RESPONSE OF LENTIL TO DIFFERENT LEVELS OF NITROGEN AND PHOSPHOROUS

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JUNE, 2010

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A Thesis

Submitted to the Department of Agronomy
Sher-e-Bangla Agricultural University, Dhaka
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE (M.S.)
IN
AGRONOMY

Semester: January–June, 2010

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CERTIFICATE

This is to certify that the thesis entitled **"Response of lentil to different levels of nitrogen and phosphorous"** submitted to the ***DEPARTMENT OF AGRONOMY*****,** Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of **MASTER *OF SCIENCE (M.S.) in AGRONOMY*,** embodies the results of a piece of bona fide research work carried out by ***MD. SADIQUZZAMAN SARKER,*** **Registration. No. 03-01188,** under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma in any other institution.

I further certify that any help or sources of information received during the course of this investigation have been duly acknowledged**.**

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DEDICATED TO

MY

BELOVED PARENTS

ACKNOWLEDGEMENT

All praises are due to the Almighty Allah, the great, the gracious, merciful and supreme ruler of the universe to complete the research work and thesis successfully for the degree of Master of Science (MS) in Agronomy.

The Author express the deepest sense of gratitude, sincere appreciation and heartfelt indebtedness to his reverend research supervisor Prof. Md. Sadrul Anam Sardar, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka for his scholastic guidance, innovative suggestion, constant supervision and inspiration, valuable advice and helpful criticism in carrying out the research work and preparation of this manuscript.

The Author deems it a proud privilege to acknowledge his gratefulness, boundless gratitude and best regards to his respectable co-supervisor Prof. Dr. Md. Fazlul Karim, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka for his valuable advice, constructive criticism and factual comments in upgrading the research work.

Special appreciation and warmest gratitude are extended to his esteemed teachers Prof. Dr. Md. Hazrat Ali, Prof. Dr. Parimal Kanti Biswas, Prof. Dr. H. M. M. Tariq Hossain, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka who provided creative suggestions, guidance and constant inspiration from the beginning to the completion of the research work. Their contribution, love and affection would persist in his memory for countless days.

The Author express his heartiest thanks to his dearest friends Shahin, Kabir, Nayan, Reza, Lotus, Liton, Sabbir, Parvez, Tashik, Tanvir, Tahazzat, Masud, Khokon, Sher-e-Bangla Agricultural University, Dhaka for their endless and active co-operation during the entire period of the research.

The Author express his cordial thanks to his roommates Mahiuddin, Mridul, Atiq, Anis, Zulquarnine vai, Rokon vai and Arif vai Sher-e-Bangla Agricultural University, Dhaka for their encouragement and active co-operation during the entire period of the research.

The Author grateful to Sharifur Rahman Khandker, Enamul Huq, Morshed Alam and Madhusudan Paul Chowdhury for helping him directly and indirectly in his research work.

The Author also express his special thanks to Section Officer, Lab. Assistants and other office staffs of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka for their extended and heartiest helps during the research work.

The Author express his unfathomable tributes, sincere gratitude and heartfelt indebtedness from his core of heart to his parents, whose blessing, inspiration, sacrifice, and moral support opened the gate and paved to way of his higher study. The Author also express his indebtedness to his brother and sister for their love and well wishings for him.

The Author want to say thanks, to all of his classmates and friends, for their active encouragement and inspiration.

The Author

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ABSTRACT

An experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from October 2008 to March 2009 to evaluate the response of lentil (BARI masur-6) to different levels of nitrogen and phosphorous. The experiment comprised four levels of nitrogen viz N_0 (0 kg N ha^{-1}), N_1 (10 kg N ha^{-1}), N_2 (20 kg N ha^{-1}) and N_3 (30 kg N ha^{-1}) and four levels of phosphorus viz. P_0 (0 kg P_2O_5 ha^{-1}), P_1 (20 kg P_2O_5 ha^{-1}), P_2 (40 kg P_2O_5 ha^{-1}) and P_3 (60 kg P_2O_5 ha^{-1}). The experiment was laid out in a Randomized Complete Block Design (factorial) with three replications. The data recorded from the experiment revealed that the tallest plant, the highest branches plant^{-1} and dry weight plant^{-1} were recorded from (20 kg N ha^{-1}(N_2). The highest pods plant^{-1}, 1000 grain weight, grain yield (1768.00 kg ha^{-1}) and stover yield (3301 kg ha^{-1}) were also found from 20 kg N ha^{-1}. Regarding phosphorus effect it revealed that the highest value of growth, yield and yield contributing parameters all were obtained from the application of 40 kg P_2O_5 ha^{-1}. The respective highest values obtained from phosphorus application at 40 kg P_2O_5 ha^{-1} were 28.38 cm, 12.99, 10.17g, 109.60, 21.20 g, 1695.00 kg ha^{-1}and 3217.75 kg ha^{-1} for plant height, branches plant^{-1}, dry weight plant^{-1}, pods plant^{-1}, 1000 grain weight, grain yield (kg ha^{-1}) and stover yield. In interaction effect, it was observed that N_2P_2 (20 kg N ha^{-1} × 40 kg P_2O_5 ha^{-1}) showed the highest grain yield as 2145.00 kg ha^{-1} and stover yield as 3545.00 kg ha^{-1}. The control treatment either as individual or interaction had the lowest performance in respect of growth, yield attributes and yield of the crop.

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LIST OF ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
FAO	=	Food and Agriculture Organization
BARC	=	Bangladesh Agricultural Research Council
SRDI	=	Soil Resources and Development Institute
SAU	=	Sher-e-Bangla Agricultural Unversity
UN	=	United Nations
UNDP	=	United Nations Development Program
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)
Max	=	Maximum
Min	=	Minimum
SE	=	Standard Errors
MP	=	Muriate of Potash
DAP	=	Di-Ammonium phosphate
m	=	Meter
P^{H}	=	Hydrogen ion conc.
RCBD	=	Randomized Complete Block Design
TSP	=	Triple Super Phosphate
Wt	=	Weight
%	=	Percent
HI	=	Harvest Index
NO	=	Number
cv.	=	Cultivar
N	=	Nitrogen
P	=	phosphorous
NPK	=	Nitrogen, phosphorous and Potassium
CV%	=	Percentage of Coefficient of Variance

CHAPTER I

INTRODUCTION

Lentil (*Lens culinaris* L. Medik) is one of the most important pulse crops grown in Bangladesh, the commonly grown pulse crops belongs to the sub family Papilionaceae under the family Leguminosae. In Bangladesh it is popularly known as masur. Various types of pulse crops can be grown in Bangladesh of which grasspea, lentil, mungbean, blackgram, cheakpea, fieldpea and cowpea are important. These are important food crop because they provide a cheap source of easily digestible protein. According to FAO (1999) a minimum intake of pulse by a human should be 80 g per head per day, whereas it is only 12 g in Bangladesh (BBS, 2008). This is because of the fact that the national production of the pulse is riot adequate to meet the national demand. Among the pulse crops lentil is one of the important crop grown in Bangladesh. In Bangladesh lentil ranks second in acreage and production but ranks first in market price. Lentil grain contains 59.8% CHO, 25.8% 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 manural value.

