EFFECT OF NITROGEN AND PHOSPHORUS ON GROWTH AND YIELD OF BARI mash-2

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CERTIFICATE

This is to certify that the thesis entitled, "**EFFECT OF NITROGEN AND PHOSPHOROUS ON GROWTH AND YIELD OF BARI mash-2**." Submitted to the **DEPARTMENT OF SOIL SCIENCE**, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE in SOIL SCIENCE** embodies the result of a piece of bona-fide research work carried out by **MD. FAHD-BIN SAFIAR RAHMAN**, Registration No. **09-03349** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:
Dhaka, Bangladesh

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Dedicated to

My

Beloved Parents

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The Author

ABSTRACT

Effect of nitrogen and phosphorous on growth and yield of BARI mash-2

A field experiment was conducted at the research farm of Sher-e-Bangla Agricultural University, Dhaka during March to June, 2014 to study the effect of nitrogen and phosphorous on growth and yield of BARI mash-2. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The unit plot size was 5.5m^2 (2.75m x 2.00m). There were two factors under the present study; Factor A – Nitrogen: three doses of nitrogen *viz*. (1) N_0 = 0 kg N ha^{-1} (2) N_1 = 20 kg N ha^{-1} (3) N_2 = 25 kg N ha^{-1} and Factor B – Phosphorus: three doses of phosphorus *viz*. (1) P_0 = 0 kg P ha^{-1} (2) P_1 = 10 kg P ha^{-1} (3) P_2 = 20 kg P ha^{-1}. There were nine treatment combinations in the experiment. All growth, yield and yield contributing parameter were significantly influenced by nitrogen and phosphorus. The highest plant height (53.57 cm), number of leaves plant^{-1} (67.33), number of branches plant^{-1} (10.58), dry weight plant^{-1} (21.70 g) was recorded under the treatment combination of N_2P_2 (25 kg N ha^{-1} combined with 20 kg P ha^{-1}) at harvest period. The highest number of pods plant^{-1} (85.41), pod length (6.34 cm), number of seeds pod^{-1} (7.91), 1000 seed weight (45.04 g), grain yield (1.70 t ha^{-1}) and harvest index (44.38%) were found from N_1P_2 (20 kg N ha^{-1} combined with 20 kg P ha^{-1}).

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BARI	=	Bangladesh Agricultural Research Institute
CBR	=	Cost Benefit Ratio
cm	=	Centimeter
^{0}C	=	Degree Centigrade
DAS	=	Days after sowing
et al.,	=	and others *(at elli)*
Kg	=	Kilogram
Kg/ha	=	Kilogram/hectare
g	=	gram (s)
LER	=	Land Equivalent Ratio
LSD	=	Least Significant Difference
MoP	=	Muriate of Potash
m	=	Meter
P^H	=	Hydrogen ion conc.
RCBD	=	Randomized Complete Block Design
TSP	=	Triple Super Phosphate
t/ha	=	ton/hectare
%	=	Percent

CHAPTER 1

INTRODUCTION

Bangladesh grows various types of pulse crops among them blackgram (Mashkalai) (*Vigna mungo* L.) is important. Blackgram is one of the most important pulse crops in Bangladesh. It has good digestibility, flavor and high protein content. Being a short duration crop it fits well into the intensive cropping system. Pulse crops belong to grain legume. It provides valuable protein in our human diet. Pulse protein is rich in lysine that is deficient in rice. According to FAO (1999) recommendation, a minimum intake of pulse by a human should be 80 g/day, where it is 7.92 in Bangladesh (BBS, 2002).This is because of fact that national production of the pulses is not adequate to meet our national demand. The area under pulse crop is 0.406 million hectare with a production of 0.322 million ton (BBS, 2005), where blackgram is cultivated in the area of 0.188 million ha with production of 9.5% of total pulse production (BBS, 2005).In respect of total land area and total production, blackgram has occupied 4th position of all pulses (BARI, 2005).

Nitrogen constitutes a part of the proteins, the basis of life the nucleic acids,(DNA, RNA), chlorophyll, phosphamide and other organic compounds. Deficiency of N results in poor growth and stunting of the plants. Higher N supply favors a higher rate of protein synthesis, growth of the leaves and formation of greater assimilation surface.

Among the pulse crops, blackgram is one of the main edible pulse crops of Bangladesh. It ranks fourth among the pulses with an area of about 82000 ha (BBS, 2006). As an excellent source of plant protein it is cultivated extensively in the tropics and subtropics. Blackgram grain contains 59% carbohydrates, 24% protein, 10% moisture, 4% mineral and 3% vitamins (Khan, 1981; Kaul, 1982). The green plants can also be used as animal feed and its residues have manual value. The crop is potentially useful in improving cropping pattern The yield of blackgram is very poor as compared to many other legume crops

(Wahhab *et al*.,1981). It can also fix atmospheric nitrogen through the symbiotic relationship between the host blackgram roots and soil bacteria and thus improves soil fertility. Slow rate of dry matter accumulation during pre-flowering phase, 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. That is why blackgram is highly responsive to nitrogen. It plays an important role to supplement protein in the cereal-based low-protein diet of the people of Bangladesh, but the acreage and production of blackgram is steadily declining (BBS, 2006).

The average yield of blackgram is 0.7 t ha^{-1} (BBS, 2006) in Bangladesh. There are many reasons of lower yield of blackgram. Nitrogen and irrigation management in kharif-1 season are one of them. For the pulse crops, nitrogen is most useful because it is the main component of protein. The management of fertilizer greatly affects the growth, development and yield of this crop. Pulses although fix nitrogen from the atmosphere, there is evident that application of nitrogenous fertilizers at flowering stage becomes helpful in increasing the yield (Patel *et al*., 1984, Ardeshana *et. al.,* 1993).

Blackgram is a rain fed crop in most countries, grown either during the wet season or on the residual soil moisture. Blackgram responses favorably to added water resulting in higher yields, especially when irrigation is given at the time of flowering (Lawn, 1978;Miah and Carangal, 1981). In summer cultivation when temperature is high, relative humidity is low and evapo-transpiration is greater, then 3-4 irrigations may be needed to obtain higher yields of blackgram (Lal and Yadav, 1981). Irrigation during flowering stage helps for retention of flowers and pod development.

Phosphorus is an essential component of deoxyribonucleic acid (DNA), the seat of genetic inheritance in plant and various forms of ribonucleic acid (RNA) are needed for protein synthesis. It is also a component of two compounds involved in the most significant energy transformations in plants, adenosine diphosphate (ADP) and adenosine triphosphate (ATP) associated with the uptake of some nutrients and their transport within the plants and as well as the synthesis of different molecules. Phosphorus plays a vital role in cell division in plants, flowering and fruiting, including seed formation, crop maturation, root development, improvement of crop quality and so on.

Slow rate of dry matter accumulation during pre-flowering phase, 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. That is why blackgram is highly responsive to nitrogen. It plays an important role to supplement protein in the cereal-based low-protein diet of the people of Bangladesh, but the acreage and production of blackgram is steadily declining (BBS, 2006). The management of fertilizer greatly affects the growth, development and yield of this crop. Pulses although fix nitrogen from the atmosphere, there is evident that application of nitrogenous fertilizers at flowering stage becomes helpful in increasing the yield (Patel *et al*., 1984, Ardeshana *et al*., 1993).

Phosphorus fertilizer application result in increased of anion adsorption sites by phosphate, which releases sulphate ions into the soil solution (Tiwari and Gupta, 2006). Dynamic of P in soil is very complex and it has also got antagonistic relationship with zinc also (Singh *et al*., 2011). Performance of different in response to integrated nutrient management may be varied and its output is mainly depends nature of crops, soil status and agro-climatic condition too (Singh *et al*., 2014). The interaction of these nutrient elements may affect the critical levels of available phosphorus and sulphur below which response to their application could be observed. Information on effect of combined application of phosphorus and sulphur on yield, quality and content of each nutrient in blackgram is rather limited. Therefore, the present investigation was undertaken to study the effects of phosphorus and sulphur application on yield and quality of blackgram.

Objectives:

- To know the growth and yield performance of BARI mash-2 by using different doses of individual and combined application of nitrogen and phosphorus fertilizers.
- To identifysuitable doses of nitrogen and phosphorus fertilizers for better yield of BARI mash-2.

CHAPTER 2

REVIEW OF LITERATURE

Among the pulse crops, blackgram occupies the medium position in Bangladesh. Blackgram being a leguminous crop having high yield potential would require an ample supply of plant nutrients to ensure proper growth, development and satisfactory yield. The crop has many similarities with other leguminous crops. Hence brief reviews of available literature with regards to the influence of nitrogen and Phosphorus fertilizers on this crop are presented in this Chapter.

Information on fertilizer management of pulse related to the study are reviewed and presented in the following heads.

