. K alone or in combination with Nand P did not show significant positive response. But the literature also witnessed that P application in addition to N and K showed beneficial effects on mashbean (Malik *et al*., 1986). Similarly, other researchers had also reported almost similar response to applied N, P and K by the crops like chickpea and mungbean (Rao *et al*., 2005).

An essential element of agricultural sustainability is the effective management of N in the environment (Rao *et al*., 2005). Nitrogen deficiency constrains leaf area expansion, enhances leaf senescence after canopy structure and subsequently reduces crop yield (Wolfe *et al*., 1988). Soils of Bangladesh are mostly deficient in nitrogen. Nitrogen increases the dry matter and protein percentage of grain as well as methionine and triptophen contents in seed with increases of levels of applied nitrogen (Vidhate *et al*., 1986). The yield of blackgram is very poor as compared to many other legume crops (Rahman, 1991). Slow rate of dry matter accumulation during pre-flowering phase, on-set of leaf senescence during the period of pod development and low partitioning efficiency of assimilates to grain are identified as the main physiological constraints for increasing yield. Adequate supply of N may minimize the yield reduction through reduced those constraints. Probably that is why blackgram is highly responsive to nitrogen. Leaf area is made up of the total green lamina area of emerged leaves (Keating and Carberry, 1993). Greater leaf area is necessary to have superior yield and yield components in grain legumes (Muchow, 1985).

Saini and Thakur (1996) stated that moderate doses of nitrogen (60 kg N per hectare) significantly increased the plant height, branches plant^{-1} and leaf area index of grain legumes compared to no N. The higher grain yield of blackgram is associated with significantly superior yield attributes e.g. effective number of pods per plant and 1000 seed weight (Singh *et al*., 1993). Flower and pod formation being the major sink during the reproductive phase. Little attention has been paid to exploit maximum N use efficiency and productivity of blackgram through judicious application of N.

The genetic variability also has significant impact on the growth and yield of a crops. As like others crops the blackgram varieties also play vital role in growth, yield and seed quality attributes.

Therefore, the present study was conducted for the following objectives

- To observe the different doses of nitrogen and phosphorous on the yield and yield attributes of blackgram,
- To select the suitable nitrogen and phosphorus dose for producing better quality seed of blackgram.

CHAPTER II

REVIEW OF LITERATURES

2.1 Effect of nitrogen

Mishra (2016) was carried a field experiment out the effect of growth regulator, organic and inorganic foliar nutrition on yield and yield attributes of blackgram. Field experiment was conducted in the department of crop physiology at Vindhya Science & Agricultural Research Institute, Raushar, Rewa (M. P.) during 2014 to 2015. Study the effect of basal application of nitrogen in combination with foliar spray of urea and plant growth regulators. Among the treatments, the basal application of nitrogen 25kg ha-1 with foliar spray of urea 2% and 0.1 ppm brassinolide significantly expressed the higher values in growth attributes. Among the treatments T7 performed its superiority and had higher leaf area (102.7, 246.0, 567.0 and 494.3 mg g^{-1}) at vegetative stage, flowering stage, pod filling stage and harvest stage respectively.

Yeasmin (2015) was carried out an experiment at Sher-e-Bangla Agricultural University research farm, Dhaka to investigate the growth and yield response of blackgram (*Vigna mungo* L.) as affected by nitrogen and postassium management during the period from August to October, 2014. The experiment consisted of two factors. Factor A: Nitrogen fertilizer (3 levels); N_0: No nitrogen (Control), N_1: 15 Kg N ha^{-1} and N_2: 30 Kg N ha^{-1}, and factor B: Potassium fertilizer (4 levels); K_0: No potassium (Control), K_1: 10 Kg K ha^{-1}, K_2: 20 Kg K ha^{-1} and K_3: 30 Kg K ha^{-1}. The variety, BARI mash-1 was used in this experiment as the test crop. The experiment was laid out in a Randomized complete block

design with three replications (RCBD). Plant height, number of leaves plant^{-1}, number of branches plant^{-1}, number of pods plant^{-1}, pod length, number of seeds pod^{-1}, weight of 1000-seed, seed yield and stover yield were compared for different treatments. Results revealed that, N_2, K_3 treatment and their interaction influenced significantly on most of the growth, yield parameters and yield of blackgram. N_2 gave the higher yield (1.43 t ha^{-1}) which was 70.23% higher than N0 (0.84 t ha^{-1}). Application of K_3 greatly influenced the seed yield and K_3 produced (1.36 t ha^{-1}) which was 72.15% higher than K_0 (0.79 t ha^{-1}). The highest seed yield (1.51 t ha^{-1}) was recorded from the treatment combination of N_2K_3 which was 98.68% higher than N_0K_0 (0.76 t ha^{-1}). The maximum yield might be attributed to higher pods plant^{-1}, seed pod^{-1}, 1000-seed weight considering the higher production of blackgram. The maximum NPK concentration in seeds and stover was found from N_2, K_3 and their interaction N_2K_3 whereas the minimum was found from N_0, K_0 and N_0K_0, respectively. Application of 30 Kg N ha^{-1} and 30 Kg K ha^{-1} could be the best fertilizer management practices for cultivation of blackgram.

Marimuthu and Surendran (2015) stated that, pulse productivity is very low in some of the sandy soil areas where, soils are having poor water and nutrient holding capacity. To improve the pulse productivity, field experiments were conducted at Agricultural Research Station, Tamil Nadu for two consecutive years to study the effect of phosphorus sources (mono- and diammonium phosphate) with brassinolide and salicylic acid on growth and yield of blackgram in sandy loam soils. The experiment was carried out in a randomized block

design with three replications during *kharif* season. The treatments include 100% recommended dose of NPK along with foliar application of monoammonium phosphate (MAP), diammonium phosphate (DAP), brassinolide (0.25 ppm), and salicylic acid (100 ppm) along with the combination of these treatments. TNAU pulse wonder at 5.0 kg ha^{-1} and TNAU micronutrient mixture (MN) at 5 kg ha^{-1} were also tried. The results revealed that application of 100% recommended dose of NPK + DAP 2% + TNAU pulse wonder 5.0 kg ha^{-1} was statistically significant and recorded higher plant growth (37.62 cm), number of pods $plant^{-1}$ (37.15), yield of blackgram (1162 kg ha^{-1}), and benefit cost ratio (2.98) over the other treatments. The lowest blackgram yield (730 kg ha^{-1}) was recorded for control.

Mir *et al*. (2014) was conducted a field experiment at Allahabad Agricultural InstituteDeemed University, Allahabad to study the effect of levels of phosphorus, sulphur and Phosphorus Solubilizing Bacteria (PSB) on growth, yield and nutrient content of blackgram for consecutive two years 2004 and 2005. The crop growth parameters viz., plant height, number of nodules and number of leaves per plant, yield and nutrient content increased significantly with the application of high levels of phosphorus, sulphur with or without bio-fertilizer inoculation. Application of 60 kg P_2O_5 ha^{-1} recorded maximum plant height (49.9 cm), number of leaves $plant^{-1}$ (50.8), number of nodules $plant^{-1}$ (27.8), haulm yield (28.9 q ha^{-1}), grain yield (8 q ha^{-1}) and phosphorus, sulphur and protein content of grain (0.356 %, 0.253% and 22.64%, respectively) as compared to lower levels. Application of Sulphur @ 40 kg ha^{-1} recorded

maximum plant height (47.31 cm), number of leaves plant^{-1} (49.80), number of nodules plant^{-1} (25.58), haulm yield (28.80 q ha^{-1}), grain yield (7.92 q ha^{-1}) and phosphorus, sulphur and protein content (0.295, 0.281 and 21.79%, respectively). Inoculation of blackgram seeds with phosphorus solubilizing bacteria recorded slightly higher grain yield (7.49 q ha^{-1}) as compared to no inoculation (7.39 q ha^{-1}).

Surendar *et al*. (2013 a) was conducted a field experiment in the department of crop physiology at TNAU during 2006 to 2007 to study the effect of basal application of nitrogen in combination with foliar spray of urea and plant growth regulators. Among the treatments, the basal application of nitrogen 25kg ha^{-1} with foliar spray of urea 2% and 0.1 ppm brassinolide significantly expressed the higher values in growth attributes viz., Leaf area index, Crop growth rate, Net assimilation rate and Specific leaf weight by showing higher accumulation of total dry matter production with increased yield.

Surendar *et al*. (2013 b) was undertaken the field experiment to study the effect of nitrogen in combination with foliar spray of bioregulators and micronutrients on growth and productivity of CO-5 blackgram. Photosynthetic pigments and foliage soluble protein content were estimated at different phenological phases of blackgram. Seed yield were assessed at the time of harvest. Significant increase in the LAI (Leaf Area Index) and SLW (Specific Leaf Weight) due to basal application of nitrogen 25 kg per hectare with foliar spray of urea 2% and 0.1 ppm brassinolide. The SLA (Specific Leaf Area) was also greatly altered by

the basal application of nitrogen 25 kg per hectare with foliar spray of urea 2% and 0.1 ppm brassinolide treatment.

Athokpam *et al*. (2009) was carried out an investigation to assess the effect of N, P and K application on seed yield and nutrient uptake by blackgram during *kharif* seasons of 2004 and 2005. Three nutrients applied in combination did increase the seed yield significantly over control, however, N and K alone were at par with control. The highest seed yield was recorded with the application of 15:60:20 kg $N:P_2O_5:K_2O$ ha^{-1}. Application of 30 kg N ha^{-1} alone reduced the seed yield than 15 kg N/ha 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. The total uptake of nutrients by the blackgram was associated with higher biomass production.

Surendar and Vijayaraghavan (2013) reported that, appropriate supply of nitrogen helps to get higher vegetative growth and yield of blackgram.

Ekanayake *et al*. (2011) was conducted a field experiment at the Field Crops Research and Development Institute, Mahailluppllama to identify an optimum seed rate and the respective nitrogen level for broadcast blackgram grown on rainfed uplands during Maha 2009/2010 with the variety MI-1. The study was carried out as a two factors factorial experiment. Six seed rates (25 kg ha^{-1}, 37.5 kg ha^{-1}, 50 kg ha^{-1}, 62.5 kg ha^{-1}, 75 kg ha^{-1}, 87.5 kg ha^{-1}) with two rates of nitrogen (30 kg of N ha^{-1}, Zero N) were the two factors tested in the experiment. The results revealed that the plant height, leaf area per plant and canopy diameter

did not vary with the seed rate but significantly varied with fertilizer rates. Number of pods per plant, number of seeds per pod and 1000 seed weight did not vary with the seed rate but number of pods per plant and 1000 seed weight varied with the fertilizer level. The maximum yield was recorded at a seed rate of 64 kg/ha. Economic analysis revealed that the optimum seed rate is 62.5 kg ha^{-1}. The number of plants m^2 at which maximum yield was obtained was estimated as 93 plants m^2 which is also comparable to this seed rate. As there were no differences observed in yield components except for the number of plants per unit area, the main contributing factor for yield increments with increasing seed rate was the number of plants per unit area. Therefore, it can be concluded that the optimum seed rate for broadcast crop of blackgram under rain-fed conditions is 62.5 kg ha^{-1} when N is supplied at the rate of 30 kg ha^{-1}.

Sulochana and Gadgi (2008) conducted an experiment to determine the effect of rhizobium inoculation and nitrogen fertilizer on performance of Green gram, Bengal gram and Groundnut. Investigations were done in pot culture experiment under natural conditions. The research material consists of Green gram, Bengal gram and Groundnut varieties with treatment of seeds and Nitrogen fertilizer at 60kg ha^{-1} for green gram and Bengal gram, 120kg ha^{-1} for Groundnut. These treatments were compared against control (no inoculation). Data were recorded on Plant Growth parameters (seed germination, nodulation index, plant height at maturity, wet weight and dry weight) and soil nitrogen levels at the end of experiment. Among all treatments plant with seed inoculation was found

effective in all three legume varieties compared to soil with nitrogen fertilizer and control.

Kulsum *et al*. (2007) was conducted the study to evaluate the performance of blackgram (*Vigna mungo* L) under various levels of nitrogen at the Agronomy Research Site of Bangabandhu Sheikh Mujibur Rahman Agricultural University during March to June 2002. Two varieties of blackgram- BARI mash-3 and BINA mash-1 and six levels of nitrogen *i.e*., 0, 20, 40, 60, 80 and 100 kg N ha^{-1} were the treatment variables. Different morphological characters including grain yield were affected significantly by the nitrogen levels. The longest plant was measured with 100 kg N ha^{-1} whereas largest leaf area was obtained with 80 kg N ha^{-1}. BINA mash1 was longer than BARI mash3. Yield and yield contributing characters were affected significantly by different levels of nitrogen. The highest grain yield was obtained with 60 kg N ha^{-1} in both the varieties, thereafter the grain yield declined. Application of 60 kg N ha^{-1} favored most of the yield contributing characters that contributed the maximum grain yield production at this level of N. Between the two varieties of blackgram, BARI mash3 out yielded BINA mash1 at all levels of nitrogen. It was obvious that grain yield of blackgram can be increased substantially with the judicious application of N.

Kumar and Elamathi (2007) stated that, A field experiment was conducted during kharif season of 2005, at crop research form, Department of Agronomy, Allahabad Agricultural Institute, Deemed University, Allahabad, with Blackgram (*Vigna mungo* L.) var. PU-19. The treatments comprised of four levels of nitrogen (10, 20, 30 and 40 kg ha^{-1}) and three methods of application of

Rhizobium (Uninoculated, soil application and seed treatment) in factorial randomized block design (4x3), with 12 treatment combinations, each replicated three times. Among the treatments, application of nitrogen @ 20 kg ha^{-1} and seed treatment with Rhizobium significantly increased the plant height, number of leaves, dry weight of plant, number of nodules, number of pods, number of grains per pod, test weight, grain yield and stover yield. This treatment combination was found superior to all other treatments in respect of growth, nodulation, yield, economic returns and benefit cost ratio.

Jongruaysup *et al*. (1997) reported that, seeds used to plant a crop may contain sufficient molybdenum (Mo) to prevent subsequent Mo deficiency in the crop even when they are sown on Mo deficient soils. However, little is known about either the sources of the Mo acquired by the seed, or the timing of its redistribution during seed development. A glasshouse experiment was set up to examine the effect of Mo supply and nitrogen source on the redistribution of Mo within blackgram, from full flowering to seed maturity. Treatments comprised two sources of N (symbiotic N_2 fixation, NH_4NO_3), two levels of Mo supply [nil (- Mo), 0.64 mg Mo kg^{-1} soil (+Mo)] and four harvests (full flowering, early pod setting, late pod filling and seed maturity). The redistribution of Mo in blackgram was examined by determining changes over time in the content of Mo in plant parts at each growth stage. Molybdenum supply and the plant growth stage strongly affected the redistribution of Mo to the seed. In -Mo plants reliant on symbiotic N_2 fixation, Mo redistributed from roots, stems and leaves was the only source of Mo for reproductive development since, from full flowering until

maturity, there was no net increase in whole plant Mo. For pod and early seed development, the roots were the major source of Mo in -Mo plants. After late pod filling, nodules replaced roots as the major source of Mo for seed fill in -Mo plants. By contrast, for +Mo plants reliant on symbiotic N_2 fixation, Mo taken up from the soil after full flowering could have supplied nearly 50% of the seed Mo. The major sources of Mo for seed filling in +Mo plants were middle stem leaves during early podding, and middle stems and pod walls from late podding. Supplying NH_4NO_3 to plants from sowing had little effect on Mo distribution or redistribution in +Mo blackgram plants. However, in -Mo plants it accelerated the loss of Mo from middle stems and their leaves compared to nodulated plants.

Dhage *et al*. (1984) stated that, fertilization of blackgram with nitrogen (20 kg N ha^{-1}) in the form of urea produced a 32% increase in yield over control, and significantly improved nutritional quality of seeds by increasing crude protein, crude fat, methionine, calcium, phosphorus and iron contents without increasing polyphenols. The highest yield of blackgram was obtained when plants were supplied with phosphorus at a rate of 40 kg P_2O_5 ha^{-1}. Crude protein, crude fats, phosphorus and iron contents increased whereas calcium content decreased significantly at 40 kg P_2O_5 ha^{-1}. A continuous increase in polyphenol content was observed with increasing levels of phosphorus but it was significantly increased at P rates above 40 kg ha^{-1}. Fertilization with N and P in a 1:2 ratio at 20 kg N ha^{-1} and 40 kg P_2O_5 ha^{-1} produced a 32% seed yield increase and improved the nutritional value of blackgram seeds.

2.2 Effect of phosphorous

Phogat (2016) concluded that the combined application of P and S showed synergistic effect on seed and stover yield of blackgram with increasing levels of P and S upto highest level. The seed and stover yield were 955.50 and 2398.30 kg ha^{-1} with combined application of 60 and 30 kg ha^{-1}, P and S respectively, indicating synergistic effect of P and S on each other as both the nutrients mutually help absorption and utilization by blackgram probably due to balanced nutrition. The various growth parameters and yield attributes of blackgram viz. plant height, number of pods $plant^{-1}$, 100-seed weight, number of nodules $plant^{-1}$ also increased significantly with increasing levels of P and S up to highest level and the optimum values were recorded with combined application of 60 kg P ha^{-1} and 30 kg S ha^{-1}. However non significant response of P and S application has been observed in case of plant population (m^{-2}), while it slightly increased with each successive application of P and S up to 60 kg P ha^{-1} and 30 kg S ha^{-1}.

Niraj and Ved (2014) was conducted the experiment at the instructional farm of Narendra Deva University of Agriculture and Technology, Narendra Nagar, Kumarganj, Faizabad (U.P.) during *Kharif* season, 2007. Sixteen treatments were replicated thrice in Randomized Block Design. Blackgram variety Pant Urd-35 was taken as test crop. The data revealed that 45 kg ha^{-1} P and 30 kg ha^{-1} S significantly increased growth parameters such as plant height, number of branches and dry matter accumulation. The same treatment combination proved most effective in improving the yield and yield attributing characters *viz.*, number of pods, number of grains per pod, grains wt. per plant, test weight, grain

and straw yield. Application of 60 kg P and 45 kg S ha^{-1} produced highest grain and straw yield along with nutrients content and uptake of nitrogen, phosphorus, potassium and sulphur over rest of the treatments. However, this treatment was at par with the application of 45 kg P and 30 kg S ha^{-1}. A considerable buildup of soil fertility was also noted in this treatment. However, benefit: cost ratio was maximum with $P_{45}S_{30}$ treatments combination. Thus, recommendation of 40 kg sulphur and 10 kg zinc ha^{-1} can be made to the farmer's of eastern Uttar Pradesh for obtaining good yield, net rerun and fertility build up of soil.