Lentil grains contain high protein, good flavor and easily digestible component. It may play an important role to supplement protein in the cereal-based low protein diet of the people of Bangladesh but the acreage and production of lentil are steadily declining (BBS, 2008).

Cultivation of high yielding varieties of wheat and boro rice has occupied considerable land suitable for lentil cultivation. Besides these, low yield potentiality of this crop is responsible for declining the area and production of lentil. At present the area under pulse crops is 0.73 million hectares with a production of 0.53 million tons where lentil is cultivated in the area of 0.20 million hectares with production of 0.17 million tons (BBS, 2008).

The average yield of lentil in Bangladesh is 0.80 ton/ha (BBS, 2006) which is very poor in comparison to lentil growing countries of the world as it has been cultivated on the increasing land. There are many reason of lower yield of lentil. The management of fertilizer is the important one that greatly affects the growth, development and yield of this crop. Pulse although fix nitrogen from the atmosphere, still there is evident that application of nitrogen fertilizer helps in increasing the yield (Patel *et a1.*, 1984, Ardeshana *et al.*, 1993).

Nitrogen is essential for pulse crops because it is the component of protein (BARC, 1997). Quoh and Jafar (1994) found that yield attributes of lentil was significantly increased by the application of nitrogen fertilizer at 40kg ha^{-1}. Satyanarayanamma *et al*. (1996) reported that application of urea at flowering and pod development stages produced the highest seed yield of mungbean. Though most of the farmers of Bangladesh did not use any fertilizer in pulse crops.

Proper fertilizer management plays a key role to get higher yield and nitrogen is an essential nutrient required for obtaining good yield. Crops are sensitive to nitrogen and this element has tremendous influence on plant height, dry matter accumulation and the yield attributes (Singh *et al.*, 2002). Excessive use of this element may produce too much of vegetative growth and thus fruit production may be impaired (Sheppard and Bates, 1980).

Phosphorus is another important factor that greatly affects the growth development and yield of this crop. Phosphorus has a great influence on the yield of pulse crops and also on plant dry matter content. On account of balanced phosphorus application in a crop field, yield can be maximized and nutrient content of seeds can be enhanced (Davaria *et al*., 2005).

Proper dose in fertilization is an essential factor to maximize pulse production in Bangladesh soil. N and P fertilizers play a vital role in enhancing the production of pulse crops and thereby reducing the protein deficit in the country (Saikia *et al.*, 2008).

Considering the above facts, the present work was conducted under nitrogen and phosphorus managements on lentil cv. BARI masur-6 with following objectives:

1. To find out the optimum nitrogen level for the yield and quality of lentil cv. BARI masur-6.
2. To find out the optimum phosphorous level for the yield and quality of lentil cv. BARI masur-6.
3. To find out combined effect of nitrogen and phosphorous in relation to yield and yield contributing characters of lentil cv. BARI masur-6.

CHAPTER II

REVIEW OF LITERATURE

In recent years, many scientists are engaged to change the pattern of growth and development of plants for long time to achieve higher yield benefit. In Bangladesh, pulse crops are generally grown without fertilizer or manures. However, there is evidence that the yield of pulse can be increased substantially by using fertilizers. Pulses, although fix nitrogen from atmosphere, it is evident that extra nitrogen application become helpful to increase the yield. But incase of phosphorus application in pulse crop give higher yield (Patra and Sahoo, 1994). Furthermore, literature revealed that nitrogen and phosphorus interface each other to increase pulse yield. Available literatures have been reviewed in this regard and presented below.

Effect of Nitrogen Fertilizers

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

Islam (2002) reported that N deficient lentil plants were shorter than the plants grown with applied N. The tallest plant was obtained by 30 kg N ha^{-1}.

Bhalu *et al* (1995) found that a starter dose of 15-20 kg N ha^{-1} applied at the time of sowing result in better initial growth & development of black gram. A positive response to increasing level of N up to 40 kg ha^{-1} has been observed at Ropar and patiala districts in punjab.

Suhartatik (1991) in a study observed the application of 30 kg N ha^{-1} fertilizers significantly increased that plant height of lentil.

Quah and Jafar (1994) found that plant height of lentil was significantly increased by the application of N fertilizer at 50 kg ha^{-1}. He also noted that 100 seed weight of lentil increased significantly by the application of N at 40 kg ha^{-1}.

Islam (2003) found the number of branches per plant in bushbean significantly increased with increasing N levels from 0 to 36.8 kg ha^{-1}. The highest number of branches per plant was obtained at 36.8 kg N ha^{-1} and the lowest at 0 kg N ha^{-1}.

Dutt (1979) found that split application of 40 kg N ha^{-1} increased the number of leaves of pulse.

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

Islam (2002) reported that N fertilizer influenced proportionally on the dry matter of lentil. Irrespective of N levels DM increased progressively till 90 DAE. The rate of dry matter production of lentil was higher during 50 to 70 DAE.

Chowdhury and Rosario (1992) studied the effect of N levels (0,30,60 or 90 kg ha^{-1}) on the rate of growth and yield performance of lentil at Los Banos, Philippines in 1988. They observed that N above the rate of 40 kg N ha^{-1} reduced the dry matter yield. They also noted that applied N at the levels above 40 kg ha^{-1} reduced the seed yield.

Clark *et al.* (1980) observed dry matter accumulation with increase in levels of N at all growth stages. The split application of N fertilizer increased the rate of photosynthetic accumulation, leaf dry weight; stem dry weight which finally resulted in increased DM production by plant at each stage of growth of lentil.

Mandal (2002) found optimum accumulation of DM in leaf, stem and petiole of lentil with 30 kg N ha^{-1}.

Sarkar and Banik (1991) reported that application of 40 kg N ha^{-1} to lentil resulted in appreciable improvement in the number of pods $plants^{-1}$ while compared with no N.

Nandan and Prasad (1998) found a linear increase in seed yield and pods per plant due to increased in N level form 10 to 30 kg ha^{-1} in lentil.

Mandal (2002) found that in lentil application of N fertilizer significantly increased seeds per pod. The crop treated with 30 kg N per ha gave the highest seed yield (1.7t ha^{-1}) which was 150% higher than those in control plot.

Cardaso *et al.* (1978) reported that lentil production showed positive linear response to N level, the highest average yield (1890 kg ha^{-1}) was obtained from the plots receiving 40 kg N ha^{-1} .

Kramer (1988) showed that *Rhizobium* inoclation along with the addition of 20 kg N ha^{-1} gave the maximum yield of lentil under both loamy sand and sandy loam soil.

Karle and Pawar (1998) examined the effect of varying levels of N and p fertilizers on lentil. They reported that lentil production higher seed yield with the application of 35 kg N ha^{-1} and 40 kg P_2O_5 ha^{-1}.

Lopes *et al.* (1988) found that the application of 40 kg N/ha produced 96.7% of estimated maximum yield. They conducted field studies to determine the response of lentil to N fertilized at different level (0, 20, 40, and 60 kg ha^{-1}) where N increased the seed yield.