2.1 Efficacy of integrated fertilizers on blackgram.

2.1.1 Plant height

Saini and Thakur (1996) stated that nitrogen at 30 and 40 kg ha^{-1} significantly increased the plant height of blackgram compared with no N.

Jamro *et al.,* (1990) observed that application of 90 kg N ha^{-1} is significantly increased the plant height of blackgram.

Yein *et al.,* (1981) conducted a field experiment on nitrogen in combination with phosphorus fertilizer to blackgram. They revealed that application of 40 kg N ha^{-1} increased plant height.

Asaduzzaman (2006) found that plant height of mungbean was significantly increased by the application of nitrogen fertilizer at 30 kg ha^{-1}.

Akhtaruzzaman (1998) conducted a field experiment on mungbean where plant height increased almost linearly up to 40 kg N ha^{-1} although response of 30 and 40 kg N ha^{-1} was identical.

Suhartatik (1991) in a study observed that increased application of NPK fertilizers significantly increased the plant height of mungbean.

Hamid (1988) conducted a field experiment to investigate the effect of nitrogen and carbon on the growth and yield performance of mungbean (*Vigna radiata* L. wilczek). He found that the plant height of mungbean cv. Mubarik was found to be increased with nitrogen at 40 kg ha^{-1}.

Trung and Yoshida (1983) conducted a field trial on mungbean in nutrient-rich soil, involving 0-100 ppm N as treatments. They observed that maximum plant height at all the stages of plant growth were obtained by the application of 25 ppm N.

2.1.2 Number of leaves

Asaduzzaman (2006) reported that different levels of nitrogen showed significantly increased number of leaves per plant of mungbean up to level of 30 kg N ha^{-1}.

Srivastava and Verma (1982) showed that N application at the rate of 15kg ha^{-1} increased the number of green leaves in green gram plants.

2.1.3 Total dry matter

Leelavathi *et al.*, (1991) reported that different levels of nitrogen showed significantly increased dry matter production of up to 60 kg N ha^{-1}.

Yakadri *et al.,* (2002) studied the effect of nitrogen (40 and 60 kg ha^{-1}) on crop growth and yield of green gram (cv. ML-267). Application of nitrogen at 20 kg ha^{-1} resulted in the significant increase in leaf area ratios indicating better partitioning of leaf dry matter.

Chowdhury and Rosario (1992) studied the effect of 0, 30, 60 or 90 kg N ha^{-1} levels on the rate of growth and yield performance of mungbean at Los Banos, Philippines in 1988. They observed that N above the rate of 30 kg N ha^{-1} reduced the dry matter yield.

Agbenin e*t al.,* (1991) carried out a field experiment under glass house condition and found that nitrogen application significantly increased the dry matter yield of mungbean.

Raju and Verma (1984) carried out a field experiment during summer season of 1979 and 1980 to study the response of mungbean var. Pusabaishaki to varying levels of nitrogen (15, 30, 45 and 60 kg N ha^{-1}) in the presence and absence of seed inoculation with Rhizobium. They found that maximum dry matter weight per plant was obtained by the application of 60 kg N ha^{-1} inoculated with Rhizobium.

2.1.4 Number of Pods

MosammauttmaKulsum (2003) reported that different levels of nitrogen showed significantly increased pods per plant of up to N 60 kg ha^{-1}.

Singh *et al.,* (1993) reported increased pod yield green gram up to N 20kg ha^{-1} and P 40 kg ha^{-1}.

Jamro *et al.,* (1990) reported that application of 90 kg N ha^{-1} to result in appreciable improvement in the number of pods per plant.

Srinivas *et al.,* (2002) examined the effect of nitrogen (0, 20, 40 and 60 kg ha^{-1}) and P (0, 25, 50 and 75 kg ha^{-1}) on the growth and seed yield of mungbean. They observed that the number of pods per plant was increased with the increasing rates of N up to 40 kg ha^{-1} followed by a decrease with further increase in N.

Sarkar and Banik (1991) reported that application of 10 kg N ha^{-1} to mungbean resulted in appreciable improvement in the number of pods per plant.

In an experiment, Yein *et al.,* (1981) applied nitrogen and phosphorus fertilizers to mungbean and reported that combined application of nitrogen and phosphorus fertilizers increased the number of pods per plant. The rate of nitrogen and phosphorus was 50 kg and 75 kg per hectare, respectively.

Patel and Parmar (1986) conducted an experiment to evaluate the response of green gram with varying levels of nitrogen and phosphorus. They observed that increasing N application to rainfedmungbean (cv. Gujrat-1) from 0 to 50 kg N ha^{-1} increased the number of pods per plant.

Tank *et al.,* (1992) reported that mungbean fertilized with 20 kg N ha^{-1} along with 75 kg P_2O_5 ha^{-1} significantly increased the number of pods per plant.

In trials, on clay soils during the summer season Patel *et al.,* (1984) observed the effect of N levels (0, 10, 20 and 30 kg N ha-1) and that of the P (0, 10, 20, 40, 60 and 80 kg P_2O_5 ha^{-1}) on the growth and seed yield of mungbean. It was found that application of 30 kg N ha^{-1} along with 40 kg P_2O_5 ha^{-1} significantly increased the number of pods per plant.

2.1.5 Number of seeds per pod

Malik *et al.,* (2003) investigated the effect of varying levels of nitrogen (0, 25 and 50 kg ha^{-1}) and P (0, 50, 75 and 100 kg ha^{-1}) on the yield and quality of mungbean cv. NM-98 during 2001. It was found that number of seeds per pod was significantly affected by varying levels of nitrogen and phosphorus.

2.1.6 1000-seed weight

Patel and Patel (1991) found that application of nitrogen, phosphorus and potassium fertilizers resulted in significant increases in 1000 seed weight of mungbean.

Mahboob and Asghar (2002) studied the effect of seed inoculation at different nitrogen levels on the yield and yield components of mungbean at the agronomic research station, Farooq Abad in Pakistan during the year of 2000 and 2001. They revealed that with the application of NPK at the rate of 50-50-0 kg ha^{-1} significantly affected the 1000 grain weight.

Quah and Jafar (1994) noted that 1000 seed weight of mungbean increased significantly with 40 kg N ha^{-1}.

(1990)observed that application of 40 kg P_2O_5 ha^{-1} along with 20 kg N ha^{-1} significantly increased the 1000 seed weight of mungbean.

A field experiment was conducted by Sarkar and Banik (1991) to evaluate the effect of varying rates of N on mungbean. Results revealed that application of 10 kg N ha^{-1} resulted in the appreciable improvement in different yield attributes along with 1000 seed weight over control.

2.1.7 Seed Yield

Saini and Thakur (1996) stated that application of 30 kg N ha^{-1} significantly increased the grain yield per plant.

Bhalu *et al.,* (1995) observed that seed yield of increased with up to 20 kg N and 40 kg P_2O_5.

Yadav *et al.,* (1994) reported that higher seed yield of blackgram with 20 kg N ha^{-1}, 40 kg P ha^{-1} and 40 kg K ha^{-1}.

Singh *et al.,* (1993) reported increased seed yield of blackgram with N 20 kg ha^{-1} and P 40 kg ha^{-1}.

Leelavathi e*t al*., (1991) reported that different levels of nitrogen showed significant difference in dry matter production of blackgram up to a certain level of 60 kg N ha^{-1}.

Upadhayay *et al.,* (1991) reported that N application markedly increased the seed yield of blackgram in nitrogen deficient sandy loam soil.

Vidhate, and Jana, P. K. (1986) explored the response of blackgram to nitrogen fertilization. They observed that an increase in the dose of N fertilizer increased the grain yield. Higher percent of grain yield increased when equal dose of 25 kg N ha^{-1} applied at sowing and at flowering.

Mozumdar *et al.,* (2003) conducted an experiment to study the effect of different nitrogen levels viz. 0, 20, 40, 60 and 80 kg N ha^{-1} on Binamoog-2 and they observed that increase of nitrogen fertilizer increased seed yield up to 40 kg N ha^{-1} and that was 1607 kg ha^{-1}.

Raju and Verma (1984) reported that application of 15-60 kg N ha^{-1} significantly increased seed yields of mungbean.

Karle and Pawar (1998) examined the effect of varying levels of N and P fertilizers on summer mungbean. They reported that mungbean produced higher seed yield with the application of 15 kg N ha^{-1} and 40 kg P_2O_5 ha^{-1}.

Patil *et al.,* (1984) showed that increased in the dose of nitrogen from 20 to 40 $kgha^{-1}$ at flowering improved grain yield from 39 to 89 percent over control. It is interesting to note that half dose of 20 $kgha^{-1}$ of nitrogen applied at sowing and remaining at the time of flowering gave higher yield than the application of 40 kg N ha^{-1} as basal in mungbean.

Pongkao and Inthong (1988) applied N at the rate of 0-60 kg ha^{-1} on mungbean and reported that application of 15 kg N ha^{-1} was found to be superior giving 23% higher seed yield over the control.