Kadam *et al*. (2014) was conducted a field experiment to study the effect of phosphorus, vermicompost and PSB inoculation on growth, yield and quality of blackgram during Kharif 2011 on the farm of Agronomy department, at college of Agriculture, Latur. The research showed that the application of 75 kg P_2O_5 ha^{-1} recorded highest seed yield (1194 kg ha^{-1}) and yield attributes as well as high economic returns but it was found at par with 50 kg P_2O_5 ha^{-1}. The higher B:C ratio (1.58) was recorded at 50 kg P_2O_5 ha^{-1}. Therefore, it is recommended to apply 50 kg phosphorus ha^{-1} to blackgram crop. The superior development and yield parameters were recorded by the combine application of vermicompost and PSB inoculation. It was also found superior in respect of gross monetary return but higher net monetary return (18377 kg ha^{-1}) and B:C ratio (1.74) was obtained by the application of PSB inoculation. Hence it is recommended to apply PSB inoculation to blackgram.

Mir *et al*. (2014) was conducted a field experiment at Allahabad Agricultural Institute Deemed University, Allahabad to study the effect of levels of phosphorus, sulphur and Phosphorus Solubilizing Bacteria (PSB) on growth, yield and nutrient content of blackgram for consecutive two years 2004 and 2005. The crop growth parameters viz., plant height, number of nodules and number of leaves per plant, yield and nutrient content increased significantly with the application of high levels of phosphorus, sulphur with or without bio-fertilizer inoculation. Application of 60 kg P_2O_5 ha^{-1} recorded maximum plant height (49.9 cm), number of leaves $plant^{-1}$ (50.8), number of nodules $plant^{-1}$ (27.8), haulm yield (28.9 q ha^{-1}), grain yield (8 q ha^{-1}) and phosphorus, sulphur and protein content of grain (0.356 %, 0.253% and 22.64%, respectively) as compared to lower levels. Application of Sulphur @ 40 kg ha^{-1} recorded maximum plant height (47.31 cm), number of leaves $plant^{-1}$ (49.80), number of nodules $plant^{-1}$ (25.58), haulm yield (28.80 q ha^{-1}), grain yield (7.92 q ha^{-1}) and phosphorus, sulphur and protein content (0.295, 0.281 and 21.79%, respectively). Inoculation of blackgram seeds with phosphorus solubilizing bacteria recorded slightly higher grain yield (7.49 q ha^{-1}) as compared to no inoculation (7.39 q ha^{-1}).

Singh and Singh (2013) was conducted a field experiment during kharif season at the agriculture research farm of Raja Balwant Singh College Bichpuri, Agra (Uttar Pradesh) to find out the effect of phosphorus, sulphur and zinc on nutrient composition in Blackgram. The results revealed that nutrient Nitrogen, phosphorus, protein and sulphur also improved in seed composition by the

application of 60 kg phosphorus per hactare and sulphur 40 kg per hactare. The present experiment was conducted in spilt plot design with three replication, three levels of phosphorus 0 kg, 30 kg, 60 kg per hectare, three levels of sulphur 0 kg, 20 kg, 40 kg per hectare, three levels of zinc 0 kg, 5 kg, 10 kg per hectare 27 treatments combination and 81 plots were used to conduct this study.

Yadav (2011) was carried out a pot experiment to study the phosphrous-sulphur interaction at Department of Agricultural Chemistry and Soil Science, Rajasthan College of Agriculture, Udaipur on a sandy loam soil (Typic Haplustept) medium in P and deficient in S with clusterbean. Number and weight of nodules, grain and straw yield, content of P and S were increased with increase in level of P and S individually as well as in various combinations. Applied P and S increased grain nitrogen and protein contents. Available P in soil was increased with increasing levels of phosphorus. Similarly, available S in soil was increased with increasing levels of sulphur. The synergistic effect of phosphorus and sulphur was reported on number and weight of nodules plant^{-1}, N, P, S and protein content of clusterbean.

Yadahalli *et al*. (2010) stated that, the seed yield and haulm yield of blackgram were not much influenced by the phosphorus levels (50 kg and 75 kg P_2O_5 ha^{-1}) tried. However, the maximum seed yield (784.77 kg ha^{-1}) was obtained by the application of 75 kg P_2O_5 ha^{-1}. The lack of response of blackgram to higher phosphorus level at 75 kg P_2O_5 ha^{-1} could be attributed to available soil phosphorus (32.4 kg ha^{-1}). All the values of growth components and yield attributing characters were also on par between 50 kg and 75 kg P_2O_5 ha^{-1}.

Singh *et al*. (2008) reported that, in two years study on the response of blackgram (*Vigna mungo* L. Hepper) cv JU 2, the optimum level of phosphorus through different sources was determined with or without application of PSB [Phosphorus solubilizing bacteria]. Significantly highest seed yield of 651 kg ha^{-1} was recorded due to application of 40 Kg P_2O_5 ha^{-1} through DAP with PSB. The increase in seed yield was attributed mainly due to increase in nodulation, plant height, branches per plant, leaves per plant and pods per plant. A net return of Rs. 2624/- ha^{-1} was also recorded highest in this treatment. It is therefore, recommended for general adoption in medium black soils of Madhya Pradesh.

Agnihotri (2005) was conducted an experiment to study the effect of rhizobium phosphorus and sulphur on yield and quality of blackgram *Vigna Mungo* L. Result revealed that, vegetative growth, yield and quality of blackgram increased due to rhizobium phosphorus and sulphur application.

Singh (2004) was conducted an experiment to find out the role of sulphur and phosphorus in blackgram production. Result indicated that, with the supplementation of phosphorus, vegetative growth, yield and quality of blackgram increased.

Tanwar *et al*. (2003) was carried out a field experiment at Udaipur during kharif, 1996 to study the effect of phosphorus and biofertilizers on yield, nutrient content and uptake by blackgram. The crop yield, N and P content and uptake by grain and straw both, significantly increased upto 60 kg P_2O_5 ha^{-1}. Dual inoculation of seeds with phosphate solubilizing bacteria (*Bacillus megaterium* var. Phosphaticuir.) and Rhizobium caused a significant increase in yield, N and

P content and uptake in grain and straw over alone inoculation and control. However, single inoculation with PSB or Rhizobium were found at par.

Maqsood *et al*. (2001) reported that, a study in a sandy clay loam field to investigate the effect of phosphorus rates on the agronomic traits of two mashbean genotypes (Mash97 and Mash88). Mashbean genotypes did not differ significantly regarding number of plants m^{-2}, plant height, number of seeds pod^{-I}, total number of seeds $plant^{-I}$, 1000 seeds weight, seed yield and harvest index. However, Mash-97 gave significantly more seeds per plant than that of the Mash-88. Phosphorus application @ 75 kg ha^{-1} gave significantly the highest seed yield of 1832 kg ha^{-I} against the minimum of 1390 kg ha^{-1} without phosphorus.

Thiyageshwari and Perumal (2000) was conducted a pot experiment with a Vertic Ustropept to test the changes in soil phosphorus fonns, uptake and grain yield due to integrated nutrient management of blackgram through conjuctive use of imported tunisia rock phosphate, vermicompost and phosphobacteria. Growth of blackgram and P uptake was slow in vegetative phase but rapid during reproductive phase. Vermicompost application significantly enhanced grain yield followed by phosphobacteria over 100 per cent P as tunisia rock phosphate. P uptake by blackgram was higher in the combined application of rock phosphate with vermicompost and phosphobacteria. Available phosphorus was higher in the vegetative stage and later decreased at harvest due to P utilisation by blackgram.

Gopala Rao *et al*. (1985) conducted an experiment to study the effect of phosphorus on yield of blackgram (*Vigna mung*). They found that, with the

application of phosphorous, along with vegetative growth the yield of blackgram increases gradually.

Dhage *et al*. (1984) stated that, fertilization of blackgram with nitrogen (20 kg N ha^{-1}) in the form of urea produced a 32% increase in yield over control, and significantly improved nutritional quality of seeds by increasing crude protein, crude fat, methionine, calcium, phosphorus and iron contents without increasing polyphenols. The highest yield of blackgram was obtained when plants were supplied with phosphorus at a rate of 40 kg P_2O_5 ha^{-1}. Crude protein, crude fats, phosphorus and iron contents increased whereas calcium content decreased significantly at 40 kg P_2O_5 ha^{-1}. A continuous increase in polyphenol content was observed with increasing levels of phosphorus but it was significantly increased at P rates above 40 kg ha^{-1}. Fertilization with N and P in a 1:2 ratio at 20 kg N ha^{-1} and 40 kg P_2O_5 ha^{-1} produced a 32% seed yield increase and improved the nutritional value of blackgram seeds.

2.3 Effect of variety

Nayak *et al*. (2015) was conducted the field investigation experiment during kharif season of 2012 on PG research farm, department of Agronomy, College of Agriculture, VNMKV, Parbhani it was observed from present investigation that the plant spacing 30 x 10 cm with variety BDU1 was found be significantly superior over rest of the plant spacings and varieties in respect to plant height (cm), number of leaves , leaf area (cm), mean dry matter production ,number of braches per plant, leaf area index, biological yield (kg ha^{-1}), seed yield (kg ha^{-1}).

Kulsum *et al*. (2007) was conducted a study to evaluate the performance of blackgram (*Vigna mungo* L) under various levels of nitrogen at the Agronomy Research Site of Bangabandhu Sheikh Mujibur Rahman Agricultural University during March to June 2002. Two varieties of blackgram BARI mash3 and BINA mash1 and six levels of nitrogen i.e., 0, 20, 40, 60, 80 and 100 kg N ha^{-1} were the treatment variables. Different morphological characters including grain yield were affected significantly by the nitrogen levels. The longest plant was measured with 100 kg N ha^{-1} whereas largest leaf area was obtained with 80 kg N ha^{-1}. BINA mash1 was longer than BARI mash3. Yield and yield contributing characters were affected significantly by different levels of nitrogen. The highest grain yield was obtained with 60 kg N ha^{-1} in both the varieties, thereafter the grain yield declined. Application of 60 kg N ha^{-1} favored most of the yield contributing characters that contributed the maximum grain yield production at this level of N. Between the two varieties of blackgram, BARI mash3 out yielded BINA mash1 at all levels of nitrogen. It was obvious that grain yield of blackgram can be increased substantially with the judicious application of N.

So, this research review's purpose will help readers to understand the influence of N and P on variety of blackgram. These above reviews indicated that, worlds are working to improve the seed quality and yield of blackgram by different treatment procedure specially, N and P. A lot of research related to the present study have been conducted worldwide, but in Bangladesh there have scanty of research. So, it is important to study the influence of N and N on quality and yield of blackgram in Bangladesh. Thus, this present study was conducted.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from March to June 2017. Detailed of the experimental materials and methods followed in the study are presented in this chapter. The experiment was conducted to study the influence of nitrogen and phosphorus level on yield and seed quality of black gram.

3.1 Site description

3.1.1 Geographical location

The experimental area was situated at 23°77′N latitude and 90°33′E longitude at an altitude of 8.6 meter above the sea level.

3.1.2 Agro-ecological region

The experimental field belongs to the Agro-ecological zone of "The Modhupur Tract", AEZ-28. This was a region of complex relief and soils developed over the Modhupur clay, where flood plain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain.

3.1.3 Climate

The area has sub-tropical climate, characterized by high temperature, high relative humidity and heavy rainfall with occasional gusty winds in Kharif

season (April-September) and scanty rainfall associated with moderately low temperature during the Rabi season (October-March). Weather information regarding temperature, relative humidity and rainfall prevailed at the experimental site during the study period were presented in Appendix I.

3.1.4 Soil

The soil of the experimental site belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH ranged from 5.6-6.5 and had organic matter 1.10-1.99%. The experimental area was flat having available irrigation and drainage system and above flood level. Soil samples from 0-15 cm depths were collected from experimental field. The analyses were done by Soil Resource and Development Institute (SRDI), Dhaka. The physical and chemical properties of the soil were presented in Appendix II.

3.2 Details of the experiment

3.2.1 Treatments

The experiment consisted of 2 factors:

Factors A: Levels of nitrogen and phosphorous-4

(a) F_0 = all fertilizer except N & P

(b) F_1 = 50% less N & P + other fertilizers

(c) F_2= Recommended dose of N & P + other fertilizers

(d) F_3= 50% higher N & P + other fertilizers

Factors B: Levels of variety-2

(a) V_1 = BARI mash2

(b) V_2 = BARI mash3

Treatment combination

F_0V_1, F_1V_1, F_2V_1, F_3V_1, F_0V_2, F_1V_2, F_2V_2, F_3V_2

3.2.2 Experimental design and layout

The experiment was laid out in a factorial RCBD with three replications. There were 8 treatment combinations. The total numbers of unit plots were 24. The size of unit plot was 2.25 m × 2.0 m. The distances between plot to plot and replication to replication were 0.75 m and 1.0 m, respectively.

3.3 Planting Material

BARI mash2 and BARI mash3 were used as plant material.

3.3.1 Description of recommended chemical fertilizer

The recommended chemical fertilizer dose was 50, 100, 55 and 1 kg ha^{-1} of Urea, triple super phosphate, muriate of potash and boric acid respectively. According to the treatments, all of the fertilizers were applied by broadcasting and was mixed with soil thoroughly at the time of final land preparation.

3.4 Crop management

3.4.1 Seed collection

Seeds were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, Bangladesh.

3.4.2 Seed sowing

The seeds of black gram having more than 80% germination were sown by hand in 30 cm apart from lines with continuous spacing at about 3 cm depth on 29 March, 2017.

3.4.3 Collection and preparation of initial soil sample

The soil sample of the experimental field was collected before fertilizer application. The initial soil samples were collected before land preparation from a 0-15 cm soil depth. The samples were collected by an auger from different location covering the whole experimental plot and mixed thoroughly to make a composite sample. After collection of soil samples, the plant roots, leaves etc. were removed. Then the samples were air-dried and sieved through a 10-mesh sieve and stored in a clean plastic container for physical and chemical analysis.

3.4.4 Preparation of experimental land

A pre- sowing irrigation was given on 15 March, 2017. The land was open with the help of a tractor drawn disc harrow on 25 March, 2017, then ploughed with rotary plough twice followed by laddering to achieve a medium tilth required for the crop under consideration. All weeds and other plant residues of previous crop

were removed from the field. Immediately after final land preparation, the field layout was made on March 29, 2017 according to experimental specification. Individual plots were cleaned and finally prepared the plot.

3.4.5 Intercultural operations

3.4.5.1 Thinning

The plots were thinned out on 15 days after sowing to maintain a uniform plant stand.

3.4.5.2 Weeding

The crop was infested with some weeds during the early stage of crop establishment. Two hand weedings were done, first weeding was done at 15 days after sowing followed by second weeding at 15 days after first weeding.

3.4.5.3 Application of irrigation water

Irrigation water was added to each plot, first irrigation was done as pre- sowing and other two were given 3 days before weeding.

3.4.5.4 Drainage

There was a heavy rainfall during the experimental period. Drainage channel were properly prepared to easy and quick drained out of excess water.

3.4.5.5 Plant protection measures

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

3.4.6 Harvesting and post-harvest operation

Maturity of crop was determined when 80-90% of the pods become blackish in color. The harvesting of black gram was on 30 June, 2017. Five pre-selected plants per plot from which different yield attributing data were collected and 1.0 m^2 areas from middle portion of each plot was separately harvested and bundled, properly tagged and then brought to the threshing floor for recording grain and straw yield. The grains were cleaned and sun dried to a moisture content of 12%. Straw was also sun dried properly. Finally grain and straw yields $plot^{-1}$ were determined and converted to kg ha^{-1}.

3.4.7 Seed quality analysis

Seeds of each plot were separately collected and dried properly. Seed quality data were taken with this seed in the agronomy laboratory of SAU.

3.4.8 Recording of data

Emergence of plants were counted from starting to a constant number of plants m^{-2} area of each plot. Experimental data were determined from 30 days of growth duration and continued until harvest. Dry weights of plant were collected by harvesting respective number of plants at different specific dates from the inner rows leaving border rows and harvest area for grain. The following data were recorded during the experimentation.

Yield characters and seed quality parameters

i. Plant height
ii. Pod length (cm)
iii. Number of pods plant^{-1}
iv. Number of seeds pod^{-1}
v. 1000 seeds weight (g)
vi. Seed yield (kg ha^{-1})
vii. Biological yield (kg ha^{-1})
viii. Harvest index

Seed quality parameters

ix. Germination (%)
x. Root length (cm)
xi. Shoot length (cm)
xii. Root weight (mg)
xiii. Shoot weight (mg)

3.4.9 Detailed procedures of recording data

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

A. Crop growth characters

3.4.9.1 Plant height

Plant height of 5 selected plants from each plot was measured at harvest. The height of the plant was determined by measuring the distance from the soil surface to the tip of the leaf of main shoot.

3.4.9.2 Number of pods plant^{-1}

Pods from 5 selected plants from each plot was measured at harvest. After that the mean number of pods were counted for each treatment.

3.4.9.3 Pod length

Pod length from 10 selected pods were measured using the measuring tape in centimeter (cm). The average length of 10 pods was termed as pod length.

3.4.9.4 Number of seeds pod^{-1}

Total number of seeds from 10 selected pods was counted and then mean value of this parameters was recorded as number of seeds pod^{-1}.

3.4.9.5 Weight of 1000 seeds

The 1000 seeds were separated from each plot and measured using balance and recorded as gram (g).

3.4.9.6 Seed yield

Seed yield was determined from the central 1.0 m^2 area of each plot and expressed as kg ha^{-1} and adjusted with 12% moisture basis

3.4.9.7 Biological yield

Biological yield was determined from each plot. Finally, the biological yield measured as kg ha^{-1}.

3.4.9.8. Harvest index

Harvest index denotes the ratio of economic yield (seed yield) to biological yield and was calculated with following formula.

$$\text{Harvest index (\%)} = \frac{Pod\ yield}{Biological\ yield} \times 100$$

Seed quality parameters

3.4.9.9 Germination percentage

After harvesting germination test was done in the laboratory of the Department of Agronomy. 25 seeds were placed in each petri dish and germinated seedling was counted. Finally, total number was converted as percentage (%).

3.4.9.10 Shoot length and root length

From the germinated seedling, shoot length and root length was measured using measuring tape and recorded as centimeter (cm).

3.4.9.11 Shoot dry weight and root dry weight

From the germinated seedling, after taking shoot length and root length the dry weight of shoot and root measured separately. As the weight was very low, the recorded data was measured as miligram (mg).

3.4.10 Statistical analysis

All the collected data were analyzed following the analysis of variance (ANOVA) technique using a statistical computer software Statistix 10 and the means were adjusted by Tukey's Test at 5% level of significance.