Kaneria and Patel (1995) conducted a field experiment on Vartisol soil in Gujarat, India with lentil using 0 or 40 kg N ha^{-1}. They found that application of 40 kg N ha^{-1} significantly increased the seed yield (1.7 t ha^{-1}) when compared with that of control (1.08 t ha^{-1}).

An experiment was conducted by Trung and Yoshida (1983) using 0 -100 ppm N as treatments in the form of ammonium nitrate or 10 or 100 ppm N as urea, sodium nitrate, ammonium nitrate or ammonium sulphate. They found that maximum plant height at all the stages of plant were obtained by the application of 25 ppm N; 1000 seed weight was the highest with 100 ppm N of all forms and seed yield of mungbean increased with the increase in N up to 50 ppm.

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, 1000 seed weight and yield of mungbean cv. Mubarik was found to be increased by nitrogen at 40 kg ha^{-1}.

Bachchhav *et al.* (1994) conducted a field experiment on a clay soil during the summer season with mungbean (*Vigna radiata*) cv. Phule-M. They observed that root nodule weight per plant was highest with 30 kg N ha^{-1}. They also observed that among nitrogen fertilizers rates (0-45 kg ha^{1}) seed yield increased up to 30 kg N (1.65 ton ha^{-1}).

Inthong (1987) observed that the application of 15 kg N ha^{-1} to mungbean increased nodule production and enhanced nitrogen fixation while further higher rates (30, 60 and 90 kg N ha^{-1}) suppressed it. In another experiment he reported that application of 15 kg N ha^{-1} was found to be superior giving 23 % higher seed yield over the control. However although not significantly, 60 kg N ha^{-1} tended to produce the highest yield.

Patel *et al.* (2001) carried out a field experiment to examine different levels of nitrogen on mungbean and reported that the highest nodules per plant was obtained with 10 kg N ha^{-1} compared to 20 and 30 kg N ha^{-1} and highest yield obtained with 30 kg N ha^{-1}.

Raju and Varma (1984) carried out a field experiment during summer season of 1979 and 1980 to study the response of mungbean var. Pusa Baishaki 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 $plant^{-1}$ was obtained by the application of 15 kg N ha^{-1}inoculated with *Rhizobium*. They also reported that seed inoculation and/or application of 15 - 60 kg N ha^{-1} significantly increased seed yields of mungbean.

Agbenin *et al.* (1991) carried out an experiment under glass house condition and found that nitrogen application significantly increased the dry matter yield of mungbean. In another study, Leelavati *et al.* (1991) using different levels of nitrogen found a significant increase in dry matter production of mungbean with 60 kg N ha^{-1}.

Santos *et al.* (1993) carried out an experiment on mungbean cv. Berken which was grown in pots in podzolic soil with 7 levels of N (0, 25, 50, 100, 200, 400 and 500 kg ha^{-1}). They noted that application of N up to 200 kg ha^{-1} increased the total dry matter and with use of higher rates decreased, the total dry matter decreased.

Phimsirkul (1992) conducted a field trial on mungbean variety, U-Thong I grown in different soils under varying N levels. Results revealed that there was no effect of N fertilizer when mungbean was grown in Mab Bon soil. However, seed yield of mungbean was increased when the crop received N at 3 kg 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 or three growth stages. They reported that spraying urea at flowering and pod development stages produced the highest seed yield.

Mandal and Sikder (1999) conducted a greenhouse pot experiment on mungbean cv. BARI mung-5 under different N rates. They noted that the yield increased significantly with N application.

Mozumder *et al.* (2003) conducted an experiment to study the effect of *Rhizobium* at different nitrogen levels viz. 0, 20, 40, 60 and 80 kg N ha^{-1} on Binamoog-2. It was reported that increase of nitrogen fertilizer increased seed yield up to 40 kg N ha^{-1}. The highest seed yield (1607 kg ha^{-1}) was obtained when 40 kg N ha^{-1} was applied with *Bradyrhizobium* inoculation and also observed that nitrogen application had negative effect on the harvest index. They also observed that applied N up to a certain level increased the seed yield of mungbean.

Effect of Phosphorus Fertilizer

Singh and Saxena (1973) noted the response of lentil to application of phosphorus and zinc in a pot culture. Phosphorus application at the rate of 100 kg TSP (48 kg P_2O_5 ha^{-1}) resulted insignificant increase (P=0.05) in plant height and P concentration of legume crop. The shoot dry weight increase was significant at 1% level of probability.

Guvisova (1981) conducted field trials with lentil on a lime meadow soil using fertilizer @ 60 to 90 kg P_2O_5 ha^{-1} and 120 to 180 kg P_2O_5 ha^{-1} and reported that fertilizer application did not improve seed production or yield and sometimes reduced seed yield.

Varkas (1982) reported the effect of five levels (0, 5, 10, 20, 40 ppm) of P and S on N, S and P uptake of bean. Sulphur application increased sulphur content but decreased P content. On the country the effect of P on dry matter, P and S content was opposite to that of S.

In a field trial, Singh *et al*. (1983) observed the effect of P fertilization on the yield of lentil. 0 to 80 kg P_2O_5 ha^{-1} as applied on lentil cv. 49-12 at sowing. Seed yields per plant were increased by all fertilizer treatments. The optimum treatment was 75 kg P_2O_5 ha^{-1} applied 50% to the soil at sowing and 50% as a foliar fertilizer giving seed yield of 1.9 and 1.7 t ha^{-1} respectively.

Prasad and Chaudhary (1984) found that minimum plant death was achieved with reduction of 60 kg P_2O_5 ha^{-1} application on lentil. Sharma *et al.*(1994) found that the soil available P content had a significant positive correlation with yield and P uptake. Singh and Saxena (1986) reported that phosphorus application significantly increased plant height of lentil, shoot P content but did into effect the number of branches $plant^{-1}$.

Sharma *et al.* (1984) reported the effect of levels, source and methods of P application on availability of P to lentil. Available P content in soil and shoots lentil 70 days of growth and harvest and seed yields were increased with increasing rates of applied P_2O_5 ha^{-1} (0-35.2 kg ha^{-1} .

Siag *et al*. (1990) stated that application of 20, 40 and 60 kg P_2O_5 ha^{-1} at the vegetative stage and again at either 50% flowering or 50% pod formation, maximum seed yield (2.68 ton ha^{-1}) was obtained with the application of 60 kg P_2O_5 ha^{-1}. The optimum P rate was calculated to be 56 kg ha^{-1}.

Khan *et al.* (1990) found that application of P showed significant favorable effect only on pod number and pod yield of peanut (*Arachis hypogaea* L.).

Azad *et al.* (1991) reported that response of 4 levels of P viz. 0, 20, 40 and 60 kg P_2O_5 ha^{-1} on grain yield of lentil The grain yield of lentil increased significantly at all levels of P application over control. The response of P application over control increased content of soi1 P.