A field experiment conducted by Sarkar and Banik (1991) to study the effect of N in combination with P on the yield of mungbean. Results showed that application of N along with P significantly increased the seed yield of mungbean. The maximum seed yield was obtained with the combination of 20 kg N and 60 kg P_2O_5 ha^{-1}.

Ardeshana *et al.,* (1993) conducted a field experiment on clay soil during the rainy season of 1990 to study the response of mungbean to nitrogen. They observed that seed yield increased with the application of nitrogen fertilizer up to 20 kg N ha^{-1} in combination with phosphorus fertilizer up to 40 kg P_2O_5 ha^{-1}.

Bachchhav *et al.,* (1994) conducted a field experiment during the summer season with green gram cv. Phule-M. They observed that among nitrogen fertilizers rates (0-45 kg N ha^{-1}) seed yield increased with 30 kg N ha^{-1}.

Kaneria and Patel (1995) conducted a field experiment on a Vertisol in Gujarat, India with mungbean cv. K 581 using 0 or 20 kg N ha^{-1} levels. They found that application of 20 kg N ha^{-1} significantly increased the seed yield.

In a field experiment conducted by Satyanarayanamma *et al.,* (1996), five mungbean cultivars were sprayed with 2% urea at pre-flowering, flowering, pod development or at all the combinations or at combination of two of three growth stages. They reported that spraying urea at flowering and pod development stages produced the highest seed yield.

Malik *et al.,* (2003) conducted an experiment to determine the effect of varying levels of nitrogen (0, 25 and 50 kg ha^{-1}) and phosphorus (0, 50, 75, and 100 kg ha^{-1}) on the yield and quality of mungbean cv. NM-98. Growth and yield components were significantly affected by varying levels of nitrogen and phosphorus. A fertilizer combination of 25 kg N + 75 kg ha^{-1} resulted with maximum seed yield (1112.96 kg ha^{-1}).

Rajender *et al.,* (2003) investigated the effects of N (0, 10, 20 and 30 kg ha^{-1}) and P (0, 20, 40 and 60 kg ha^{-1}) fertilizer rates on mungbean genotypes MH 85-111 and T44.They observed grain yield increased with increasing N rates up to 20 kg ha^{-1}.

Results from field experiments conducted by Mahadkar and Saraf (1988) during summer season mungbean showed that the application of N with P and K at 20, 2, 5 kg ha^{-1} gave higher seed yield.

2.1.8 Harvest Index

Mozumdar *et al.,* (2003) conducted a field experiment at the Bangladesh Agricultural University, Mymensingh. They tested five levels of nitrogen (0, 20, 40, 60 and 80 kg ha^{-1}) and two varieties of summer mungbean viz., Binamoog-2 and Kanti. The results revealed that nitrogen application had negative affect on the harvest index in both the varieties.

A field experiment was conducted by Manpree *et al.*, (2004) in Ludhiana. Punjab.India during summer 2000 to investigate the response of mungbean genotypes (SML 134 SML 357 and SML 668) to P application (0, 20, 40 and 60 kg $P_2O_5 ha^{-1}$) under irrigated conditions. The harvest index significantly compared to SML 668 and SML 357. Phosphorus application showed a non-significant effect on number of branches $plant^{-1}$, number of 9 $seedspod^{-1}$, pod length and 100-seed weight. However, the increase in P level showed significant increase in the number of pods per plant, which accounted for significantly higher grain and straw yields at higher levels (40 and 60 kg ha^{-1}) compared to lower levels (0 and 20 $kgha^{-1}$). Harvest index remained unaffected with P application. The economic optimum P level for all the 3 summer mungbean genotypes was found to be 46. 1 kg P_2O_5 ha^{-1}.

CHAPTER 3

MATERIALS AND METHODS

The experiment was conducted at the Sher-e-Bangla Agricultural University farm, Dhaka, during the period of March to June, 2014 in the kharif-1 season to study the efficacy of integrated nitrogen and irrigation managements on the yield attributes and yield of blackgram (cv. BARI mash-2). Materials used and methodologies followed in the present investigation have been described in this chapter.

3.1 Experimental site

The experiment is being conducted at the research field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 ($90^0$30’ E longitude and $23^0$77’ N latitude), during Kharif season (March-June) 2014. Total number of plot was 27.

3.2 Soil

The soil belongs to the Agro-Ecological Zone – Modhupur Tract (AEZ 28). The land topography is medium high and soil texture is silty clay with pH 5.6. The morphological, physical and chemical characteristics of the experimental soil have been presented in Appendix-I.

3.3 Climate

The climate of the experimental area was sub-tropical. The rainfall was heavy during Kharif season and low rainfall in Rabi season. The atmospheric temperatures were higher in Kharif season. The weather conditions during experimentation such as monthly total rainfall (mm), mean temperature (^{0}C), sunshine hours and humidity (%) are presented in Appendix II.

3.4Planting material

The variety of blackgram used for the present study was BARI mash-2. The required seeds for the experiment were collected from the pulse Research centre of Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. The seeds were healthy, well matured and free from mixture of other seeds, weed seeds and extraneous materials. Before sowing, the seeds were tested for germination in the laboratory and the percentage of germination was found to be over 90%. The important characteristic of this variety is mentioned below:

3.4.1 BARI mash-2

The plant height of this variety ranges from 40-45 cm. Leaves are dark green. The variety is resistant to *Cercospora* leaf spot and yellow mosaic virus. Maximum seed yield is 1.1-1.4 ton ha^{-1}. Seeds contain 23.9% protein and 46.8% carbohydrate.

3.5Land preparation

The land was irrigated and first opened with the tractor drawn disc plough. Ploughed soil was then brought into desirable fine tilth by 4 operations of ploughing, harrowing and laddering. The stubble and weeds were removed. The first ploughing and the final land preparation were done on 1 March and 8 March 2014, respectively. Experimental land was divided into unit plots following the design of experiment. The plots were spaded one day before planting and the basal dose of fertilizers was incorporated thoroughly.

3.6 Fertilizer application

Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MoP) were used as a source of nitrogen, phosphorous, and potassium respectively. Nitrogen and phosphorus was applied in the experiment as per treatment. MoP were applied as basaldose at the rate of 45 kg per hectare respectively following BARI recommendation. All K, P (as per treatment), half of N (as per treatment) were applied during final land preparation. Rest of nitrogenous fertilizer were applied as broadcast applying on 20 DAS.

3.7 Treatments of the experiment

A. Nitrogen level

1) N_0:0 kg N ha^{-1}

2) N_1:20 kg N ha^{-1}

3) N_2: 25 kg N ha^{-1}

B. Phosphorus level

1) P_0:0 kg Pha^{-1}

2) P_1:10 kg P ha^{-1}

3) P_2:20 kg P ha^{-1}

There were nine treatment combinations of nitrogen and phosphorus levels used in the experiment the treatment combinations are as follows:

N_0P_0, N_0P_1, N_0P_2, N_1P_0, N_1P_1, N_1P_2, N_2P_0, N_2P_1, N_2P_2.

3.8 Experimental design

The experiment was laid out in a Randomized complete block design with three replication (RCBD). Each replication had 9 unit plots in which the treatment combination were assigned at random. The size of each plot was 2.75m×2m ($5.5m^2$). The blocks and unit plots were separated by 1m and 1m, respectively. The intra block and plot spaces were used as irrigation and drainage channel.

3.9Sowing of seeds in the field

Seeds were sown on the furrow on 9th March, 2014 and the furrows were covered by soils soon after seeding. Seeds were treated with Bavistin before sowing the seeds to control the seed borne disease. The seeds were sown continuously in 30cm apart rows at about 2-3 cm depth in afternoon and covered with soil.

3.10 Germination of seeds

Seed germination occurred from 6th days after sowing. On the 7th day the percentage of germination was more than 85% and on the 9th day nearly all baby plants came out of the soil.

3.11 Intercultural operations

3.11.1 Thinning and weeding

Thinning and weeding were done at 20 days after sowing (DAS) when the plant attained at a height of about 10 cm. Plant to plant distance was maintained at 6-7 cm. Second weeding was done at 35 DAS when the plants attained about 15-20 cm height.

3.11.2 Gap filling

During seed sowing, few seeds were sown in the border of the plots. Seedlings were transferred to fill up the gap where seeds failed to germinate. Seedlings of about 5 cm height were transplanted from border rows with roots plunged 3 cm below the soil in the hills in the evening and watering was done to protect the seedling from wilting. All gaps were filled up within two weeks after germination of seeds.

3.11.3 Weeding

The experimental plots were kept weed free by hand weeding. Weeding was done three times as and when necessary and soil surface crusts were broken. It helped to increase soil moisture conservation.

3.11.4 Irrigation

Irrigation was done whenever necessary. The young plants were irrigated by watering can. Beside this, two irrigation was given at an interval of 4 days depending on soil moisture content.