CHAPTER IV

RESULTS AND DISCUSSIONS

This chapter represents the results and discussion on the influence of nitrogen and phosphorus level on yield and seed quality of blackgram. Data analysis for the different parameters are presented with the help of tables and figures. ANOVA is presented in the appendix section.

Growth and yield contributing characters

4.1 Plant height

The plant height of black gram is positively affected by the application of nitrogen + phosphorus and it showed statistically significant variation (Figure 1 and Appendix IV). Plant height showed an increasing trend with an increasing the higher dose of fertilizer (50% higher than recommended dose of N &P). The tallest plant (77.13 cm) was found in F_3 (50% higher N & P) and shortest plant (69.55 cm) was recorded in F_0 (all fertilizer except N & P). The plant height is directly associated with the adequate supply of proper proportion of fertilizers. The finding is close conformity of finding Mishra (2016).

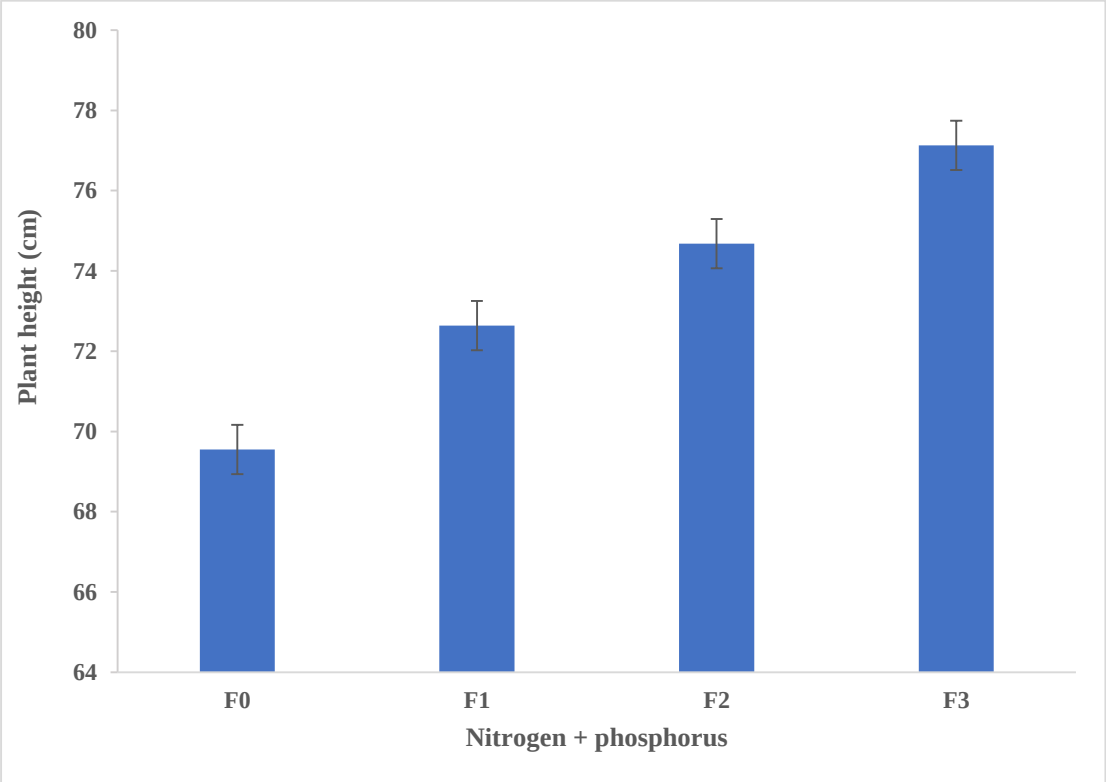

Figure 1. Effect of nitrogen + phosphorus on plant height of black gram (Vertical bar represents the standard error of the mean**)**

F_0 = all fertilizer except N & P, F_1 = 50% less N & P, F_2= Recommended dose of N & P with others, F_3= 50% higher N & P

Varietal difference had significant impact on plant height of black gram (Figure 2 and Appendix IV). The tallest plant (77.01 cm) was recorded in V_2 (BARI mash3) and the shortest plant (70.00 cm) was found in V_1 (BARI mash2). This might be due to genetic variations among the varieties. Our finding is agreed with the finding of Nayak *et al.* (2015).

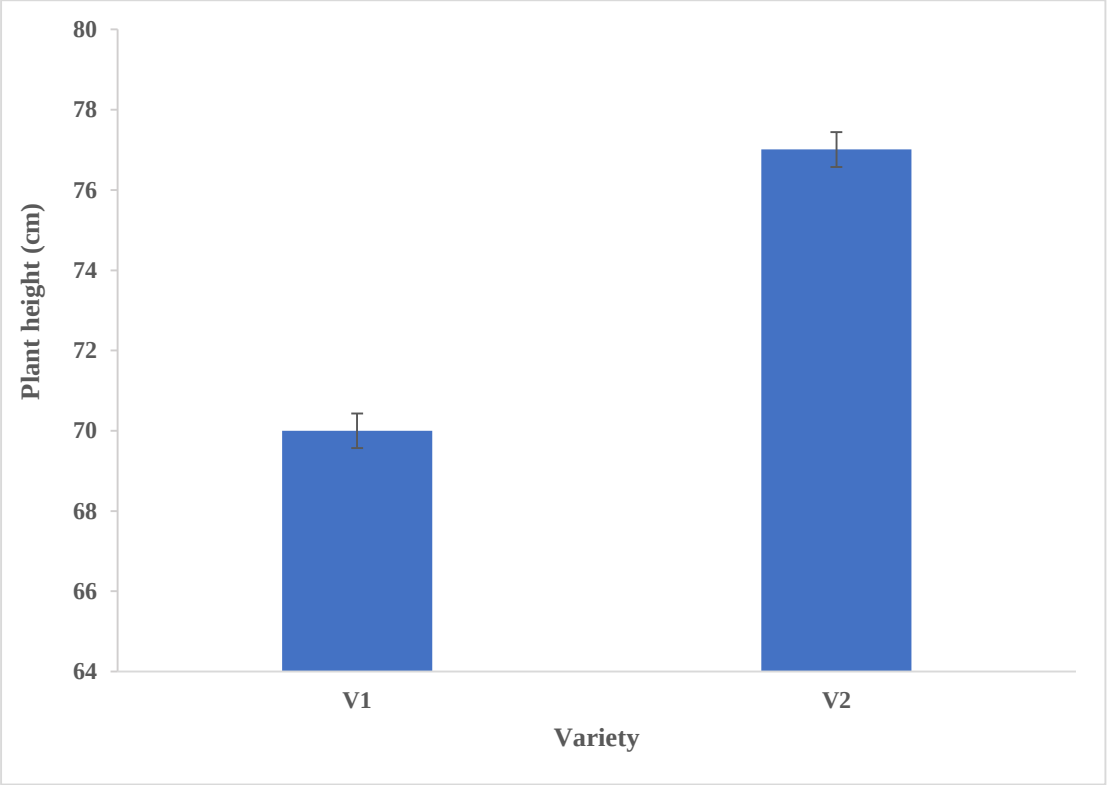

Figure 2. Effect of variety on plant height of black gram (Vertical bar represent the standard error of the mean**)**

V_1= BARI mash2, V_2=BARI mash3

Combine effect of nitrogen + phosphorus and variety produced non-significant plant height of black gram (Table 1 and appendix IV). The tallest plant (81.26 cm) was found in F_3V_2 combine compared to others combinations while the shortest plant (66.47 cm) was produced by F_0V_1 combinations.

Table 1. Effect of N+P fertilizer and variety on plant height of black gram

Treatments	Plant height (cm)
F_0V_1	66.47
F_0V_2	72.63
F_1V_1	69.25
F_1V_2	76.04
F_2V_1	71.29
F_2V_2	78.08
F_3V_1	73.01
F_3V_2	81.26
SE (±)	NS
CV (%)	**2.45**

F_0 = all fertilizer except N & P, F_1 = 50% less N & P, F_2= Recommended dose of N & P with others, F_3= 50% higher N & P; V_1= BARI mash2, V_2=BARI mash3

4.2 Number of pods plant^{-1}

The application of nitrogen + phosphorus exerted significant impact on number of pods plant^{-1} of black gram (Figure 3, Appendix V). The pods number showed increasing trend up to the treatment F_3 (50% higher than recommended dose of N & P). The maximum number of pods was recorded in F_3 (68.73) and minimum number was found in F_0 (48.50). The similar result also reported by the Mishra (2016), Phogat (2016), Yeasmin (2015), Marimuthu and Surendran (2015) and Mir *et al*. (2014).

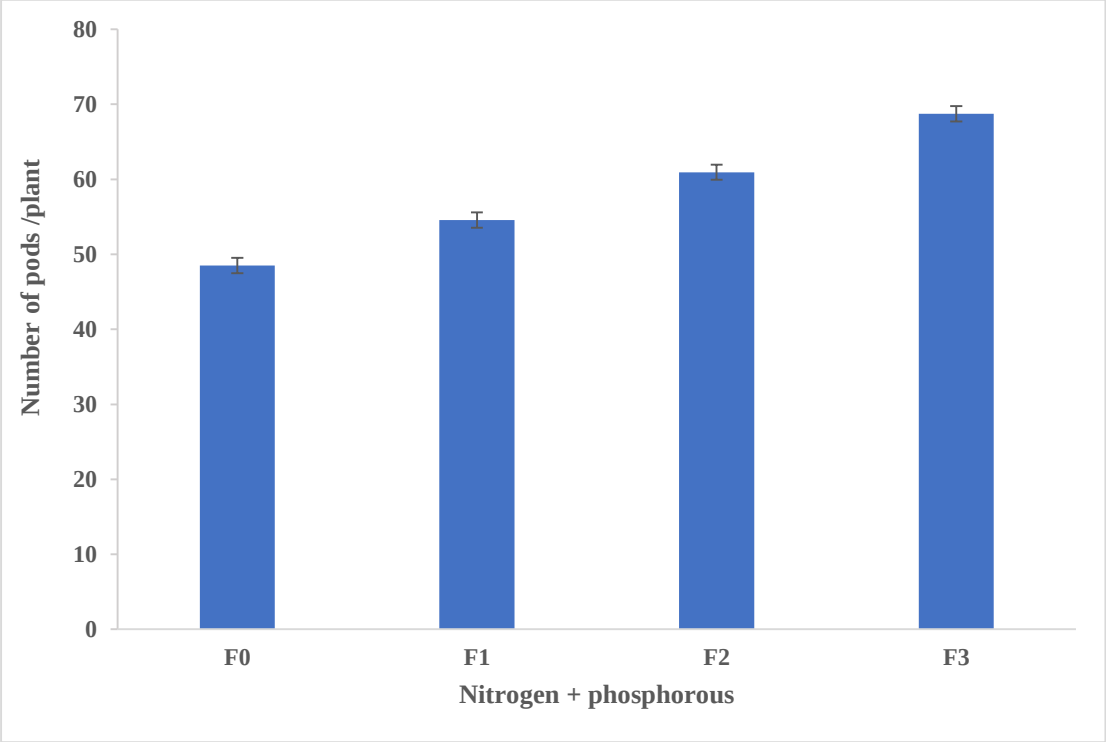

Figure 3. Effect of nitrogen + phosphorus on number pods plant^{-1} of black gram (Vertical bar represents the standard error of the mean**)**

F_0 = all fertilizer except N & P, F_1 = 50% less N & P, F_2= Recommended dose of N & P with others, F_3= 50% higher N & P

Varietal difference had a positive effect on number of pods plant^{-1} and varied significantly on black gram (Figure 4, Appendix V). The variety V_2 (BARI mash3) produced maximum number of pods plant^{-1} (60.45) where V_1 produced minimum number of pods (55.92). The present finding is agreed with the findings of Nayak *et al*. (2015) and Kulsum *et al*. (2007).

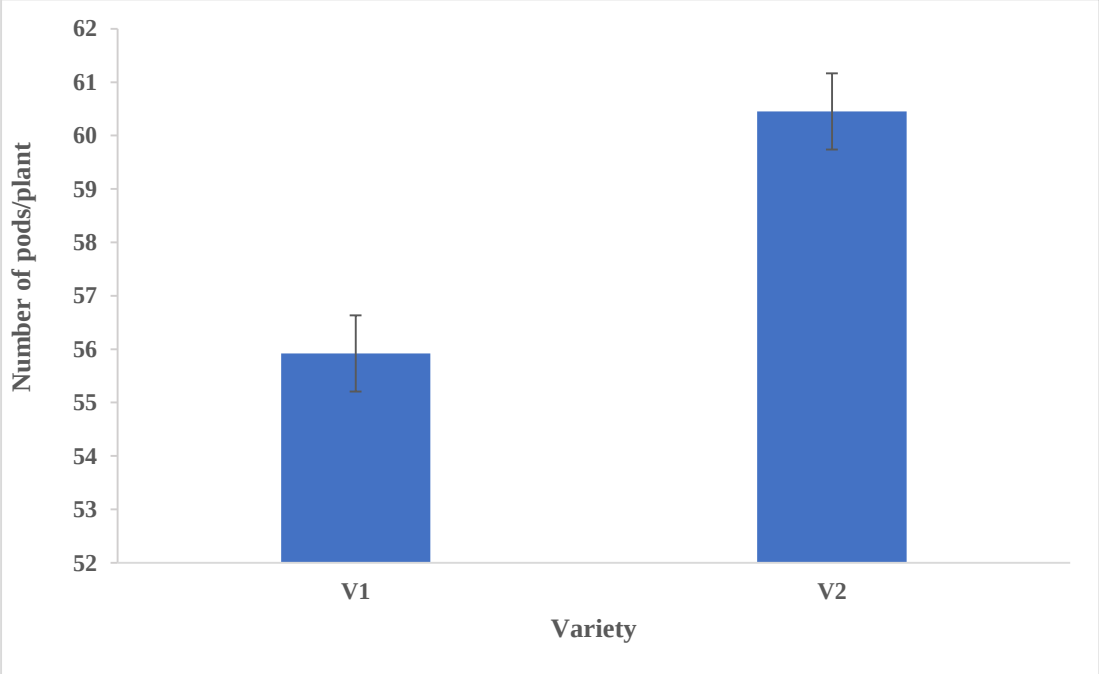

Figure 4. Effect of variety on number of pods plant^{-1} of black gram (Vertical bar represents the standard error of the mean**)**

V_1= BARI mash2, V_2=BARI mash3

Number of pods plant^{-1} showed non-significant variations due to combine effect of nitrogen + phosphorus and variety (Table 1, Appendix V). The maximum number of pods plant^{-1} was recorded in F_3V_2 (72.13) and lowest was in F_0V_1 (46.86).

Table 2. Effect of N+P fertilizer and variety on number pod plant^{-1} of black gram

Treatments	**Number of pods plant^{-1}**
F_0V_1	46.86
F_0V_2	50.13
F_1V_1	52.93
F_1V_2	56.20
F_2V_1	58.55
F_2V_2	63.33
F_3V_1	65.33
F_3V_2	72.13
SE (±)	**NS**
CV (%)	**3.00**

F_0 = all fertilizer except N & P, F_1 = 50% less N & P, F_2= Recommended dose of N & P with others, F_3= 50% higher N & P; V_1= BARI mash2, V_2=BARI mash3

4.3 Pod length

Nitrogen + phosphorus levels exerted significant impact on pod length of black gram (Figure 5, Appendix VI). It can be inferred from the figure that the pod length exerted a steady increasing trend with the increases of fertilizer doses up to F_3. However, the highest values (4.86 cm) was obtained for pod length in F_3 (50% higher than recommended dose of N & P). The lowest values of pod length (4.30 cm) were in F_0 (control). The similar result also reported by the Mishra (2016), Phogat (2016), Yeasmin (2015), Marimuthu and Surendran (2015) and Mir *et al*. (2014).

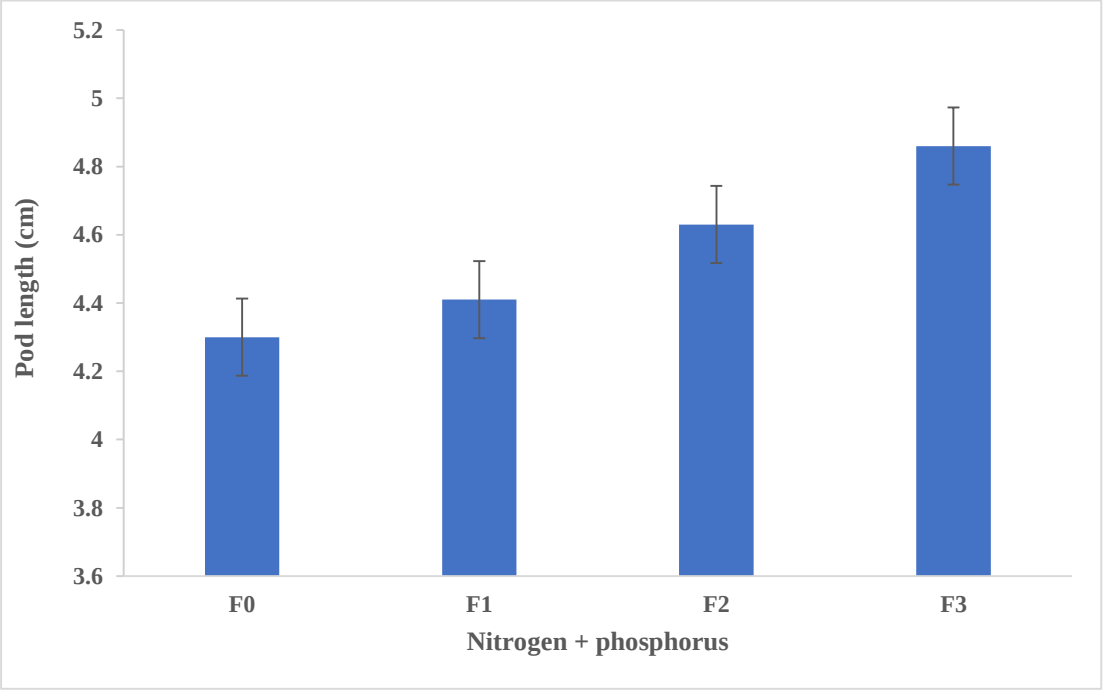

Figure 5. Effect of nitrogen + phosphorus on pod length of black gram (Vertical bar represents the standard error of the mean**)**

F_0 = all fertilizer except N & P, F_1 = 50% less N & P, F_2= Recommended dose of N & P with others, F_3= 50% higher N & P

Pod length of black gram did not significantly influence by varietal different of black gram (Figure 6, Appendix VI). However, the tallest pod (4.62 cm) was found in V_2 (BARI mash3). The shortest pod was recorded in V_1 (BARI mash2). The present finding is agreed with the findings of Nayak *et al*. (2015) and Kulsum *et al*. (2007).