Zeidan (2007) carried out two field experiments during the two winter seasons of 2003/04 and 2004/05 to study the effects of organic manure at 0, 10 and 20 m^3 $feddan^{-1}$ and P at 0, 30, 45 and 60 kg P< sub>2</ sub>O< sub>5</sub>/feddan on the growth, yield and quality of lentil grown on sandy soil. Plant height, number of branches plant number of pods $plant^{-1}$, 1000-seed weight, seed yield $plant^{-1}$, seed yield $feddan^{-1}$, and straw yield $feddan^{-1}$, were significantly affected by organic manure application. Increasing rates of applied organic manure from 0 to 20 m^3 $feddan^{-1}$ markedly increased all the characters. The plots that received 20 m^3 $feddan^{-1}$ had the highest values of protein, P, K, Fe, Mn and Zn compared to the control. Increasing P levels from 0 to 60 kg feddan^{-1} increased plant height, number of branches plant^{-1}, number of pods plant$^{-1,}$ 1000-seed weight, and seed yield plant^{-1} seed yield feddan^{-1} and straw yield feddan^{-1}. P levels increased the contents of protein, P, K, Fe, Mn and Zn in seeds. P at 60 kg feddan^{-1} recorded the highest levels of protein, P, K, Fe, Mn and Zn in seeds.

Hussain *et al.* (2003) conducted an experiment to observed the effect of different P rates (0, 25, 50 and 75 kg ha^{-1}) on the chemico-qualitative parameters of lentil cultivars Masoor local, Masoor-85 and Masoor-93 were studied under field conditions in Faisalabad, Pakistan on a sandy-clay loam soil for two years. The seed protein concentration was significantly higher (25.36%) in Masur-93 than Masur-85 (23.24%) and Masur-local (23.07%) whereas the seed contents of P, K, Ca, Mg, and phytic acid and cooking quality were similar in all cultivars. By contrast, 50 kg P_2O_5 ha^{-1} significantly improved the cooking quality, seed P and phytic acid content compared to the control.

Zafar *et al.* (2003) conducted an experiment in Faisalabad, Pakistan to see the effects of phosphorus rate (25, 50, and 75 kg P< sub>2</ sub>O< sub>5</ sub>ha^{-1}) on lentil. The application of 75 kg P< sub>2</ sub>O< sub>5</ sub>ha^{-1} gave the tallest plants (49.92 cm) and the highest number of pods per plant (62.37), number of seeds plant^{-1} (1.89), 1000-seed weight (19.38 g), seed yield (12.50 kg ha^{-1} and harvest index (43.69%). The lowest values of yield and yield components were recorded for the untreated control.

Harmsen and Mahmood (2004) conducted an experiment to see the response of lentil to different levels of phosphorus fertilizer (0, 15, 30, 45 and 60 kg P< sub>2</ sub >0< sub>5</ sub> ha^{-1}) was measured at three sites: Haripur (LI), Baffa (L2) and Pharana (L3), in the Hazara division of NWFP-Pakistan during the Rabi season of 2004-05. Phosphate treatments yielded significantly more than the control. The response to phosphate fertilizer was linear. Higher doses of P< sub>2</ sub>O< sub>5<*I* sub> (45 & 60 kg P< sub>2</ sub>0< sub>5</ sub> ha^{-1}) significantly induced early flowering but delayed maturity, which might be due to enhanced nitrogen's activity of intact root nodules and balancing effect of Phosphorus on the lentil physiological processes and uptake of other nutrients. The maximum mean yield of 1092 kg ha^{-1} was recorded with the 60 kg P< sub>2</ sub> 0₅ ha^{-1} treatment producing 8.8 kg grain yield kg^{-1} of NPK fertilizer with a return of Rs. 9.0 for each invested rupee in fertilizer. The response to the application of phosphorus fertilizer was greatest in soil with a low available phosphorus status.

Dubey *et al.* (1993) conducted a micro plot (2m x 2m) field experiment in the farm of the Indian Agricultural research Institute with the application of P as basal through DAP @ 0, 25 and 50 kg P_2O_5 ha^{-1} and found that application of 50 kg P_2O_5 ha^{-1} gave the highest grain yield ha^{-1}.

Saraf and Shivakumar (1997) showed that lentil growth parameters (plant height, number of leaves plant^{-1} and branches plant^{-1}) with grain yield increased with the increase of phosphorous up to 60 kg P_2O_5 ha^{-1} (866 kg ha^{-1}).

Saxena *et al.* (1996) reported that seed yield was the highest with 60 kg P_2O_5 ha^{-1} in 2003 and increased up to 30 kg P_2O_5 ha^{-1} in 2005. Seed yield of lentil was positively correlated with leaf area, dry matter plant^{-1}, relative moisture content in leaves, number of branches plant^{-1}, number of pods plant^{-1}, seed yield plant^{-1}, 1000-seeds weight and harvest index.

Tomar *et al.* (1999) observed that 60 kg P_2O_5 ha^{-1} with 150 mm gave the highest harvest index and net returns. They also reported that leaf number, brunch number and dry weight plant^{-1} were the highest with 20 kg seed ha^{-1}, 60 kg P_2O_5 ha^{-1} and irrigation at 100 mm CPE.

Tomar *et al.* (2000) conducted a field experiment to study the effect of seed rate, moisture regime and phosphorous levels on mungbean. They found that absolute growth rate, relative growth rate; net assimilation rate and dry matter at all the growth stages and crop growth rate at 65 days recorded significantly higher with application of phosphorous at 60 kg P_2O_5 ha^{-1} as compared to the other levels of phosphorous.

Sharma *et al.* (1994) observed the effect of 0-90 kg P_2O_5 ha^{-1} sprayed 35 days after sowing with water or 10 ppm IAA and inter-row hoeing after the first irrigation on green gram. Leaf and stem dry matter yields at maturity were the highest with 60 kg P_2O_5 ha^{-1} and with hoeing and IAA. Nodule number and nodule dry weight plant^{-1} at 50 days after sowing were the highest in the same treatment.

Singh *et al.* (1994) observed that application of 60 kg P_2O_5 ha^{-1} with irrigation at vegetative + flowering stages gave the highest seed yield (1.54 t ha^{-1}) in mungbean.

Rao *et al.* (1993) also observed that application of 50 kg P_2O_5 ha^{-1} gave the highest yield (13.00 q ha^{-1}) of mungbean.

Sarkar (1992) carried out a field experiment to study the response of greengram to irrigation and P and found that 80 kg P_2O_5 ha^{-1} gave the highest grain yield.

Tank *et al.* (1992) showed that application of 80 kg P_2O_5 ha^{-1} gave the highest yield (808 kg ha^{-1}) which was statistically identical to 40 kg P_2O_5 ha^{-1} (807 kg ha^{-1}).

Thind *et al.* (1993) carried out a pot experiment in a green house with 0, 30, 60 and 90 kg P_2O_5 ha^{-1} as DAP and reported that yield of *Vigna radiata* was highest with 90 kg P_2O_5 after 30days growth and with 60 kg P_2O_5 after 60d growth.

Balaguravaiah *et al.* (1989) conducted a field experiment in 2 kharif seasons to study the response of *Vigna radiata* to applied P under rainfall conditions and found that there was significant response to phosphate equivalent to 60 kg ha^{-1} in terms of the level of soil available P.

Kalita (1989) observed the effect of 0, 15, 30 and 45 kg P_2O_5 ha^{-1} on green gram and reported that application of phosphate significantly increased the entire yield attributing characters, grain yield and dry matter with increasing levels of phosphate. However, difference in grain yield due to 30 and 45 kg P_2O_5 ha^{-1} was not significant.