3.11.5 Protection against insect and pest

At early stage of growth few worms (*Agrotis ipsilon*) and virus vectors (Jassid) attacked the young plants and at latter stage of growth pod borer (*Marucate stulalis*) attacked the plant. Dimacron 50EC was sprayed at the rate of 1litreha^{-1} to control this insects.

3.12 Crop sampling and data collection

Ten plants were selected randomly from each plot and were uprooted for data recording. The data of plant height, number of branches, number of flowers, and leaves per plant were recorded from sampled plants at an interval of fifteen days which was started from 30 DAS.

3.13 Harvest and post-harvest operations

Date of begin of harvest was done in 20th April, 2014. Harvesting was done when 90% of the pods became brown to black in color. The matured pods were collected by hand picking from a pre demarcated area of 1 m^2 at the center of each plot.

3.14Data collection

Data were collected on the following parameters:

- Plant height(cm) at 30 DAS,45 DAS and 60 DAS(Harvesting)
- Number of leaves per plant
- Days to 50% flowering
- Total no branches per plant
- Number of pod per plant
- Pod length(cm)
- Pod weight(gm)
- No. of seed per pod
- Dry matter weight per plant
- Fresh weight of 1000 seed(gm)
- Dry weight of 1000 seed(gm)
- Yield per plant(Fresh weight in gm)
- Yield per plant(Dry weight in gm)
- Harvest index (%)

3.15 Procedure of recording data

3.15.1 Plant height (cm)

The height of the selected plant was measured from the ground level to the top of the plants and the mean height was expressed in cm.

3.15.2 Number of leaves per plant

The leaves (trifoliate) were counted from ten sample plants. The average number of leaves per plant was determined.

3.15.3 Number of branches per plant

The branches were counted from ten plants. The average number of branches per plant was determined.

3.15.4 Stem dry weight

Ten plants were randomly selected from each treatment. Whole plants were dried in oven for 72 hours dry was taken carefully. This procedure was done from 25 DAS to 85 DAS at 15 days interval

3.15.5 Number of pods per plant

The number of pod from ten randomly selected plants from each plot was determined at the time of harvest to find out the number of pods per plant.

3.15.6 Number of seeds per pods

Ten pods were taken randomly from each treatment and the seeds were separated and counted. Then the average seed number per pod was calculated.

3.15.7 Weight of 1000-seed (g)

1000-seed were counted from each plot and weight was taken on an electrical balance and data were recorded.

3.15.8 Seed yield (t ha^{-1})

Plants of selected 0.9m2 from each plot were harvested at complete maturity. The seeds of each pod were separated from the plants manually and were dried in the sun to a constant weight. Seed weight was recorded plot wise and yields were then converted to t ha^{-1} basis.

3.15.9 Harvest index (%)

Harvest index was calculated with the following formula.

$$\text{Harvest Index (\%)} = \frac{\text{Grain Yield (t}ha^{-1}\text{)}}{\text{Biological Yield (t}ha^{-1}\text{)}} \times 100$$

3.16 Analysis of data

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program MSTAT-C. The means were separated following least significance deference (LSD) test at 0.05 level of significance.

CHAPTER 4

RESULTS AND DISCUSSION

The depiction of experimental results along with discussion in response of BARI mash-2 to effects of nitrogen and phosphorus on the plant height, number of leaves, number of branches, dry weight, yield contributing parameters and yield parameters were shown in Table 1 to 6.

4.1 Effect of Nitrogen and Phosphorus on plant height of BARI mash-2

Effect of nitrogen

Plant height of BARImash-2 was significantly influenced by different treatments of nitrogen at all the stages (Table 1). The effect of N_0, N_1 and N_2 for 30 DAS of plant height were 17.14, 20.44 and 23.56 cm respectively. The maximum plant height for 30 DAS was found (23.56 cm) in treatment N_2. Similarly, the plant heights for 45 DAS were 27.60, 32.93 and 35.73 cm respectively. The maximum plant height in this stage was 35.73 cm in treatment N_2. Moreover, the plant heights at harvest period were 39.56, 46.00 and 51.13 cm respectively. At harvest period the maximum plant height (51.13 cm) was attained in the treatment N_2.

Results also revealed that the lowest plant height (17.14, 27.60 and 39.56 cm at 30 DAS, 45 DAS and at harvest respectively) was found from N_o (0 kg N ha^{-1}). Higher nitrogen application to the soil favored in increasing vegetative growth of crop which resulted in increasing plant height appreciably. Similar result was found by Saini and Thakur (1996) stated that nitrogen at 30 and 40 kg ha^{-1} significantly increased the plant height of blackgram compared with no N.

Effect of phosphorus

Plant height of BARI mash-2 influenced significant by the application of different levels of phosphorus (Table 1). Plant height of the BARI mash-2 varied with the variation of treatment. The plant heights at 30 DAS, 45 DAS and harvest period ranged from 18.68 to 22.10, 30.11 to 33.63 and 43.05 to 47.91 cm respectively. The maximum plant height for 30 DAS (22.10 cm) was found in treatment P_2, at 45 DAS was33.63 cm and harvest period was 47.91 cm in treatment P_2 respectively. Application of phosphorus resulted significant increases of plant height. Malik *et al.,* (2006) reported that phosphorus application at 40 kg P_2O_5 ha^{-1} affected the crop positively.

Combined effect of nitrogen and phosphorus

The highest plant height (25.58 cm) was recorded under the treatment combination of N_2P_2 after 30 days of sowing. The lowest plant height 16.35 cm was found from the treatment applied with no fertilizer in this stage. The above findings indicate that chemical fertilizer N and P are dominating factor influence the pant height. Similar result was found by Yein *et al.,* (1981) conducted a field experiment on nitrogen in combination with phosphorus fertilizer to blackgram. They revealed that application of 40 kg N ha^{-1} increased plant height. Similarly, the highest plant height (38.08 cm) was recorded under the treatment combination of N_2P_2 after 45 days of sowing applied with 25 kg of N and 20 kg of P ha^{-1}. The lowest plant height 26.77 cm was found from the treatment applied with no fertilizer in this stage. In a similar way, the effects of Nitrogen and Phosphorus on the height of BARI mash-2 were found to be positive and significant in case of all stages of plant cycle (Table 1). Most of the treatments recorded significantly higher plant height of the experiment. The highest plant height (53.57 cm) was recorded under the treatment combination of N_2P_2 at harvesting period where applied 25 kg of N combined with 20 kg of P ha^{-1}. The lowest plant height 38.05 cm was found from the control treatment applied with no fertilizer in this stage.

Table 1.Effect of N and P on plant height of BARI mash-2

Treatments	Plant height (cm)		
	30 DAS	**45 DAS**	**At harvest**
Effect of nitrogen			
N_o	17.14 c	27.60 c	39.56 c
N_1	20.44 b	32.93 b	46.00 b
N_2	23.56 a	35.73 a	51.13 a
$LSD_{0.05}$	0.6046	0.9438	1.105
Effect of phosphorus			
P_0	18.68 c	30.11 c	43.05 c
P_1	20.36 b	32.52 b	45.73 b
P_2	22.10 a	33.63 a	47.91 a
$LSD_{0.05}$	0.6004	0.9412	1.101
Combined effect of nitrogen and phosphorus			
N_oP_0	16.35 h	26.77 e	38.05 g
N_oP_1	17.19 gh	27.82 e	39.95 fg
N_oP_2	17.88 fg	28.20 e	40.67 f
N_1P_0	18.68 f	30.47 d	42.71 e
N_1P_1	19.79 e	33.72 c	45.81 d
N_1P_2	22.85 c	34.59 bc	49.50 c
N_2P_0	21.00 d	33.09 c	48.39 c
N_2P_1	24.09 b	36.01 b	51.43 b
N_2P_2	25.58 a	38.08 a	53.57 a
$LSD_{0.05}$	1.050	1.608	1.909
CV (%)	7.59	6.34	8.29

N_o = 0 kg N ha^{-1}
N_1 = 20 kg N ha^{-1}
N_2 = 25 kgN ha^{-1}

P_o = 0 kg P ha^{-1}
P_1 = 10 kg P ha^{-1}
P_2 = 20 kg P ha^{-1}

4.2 Effect of Nitrogen and Phosphorus on number of leaves plant^{-1} of BARI mash-2

Effect of nitrogen

The effect of nitrogen on number of leaves plant^{-1} of BARI mash-2 plant was found to be positive and significant (Table 2). Most of the treatments recorded significantly number of plant leaves over control. The average number of leaves plant^{-1}for three stages of plant cycle as 30 DAS, 45 DAS and harvest period ranged from 10.50 to 16.61, 28.17 to 36.50 and 44.78 to 63.44 respectively. The maximum number of average leaves plant^{-1} for 30 DAS (16.31), 45 DAS (36.50) and harvest period (63.44) were attained in the treatment N_2. Srivastava and Verma (1982) showed that N application at the rate of 15kg ha^{-1} increased the number of green leaves in green gram plants.