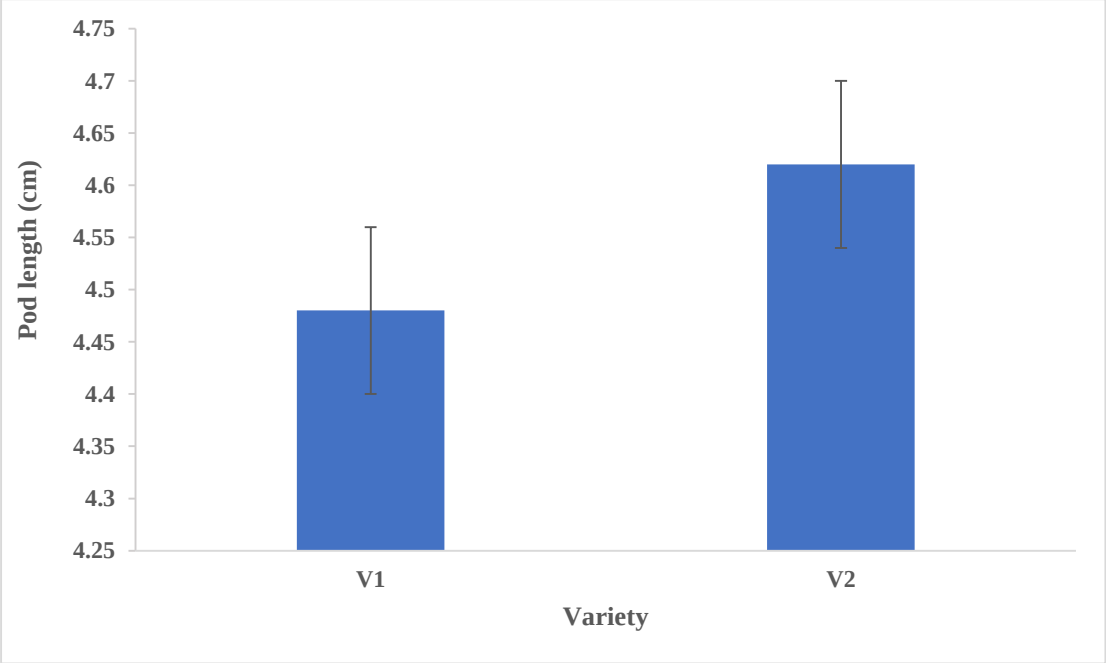

Figure 6. Effect of variety on pod length of black gram (Vertical bar represents the standard error of the mean**)**

V_1= BARI mash2, V_2=BARI mash3

The combined effect of nitrogen + phosphorus and variety showed non-significant variations on pod length of black gram (Table 3, Appendix VI). Numerically, the tallest pod was found in F_3V_2 and shortest pod was recorded in F_0V_1 combination compared to other combinations. This might be varietal characters of the varieties which may have controlled by genetic makeup of the varieties.

Table 3. Effect of N+P fertilizer and variety on pod length of black gram

Treatments	Pod length (cm)
F_0V_1	4.23
F_0V_2	4.36
F_1V_1	4.30
F_1V_2	4.52
F_2V_1	4.61
F_2V_2	4.66
F_3V_1	4.80
F_3V_2	4.93
SE (±)	**NS**
CV (%)	**4.33**

F_0 = all fertilizer except N & P, F_1 = 50% less N & P, F_2= Recommended dose of N & P with others, F_3= 50% higher N & P; V_1= BARI mash2, V_2=BARI mash3

4.4 Number of seeds pod^{-1}

Nitrogen + phosphorus showed significant impact in terms of number of seeds pod^{-1} of black gram (Figure 9, Appendix VII). The maximum number of seeds pod^{-1} was obtained in higher fertilizer applied plots. The highest value obtained for number of seeds pod^{-1} (7.21) in F_3 treatment while the minimum value of number of seeds pod^{-1} (5.38) was in F_0. The similar result also reported by the Mishra (2016), Phogat (2016), Yeasmin (2015), Marimuthu and Surendran (2015) and Mir *et al*. (2014).

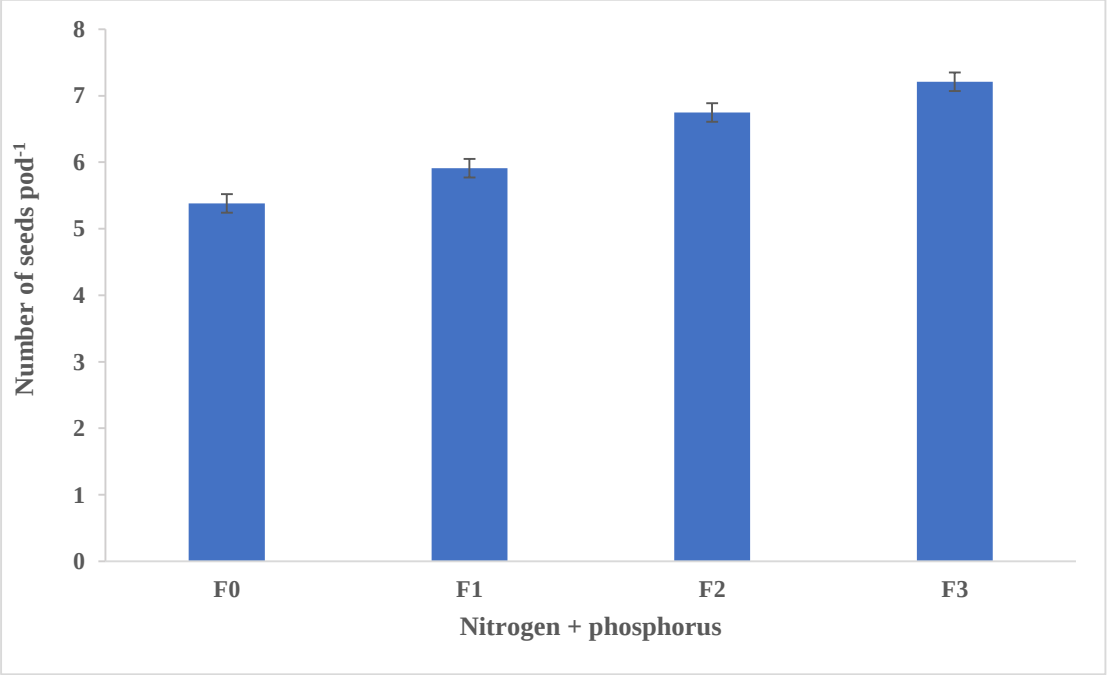

Figure 7. Effect of nitrogen + phosphorus on number of seeds pod^{-1} of black gram (Vertical bar represents the standard error of the mean**)**

F_0 = all fertilizer except N & P, F_1 = 50% less N & P, F_2= Recommended dose of N & P with others, F_3= 50% higher N & P

The number of seeds pod^{-1} of black gram influenced significantly due to varietal treatments (Figure 10, Appendix VII). The maximum number of seeds pod^{-1} was found in V_2 variety (6.57). The lowest value of number of seeds pod^{-1} was recorded in V_1 variety (6.05). The present finding is agreed with the findings of Nayak *et al*. (2015) and Kulsum *et al*. (2007).

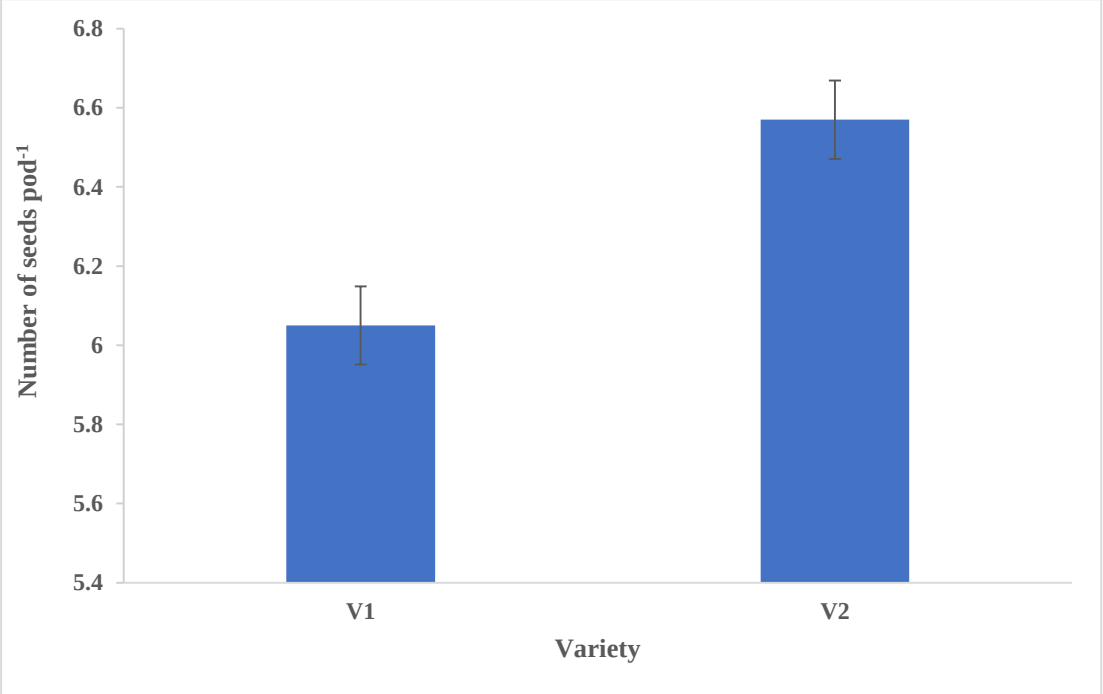

Figure 8. Effect of variety on number of seeds pod^{-1} of black gram (Vertical bar represents the standard error of the mean**)**

V_1= BARI mash2, V_2=BARI mash3

For the combine effect of nitrogen + phosphorus and variety showed non-significant variations on number of seeds pod^{-1} (Table 4, Appendix VII). For the combine effect the maximum number of seeds pod^{-1} (7.40) was found in F_3V_2 and the minimum number of seeds pod^{-1} (5.03) was recorded in F_0V_1 combination compared to other combinations.

Table 4. Effect of N+P fertilizer and variety on number of seeds pod^{-1} of black gram

Treatments	Number of seeds pod^{-1}
F_0V_1	5.03
F_0V_2	5.73
F_1V_1	5.53
F_1V_2	6.30
F_2V_1	6.63
F_2V_2	6.87
F_3V_1	7.03
F_3V_2	7.40
SE (±)	**NS**
CV (%)	**3.86**

F_0 = all fertilizer except N & P, F_1 = 50% less N & P, F_2= Recommended dose of N & P with others, F_3= 50% higher N & P; V_1= BARI mash2, V_2=BARI mash3

4.5 Weight of 1000 seeds

Application of nitrogen + phosphorus had a positive effect on weight of 1000 seeds of black gram (Figure 9, Appendix VIII). Figure indicated that the values of weight of 1000 seeds had an increasing trend with the increment of fertilizer dose. The treatment F_3 (50% higher more than recommended dose of N & P) produced the highest value of weight of 1000 seeds (40.79 g) where F_0 (control) produced lowest value of weight of 1000 seeds (34.70 g). The similar result also reported by the Mishra (2016), Phogat (2016), Yeasmin (2015), Marimuthu and Surendran (2015) and Mir *et al*. (2014).

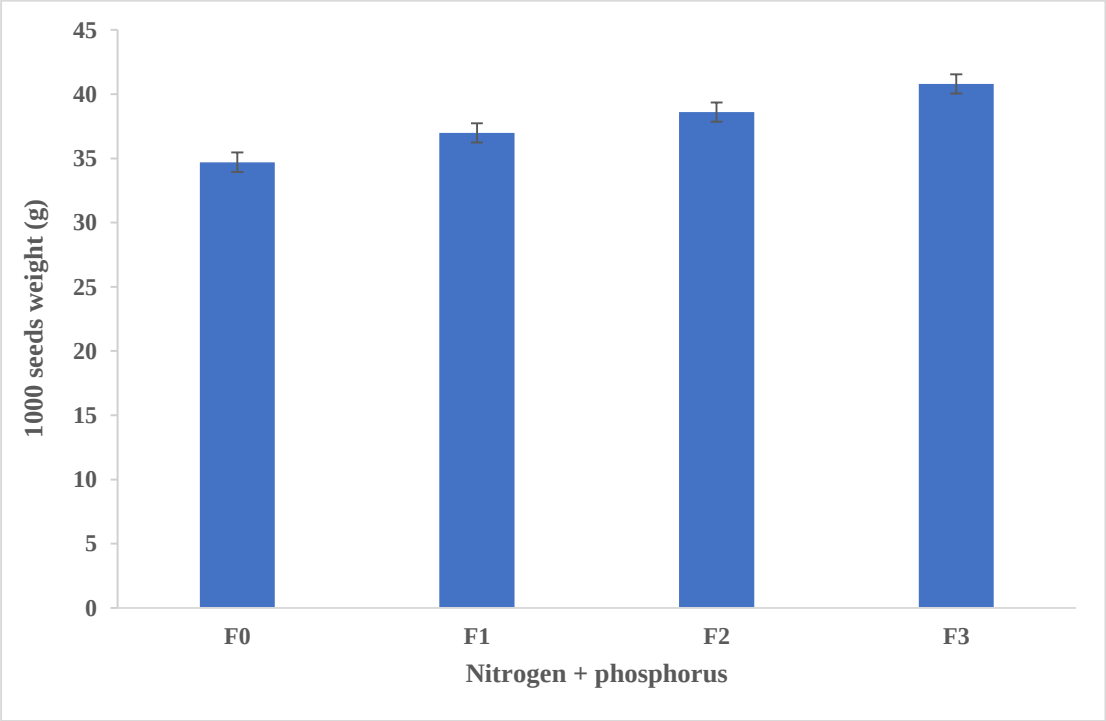

Figure 9. Effect of nitrogen + phosphorus weight of 1000 seeds of black gram (Vertical bar represents the standard error of the mean**)**

F_0 = all fertilizer except N & P, F_1 = 50% less N & P, F_2= Recommended dose of N & P with others, F_3= 50% higher N & P

The varietal treatment showed significant impact on weight of 1000 seeds of black gram (Figure 10, Appendix VIII). The highest weight of 1000 seeds (39.56 g) was recorded in V_2 (BARI mash3) and the lowest weight of 1000 seeds in V_1 (BARI mash2). This might the varietal characters of the varieties which may perhaps be controlled by the genetic makeup of the varieties. The present finding is agreed with the findings of Nayak *et al*. (2015) and Kulsum *et al*. (2007).

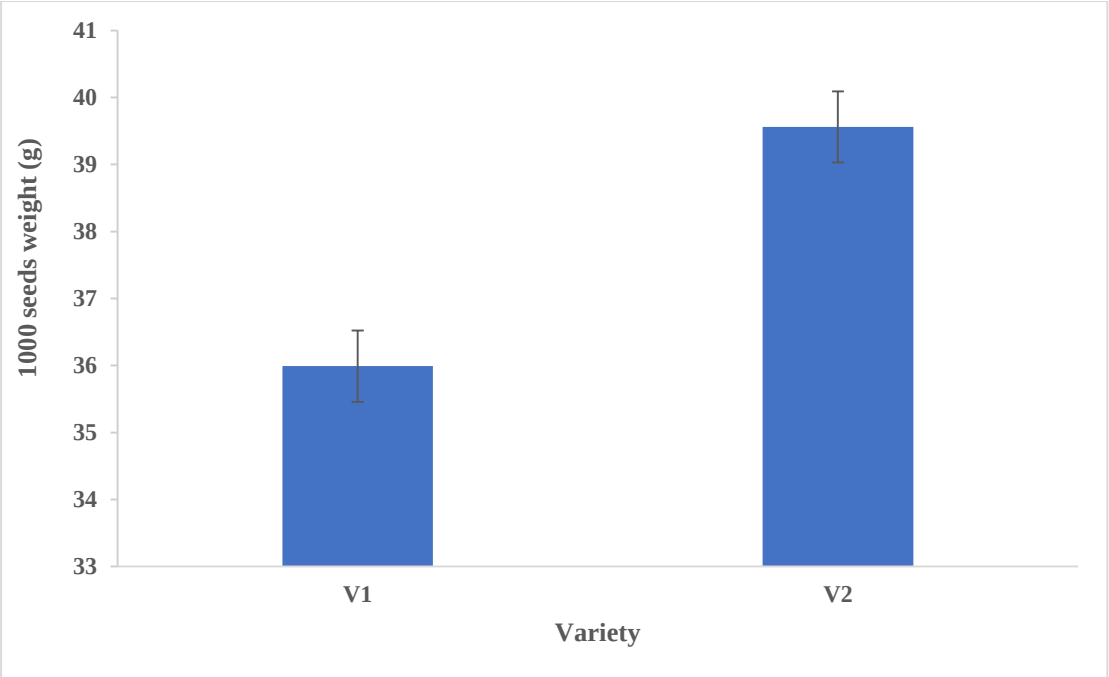

Figure 10. Effect of variety on weight of 1000 seeds of black gram (Vertical bar represents the standard error of the mean**)**

V_1= BARI mash2, V_2=BARI mash3

The weight of 1000 seeds had a non-significant effect due to combine effect of nitrogen + phosphorus and variety (Table 5, Appendix VIII). Although having non-significant effect, the highest weight of 1000 seeds was recorded in the combination of F_3V_2 (42.94 g) while the lowest weight of 1000 seeds was found in the combination of F_0V_1 combination (33.50 g).

Table 5. Effect of N+P fertilizer and variety on weight of 1000 seeds of black gram

Treatments	**1000 seed weight (g)**
F_0V_1	33.50
F_0V_2	35.91
F_1V_1	35.36
F_1V_2	38.63
F_2V_1	36.46
F_2V_2	40.76
F_3V_1	38.64
F_3V_2	42.94
SE (±)	**NS**
CV (%)	**3.45**

F_0 = all fertilizer except N & P, F_1 = 50% less N & P, F_2= Recommended dose of N & P with others, F_3= 50% higher N & P; V_1= BARI mash2, V_2=BARI mash3

4.6 Seed yield

Nitrogen + phosphorus showed significant variations on seed yield of black gram (Figure 11, Appendix IX). Seed yield values showed a gradual increased with the higher doses of fertilizer up to F_3 treatment (2014.70 kg ha^{-1}). Among the fertilizer doses seed yield ranges from 1270.50 kg ha^{-1} to 2014.70 kg ha^{-1}. The similar result also reported by the Mishra (2016), Phogat (2016), Yeasmin (2015), Marimuthu and Surendran (2015) and Mir *et al*. (2014).