Arya and Kalra (1988) conducted an experiment to study the effect of phosphorous on the yield and quality of mungbean and reported that application of 27-75 kg P_2O_5 increased the yield components, seed and protein yields and P uptake. The optimum economic rate was found to be 50 kg P_2O_5 ha^{-1}.

Dwivedi *et al.* (1988) reported that application of 40 kg P_2O_5 ha^{-1} increased seed yield of mungbean and 60 kg P_2O_5 gave no further increase in yield.

Khade *et al.* (1990) showed that green gram (*Vigna radiata* L. Wilczek) in the winter season gave higher yields with 50 and 57 kg P_2O_5 ha^{-1} than with 25 kg P_2O_5 ha^{-1} or no phosphorous application. Similar results were found with 40 kg P_2O_5 ha^{-1} in seed yield of *Vigna radiata* by Mahadkar and Saraf (1988).

Metha *et al.* (1987) in a field experiment with summer black gram (*Vigna mungo* Hepper) observed that seed protein content increased with applied phosphorous at the rate of 25 kg P_2O_5 ha^{-1}.

Interaction effect of Nitrogen and Phosphorus

Nandan and Prasad (1998) also reported highest plant height at 40kg N ha^{-1} sardana and Varma (1987) carried out a study in New Delhi, India in 1983-84. They found that application of N. phosphorus and potassium fertilizers in combination resulted in significant increase in plant height of lentil.

Ashtana (1998) suggested a starter dose of 20kg N ha^{-1} along with 50kg p_2O_5 ha^{-1} as basal for optimum plant height for lentil.

Saxena and Varma (1985) carried out a field on lentil in Assam India and reported that combined application of N and phosphorus significantly increased the dry weight of plants.

In an experiment, Yien *et al.* (1981) applied N and phosphorus fertilizer to lentil and reported that combined application of N and phosphorus fertilizers increased the number of pods $plant^{-1}$. The rate of N and phosphorus was 40 kg and 75 kg per hectare, respectively.

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

Sardana and Varma (1987) stated that application of N, Phosphorus and potassium fertilizers resulted in significant increased in 1000 seed weight of lentil.

Mahboob and Asghar (2002) studies the effect of seed inoculation at different NPK level on the yield and yield components of lentil at the agronomic research station, Farooqabad in Pakistan during the year of 2000 and 2001. They reported that various yield components like 1000 grain weight were affected significantly with 50-50-0 NPK kg ha^{-1} application.

Yein (1982) conducted field tried on lentil in Assam, India and found that 40 kg N ha^{-1} in combination with 20kg P_2O_5 ha^{-1} resulted in significant increase in the seed yield.

Arya and Kalra (1988) reported that application of N at the rate of 50 kg ha^{-1} along with 50 kg P_2O_5 ha^{-1} increased lentil yield.

Karle and Pawar (1998) examined the effect of varying levels of N and p fertilizers on lentil. They reported that lentil production higher seed yield with the application of 35 kg N ha^{-1} and 40 kg P_2O_5 ha^{-1}.

Mahboob and Asghar (2002) studied the effect of seed inoculation at different N level on lentil at the agronomic research station. Farooqabad in pakistan. They reported that seed inoculat in+ 40-80-30 NPK kg ha^{-1} exhibits superior performance in respect of seed yield (1670 kg ha^{-1}).

Yein (1982) conducted field trials on lentil in Assam, India and found 40 kg N ha^{-1} in combination with 20kg P_2O_5 ha^{-1} resulted in significant increase in the seed yield.

Rajender *et al.* (2003) investigated the effects of N (10, 20, 40, and 50 kg ha^{-1}) and P_2O_5 (20, 40, 60 and 80 kg ha^{-1}) fertilizer rates on lentil. Grain yield increased with increasing N rates up to 40 kg ha^{-1}. Further increase in N did not affect yield.

Sarkar and Banik (1991) made a field experiment to study the response of green gram to nitrogen, phosphorous and molybdenum. They reported that application of N and P improved plant productivity and enhanced the grain yield of green gram significantly. Growth parameters were recorded as better response for increased productivity. They also reported that response to N and P_2O_5 was recorded up to 45 and 60 kg ha^{-1} respectively for better yield.

In a field experiment, Yein *et al.* (1981) applied nitrogen in combination with phosphorus fertilizer to mungbean. They revealed that application of N fertilizer along with P increased plant height, dry weight $plant^{-1}$, number of pods $plant^{-1}$ and grain yield.

In trials, on clay soils during the summer season, Patel *et al.* (1984) studied the effect of N (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. In that experiment, 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 and seed yield. They also observed that application of 40 kg P_20_5 ha^{-1} along with 20 kg N ha^{-1}significantly increased the 1000 seed weight of mungbean.

A field trial was carried out by Sardana and Verma (1987) in New Delhi, India. In that trial, they observed that application of nitrogen in combination with phosphorus and potassium fertilizers resulted the significant increase in plant height, number of pods $plant^{-1}$, 1000 seed weight and seed yield of lentil.

Tank *et al.* (1992) reported that mungbean fertilized with 20 kg N ha^{-1} along with 40 kg P_2O_5 ha^{-1} significantly increased the number of pods $plant^{-1}$ and seed yield over the unfertilized control.

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 P_2O_5 ha^{-1} resulted in the maximum seed yield (1112.96 kg ha^{-1}) and harvest index (41.88%). They also observed that number of flowers $plant^{-1}$ was found to be significantly higher by varying levels of nitrogen and phosphorus and pod length was significantly affected by both nitrogen and phosphorus application.

Salimullah *et al.* (1987) also reported that the number of pods $plant^{-1}$ was highest with the application of 10 kg N along with 75 kg P_2O_5 $ha^{-1}$and 60 kg K_2O ha^{-1} in summer mungbean.

Patel *et al.* (1992) conducted a field trial to evaluate the response of mungbean to sulphur fertilizaton under different levels of nitrogen and phosphorus. Greengram cv. Gujrarat 2 and K 851 were given 10 kg N + 20 kg P_2O_5 ha^{-1} or triple these rates and 0, 10, 20 or 30 kg sulphur ha^{-1}as gypsum. Seed yield was 1.20 and 1.24 t ha^{-1} in Gujrarat 2 and K 851, respectively and was increased with the increase of fertilizer up to 20 kg N + 40 kg P_2O_5 ha^{-1}.

Patel and Parmer (1986) conducted an experiment on the response of greengram to varying levels of nitrogen and phosphorus. They observed that increasing N application (30 to 45 kg ha^{-1}) with phosphorus (60 to 75 kg ha^{-1} to rainfed mungbean (cv. Gujrat-1) increased the number of branches plant^{-1}, pods plant^{-1} and seed yield.

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

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 number of pods plant^{-1}, 1000 seed weight over the control (no application). Application of N along with P significantly increased the seed yield of mungbean. The higher yield was found with the application of N and P_2O_5 up to 10 and 60 kg ha^{-1}, respectively. However, the maximum seed yield was obtained with the combination of 20 kg N and 60 kg P_2O_5 ha^{-1}.