Effect of phosphorus

Number of leaves plant^{-1}of BARI mash-2 influenced significantly by the application of different levels of phosphorus (Table 2). The average number of leaves plant^{-1} for three stages of plant cycle as 30 DAS, 45 DAS and harvest period ranged from 12.50 to 15.22, 29.78 to 34.39 and 50.22 to 59.56 respectively. The maximum number of average leaves plant^{-1} for 30 DAS (15.22), 45 DAS (34.39) and harvest period (59.56) were found in the treatment P_2. Similar result was found by Bhat *et al.*, (2005) observed 60 kg P ha^{-1} significantly improved the yield attributes compared to the control.

Combined effect of nitrogen and phosphorus

The combined effects of N and P on number of leaves plant^{-1}of BARI mash-2 were found to be positive and significant at different growth stages (Table 2). Most of the treatment recorded significant number of leaves plant^{-1}. The highest average number of leaves plant^{-1} (67.33) was recorded under the treatment combination of N_2P_2 at harvest period where applied 25 kg of N combined with 20 kg of P ha^{-1}. The lowest average number of leaves $plant^{-1}$ 41.00 was found from the control treatment applied with no fertilizer in this stage. Similarly, the highest average number of leaves $plant^{-1}$ (38.33) was recorded under the treatment combination of N_2P_2 after 45 days of sowing applied with 25 kg of N and 20 kg of Pha^{-1}. The lowest average number of leaves $plant^{-1}$(25.33) was found from the treatment applied with no fertilizer in this stage. In a similar way, the highest average number of leaves $plant^{-1}$ (18.50) was recorded under the treatment combination of N_2P_2 after 30 days of sowing. The lowest average number of leaves $plant^{-1}$9.50 was found from the treatment applied with no fertilizer in this stage. The above findings indicate that chemical fertilizer N and P are dominating factor influence the number of leaves $plant^{-1}$.

Table 2. Effect of N and P on number of leaves plant^{-1} of BARI mash-2

Treatments	**Number of leaves plant^{-1}**		
	30 DAS	**45 DAS**	**At harvest**
Effect of nitrogen			
N_o	10.50 c	28.17 c	44.78 c
N_1	14.50 b	32.33 b	56.78 b
N_2	16.61 a	36.50 a	63.44 a
$LSD_{0.05}$	0.7158	2.046	2.649
Effect of phosphorus			
P_0	12.50 c	29.78 c	50.22 c
P_1	13.89 b	32.83 b	55.22 b
P_2	15.22 a	34.39 a	59.56 a
$LSD_{0.05}$	0.7158	1.452	2.648
Combined effect of nitrogen and phosphorus			
N_oP_0	9.50 f	25.33 e	41.00 f
N_oP_1	10.50 ef	29.17 d	45.00 ef
N_oP_2	11.50 e	30.01 cd	48.33 de
N_1P_0	13.17 d	28.83 de	52.33 cd
N_1P_1	14.67 c	33.33 bc	55.00 bc
N_1P_2	15.67 bc	34.83 ab	63.00 a
N_2P_0	14.83 c	35.17 ab	57.33 b
N_2P_1	16.50 b	36.00 ab	65.67 a
N_2P_2	18.50 a	38.33 a	67.33 a
$LSD_{0.05}$	1.255	3.518	4.587
CV (%)	7.58	10.28	9.37

N_o = 0 kg N ha^{-1}
N_1 = 20 kg N ha^{-1}
N_2 = 25 kg N ha^{-1}

P_o = 0 kg P ha^{-1}
P_1 = 10 kg P ha^{-1}
P_2 = 20 kg P ha^{-1}

4.3 Effect of Nitrogen and Phosphorus on number of branches plant^{-1} of BARI mash-2

Effect of nitrogen

The effect of nitrogen on number of branches plant^{-1} of BARI mash-2 plant was found to be significant in all the stages (Table 3). Most of the treatments recorded significantly number of branches. The average number of branches plant^{-1}for three stages of plant cycle as 30 DAS, 45 DAS and harvest period ranged from 2.46 to 3.80, 3.10 to 6.17 and 7.13 to 9.67 respectively. The maximum number of average branches plant^{-1} for 30 DAS (3.80), 45 DAS (6.17) and harvest period (9.67) were attained in the treatment N_2.

Effect of phosphorus

The effects of phosphorus on the number of branches plant^{-1} of BARI mash-2 was found to be positive and significant in all the stages (Table 3). The average number of branches plant^{-1} for three stages of plant cycle as 30 DAS, 45 DAS and harvest period ranged from 2.69 to 3.48, 3.82 to 5.19 and 7.72 to 9.23 respectively. The maximum number of average branches plant^{-1} for 30 DAS (3.48), 45 DAS (5.19) and harvest period (9.23) were found in the treatment P_2.

Combined effect of nitrogen and phosphorus

The combined effects of N and P on number of branches plant^{-1} of BARI mash-2 were found to be positive and significant at different growth stages (Table 3). Most of the treatment recorded significant number of branches plant^{-1}. The highest average number of branches plant^{-1} (10.58) was recorded under the treatment combination of N_2P_2 at harvest period where applied 25 kg of N combined with 20 kg of P ha^{-1}. The lowest average number of branches plant^{-1} 6.00 was found from the treatment applied with no fertilizer in this stage. Similarly, the highest average number of branches plant^{-1} (6.82) was recorded under the treatment combination of N_2P_2 after 45 days of sowing applied with 25 kg of N and 20 kg of P ha^{-1}. The lowest average number of branches $plant^{-1}$ 3.05 was found from the treatment applied with no fertilizer in this stage. In a similar way, the highest average number of branches $plant^{-1}$ (4.21) was recorded under the treatment combination of N_2P_2 after 30 days of sowing. The lowest average number of branches $plant^{-1}$ 2.29 was found from the treatment applied with no fertilizer in this stage. The above findings indicate that chemical fertilizer N and P are also dominating factor influence the number of branches $plant^{-1}$.

Table 3. Effect of Nitrogen and Phosphorus on number of branches plant^{-1} of BARI mash-2

Treatments	Number of branches plant^{-1}		
	30 DAS	**45 DAS**	**At harvest**
Effect of nitrogen			
N_o	2.45 c	3.10 c	7.13 c
N_1	2.99 b	4.40 b	8.68 b
N_2	3.79 a	6.17 a	9.63 a
$LSD_{0.05}$	0.1788	0.2965	0.3269
Effect of phosphorus			
P_0	2.69 b	3.82 c	7.72 b
P_1	3.08 ab	4.67 b	8.53 ab
P_2	3.47 a	5.18 a	9.23 a
$LSD_{0.05}$	0.6079	0.2844	0.8379
Combined effect of nitrogen and phosphorus			
N_oP_0	2.29 e	3.04 e	6.00 g
N_oP_1	2.61 de	3.10 e	7.50 f
N_oP_2	2.46 de	3.14 e	7.90 ef
N_1P_0	2.53 de	3.45 e	8.33 de
N_1P_1	2.71 d	4.17 d	8.53 d
N_1P_2	3.75 b	5.59 b	9.20 bc
N_2P_0	3.25 c	4.95 c	8.83 cd
N_2P_1	3.93 ab	6.75 a	9.57 b
N_2P_2	4.21 a	6.81 a	10.58 a
$LSD_{0.05}$	0.3144	0.4772	0.5528
CV (%)	8.37	5.26	7.92

N_o = 0 kg N ha^{-1}
N_1 = 20 kg N ha^{-1}
N_2 = 25 kg N ha^{-1}

P_o = 0 kg P ha^{-1}
P_1 = 10 kg P ha^{-1}
P_2 = 20 kg P ha^{-1}

4.4 Effect of Nitrogen and Phosphorus on dry weight plant^{-1} of BARI mash-2

Effect of nitrogen

The effect of nitrogen on dry weight plant^{-1} of BARI mash-2 was found to be significant in all the stages (Table 4). Most of the treatments recorded significantly related to dry weight plant^{-1}. The dry weight plant^{-1} for three stages as 30 DAS, 45 DAS and harvest period ranged from 2.56 to 3.25, 10.90 to 12.26 and 17.78 to 19.89 gram respectively. The maximum weight plant^{-1} for 30 DAS (3.25gm), 45 DAS (12.26gm) and harvest period (19.89gm) were attained in the treatment N_2.

Effect of phosphorus

The effects of phosphorus on the dry weight plant^{-1} of BARI mash-2 was found to be positive and significant in all the stages (Table 3). The dry weight plant^{-1} for three stages as 30 DAS, 45 DAS and harvest period ranged from 3.07 to 3.53, 10.53 to 13.26 and 17.43 to 21.46gm respectively. The maximum dry weight plant^{-1} for 30 DAS (3.53gm), 45 DAS (13.26gm) and harvest period (21.46gm) were found in the treatment P_2.