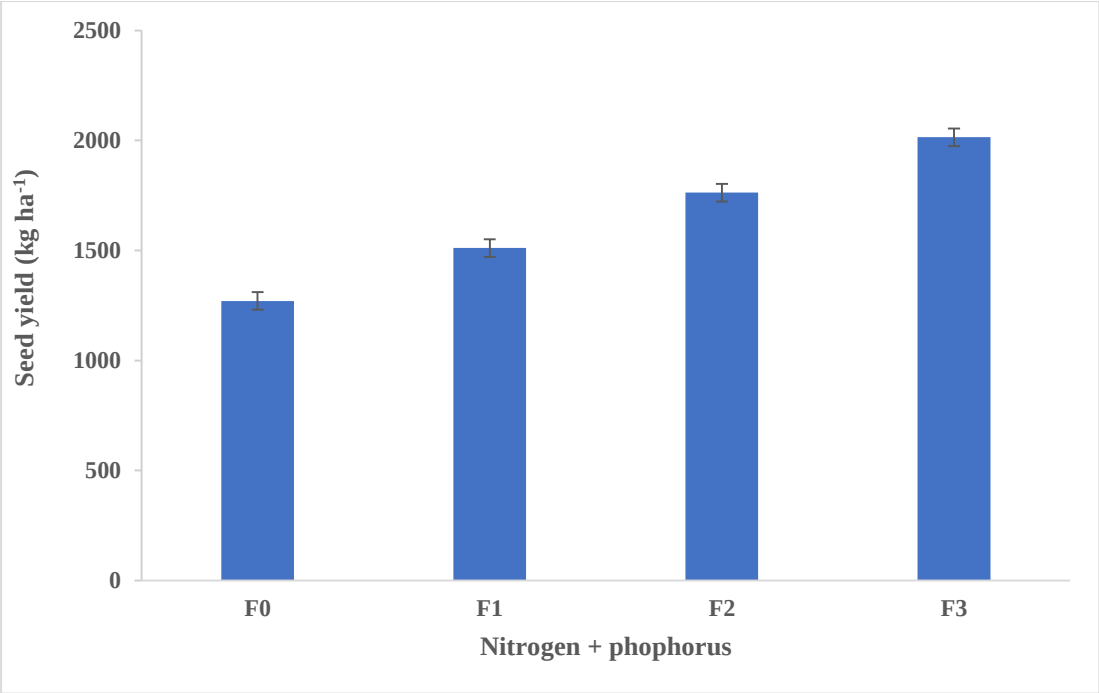

Figure 11. Effect of nitrogen + phosphorus on seed yield of black gram (Vertical bar represents the standard error of the mean**)**

F_0 = all fertilizer except N & P, F_1 = 50% less N & P, F_2= Recommended dose of N & P with others, F_3= 50% higher N & P

Seed yield of black gram showed significant influences by the varietal difference (Figure 12, Appendix IX). The highest seed yield was found in V_2 (1726.90 kg ha^{-1}). The lowest seed yield was recorded in V_1 (1553.00 kg ha^{-1}). It can be inferred from the result that V_2 variety was superior by producing 11.19% higher seed yield over V_1 variety. The present finding is agreed with the findings of Nayak *et al*. (2015) and Kulsum *et al*. (2007).

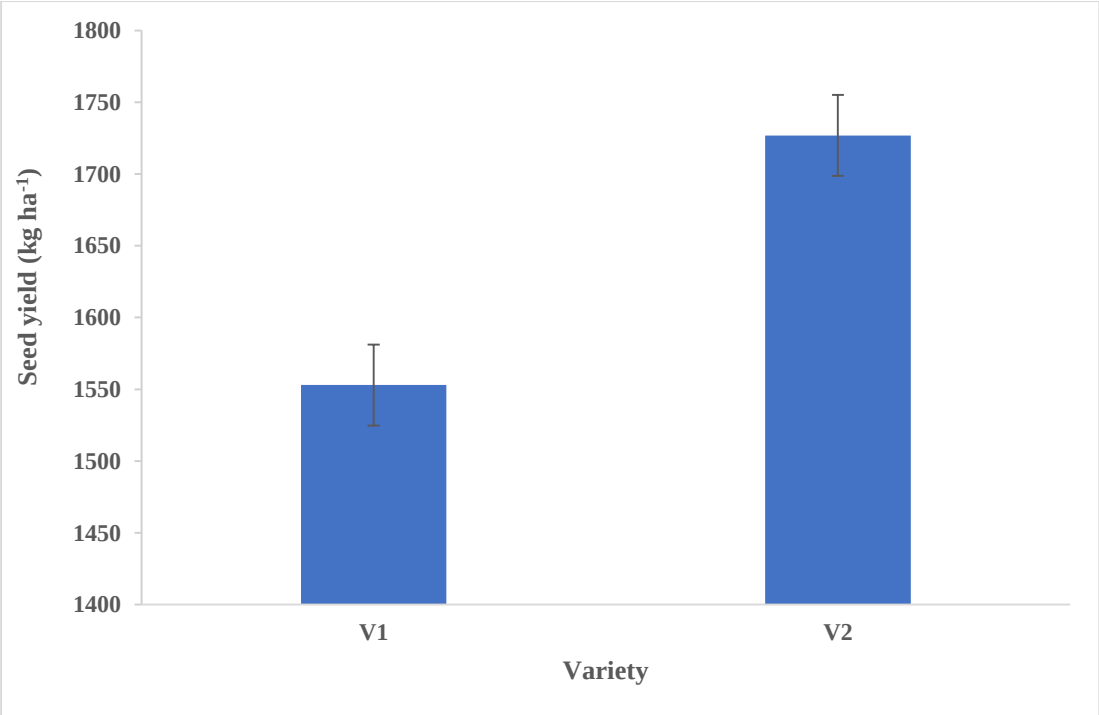

Figure 12. Effect of variety on seed yield of black gram (Vertical bar represents the standard error of the mean**)**

V_1= BARI mash2, V_2=BARI mash3

The combine effect of nitrogen + phosphorus and variety showed significant impact on seed yield (Table 6, Appendix IX). Table represented that highest seed yield was found in F_3V_2 (2181.05 kg ha^{-1}) and the lowest seed yield was recorded in F_0V_1 (1204.00 kg ha^{-1}) combination. It was also observed that F_2V_2 and F_3V_1 interaction also showed statistically similar seed yield, which was second highest that F_3V_2 interaction.

Table 6. Effect of N+P fertilizer and variety on seed yield of black gram

Treatments	Seed yield (kg ha^{-1})
F_0V_1	1204.00 e
F_0V_2	1336.90 de
F_1V_1	1539.61 c
F_1V_2	1482.72 cd
F_2V_1	1619.90 c
F_2V_2	1906.83 b
F_3V_1	1848.41 b
F_3V_2	2181.05 a
SE (±)	**2.39**
CV (%)	**4.21**

F_0 = all fertilizer except N & P, F_1 = 50% less N & P, F_2= Recommended dose of N & P with others, F_3= 50% higher N & P; V_1= BARI mash2, V_2=BARI mash3

4.7 Biological yield

Nitrogen + phosphorus showed significant impact on biological yield of black gram (Figure 13, Appendix X). The highest biological yield was obtained in highest fertilizer application treatment. The figure showed an increasing trend with the higher dose of fertilizer (F_3). The highest value obtained for biological yield (6102.50 kg ha^{-1}) in F_3 while the lowest value of biological yield (4868.30 kg ha^{-1}) was recorded in F_0. The similar result also reported by the Mishra (2016), Phogat (2016), Yeasmin (2015), Marimuthu and Surendran (2015) and Mir *et al*. (2014).

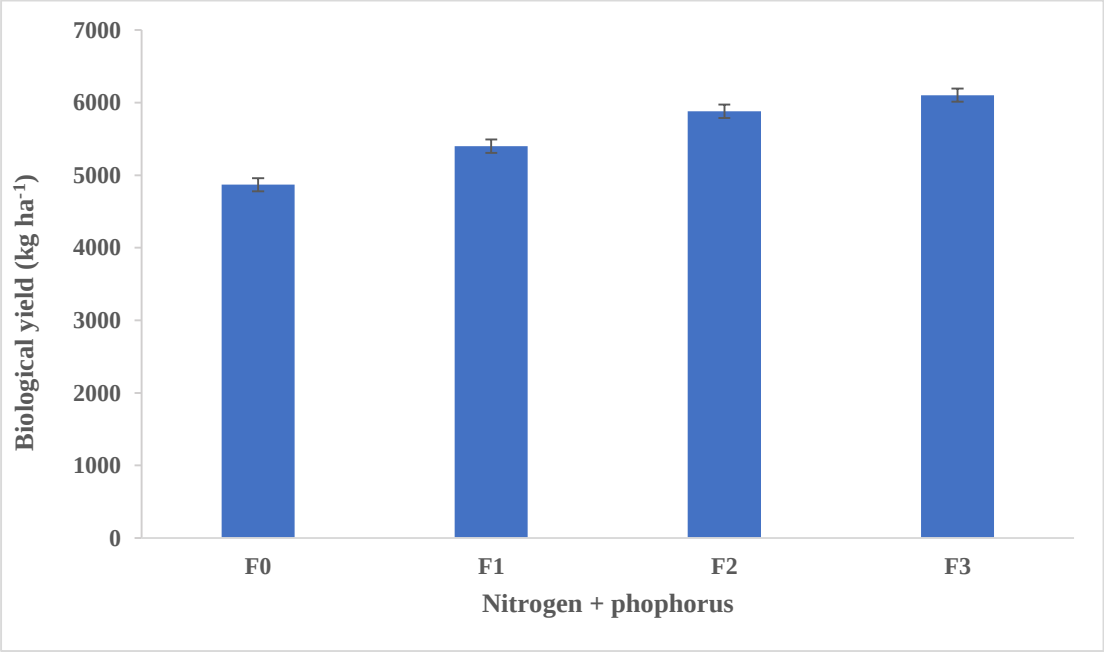

Figure 13. Effect of nitrogen + phosphorus on biological yield of black gram (Vertical bar represents the standard error of the mean**)**

F_0 = all fertilizer except N & P, F_1 = 50% less N & P, F_2= Recommended dose of N & P with others, F_3= 50% higher N & P

The biological yield of black gram was significantly influenced by varietal treatment (Figure 14, Appendix X). The highest biological yield (5681.00 kg ha^{-1}) was found in V_2 (BARI mash3). The lowest value (5444.22 kg ha^{-1}) of the same trait was recorded in V_1 (BARI mash2). The present finding is agreed with the findings of Nayak *et al*. (2015) and Kulsum *et al*. (2007).

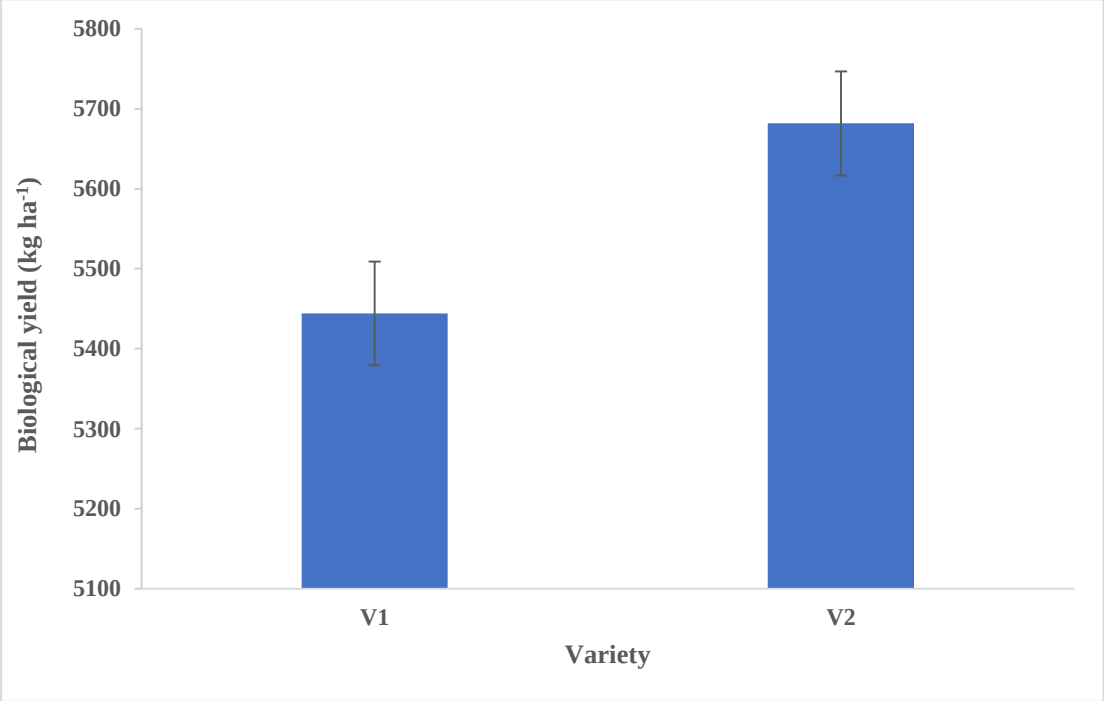

Figure 14. Effect of variety on biological yield of black gram (Vertical bar represents the standard error of the mean**)**

V_1= BARI mash2, V_2=BARI mash3

The combine effect of nitrogen + phosphorus and variety on biological yield showed non-significant variations (Table 7, Appendix X). Though having non-significant impact, the highest biological yield (6290 kg ha^{-1}) was found in F_3V_2 combination and the lowest biological yield (4741.71 kg ha^{-1}) was recorded in F_0V_1 combination.

Table 7. Effect of N+P fertilizer and variety on biological yield of black gram

Treatments	**Biological yield (kg ha^{-1})**
F_0V_1	4741.71
F_0V_2	4995.01
F_1V_1	5370.00
F_1V_2	5430.10
F_2V_1	5750.03
F_2V_2	6011.71
F_3V_1	5915.05
F_3V_2	6290.00
SE (±)	**NS**
CV (%)	2.86

F_0 = all fertilizer except N & P, F_1 = 50% less N & P, F_2= Recommended dose of N & P with others, F_3= 50% higher N & P; V_1= BARI mash2, V_2=BARI mash3

4.7 Harvest index

The harvest index of black gram is positively affected by the application of nitrogen + phosphorus and it showed statistically significant variation (Figure 15 and Appendix XI). The harvest index showed an increasing trend with an increasing the higher dose of fertilizer (50% higher than recommended dose of N &P). The highest harvest index (36.05%) was found in F_3 (50% higher N & P) and the lowest value of harvest index (32.95%) was recorded in F_0 (all fertilizer except N & P). The harvest index is directly associated with the adequate supply of proper proportion of fertilizers. The finding is close conformity of finding Mishra (2016).

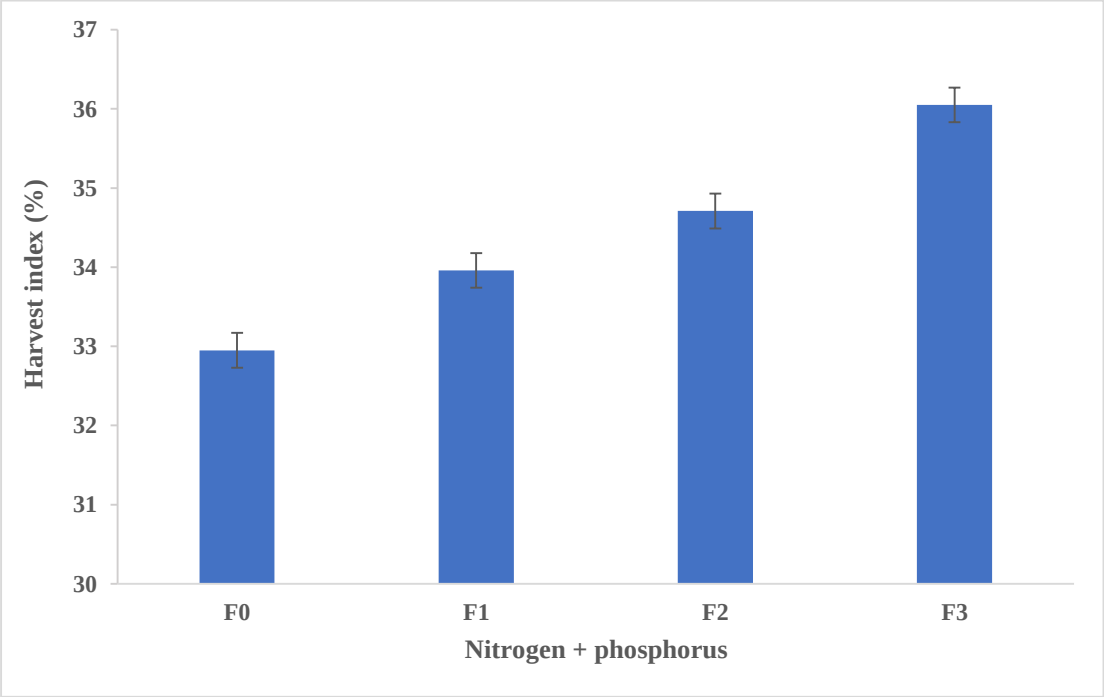

Figure 15. Effect of nitrogen + phosphorus on harvest index of black gram (Vertical bar represents the standard error of the mean**)**

F_0 = all fertilizer except N & P, F_1 = 50% less N & P, F_2= Recommended dose of N & P with others, F_3= 50% higher N & P

Varietal difference had a significant effect on harvest index of black gram (Figure 16 and Appendix XI). The highest harvest index (34.82%) was recorded in V_2 (BARI mash3) and the lowest harvest index (34.02%) was found in V_1 (BARI mash2). This might be due to genetic variations among the varieties. Our finding is agreed with the finding of Nayak *et al*. (2015).