Suhartatik (1991) observed that N, P and K fertilizers in combination significantly increased the number of leaves, pods plant^{-1},1000 seed weight and seed yield.

Srinivas *et al.* (2002) examined the effect of nitrogen (0, 20, 40 and 60 kg ha^{-1}) and phosphorus (0, 25, 50 and 75 kg ha^{-1}) on the growth and yield of mungbean. They observed that the number of pods plant^{-1} was increased with the increasing rates of N up to 40 kgha^{-1} followed by a decrease with further increase in N. Pod length was increased with the increasing rates of N up to 40 kg ha^{-1}which was followed by a decrease with further increase. 1000 seed weight was generally increased with increasing rates of P along with increasing rates of N up to 40 kg ha^{-1} which was than followed by a decrease with further increase in N.

Bali *et al*. (1991) conducted a field trail in kharif seasons on silty clay loam soil. They revealed that seed yield, 1000-seed weight and LAI were increased with up to 40 kg N and 60 kg P_2O_5 ha^{-1}.

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, Farooqabad in Pakistan during the year of 2000 and 2001. They revealed that various yield components like 1000 grain weight were affected significantly with fertilizer (50 - 50 - 0 NPK kg ha^{-1}) application. They also revealed that seed inoculation + 50-50-0 NPK kg ha^{-1} exhibited superior performance in respect of seed yield (955 kg ha^{-1}).

Werakonphanit *et al.* (1979) stated that mungbean showed no significant differences in response to different fertilizer levels. NPK levels of 0 - 0 - 0, 3 - 0 - 0 and 3 - 9 - 0 gave seed yield of 156, 168 and 175 kg ha^{-1} respectively. From the results of that study, it was concluded that the fertilizer application in mungbean was not necessary.

Yein *et al.* (1981) conducted field trials in Assam, India, and applied N and P fertilizers to study their relative contributions towards increasing the seed yield of mungbean. Their studies showed that N along with P fertilizers increased the seed yield. They observed that 10 kg N in combination with 20 kg P_2O_5 ha^{-1} resulted in significant increases in the seed yield.

Arya and Kalra (1988) reported that application of N at the rate of 50 kg ha^{-1} along with P_2O_5 (50 kg ha^{-1}) increased mungbean yield. Results from field experiments conducted by Mahadkar and Saraf (1988) during summer season showed that the application of N with P and K at 20 :2 :5 kg ha^{-1} gave higher seed yield.

Ardesna *et al.* (1993) conducted a field experiment on clay soil during the rainy season of 1990 to study the response of mungbean to nitrogen, phosphorus and Rhizobium inoculation. 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 and inoculation with *Rhizobium.*

In a field experiment on clay soil during kharif season of 1990, Badole and Umale (1994) observed that the seed yield of mungbean cv. TAP was increased by N and P_2O_5 application. Application of 50% of the recommended N and P rate gave the highest yield of 1.17 t ha^{1}.

Yadav *et al.* (1994) conducted a field experiment on sandy loam soil during the kharif (monsoon) season of 1986 at Hisar, Hariana, India, with mungbean cv. k 851. Treatments 0, 50 or 100% of the recommended N and P fertilizers (20 kg N as Urea and 40 kg P_2O_5 ha^{-1} as single super phosphate) were tested. They found that mungbean receiving the recommended dose gave the highest seed yield.

Khanam *et al.* (1996) reported that the use of recommended dose of NPK plus compost increased the seed yield of mungbean by 83 - 87%.

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

A field experiment was carried out by Sharma and Sharma (1999) during summer seasons at Golaghat, Assam, India. Mungbean was grown using farmers' practices (no fertilizer) or using different combinations of fertilizer application (10 kg N + 35 kg P_2O_5 ha^{-1}). Seed yield was 0.40 to N ha^{-1} with farmers' practices, while the highest yield was obtained by the fertilizer application (0.77 t 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. Grain yield increased with increasing N rates up to 20 kg ha^{-1}. Further increase in N rate did not affect yield.

Nadeem *et al.* (2004) studied the response of mungbean cv. NM - 98 to seed inoculation and different levels of fertilizer (0 - 0, 15 - 30, 30 - 60 and 45 - 90 kg N- P_2O_5 ha^{-1}) under field conditions. Results showed that the application of fertilizer significantly increased the seed yield and the maximum seed yield was obtained when 30 N ha^{-1} was applied.

Panda (1979) observed that the application of N and P fertilizer @ 0 to 90 kg P_2O_5 ha^{-1} increased grain yield, hay, plant height, number of branches $plant^{-1}$.

Azad and Gill (1989) set up a experiment where lentils cv.L9-12 were given 0 to 40 kg P_2O_5 ha^{-1} + 12.5 kg N ha^{-1} or soils low in available P and organic matter in Rabi (winter) season and found that seed yield increased with increasing P rate from cv. of 285 kg ha^{-1} without applied P to 758 kg with 40 kg P_2O_5. They got the greatest response of P in soil with lowest available P contents.

Kumar *et al.* (1993) have described the effect of P and N on growth and grain yield of lentil. They found that all the growth attributes were significantly F increased by 20 kg N and 50 kg P_2O_5. Yield, yield attributes and quality of lentil also exhibited the same trend, although N application did not significantly increased seed yield.

Amanullah (2004) conducted an experiment during 2000-01 in Pesbawar, Pakistan to investigate the effect of various levels of N (0 and 20 kg ha^{-1} and P (0, 30, 60 and 90 kg ha^{-1}) on the growth and yield components of lentil cultivars masur-85, Masur-93 and Manshera-89 under rainfed conditions. P application had significantly affected the number of pods $plant^{-1}$, 1000-seed weight and dry matter yield. Lower number of pods $plant^{-1}$ (81), seeds pod (1.5), 1000-seed weight (14.2 g) and grain yield (550 kg ha^{-1}) were recorded without P application. P applied at 60 kg ha^{-1} resulted in the highest number of pods $plant^{-1}$ (84), number pod^{-1} (1.6), 1000-seed weight (14.8 g), dry matter yield (2875 kg ha^{-1}) and grain yield (595 kg ha^{-1}) but had no significant effect on nodule numbers.

Patel and Patel (1999) found that 20 kg N + 40 kg P_2O_5 ha^{-1} gave the highest seed yield (1.74t ha^{-1}) which was not significantly different from foliar application of urea (1.5%) + DAP (0.5%) at 30 and 40 days after sowing (1.67 t ha^{-1}).

From the reviews presented this chapter it is evident that the optimum level of N and P application in lentil field has a great effect in achieving its yield potentiality.

CHAPTER III

MATERIALS AND METHODS

The experiment was undertaken during rabi season (October to March) of 2008 to 2009 to determine 'Response of lentil to different levels of nitrogen and phosphorous'.

3.1 Experimental site

The experiment was conducted in the Agronomy farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The location of the experimental site is $23^{0}74^{/}$N latitude and $90^{0}35^{/}$E longitude and at an elevation of 8.2 m from sea level (Anon., 1989).