Combined effect of nitrogen and phosphorus

The combined effects of N and P on dry weight plant^{-1} of BARI mash-2 were found to be positive and significant at different growth stages (Table 4). Most of the treatment recorded significantly related to dry weight plant^{-1}. The highest dry weight plant^{-1} (21.70) was recorded under the treatment combination of N_2P_2 at harvest period where applied 25 kg of N combined with 20 kg of P ha^{-1}. The lowest dry weight plant^{-1} 6.00 was found from the treatment applied with no fertilizer in this stage. Similarly, the highest dry weight plant^{-1} (13.17gm) was recorded under the treatment combination of N_2P_2 after 45 days of sowing applied with 25 kg of N and 20 kg of P ha^{-1}. The lowest dry weight $plant^{-1}$ 8.49 was found from the treatment applied with no fertilizer in this stage. In a similar way, the highest dry weight $plant^{-1}$ (3.68gm) was recorded under the treatment combination of N_2P_2 after 30 days of sowing. The lowest dry weight $plant^{-1}$ (1.91gm) was found from the treatment applied with no fertilizer in this stage. The above findings indicate that chemical fertilizer N and P are also dominating factor influence the number of branches $plant^{-1}$.

Table 4. Effect of N and P on dry weight plant^{-1} of BARI mash-2

Treatments	Dry Weight Plant^{-1} (gm)		
	30 DAS	45 DAS	At harvest
Effect of nitrogen			
N_o	2.56 b	10.90 c	17.78 c
N_1	3.91 a	13.11 a	21.16 a
N_2	3.25 ab	12.26 b	19.89 b
$LSD_{0.05}$	0.9993	0.09993	0.3547
Effect of phosphorus			
P_0	3.06 c	10.53 c	17.43 c
P_1	3.13 b	12.48 b	19.94 b
P_2	3.53 a	13.26 a	21.46 a
$LSD_{0.05}$	0.05288	0.1303	0.3547
Combined effect of nitrogen and phosphorus			
N_oP_0	1.90 d	8.487 h	15.50 g
N_oP_1	2.69 c	11.85 f	18.47 e
N_oP_2	3.09 bc	12.36 d	19.35 d
N_1P_0	3.47 a	12.11 e	18.98 de
N_1P_1	3.45 bc	12.98 b	21.16 b
N_1P_2	3.31 ab	12.25 b	20.34 b
N_2P_0	2.83 c	11.00 g	17.81 f
N_2P_1	3.24 bc	12.61 c	20.18 c
N_2P_2	3.68 ab	13.17 a	21.70 a
$LSD_{0.05}$	0.7624	0.1974	0.6193
CV (%)	7.53	9.24	5.39

N_o = 0 kg N ha^{-1} P_o = 0 kg P ha^{-1}
N_1 = 20 kg N ha^{-1} P_1 = 10 kg P ha^{-1}
N_2 = 25 kg N ha^{-1} P_2 = 20 kg P ha^{-1}

4.5 Effect of Nitrogen and Phosphorus on yield contributing parameters of BARI mash-2

4.5.1 Days to 1st flowering

Effect of nitrogen

Nitrogen had significant effect on the days to 1st flowering of BARI mash-2 (Table 5). It was observed that the days to 1st flowering of plant was extended with the increase of nitrogen doges. The maximum average days to 1st flowering of plant required 32.44 days with applied of 25 kg N ha^{-1} and the lowest 28.67 days estimated of 1st flowering with no fertilizer (N_0 kg). Similar result was found by Vidhate, and Jana, P. K. (1986) explored the response of blackgram to nitrogen fertilization.

Effect of phosphorus

The effect of phosphorus on the days to 1st flowering of BARI mash-2 was significantly related (Table 5). It was observed that the days to 1st flowering of plant was decreased with the increase of phosphorus doses. The maximum average days to 1st flowering of plant required 31.44 days with no phosphorus fertilizer (P_0 kg ha^{-1}) and the lowest 29.89 days estimated of 1st flowering with applied of 20 kg P ha^{-1}.

Interaction effect of nitrogen and phosphorus

The effects of N and P on the days of 1st flowering of BARI mash-2 were found on to be positive and significant of flowering stage (Table 5). The lowest days were observed of flowering in the treatment N_0P_2. Moreover, the highest days were observed of flowering in the treatment N_2P_2 with applied of only 25 kg nitrogen and phosphate 20 kg per hector.

4.5.2 Number of pods plant^{-1}

Effect of nitrogen

Nitrogen had significant effect on the number of pods per plant (Table 5). The number of pods per plant ranged from 59.59 to 69.15. The highest number of pods per plant (70.77) was recorded in N_1 treatment (20 kg N ha^{-1}). The lowest number of pods per plant (59.59) was found in the treatment (0 kg N ha^{-1}).In a field experiment conducted by Satyanarayanamma *et al.,* (1996), five mungbean cultivars were sprayed with 2% urea at pre-flowering, flowering, pod development or at all the combinations or at combination of two of three growth stages.

Effect of phosphorus

The number of pods per plant was significantly influenced by different levels of phosphorus (Table 5). The number of pods per plant ranged from 58.02 to 71.64. The highest number of pods per plant (71.64) was recorded in P_2 treatment of 25 kg (P ha^{-1}). The lowest number of pods per plant (58.02) was found in the treatment (0 kg P ha^{-1}).

Combined effect of nitrogen and phosphorus

There was a significant variation in the number of pods per plant with the different treatments of nitrogen and phosphorus (Table 5). Plant receiving N @ 20 kg ha^{-1} along with 20 kg P ha^{-1} produced the highest number of pods per plant (85.41). This treatment was followed by 74.94 pods per plant from the combined treatment of N @ 25 kg ha^{-1} and P @ 10 kg ha^{-1}. The lowest number of pods per plant 51.58 found in the combined effect of N_0P_0. The contribution of N and P on increasing the pod number was remarkable. Results indicated that additional N created expected vegetative growth and as well as formation of edible pods.

4.5.3 Number of pod length

Effect of nitrogen

The effect of different levels of N on the length of pod was significant (Table 5). The length of pods ranged from 4.51 to 5.49 cm. The highest pod length (5.49 cm) was recorded in the treatment of 20 kg N ha^{-1}. The lowest pod length (4.51 cm) was found in the treatment (0 kg N ha^{-1}). Similar results were also reported by Naik *et al.*, (1989) recorded highest pod length with higher N rate.

Effect of phosphorus

The effect of different levels of P on the length of pod was significant (Table 5). The length of pods ranged from 4.21 to 5.84 cm. The highest pod length (5.84 cm) was recorded in the treatment of 20 kg P ha^{-1}. The lowest pod length (4.21 cm) was found in the treatment (0 kg P ha^{-1}).

Combined effect of nitrogen and phosphorus

There was a significant variation in the length of pod per plant with the different treatments of nitrogen and phosphorus (Table 5). Plant receiving N @ 20 kg ha^{-1} along with 20 kg P ha^{-1} produced the highest length of pod per plant (6.34 cm). This treatment was followed by 5.89 cm pod length from the combined treatment of N @ 25 kg ha^{-1} and P @ 20 kg ha^{-1}. The lowest length of pod (3.83 cm) found in the combined treatment of N_0P_0. The contribution of N and P on increasing the pod length was remarkable.

4.5.4 Number of seed per pod

Effect of nitrogen

Nitrogen had highly significant effect on the number of seed per pod (Table 5). The number of seed per pod ranged from 5.75 to 6.80. The highest number of seed per pod (6.80) was recorded in the treatment of 20 kg N h^{-1}. The lowest number of seed per pod (5.75) was found in the treatment (0 kg N ha^{-1}).

Effect of phosphorus

The number of seed per pod was significantly influenced by different levels of phosphorus (Table 5). The number of seed per pod ranged from 5.92 to 6.71. The highest number of seed per pod (6.71) was recorded in the treatment of 20 kg P ha^{-1}. The lowest number of seed per pod (5.92) was found in the treatment (10 kg P ha^{-1}).

Combined effect of nitrogen and phosphorus

There was a significant variation in the number of seed per pod with the different treatments of nitrogen and phosphorus (Table 5). Plant receiving N @ 20 kg ha^{-1} along with 20 kg P ha^{-1} produced the highest number of seed per pod (7.91). This treatment was followed by 7.10 seed per pod from the combined treatment of N @ 25 kg ha^{-1} and P @ 0 kg ha^{-1}. The lowest number of seed per pod 5.07 found in the combined treatment of N_0P_0. The contribution of N and P on increasing the seed per pod was remarkable. Results indicated that N addition favored vegetative growth and as well as formation of edible pods.