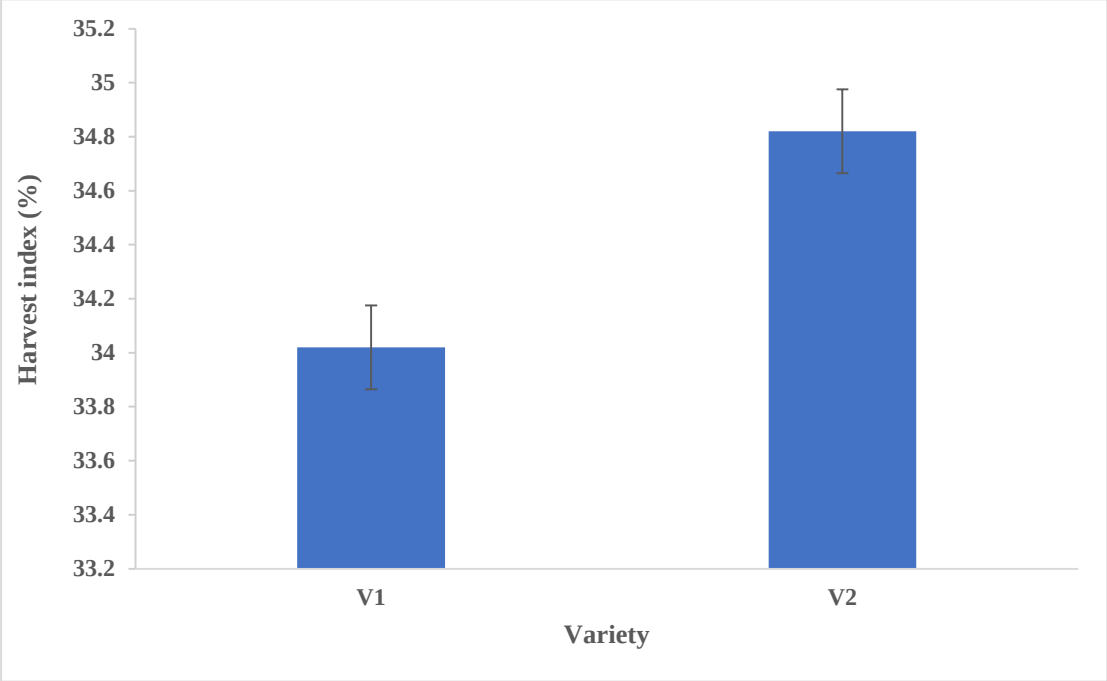

Figure 16. Effect of variety on harvest index of black gram (Vertical bar represents the standard error of the mean**)**

V_1= BARI mash2, V_2=BARI mash3

Combine effect of nitrogen + phosphorus and variety produced non-significant variations in terms of harvest index of black gram (Table 8 and appendix XI). The highest harvest index (36.51%) was found in F_3V_2 combine compared to others combinations while the lowest value of the harvest index (32.60%) was produced by F_0V_1 combinations.

Table 8. Effect of N+P fertilizer and variety on harvest index (%) of black gram

Treatments	Harvest index (%)
F_0V_1	32.60
F_0V_2	33.30
F_1V_1	33.57
F_1V_2	34.34
F_2V_1	34.30
F_2V_2	35.13
F_3V_1	35.60
F_3V_2	36.51
SE (±)	**NS**
CV (%)	**2.10**

F_0 = all fertilizer except N & P, F_1 = 50% less N & P, F_2= Recommended dose of N & P with others, F_3= 50% higher N & P; V_1= BARI mash2, V_2=BARI mash3

Seed quality parameters

After harvesting, the different seed quality parameters were studied. The studied parameters i.e. germination (%), shoot length (cm), root length (cm), shoot weight (mg) and root weight (mg) are discussed below.

4.9 Germination (%)

Application of nitrogen + phosphorus had a significant effect on germination (%) of black gram (Figure 17, Appendix XII). The figure indicated that the values of germination (%) increased gradually with the applied higher doses of N and P fertilizers. The highest increment was observed with F_3 treatment (94.66%). The values of germination (%) range is 74.33% to 94.66%. The treatment F_0 showed lowest germination (%) (74.33%). The similar results were also reported by the Mishra (2016), Phogat (2016), Yeasmin (2015), Marimuthu and Surendran (2015) and Mir *et al*. (2014).

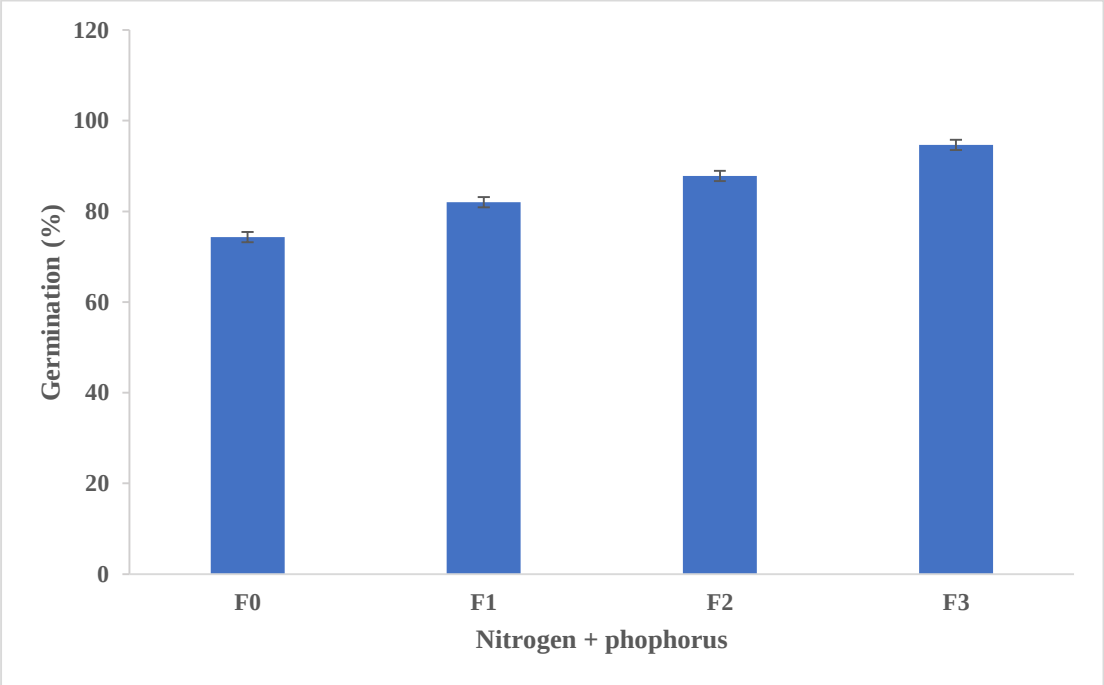

Figure 17. Effect of nitrogen + phosphorus on germination (%) of black gram (Vertical bar represents the standard error of the mean**)**

F_0 = all fertilizer except N & P, F_1 = 50% less N & P, F_2= Recommended dose of N & P with others, F_3= 50% higher N & P

The varietal treatment showed significant impact on germination (%) of black gram (Figure 18, Appendix XII). The maximum germination (%) was recorded in V_2 (86.08%) and the lowest germination (%) was in V_1 (83.33). The present finding is agreed with the findings of Nayak *et al*. (2015) and Kulsum *et al*. (2007).

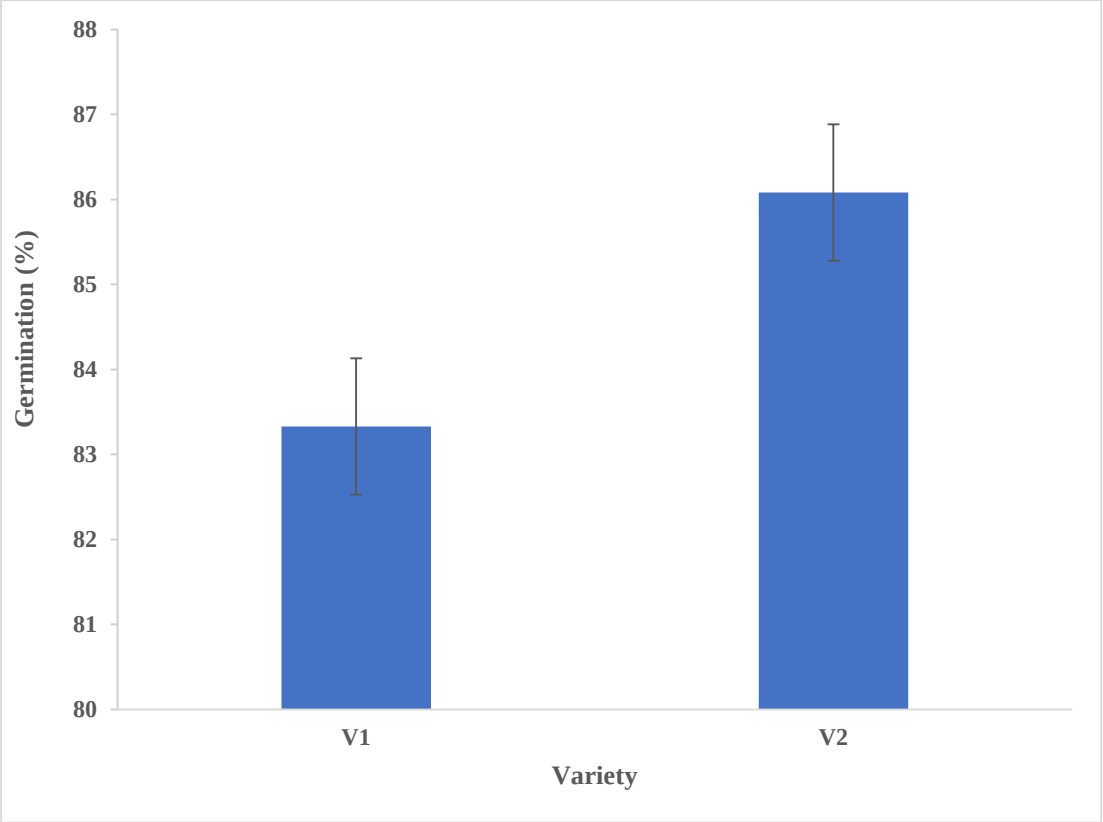

Figure 18. Effect of variety on germination (%) of black gram (Vertical bar represents the standard error of the mean**)**

V_1= BARI mash2, V_2=BARI mash3

The germination (%) didn't influenced significantly due to combine effect of nitrogen + phosphorus and variety of black gram (Table 7, Appendix XII). The maximum germination (%) was recorded in F_3V_2 (95.66%) which was higher than others combinations and lowest in F_0V_1 (73.33%).

Table 9. Effect of N+P fertilizer and variety on germination (%) of black gram

Treatments	Germination (%)
F_0V_1	73.33
F_0V_2	75.33
F_1V_1	80.33
F_1V_2	83.66
F_2V_1	86.00
F_2V_2	89.66
F_3V_1	93.66
F_3V_2	95.66
SE (±)	**NS**
CV (%)	2.32

F_0 = all fertilizer except N & P, F_1 = 50% less N & P, F_2= Recommended dose of N & P with others, F_3= 50% higher N & P; V_1= BARI mash2, V_2=BARI mash3

4.10 Root length

Nitrogen + phosphorus showed significant impact on root length of black gram (Figure 19, Appendix XIII). The highest value obtained for the root length (9.85 cm) in higher dose of fertilizer (F_3). Similarly, the lowest value of root length was in F_0 treatment and that was 6.28 cm. The similar result also reported by the Mishra (2016), Phogat (2016), Yeasmin (2015), Marimuthu and Surendran (2015) and Mir *et al*. (2014).

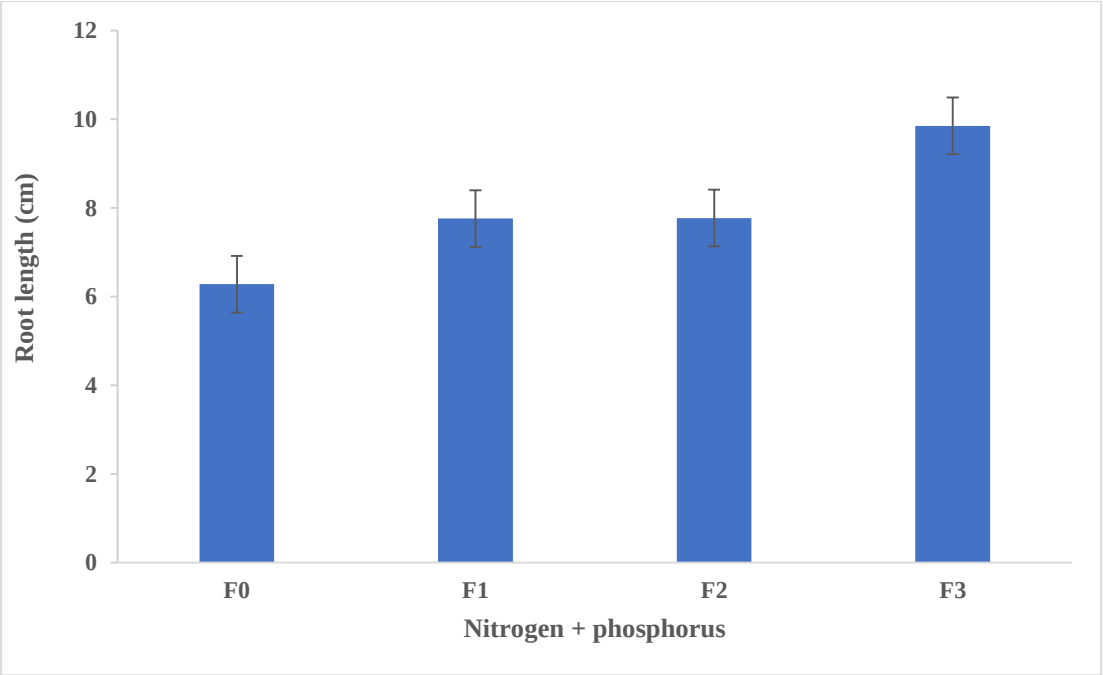

Figure 19. Effect of nitrogen + phosphorus on root length of black gram (Vertical bar represents the standard error of the mean**)**

F_0 = all fertilizer except N & P, F_1 = 50% less N & P, F_2= Recommended dose of N & P with others, F_3= 50% higher N & P

The root length of black gram significantly influenced by varietal treatment (Figure 20, Appendix XIII). The highest value of root length (9.85 cm) was found in V_2 (BARI mash3). The lowest value (6.28 cm) of the same trait was recorded in V_1 (BARI mash2). The present finding is agreed with the findings of Nayak *et al*. (2015) and Kulsum *et al*. (2007).

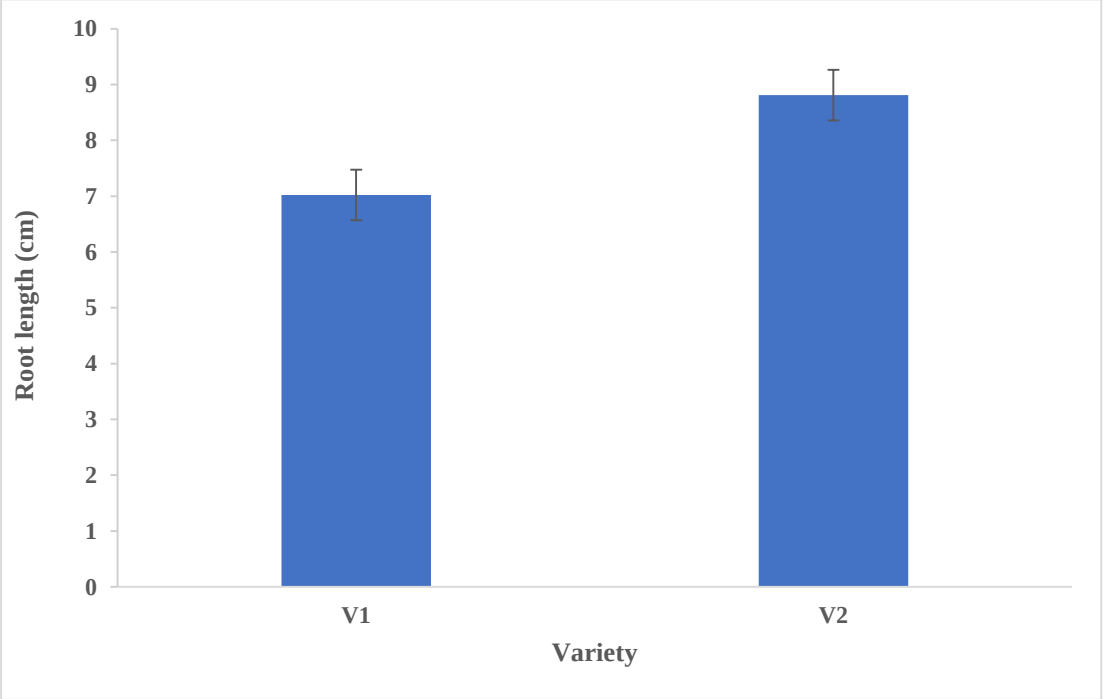

Figure 20. Effect of variety on root length of black gram (Vertical bar represents the standard error of the mean**)**

V_1= BARI mash2, V_2=BARI mash3

The combine effect of nitrogen + phosphorus and variety showed non-significant variations on root length of black gram (Table 10, Appendix XIII). In spite of having non-significant variation the highest value of the root length (11.00 cm) was found in F_3V_2 (50% higher than recommended N & P × BARI mash3) and the lowest root length (5.52 cm) was recorded in F_0V_1 combination (Control fertilizer of N & P × BARI mash2).

Table 10. Effect of N+P fertilizer and variety on root length of black gram

Treatments	Root length (cm)
F_0V_1	5.52
F_0V_2	7.04
F_1V_1	6.51
F_1V_2	9.00
F_2V_1	7.34
F_2V_2	8.20
F_3V_1	8.70
F_3V_2	11.00
SE (±)	**NS**
CV (%)	14.00

F_0 = all fertilizer except N & P, F_1 = 50% less N & P, F_2= Recommended dose of N & P with others, F_3= 50% higher N & P; V_1= BARI mash2, V_2=BARI mash3

4.11 Shoot length

The application of nitrogen + phosphorus showed significant effect on shoot length of black gram (Figure 21, Appendix XIV). Figure indicated that the length showed increasing trend up to the application of higher dose of N and P. The highest shoot length (16.41 cm) was recorded in F_3 treatment while the lowest shoot length (13.07 cm) was found in control treatment (F_0). The similar result also reported by the Mishra (2016), Phogat (2016), Yeasmin (2015), Marimuthu and Surendran (2015) and Mir *et al*. (2014).