3.2 Climate

The climate of experimental site was under the subtropical climate, characterized by three distinct seasons, the winter season from November to February and the pre-monsoon or hot season from March to April and the monsoon period from May to October (Edris *et al*., 1979). Cold temperature and minimum rainfall is the main feature of the rabi season. During October to February the average Relative Humidity, average Max. Temp, average min. temp. were 66.53%, 27.34^{0}c, 16.04^{0}c respectively. The monthly total rainfall, average relative humidity, temperature during the study period (October to March) collected from the Bangladesh Meteorological Department, Agargoan, Dhaka are presented in Appendix I.

3.3 Characteristics of Soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28. It had shallow red brown terrace soil. The selected plot was medium high land. The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI, Khamarbari, Dhaka and details of the recorded soil characteristics were presented in Appendix II.

3.4 Materials

3.4.1 Seed

A high yielding variety of lentil named 'BARI masur-6' developed by Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur was used in the experiment as a plant material. This variety bears good phenotypic characters; such as deep green leaf, no tendril in front of leaf, bushy type plant, 35-40 cm height, white color flower, seed size is larger than local seed, deep brown color, duration of 105-110 days and seed yield of 2200-2300 kg ha^{-1}.

3.4.2 Fertilizers

In this experiment nitrogen (as Urea) and phosphorus (as TSP) were app- -lied as per treatment and potash as recommended dose MOP (35 kg ha^{-1}).

3.5 Methods

3.5.1 Treatments

Two factors i.e., nitrogen & phosphorus were used as treatments. Four levels of nitrogen and four levels of phosphorus were used for the combination of sixteen (16) treatments of the present experiment.

Factor A: 4 levels of nitrogen

(i) N_0 = 0 kg N ha^{-1}

(ii) N_1 = 10 kg N ha^{-1}

(iii) N_2 = 20 kg N ha^{-1}

(iv) N_3 = 30 kg N ha^{-1}

Factor B: 4 levels of phosphorus

(i) P_0 = 0 kg P_2O_5 ha^{-1}

(ii) P_1 = 20 kg P_2O_5 ha^{-1}

(iii) P_2 = 40 kg P_2O_5 ha^{-1}

(iv) P_3 = 60 kg P_2O_5 ha^{-1}

The following 16 treatment combinations were used for the present experiment:

1. 0 kg N ha^{-1} with 0 kg P_2O_5 ha^{-1} (N_0P_0)
2. 0 kg N ha^{-1} with 20 kg P_2O_5 ha^{-1} (N_0P_1)
3. 0 kg N ha^{-1} with 40 kg P_2O_5 ha^{-1} (N_0P_2)
4. 0 kg N ha^{-1} with 60 kg P_2O_5 ha^{-1} (N_0P_3)
5. 10 kg N ha^{-1} with 0 kg P_2O_5 ha^{-1} (N_1P_0)
6. 10 kg N ha^{-1} with 20 kg P_2O_5 ha^{-1} (N_1P_1)
7. 10 kg N ha^{-1} with 40 kg P_2O_5 ha^{-1} (N_1P_2)
8. 10 kg N ha^{-1} with 60 kg P_2O_5 ha^{-1} (N_1P_3)
9. 20 kg N ha^{-1} with 0 kg P_2O_5 ha^{-1} (N_2P_0)
10. 20 kg N ha^{-1} with 20 kg P_2O_5 ha^{-1} (N_2P_1)
11. 20 kg N ha^{-1} with 40 kg P_2O_5 ha^{-1} (N_2P_2)
12. 20 kg N ha^{-1} with 60 kg P_2O_5 ha^{-1} (N_2P_3)
13. 30 kg N ha^{-1} with 0 kg P_2O_5 ha^{-1} (N_3P_0)
14. 30 kg N ha^{-1} with 20 kg P_2O_5 ha^{-1} (N_3P_1)
15. 30 kg N ha^{-1} with 40 kg P_2O_5 ha^{-1} (N_3P_2)
16. 30 kg N ha^{-1} with 60 kg P_2O_5 ha^{-1} (N_3P_3)

3.5.2 Land preparation

The experiment plot was irrigated to remove its hard dryness before ploughing. Then it was first opened with tractor drawn disc plough after having 'zoe' condition. Ploughed soil was then brought into desirable 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 15 October and 25 October 2008, 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 were incorporated thoroughly.

3.5.3 Fertilization

The amounts of fertilizer as per treatment in the forms of urea, Triple Super Phosphate and Muriate of Potash were calculated and half of urea and total amount of all other fertilizers of each plot were applied and incorporated into soil as basal dose. Rest of the urea was top dressed after 30 days of sowing.

3.5.4 Design and layout

The experiment was laid out in a Randomized Complete Block Design (factorial) with three replications. The total plot number was 16 × 3 = 48. The unit plot size was 3 m × 2 m = 6 m^2. The replications were separated from one another by 1.5 m. The distance between plots was 0.75 m.

3.5.5 Sowing of seeds

Sowing was done on 26 October, 2008 in rows 30 cm apart. Seeds were sown continuously in rows. The seeds were sown at a rate of 35 kg ha^{-1}. Seeds were treated with Bavistin before sowing to control the seed borne disease. After sowing; the seeds were covered with soil, and slightly pressed by hand.

3.5.6 Thinning

The optimum plant population was maintained by thinning excess plant. Seeds were germinated 6 days after sowing (DAS). First and second thinning was done at 15 and 25 DAS respectively to maintain plant to plant distance as 10 cm.

3.5.7 Weeding

Weeding was done twice; first weeding was done at 20 DAS and second weeding was done at 45 DAS.

3.5.8 Irrigation

Three irrigations were given as plants required. First irrigation was given immediate after topdressing and second and third irrigations were applied at 45 and 65 DAS. After irrigation when the crushed was found to be formed plots were in zoe condition, spading was done uniformly and carefully to break the crush and conserve the soil moisture.

3.5.9 Crop protection

At vegetative stage, aphid (*Aphis craccivora*) attacked the young plants and at latter stage of growth, pod borer (*Maruca testulalis*) attacked the plant. For aphid control, Ripcord 2 ml l^{-1} water and for pod borer Dimacron 50 EC at the rate of 3 ml l^{-1} were sprayed.

3.6 Crop sampling and data collection

Ten plants from each treatment were randomly selected and marked with tag for recording plant characters. The data of plant height, number of branches, dry weight were recorded from 25 days of sowing to harvesting and 1000 seed weight and yield were recorded in harvesting time.

3.7 Harvesting and threshing

Crop was harvested when 90% of the pods became brown to black in color. The matured crops was harvested and tied into bundles and carried to the threshing floor. The crop bundles were sun dried by spreading those on the threshing floor. The seeds were separated from the plants by beating the bundles with bamboo sticks.

3.8 Drying and weighing

The seeds and stovers thus collected were dried in the sun for couple of days. Dried seeds and stovers of each plot was weighed and subsequently converted into kg ha^{-1} basis.

3.9 Data collection

At harvesting, 10 plants were selected randomly from each plot to record the following data.