4.5.6 Weight of 1000 seed

Effect of nitrogen

The effects of nitrogen were significant on 1000-seed weight of BARI mash-2 (Table 5). Due to the different levels of nitrogen varied the weight of BARI mash-2 seed varied significantly. Ranges of 1000-seed weight of BARI mash-2 were 38.71 to 43.27 g. The highest weight of 1000-seed (43.27 g) was found in the treatment of 20 kg N ha^{-1} and the lowest weight of 1000-seed (38.71 g) were found in the treatment of 0 kg N ha^{-1}.

Effect of phosphorus

The effects of phosphorus were significant on 1000-seed weight of BARI mash-2 (Table 5). Due to the different levels of phosphorus varied the weight of BARI mash-2 seed varied significantly. Ranges of 1000-seed weight of BARI mash-2 were 40.05 to 42.27 g. The highest weight of 1000-seed (42.27 g) were found in the treatment of 20 kg P ha^{-1} and the lowest weight of 1000-seed (40.05 g) were found in the treatment of 0 kg P ha^{-1}.

Interaction effect of nitrogen and phosphorus

The combined effect of different levels of N and P on 1000-seed weight was significant at both stages. Different levels of nitrogen in association with different levels of phosphorus increased 1000-seed weight (Table 5). Treatment combinations of N @ 20 kg ha^{-1} combined with P @ 20 kg ha^{-1} produced highest 1000-seed weight (45.04 g). This treatment was followed by 1000-seed weight 43.58 g from the combined treatment of N @ 20 kg ha^{-1} and P @ 10 kg ha^{-1}. The lowest 1000-seed weight (36.44g) was found in the combined treatment of N_0P_0. The contribution of N and P on increasing the 1000-seed weight was remarkable.

Table 5. Effect of Nitrogen and Phosphorus on yield contributing parameters of BARI mash-2

Treatments	Days to first flowering	Number of podsplant^{-1}	Pod length (cm)	Number of seeds pod^{-1}	Weight of 1000 seeds (g)
Effect of nitrogen					
N_o	28.67 c	59.59 b	4.51 c	5.75 c	38.71 b
N_1	31.00 b	70.77 a	5.49 a	6.80 a	43.27 a
N_2	32.44 a	69.15 a	5.23 b	6.56 b	42.15 ab
$LSD_{0.05}$	0.58	6.05	0.14	0.12	3.46
Effect of phosphorus					
P_0	31.44 a	58.02 b	4.21 c	6.49 b	40.05 c
P_1	30.78 b	69.86 a	5.16 b	5.92 c	41.80 b
P_2	29.89 c	71.64 a	5.84 a	6.71 a	42.27 a
$LSD_{0.05}$	0.58	5.93	0.49	0.13	0.4084
Combined effect of nitrogen and phosphorus					
N_oP_0	28.67 f	51.58 h	3.83 g	5.07 h	36.44 f
N_oP_1	29.00 ef	61.61f	4.39 ef	5.92 fg	41.22 d
N_oP_2	28.33 f	65.59 de	5.30 d	6.27 de	38.46 e
N_1P_0	30.33 ab	64.61 ef	4.64 e	6.48 d	41.17 d
N_1P_1	30.67 cd	67.89 cd	5.45 cd	6.10 ef	43.58 b
N_1P_2	30.67 ab	85.41 a	6.34 a	7.91 a	45.04 a
N_2P_0	30.00 a	57.86 g	4.15 f	7.10 b	40.53 d
N_2P_1	30.42 a	64.94 b	5.64 bc	5.73 g	42.01 c
N_2P_2	30.34 bc	69.04 c	5.88 b	6.75 c	43.90 b
$LSD_{0.05}$	1.023	3.07	0.2844	0.2386	0.7095
CV (%)	6.752	9.327	11.293	12.489	8.262

N_o = 0 kg N ha^{-1}
N_1 = 20 kg N ha^{-1}
N_2 = 25 kg N ha^{-1}

P_o = 0 kg P ha^{-1}
P_1 = 10 kg P ha^{-1}
P_2 = 20 kg P ha^{-1}

4.6 Effect of Nitrogen and Phosphorus on yield parameters of BARI mash-2

Effect of nitrogen

The seed yield per hectare was significantly influenced by different levels of nitrogen (Table 6). The highest seed yield (1.48 t ha^{-1}) was obtained in 20 kg N ha^{-1} and lowest (1.18 t ha^{-1}). From these results it was found that mainly nitrogenous fertilizer increased vegetative growth as well as seed yield. The highest harvest index (40.94%) was found in the treatment of 20 kg N ha^{-1} and the lowest harvest index (34.55%) was found in the treatment of 0 kg N ha^{-1}.

Effect of phosphorus

The seed yield per hectare was significantly influenced by different levels of phosphorus (Table 6). The highest seed yield (1.49 t ha^{-1}) was obtained in 20 kg P ha^{-1} and lowest yield was 1.13 t ha^{-1} in 0 kg P ha^{-1}. Increasing levels of phosphorus increased the seed yield of garden pea gradually. The highest harvest index (41.52%) was found in the treatment of 20 kg P ha^{-1} and the lowest harvest index (33.42%) was found in the treatment of 0 kg P ha^{-1}.

Effect of nitrogen and phosphorus

The combined effect of N and P on seed yield of BARI mash-2 was significant. Seed yield of BARI mash-2 varied significantly with the variation of different treatment combinations (Table 6). Seed yield of BARI mash-2 was significantly influenced due to N and P fertilizer application. The effect of N @ 20 kg ha^{-1} with same doses of P on seed yield was statistically highest and superior to other treatments (1.70 t ha^{-1}). The treatment combination N @ 20 kg ha^{-1} and P @ 20 kg ha^{-1} produced the maximum seed yield where the lowest (0.96 t ha^{-1}) was found from N_0P_0. The highest harvest index (44.38%) was found in the treatment of 20 kg P ha^{-1} and the lowest harvest index (30.26%) was found in the treatment of 0 kg P ha^{-1}.

Table 6. Effect of N and P on yield parameters of BARI mash-2

Treatments	Yield (ton ha^{-1})	Harvest Index (%)
Effect of nitrogen		
N_o	1.18 c	34.55 c
N_1	1.48 a	40.94 a
N_2	1.35 b	38.86 b
$LSD_{0.05}$	0.1264	0.4666
Effect of phosphorus		
P_0	1.13 c	33.42 c
P_1	1.39 b	39.42 b
P_2	1.49 a	41.52 a
$LSD_{0.05}$	0.1139	0.4612
Combined effect of nitrogen and phosphorus		
N_oP_0	0.96 g	30.26 h
N_oP_1	1.27 e	35.34 f
N_oP_2	1.31 d	38.06 d
N_1P_0	1.29 de	36.48 e
N_1P_1	1.48 b	41.95 b
N_1P_2	1.70 a	44.38 a
N_2P_0	1.14 f	33.52 g
N_2P_1	1.42 c	40.97 c
N_2P_2	1.50 b	42.11 b
$LSD_{0.05}$	0.2386	0.8174
CV (%)	9.38	9.27

N_o = 0 kg N ha^{-1}
N_1 = 20 kg N ha^{-1}
N_2 = 25 kg N ha^{-1}

P_o = 0 kg P ha^{-1}
P_1 = 10 kg P ha^{-1}
P_2 = 20 kg P ha^{-1}

CHAPTER 5

SUMMARY AND CONCLUSION

A field experiment was conducted at the research farm of Sher-e-Bangla Agricultural University, Dhaka, during March 2014 to June 2014 to study the effects of different levels of nitrogen and phosphorus on the growth and yield of BARI mash-2. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications.Nitrogen and phosphorus fertilization at different levels individually influenced plant characters.

Nitrogen had significant effect on growth and yield parameters.The maximum plant height (23.56, 35.73 and 51.43 cm at 30, 45 DAS and at harvest respectively), highest number of leaves plant^{-1} (16.61, 36.50 and 63.44 at 30, 45 DAS and at harvest respectively) and highest number of branches plant^{-1} (3.79, 6.17 and 9.63 at 30, 45 DAS and at harvest respectively) were found from N_2 (25 kg N ha^{-1}). But the highest dry weight plant^{-1} (3.91, 13.11 and 21.16 g at 30, 45 DAS and at harvest respectively) was found from N_1 (20 kg N ha^{-1}).The lowest plant height (17.14, 27.60 and 39.56 cm at 30, 45 DAS and at harvest respectively),lowest number of leaves plant^{-1} (10.50, 28.17 and 44.78 at 30, 45 DAS and at harvest respectively), lowest number of branches plant^{-1} (2.45, 3.10 and 7.13 at 30, 45 DAS and at harvest respectively) and lowestdry weight plant^{-1} (2.56, 10.90 and 17.78 g at 30, 45 DAS and at harvest respectively) were found from N_0 (0 kg N ha^{-1}).The maximum days to 1st flowering (32.44) required from the N_2 (25 kg Nha^{-1}) where the lowest (28.67) was from N_0(0 kg N ha^{-1}). The highest number of pods plant^{-1} (70.77), pod length (5.49 cm), number of seeds pod^{-1} (6.80), 1000 seed weight (43.27 g), grain yield (1.48 t ha^{-1}) and harvest index (40.94%) were found from N_1 (20 kg N ha^{-1})where the lowest number of pods plant^{-1} (59.59), pod length (4.51 cm), number of seeds pod^{-1} (5.75), 1000 seed weight (38.71 g), grain yield (1.18 t ha^{-1}) and harvest index (34.55%) were found fromN_0 (0 kg N ha^{-1}).