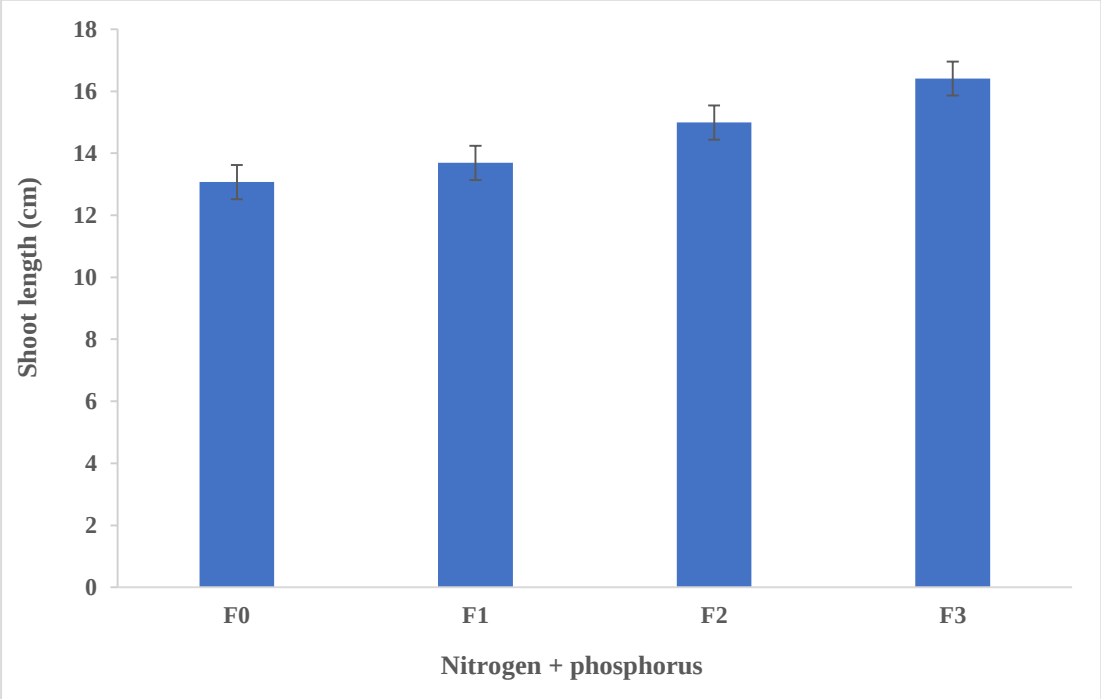

Figure 21. Effect of nitrogen + phosphorus on shoot length of black gram (Vertical bar represents the standard error of the mean**)**

F_0 = all fertilizer except N & P, F_1 = 50% less N & P, F_2= Recommended dose of N & P with others, F_3= 50% higher N & P

Varietal treatment had a positive effect on shoot length of black gram (Figure 22, Appendix XIV). However, the variety V_2 produced highest shoot length (15.11 cm) where V_1 produced the lowest shoot length (13.97). The present finding is agreed with the findings of Nayak *et al*. (2015) and Kulsum *et al*. (2007).

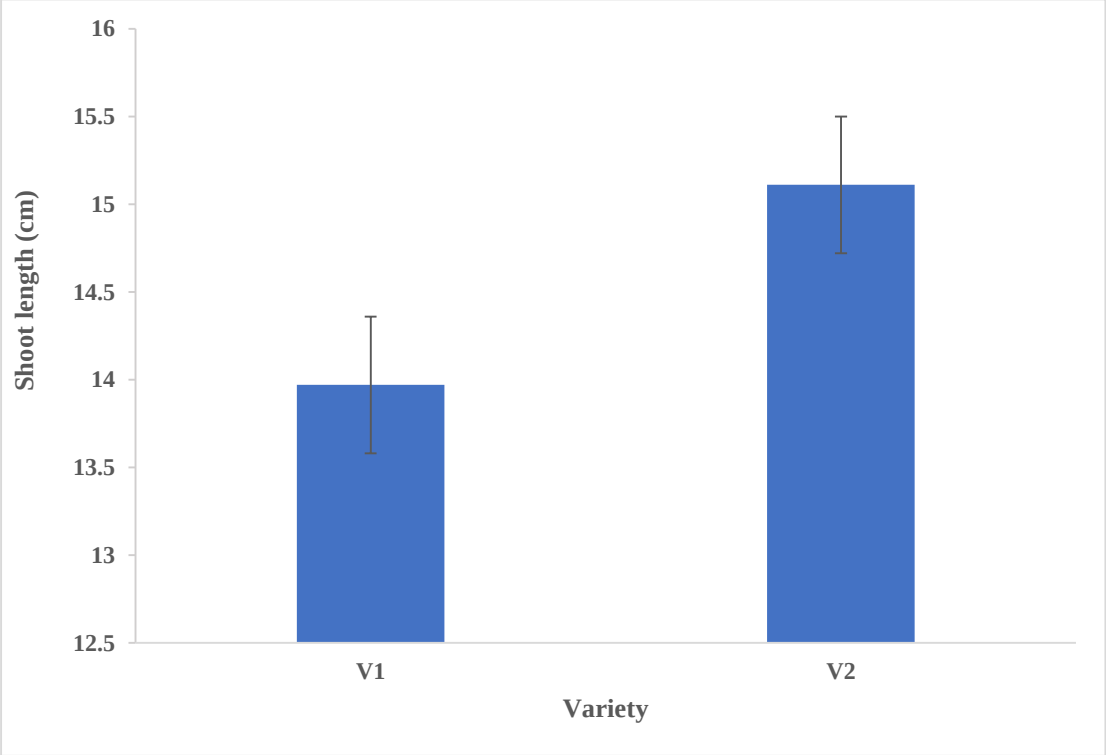

Figure 22. Effect of variety on shoot length of black gram (Vertical bar represents the standard error of the mean**)**

V_1= BARI mash2, V_2=BARI mash3

The shoot length showed non-significant impact due to combine effect of nitrogen + phosphorus and variety of black gram (Table 11, Appendix XIV). Although having non-significant effect, the highest value of shoot length was recorded in F_3V_2 (17.37 cm) and the lowest value of the same trait was found in F_0V_1 (12.92 cm).

Table 11. Combined effect of N+P fertilizer and variety on shoot length of black gram

Treatments	shoot length (cm)
F_0V_1	12.92
F_0V_2	13.22
F_1V_1	13.10
F_1V_2	14.28
F_2V_1	14.42
F_2V_2	15.56
F_3V_1	15.44
F_3V_2	17.37
SE (±)	**NS**
CV (%)	6.58

F_0 = all fertilizer except N & P, F_1 = 50% less N & P, F_2= Recommended dose of N & P with others, F_3= 50% higher N & P; V_1= BARI mash2, V_2=BARI mash3

4.12 Root dry weight

Root dry weight of black gram showed significant influences by the application of nitrogen + phosphorus (Figure 23, Appendix XV). Figure demonstrated that with an increasing the N & P the root dry weight showed increasing trend. The highest root dry weight (17.36 mg) was found in 50% higher than recommended dose of N & P (F_3). The lowest value of root dry weight (11.36 mg) was recorded in control treatment (F_0). The similar result also reported by the Mishra (2016), Phogat (2016), Yeasmin (2015), Marimuthu and Surendran (2015) and Mir *et al*. (2014).

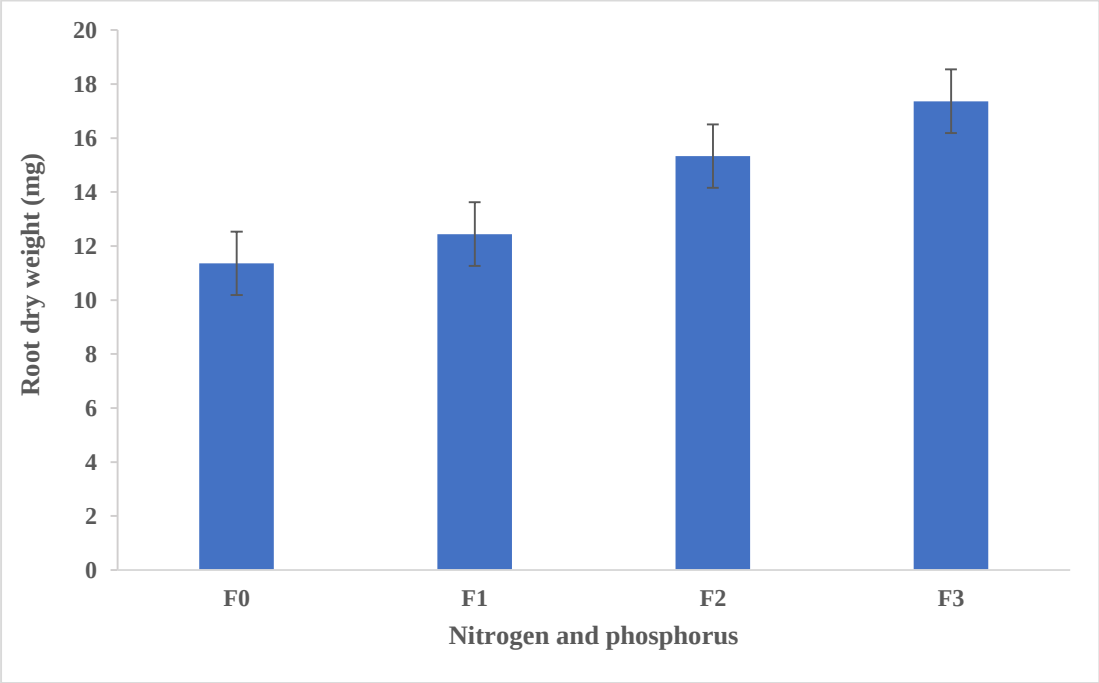

Figure 23. Effect of nitrogen + phosphorus on root dry weight of black gram (Vertical bar represents the standard error of the mean**)**

F_0 = all fertilizer except N & P, F_1 = 50% less N & P, F_2= Recommended dose of N & P with others, F_3= 50% higher N & P

Varietal difference showed significant impact on root dry weight of black gram (Figure 24, Appendix XV). The highest value of root dry weight (15.33 mg) observed in the BARI mash3 (V_2) variety compared to the BARI mash2 (V_1) variety (14.45 mg). The present finding is agreed with the findings of Nayak *et al*. (2015) and Kulsum *et al*. (2007).

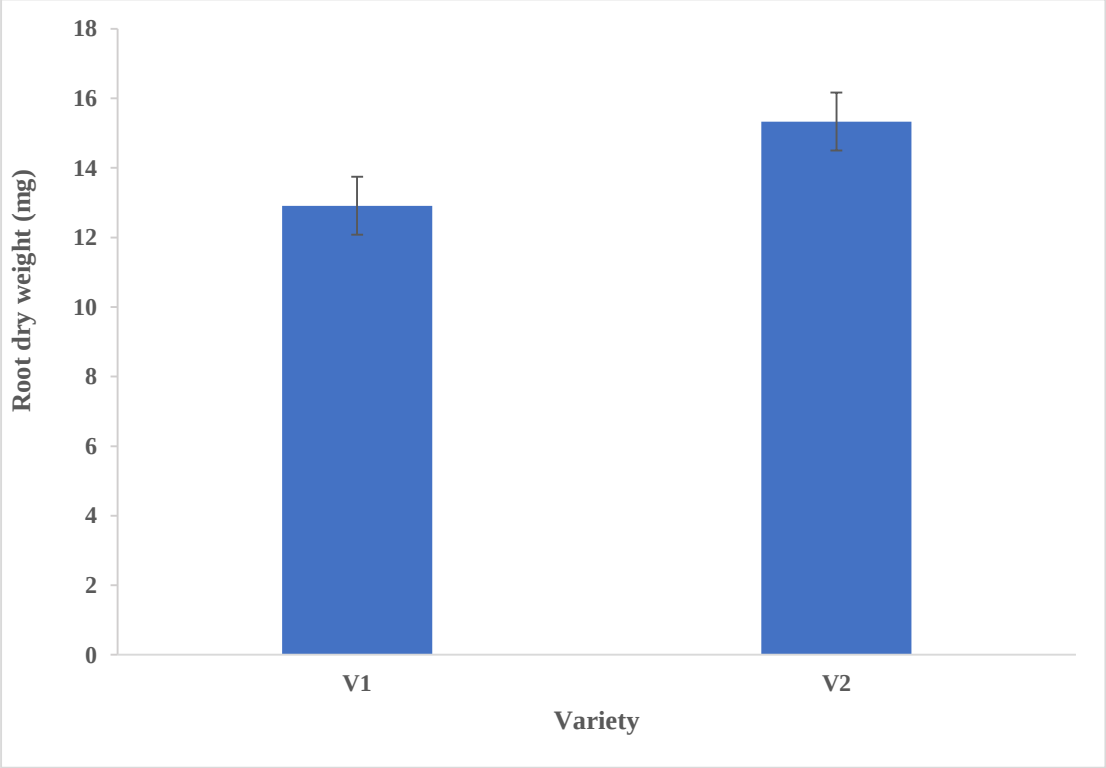

Figure 24. Effect of variety on root dry weight of black gram (Vertical bar represents the standard error of the mean**)**

V_1= BARI mash2, V_2=BARI mash3

The combine effect of nitrogen + phosphorus and variety showed non-significant variations on of root dry weight of black gram (Table 12, Appendix XV). In spite of having non-significant effect the highest root dry weight was found in V_2F_3 (18.46 mg) and the lowest in V_1F_0 (9.93 mg) combination.

Table 12. Effect of N+P fertilizer and variety on root dry weight of black gram

Treatments	Root dry weight (mg)
F_0V_1	9.93
F_0V_2	12.80
F_1V_1	11.13
F_1V_2	13.75
F_2V_1	14.33
F_2V_2	16.33
F_3V_1	16.26
F_3V_2	18.46
SE (±)	**NS**
CV (%)	14.45

F_0 = all fertilizer except N & P, F_1 = 50% less N & P, F_2= Recommended dose of N & P with others, F_3= 50% higher N & P; V_1= BARI mash2, V_2=BARI mash3

4.13 Shoot dry weight

Application of nitrogen + phosphorus had a positive effect on shoot dry weight of black gram (Figure 25, Appendix XVI). The treatment F_3 (50% higher than recommended of N & P) produced the highest shoot dry weight (70.96 mg) where F_0 produced lowest shoot dry weight (47.16 mg). The similar result also reported by the Mishra (2016), Phogat (2016), Yeasmin (2015), Marimuthu and Surendran (2015) and Mir *et al*. (2014).

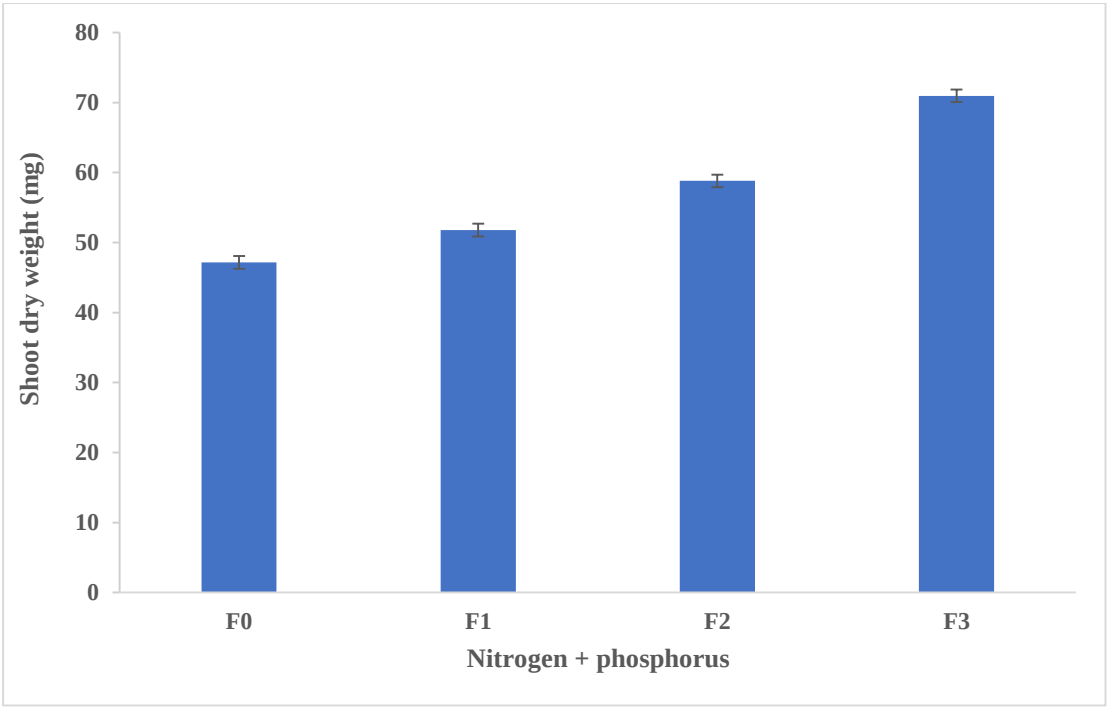

Figure 25. Effect of nitrogen + phosphorus on shoot dry weight of black gram (Vertical bar represents the standard error of the mean**)**

F_0 = all fertilizer except N & P, F_1 = 50% less N & P, F_2= Recommended dose of N & P with others, F_3= 50% higher N & P

The varietal treatment showed significant effect on shoot dry weight of black gram (Figure 26, Appendix XVI). The highest value of the shoot dry weight was recorded in V_2 (60.35 mg) variety and the lowest value of the same trait was recorded in V_1 (54.00 mg) variety. The present finding is agreed with the findings of Nayak *et al*. (2015) and Kulsum *et al*. (2007).

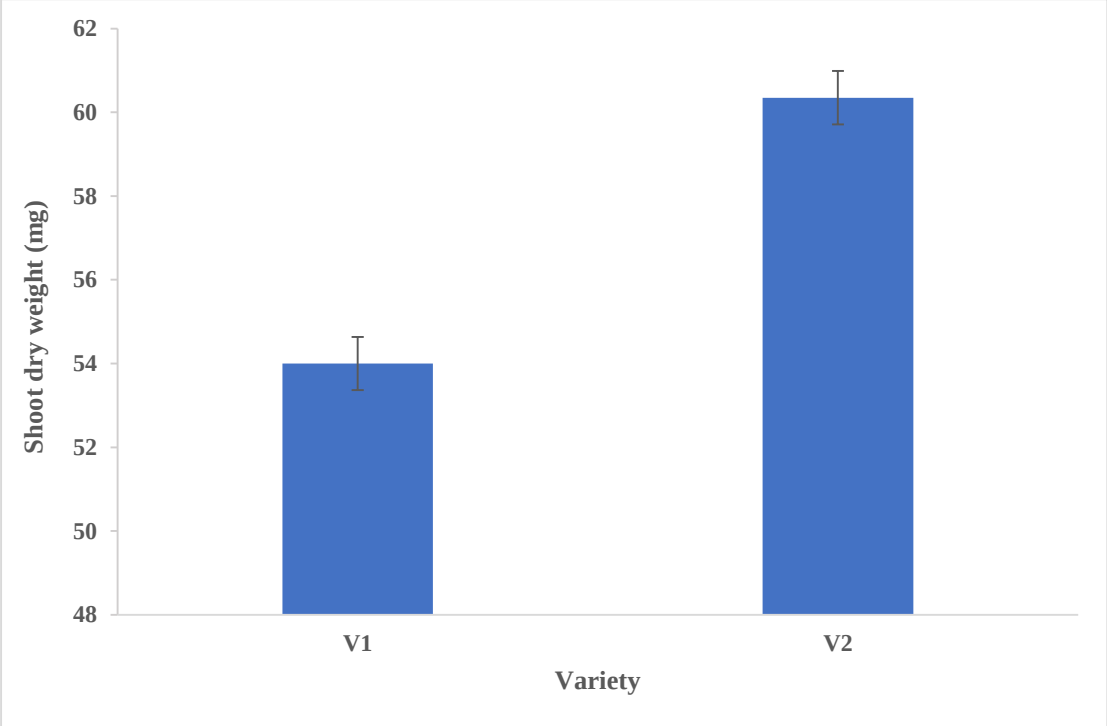

Figure 26. Effect of variety on shoot dry weight of black gram (Vertical bar represents the standard error of the mean**)**

V_1= BARI mash2, V_2=BARI mash3

The shoot dry weight showed non-significant effect due to combine effect of nitrogen + phosphorus and variety (Table 13, Appendix XVI). Although having non-significant effect, the highest shoot dry weight was recorded in F_3V_2 (74.60 mg) and the lowest in F_0V_1 (44.80 mg).