Again, P had also significant effect on growthand yield parameters. The maximum days to 1st flowering (31.44) required from the P_0 (0 kg P ha^{-1}) where the lowest (29.89) was from P_2 (20 kg P ha^{-1}). The maximum plant height (23.56, 35.73 and 51.43 cm at 30, 45 DAS and at harvest respectively),highest number of leaves $plant^{-1}$ (15.22, 34.39 and 59.56 at 30, 45 DAS and at harvest respectively), highest number of branches $plant^{-1}$ (3.47, 5.18 and 9.23 at 30, 45 DAS and at harvest respectively), highest dry weight $plant^{-1}$ (3.53, 13.26 and 21.46 g at 30, 45 DAS and at harvest respectively),highest number of pods $plant^{-1}$ (71.64), pod length (5.84 cm), number of seeds pod^{-1} (6.71), 1000 seed weight (42.27 g), grain yield (1.49 t ha^{-1}) and harvest index (41.51%) were found from P_2 (20 kg P ha^{-1}) where the lowest plant height (17.14, 27.60 and 39.56 cm at 30, 45 DAS and at harvest respectively), lowest number of leaves $plant^{-1}$ (12.50, 29.78 and 50.22 at 30, 45 DAS and at harvest respectively), lowest number of branches $plant^{-1}$ (2.69, 3.82 and 7.72 at 30, 45 DAS and at harvest respectively),lowest dry weight $plant^{-1}$ (3.06, 10.53 and 17.43 g at 30, 45 DAS and at harvest respectively), lowest number of pods $plant^{-1}$ (58.02), pod length (4.21 cm), number of seeds pod^{-1} (6.49), 1000 seed weight (40.05 g), grain yield (1.13 t ha^{-1}) and harvest index (33.42%) were found from P_0 (0 kg P ha^{-1}).

Combined effect of N and P had also significant effect on growth and yield parameters. The maximum plant height (25.58, 38.08 and 53.57 cm at 30, 45 DAS and at harvest respectively), highest number of leaves $plant^{-1}$ (18.50, 38.33 and 67.33 at 30, 45 DAS and at harvest respectively) and highest number of branches $plant^{-1}$ (4.21, 6.81 and 10.58 at 30, 45 DAS and at harvest respectively) were found from N_2P_2 (20 kg P ha^{-1}) where the minimum plant height (16.35, 26.77 and 38.05 cm at 30, 45 DAS and at harvest respectively), lowest number of leaves $plant^{-1}$ (9.50, 25.33 and 41.00 at 30, 45 DAS and at harvest respectively) and lowest number of branches $plant^{-1}$ (2.29, 3.04 and 6.00 at 30, 45 DAS and at harvest respectively) were found from N_0P_0 (0 kg P ha^{-1}).The maximum dry weight $plant^{-1}$at harvest (21.70 g) was found from N_2P_2 where the minimum dry weight $plant^{-1}$ at harvest (15.50 g) was recorded from

N_0P_0. The maximum days to 1st flowering (30.67) required from the treatment combination of N_2P_1 where the lowest (28.67) was from N_0P_0.Moreover, the highest number of pods plant^{-1} (85.41), pod length (6.34 cm), number of seeds pod^{-1} (7.91), 1000 seed weight (45.04 g), grain yield (1.70 t ha^{-1}) and harvest index (44.38%) were found from $N_1P_2$where the lowest number of pods plant^{-1} (51.58), pod length (3.83 cm), number of seeds pod^{-1} (5.07), 1000 seed weight (36.44 g), grain yield (0.96 t ha^{-1}) and harvest index (30.26%) were found from N_0P_0.

Seed yield of BARI mash-2 was significantly influenced due to N and P fertilizer application. The effect of N @ 20 kg ha^{-1} with same doses of P on seed yield was statistically highest and superior to other treatments (1.70 t ha^{-1}). The treatment combination N @ 20 kg ha^{-1} and P @ 20 kg ha^{-1} (N_1P_2) produced the maximum seed yield with highest harvest index.

Bangladesh has made significant improvement in agriculture sector but the chronic food deficiency has persisted unabated for many years. It is not possible to increase the production of blackgram horizontally due to lack of land. So we can improve the production of blackgram by suitable doses of nitrogen and phosphorus fertilizers. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performance. Another combination of nitrogen and phosphorus with different management practices may be included for further study.

CHAPTER 6

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CHAPTER 7

APPENDICES

Appendix 1. The mechanical and chemical characteristics of soil of the experimental site as observed prior to experimentation

A. Morphological Characteristics of the experimental field:

Morphological features	Characteristics
Location	SAU Farm, Dhaka.
AEZ	Madhupur Tract (28)
General soil type	Shallow red brown terrce soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well-drained
Cropping pattern	Fallow- BARI mash-2

B. Physical and Chemical properties of the initial soil

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(%)	0.077
Available P (ppm)	20.00
Exchangeable K (mel 100g soil)	0.10
Available S (ppm)	45

Source: SRDI, 2014

Appendix 2. Monthly records of Temperature, Rainfall, and Relative humidity of the experiment site during the period from March 2014 to June 2014

Year	Month	Air Temperature (^{0}c)			Relative humidity (%)	Rainfall (mm)	Sunshine (hr.)
		Maximum	Minimum	Mean			
2014	March	33.60	29.50	31.60	72.70	3.00	227.00
2014	April	33.50	25.90	299.20	68.50	1.00	194.10
2014	May	34.90	27.00	30.95	61.00	2.00	221.50
2014	June	35.60	29.30	32.45	72.65	2.50	229.40

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1207

Appendix 3. Effect of N and P on plant height of BARI mash-2

Source of variation	Degrees of freedom	Mean square plant height (cm)		
		30 DAS	45 DAS	At harvest
Replication	2	0.461	1.3267	1.56
Factor A	2	5.821*	4.55709**	6.941*
Factor B	2	9.261*	11.23*	9.628*
AB	4	7.191*	10.189*	7.634**
Error	16	1.854	2.478	2.457

Appendix 4. Effect of N and P on number of leaves plant^{-1} of BARI mash-2

Source of variation	Degrees of freedom	Mean square of number of leaves plant^{-1}		
		30 DAS	45 DAS	At harvest
Replication	2	0.716	1.628	1.471
Factor A	2	3.420*	3.379*	6.893*
Factor B	2	9.817*	8.186*	14.173**
AB	4	5.748**	4.397**	1.194*
Error	16	1.027	2.091	2.806

Appendix 5. Effect of N and P on number of branches plant^{-1} of BARI mash-2

Source of variation	Degrees of freedom	Mean square of number of branches plant^{-1}		
		30 DAS	45 DAS	At harvest
Replication	2	0.187	0.376	0.327
Factor A	2	5.20*	3.938*	4.70*
Factor B	2	9.17*	6.179*	11.672**
AB	4	4.48**	3.384**	3.316*
Error	16	1.002	2.074	1.287

Appendix 6. Effect of N and P on Dry weight plant^{-1} of BARI mash-2

Source of variation	Degrees of freedom	Mean square dry weight plant^{-1}		
		30 DAS	45 DAS	At harvest
Replication	2	0.136	0.237	0.31
Factor A	2	1.170*	1.270*	0.88*
Factor B	2	2.362**	2.283*	1.15**
AB	4	0.631*	1.11*	1.14*
Error	16	0.241	0.871	0.306

Appendix 7. Effect of N and P on yield contributing parameters of BARI mash-2

Source of variation	Degrees of freedom	Mean square				
		Days to 1st flowering	No of pods per plant	Pod length (cm)	No of seeds per pod	Weight of 1000 seed (g)
Replication	2	0.251	0.381	0.893	1.812	0.906
Factor A	2	4.730*	5.534*	5.285*	2.035*	7.617*
Factor B	2	9.62**	6.086*	9.792*	7.744*	11.694*
AB	4	2.321*	2.634*	3.271*	4.623*	3.241**
Error	16	2.210	1.149	2.238	1.127	1.188

Appendix 8. Effect of N and P on yield parameters of BARI mash-2

Source of variation	Degrees of freedom	Mean square		
		Yield plant^{-1} (g)	Yield (kg ha^{-1})	Harvest Index
Replication	2	0.17	0.313	0.331
Factor A	2	3.20*	5.38*	2.881*
Factor B	2	6.17*	7.139*	6.158**
AB	4	2.48**	4.363**	1.164*
Error	16	1.036	2.05	1.076