Table 13. Effect of N+P fertilizer and variety on shoot dry weight of black gram

Treatments	Shoot dry weight (mg)
F_0V_1	44.80
F_0V_2	49.53
F_1V_1	48.93
F_1V_2	54.62
F_2V_1	54.95
F_2V_2	62.66
F_3V_1	67.33
F_3V_2	74.60
SE (±)	**NS**
CV (%)	2.73

F_0 = all fertilizer except N & P, F_1 = 50% less N & P, F_2= Recommended dose of N & P with others, F_3= 50% higher N & P; V_1= BARI mash2, V_2=BARI mash3

CHAPTER V

SUMMARY AND CONCLUSION

The investigation was conducted at the central farm of Sher-e-Bangla Agricultural University to study the influence of nitrogen and phosphorus level on yield and seed quality of black gram. Summary and conclusion of the study are presented in this chapter.

Plant height showed an increasing trend with an increasing the higher dose of fertilizer (50% higher than recommended dose of N & P). The tallest plant (77.13 cm) was found in F_3 (50% higher N & P) and shortest plant (69.55 cm) was recorded in F_0 (all fertilizer except N & P). The tallest plant (77.01 cm) was recorded in V_2 (BARI mash3) and the shortest plant (70.00 cm) was found in V_1 (BARI mash2). This might be due to genetic variations among the varieties. The tallest plant (81.26 cm) was found in F_3V_2 combine compared to others combinations while the shortest plant (66.47 cm) was produced by F_0V_1 combinations.

The pods number showed increasing trend up to the treatment F_3 (50% higher than recommended dose of N & P). The maximum number of pods was recorded in F_3 (68.73) and minimum number was found in F_0 (48.50). The variety V_2 (BARI mash3) produced maximum number of pods plant^{-1} (60.45) where V_1 produced minimum number of pods (55.92). The maximum number of pods plant^{-1} was recorded in F_3V_2 (72.13) and lowest was in F_0V_1 (46.86).

The highest values (4.86 cm) obtained for pod length in F_3 (50% higher than recommended dose of N & P). The lowest values of pod length (4.30 cm) were in F_0 (control). The longest pod (4.62 cm) was found in V_2 (BARI mash3). The shortest pod was recorded in V_1 (BARI mash2). The tallest pod was found in F_3V_2 and shortest pod was recorded in F_0V_1 combination compared to other combinations.

The maximum number of seeds pod^{-1} was obtained in higher fertilizer applicated plot. The highest value obtained for number of seeds pod^{-1} (7.21) in F_3 treatment while the minimum value of number of seeds pod^{-1} (5.38) was in F_0. The maximum number of seeds pod^{-1} was found in V_2 variety (6.57). The lowest value of number of seeds pod^{-1} was recorded in V_1 variety (6.05). For the combine effect the maximum number of seeds pod^{-1} (7.40) was found in F_3V_2 and the minimum number of seeds pod^{-1} (5.03) was recorded in F_0V_1 combination compared to other combinations.

The treatment F_3 (50% higher more than recommended dose of N & P) produced the highest value of 1000 seeds weight (40.79 g) where F_0 (control) produced lowest value of 1000 seeds weight (34.70 g). The highest 1000 seeds weight (39.56 g) was recorded in V_2 (BARI mash3) and the lowest 1000 seeds weight in V_1 (BARI mash2). Although having non-significant effect, the highest 1000 seeds weight was recorded in the combination of F_3V_2 (42.94 g) while the lowest 1000 seeds weight was found in the combination of F_0V_1 combination (33.50 g).

Seed yield values showed a gradual increasing trend with the higher doses of fertilizer up to F_3 treatment (2014.70 kg ha^{-1}). Among the fertilizer doses seed

yield ranges from 1270.50 kg ha^{-1} to 2014.70 kg ha^{-1}. The highest seed yield was found in V_2 (1726.90 kg ha^{-1}). The lowest seed yield was recorded in V_1 (1553.00 kg ha^{-1}). Table represented that highest seed yield was found in F_3V_2 (2181.05 kg ha^{-1}) and the lowest seed yield was recorded in F_0V_1 (1204.00 kg ha^{-1}) combination.

The highest biological yield was obtained in fertilizer application area and showed increasing trend up to the higher dose of fertilizer (F_3). The highest value obtained for biological yield (6102.50 kg ha^{-1}) in F_3 while the lowest value of biological yield (4868.30 kg ha^{-1}) was recorded in F_0. The highest biological yield (5681 kg ha^{-1}) was found in V_2 (BARI mash3). The lowest value (5444.22 kg ha^{-1}) of the same trait was recorded in V_1 (BARI mash2). Though having non-significant impact, the highest biological yield (6290 kg ha^{-1}) was found in F_3V_2 combination and the lowest biological yield (4741.71 kg ha^{-1}) was recorded in F_0V_1 combination.

The harvest index showed an increasing trend with an increasing the higher dose of fertilizer (50% higher than recommended dose of N & P). The highest harvest index (36.05%) was found in F_3 (50% higher N & P) and the lowest value of harvest index (32.95%) was recorded in F_0 (all fertilizer except N & P). The highest harvest index (34.82%) was recorded in V_2 (BARI mash3) and the lowest harvest index (34.02%) was found in V_1 (BARI mash2). The highest harvest index (36.51%) was found in F_3V_2 combine compared to others combinations while the lowest value of the harvest index (32.60%) was produced by F_0V_1 combinations.

The highest increment was observed with F_3 treatment (94.66%). The treatment F_0 produced lowest germination (%) (74.33%). The maximum germination (%) was recorded in V_2 (86.08%) and the lowest germination (%) was in V_1 (83.33). The maximum germination (%) was recorded in F_3V_2 (95.66%) which was higher than others combinations and lowest in F_0V_1 (73.33%).

The highest value obtained for the root length (9.85 cm) in higher dose of fertilizer (F_3). Similarly, the lowest value of root length was in F_0 treatment and that was 6.28 cm. The highest value of root length (9.85 cm) was found in V_2 (BARI mash3). The lowest value (6.28 cm) of the same trait was recorded in V_1 (BARI mash2). In spite of having non-significant variation the highest value of the root length (11.00 cm) was found in F_3V_2 (50% higher than recommended N & P × BARI mash3) and the lowest root length (5.52 cm) was recorded in F_0V_1 combination (Control fertilizer of N & P × BARI mash2).

The highest shoot length (16.41 cm) was recorded in F_3 treatment while the lowest shoot length (13.07 cm) was found in control treatment (F_0). The variety V_2 produced highest shoot length (15.11 cm) where V_1 produced the lowest shoot length (13.97). The highest value of shoot length was recorded in F_3V_2 (17.37 cm) and the lowest value of the same trait was found in F_0V_1 (12.92 cm).

The highest root dry weight (17.36 mg) was found in 50% higher than recommended dose of N & P (F_3). The lowest value of root dry weight (11.36 mg) was recorded in control treatment (F_0). The highest value of root dry weight (15.33 mg) observed in the BARI mash3 (V_2) variety compared to the BARI

mash2 (V_1) variety (14.45 mg). The highest root dry weight was found in F_3V_2 (18.46 mg) and the lowest in F_0V_1 (9.93 mg) combination.

The treatment F_3 (50% higher than recommended of N & P) produced the highest shoot dry weight (70.96 mg) where F_0 produced lowest shoot dry weight (47.16 mg). The highest value of the shoot dry weight was recorded in V_2 (60.35 mg) variety and the lowest value of the same trait was recorded in V_1 (54.00 mg) variety. Although having non-significant effect, the highest shoot dry weight was recorded in F_3V_2 (74.60 mg) and the lowest in F_0V_1 (44.80 mg).

From the present study it may be concluded that F_3 (50% higher N+P than recommended dose) treatment, V_2 (BARI mash3) variety and their interaction seems promising for better yield and seed quality of blackgram.

Recommendation

The present experiment was conducted only one season even in a single location. So, it is difficult to recommend this finding without further study. By considering the results of the present experiment, further studies in the following areas are suggested below

I. Studies of similar nature could be carried out in different agro-ecological zones (AEZ) in different seasons of Bangladesh for the evaluation of zonal adaptability.
II. In this study, few levels of fertilizers and variety was used, it is recommended to increase the fertilizer levels and variety to get accurate result.

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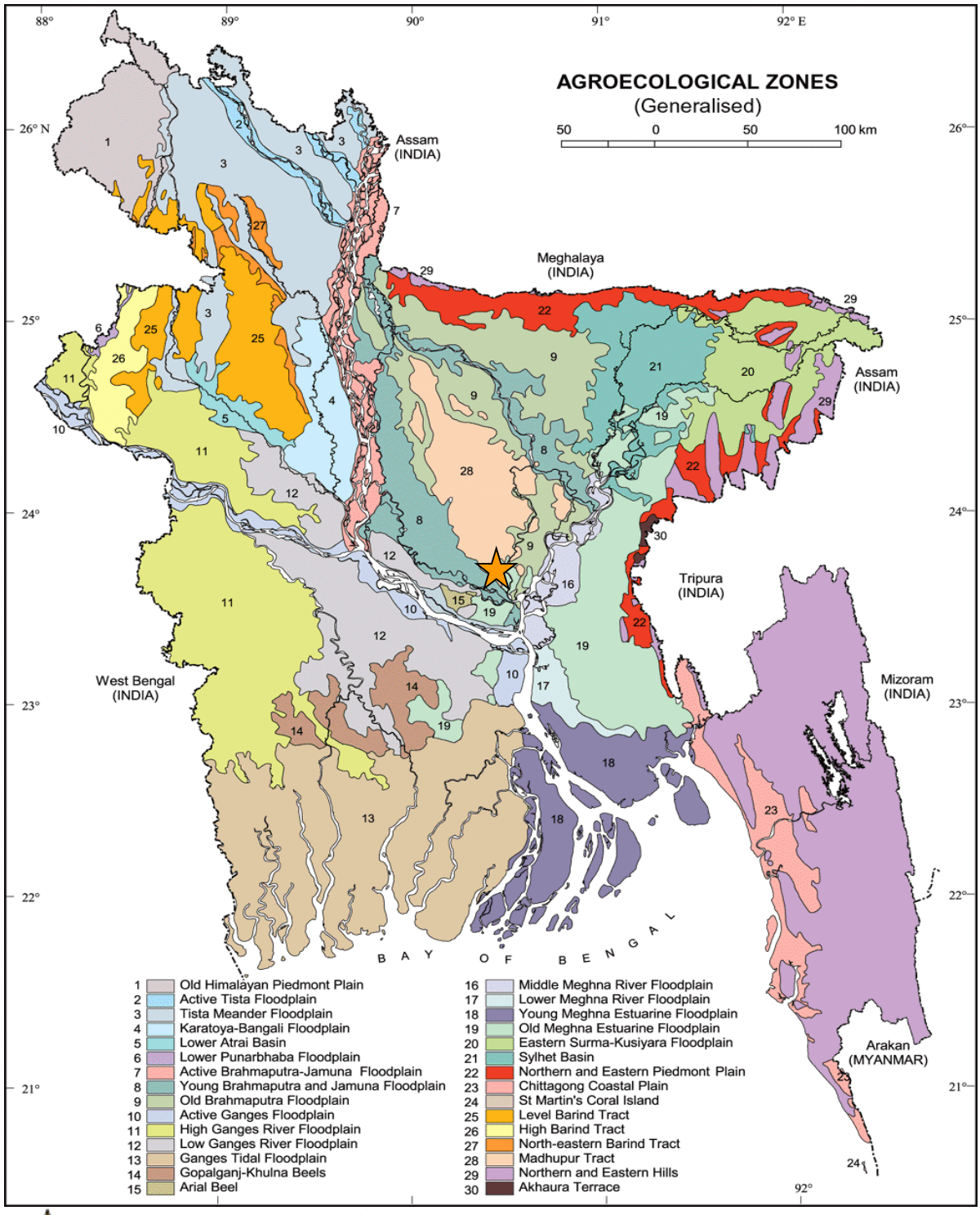
APPENDIX

Appendix I. Map showing the experimental sites under study



★ **The experimental site under study**

Appendix II. Monthly recorded the average air temperature, total rainfall, relative humidity and sunshine of the experimental site during the period from March to June 2017.

Month	Air temperature (^{0}C)		Relative humidity (%)	Total rainfall(mm)	Sunshine (hr)
	Maximum	Minimum			
March, 2017	28.1	15.5	68	28.9	5.5
April, 2017	32.5	20.4	64	65.8	5.2
May, 2017	38.9	23.6	70	76.4	5.7
June, 2017	40.5	24.5	75	80.6	5.8

Source: Sher-e-Bangla Agricultural University Weather Station

Appendix III. Physical and chemical soil properties of experimental plot

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
Textural class	silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: Soil Resources Development Institute (SRDI)

APPENDIX IV. ANOVA for plant height

Source	DF	SS	MS	F	P
Replication	2	27.338	13.669		
Variety	1	293.930	293.930	260.45	0.0000
Fertilizer	3	185.554	61.851	54.81	0.0000
Variety*Fertilizer	3	3.539	1.180	1.05	0.4032
Error	14	15.799	1.129		
Total	23	526.160			

APPENDIX V. ANOVA for number of pods plant^{-1}

Source	DF	SS	MS	F	P
Replication	2	3.50	1.749		
Variety	1	122.99	122.990	40.29	0.0000
Fertilizer	3	1354.66	451.553	147.91	0.0000
Variety*Fertilizer	3	12.61	4.203	1.38	0.2907
Error	14	42.74	3.053		
Total	23	1536.50			

APPENDIX VI. ANOVA for pod length

Source	DF	SS	MS	F	P
Replication	2	0.14853	0.07426		
Variety	1	0.10534	0.10534	2.71	0.1217
Fertilizer	3	1.14075	0.38025	9.80	0.0010
Variety*Fertilizer	3	0.02175	0.00725	0.19	0.9036
Error	14	0.54341	0.03881		
Total	23	1.95976			

APPENDIX VII. ANOVA for number of seeds pod^{-1}

Source	DF	SS	MS	F	P
Replication	2	0.6673	0.33365		
Variety	1	1.6172	1.61720	27.21	0.0001
Fertilizer	3	12.1994	4.06648	68.42	0.0000
Variety*Fertilizer	3	0.2899	0.09665	1.63	0.2283
Error	14	0.8321	0.05944		
Total	23	15.6060			

APPENDIX VIII. ANOVA for 1000 seeds weight

Source	DF	SS	MS	F	P
Replication	2	0.309	0.1546		
Variety	1	76.469	76.4694	45.08	0.0000
Fertilizer	3	118.804	39.6013	23.35	0.0000
Variety*Fertilizer	3	3.735	1.2450	0.73	0.5489
Error	14	23.747	1.6962		
Total	23	223.065			

APPENDIX IX. ANOVA for seed yield

Source	DF	SS	MS	F	P
Replication	2	55107	27553		
Variety	1	181372	181372	37.98	0.0000
Fertilizer	3	1852787	617596	129.32	0.0000
Variety*Fertilizer	3	139396	46465	9.73	0.0010
Error	14	66860	4776		
Total	23	2295523			

APPENDIX X. ANOVA for biological yield

Source	DF	SS	MS	F	P
Replication	2	93233	46617		
Variety	1	338437	338437	13.39	0.0026
Fertilizer	3	5407254	1802418	71.31	0.0000
Variety*Fertilizer	3	76871	25624	1.01	0.4160
Error	14	353850	25275		
Total	23	6269646			

APPENDIX XI. ANOVA for harvest index

Source	DF	SS	MS	F	P
Replication	2	2.2012	1.1006		
Variety	1	3.8400	3.8400	26.57	0.0001
Fertilizer	3	30.8586	10.2862	71.18	0.0000
Variety*Fertilizer	3	0.0334	0.0111	0.08	0.9713
Error	14	2.0230	0.1445		
Total	23	38.9563			

APPENDIX XII. ANOVA for germination percentage

Source	DF	SS	MS	F	P
Replication	2	28.58	14.292		
Variety	1	45.38	45.375	11.75	0.0041
Fertilizer	3	1343.46	447.819	115.92	0.0000
Variety*Fertilizer	3	3.46	1.153	0.30	0.8260
Error	14	54.08	3.863		
Total	23	1474.96			

APPENDIX XIII. ANOVA for root length

Source	DF	SS	MS	F	P
Replication	2	0.4228	0.2114		
Variety	1	19.2604	19.2604	15.68	0.0014
Fertilizer	3	38.7218	12.9073	10.51	0.0007
Variety*Fertilizer	3	2.5287	0.8429	0.69	0.5752
Error	14	17.1945	1.2282		
Total	23	78.1282			

APPENDIX XIV. ANOVA for shoot length

Source	DF	SS	MS	F	P
Replication	2	3.9260	1.9630		
Variety	1	7.7521	7.7521	8.47	0.0114
Fertilizer	3	39.3115	13.1038	14.33	0.0002
Variety*Fertilizer	3	1.9890	0.6630	0.72	0.5538
Error	14	12.8060	0.9147		
Total	23	65.7845			

APPENDIX XV. ANOVA for root dry weight

Source	DF	SS	MS	F	P
Replication	2	6.793	3.3967		
Variety	1	35.211	35.2110	8.45	0.0115
Fertilizer	3	134.395	44.7985	10.75	0.0006
Variety*Fertilizer	3	0.698	0.2328	0.06	0.9819
Error	14	58.362	4.1687		
Total	23	235.460			

APPENDIX XVI. ANOVA for shoot dry weight

Source	DF	SS	MS	F	P
Replication	2	4.24	2.120		
Variety	1	242.06	242.062	99.53	0.0000
Fertilizer	3	1933.01	644.337	264.94	0.0000
Variety*Fertilizer	3	8.64	2.879	1.18	0.3515
Error	14	34.05	2.432		
Total	23	2222.00			