1) Plant height (cm)
2) Branches $plant^{-1}$
3) Dry weight $plant^{-1}$
4) Pods $plant^{-1}$
5) Seeds pod^{-1}
6) 1000-seed weight (g)
7) Seed yield (kg ha^{-1})
8) Stover yield (kg ha^{-1})
9) Biological yield (kg ha^{-1})
10) Harvest index (%)

3.9.1 Plant height (cm)

The height of pre-selected ten plants from each plot was measured from ground level (stem base) to the tip of the plant at each measuring date. Mean plant height was calculated and expressed in cm.

3.9.2 Branches plant^{-1}

The number of branches of ten randomly pre-selected plants from each plot were counted and recorded at each measuring date. Average value of ten plants was recorded as branches plant^{-1}.

3.9.3 Dry weight plant^{-1}

Randomly selected plants from each plot excluding the harvest area and sampled plants were uprooted and oven dried and weighed. The average value were recorded in g plant^{-1}.

3.9.4 Pods plant^{-1}

Total number of pods were collected from 10 randomly selected plants and then averaged to express in number of pods plant^{-1}.

3.9.5 Weight of 1000-seeds

A composite sample was taken from each plot from where the 1000-seeds were counted and weighed with a digital electric balance. The 1000-seed weight was recorded in gram.

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

After threshing, cleaning and drying, total seed from harvested area (3.24 m^2) were recorded and was converted to kg ha^{-1}.

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

After separation of seeds from plant, the straw and shell harvested area was sun dried and the weight was recorded and then converted into kg ha^{-1}.

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

The summation of seed yield and above ground stover yield was the biological yield. Biological yield =Grain yield + Stover yield.

3.9.9 Harvest index (%)

Harvest index was calculated by dividing the economic (seed) yield from the net plot by the total biological yield (seed + stover) from the same area (Donald, 1963) and multiplying by 100.

$$\text{Harvest index (\%)} = \frac{\text{Seed yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}} \times 100$$

3.10 Statistical analysis

The data obtained for different parameters were statistically analyzed to find out the significant difference between the results of nitrogen and phosphorus application on growth, yield and yield contributing characters of lentil. The mean values of all the characters were calculated and analysis of variance was performed by the ‘F’ (variance ratio) test. The significance of the difference among the treatment combinations means was estimated by the Duncan’s Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The results on effectiveness of various treatments including untreated control for achieving quality and higher yield of lentil have been described and discussed below in detail under the following heading:

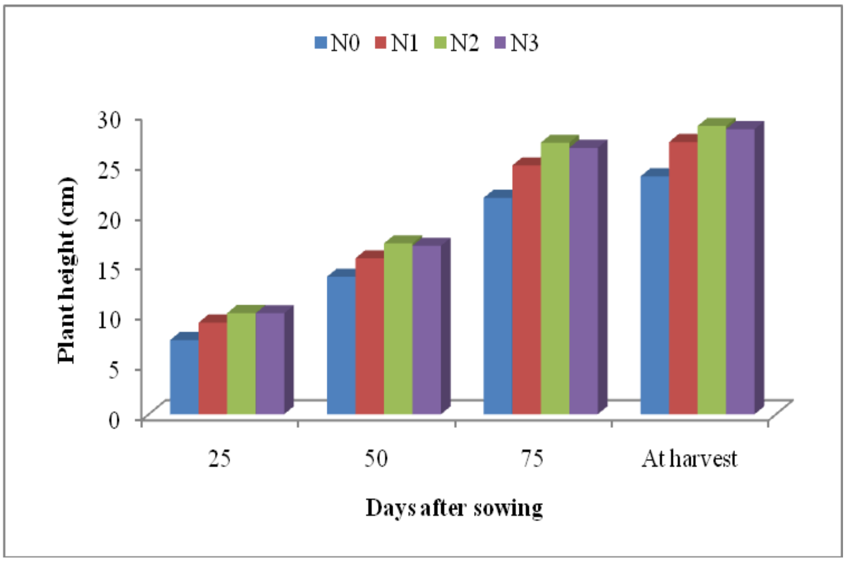
4.1 Growth parameters

The response of growth parameters like plant height (cm), branches plant^{-1} and dry weight plant^{-1} of lentil cv. BARI musar-6 following individual treatment of nitrogen and phosphorus levels and their combinations were found statistically significant (Figure 1 to 10 and Table 1, 2, 3).

4.1.1 Plant height

4.1.1.1 Effect of nitrogen

Plant height was significantly influenced by different rate of nitrogen application at different days after sowing (DAS) under the present study (Fig. 1). Results showed that application of 20 kg N ha^{-1} produced the tallest plant; 10.12, 17.09, 27.16 and 28.83 cm at 25, 50, 75 DAS and at harvest respectively and control treatment gave the lowest plant height; 7.42, 13.75, 21.65 and 23.79 cm at 25, 50, 75 DAS and at harvest, respectively. Further increase in nitrogen level beyond 30 kg N ha^{-1}could not improves plant height. These findings were in agreement with those of Quah and Jafar (1994), Hamid (1988) and Trung and Yoshida (1983).

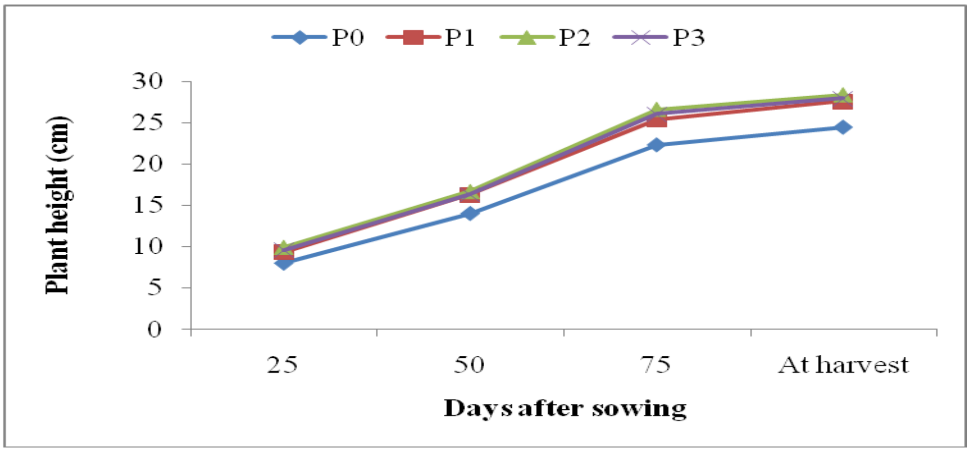


N_o= O kg N ha^{-1}, **N_1= 10 kg N** ha^{-1}, **N_2= 20 kg N** ha^{-1}, **N_3= 30 kg N** ha^{-1}

Figure 1. The effect of different levels of nitrogen on plant height of Lentil cv. 'BARI masur-6' (SE = 0.0021, .0019, .0015 and .0018 at 25, 50, 75 DAS and at harvest respectively).

4.1.1.2 Effect of phosphorus

Application of phosphorus fertilizer significantly increased plant height. The tallest plant; 9.96, 16.70, 26.63 and 28.38 cm at 25, 50, 75 DAS and at harvest respectively was recorded from phosphorus at the rate of 40 kg P_2O_5 ha^{-1}. The shortest plant at 25, 50, 75 DAS and at harvest (8.01, 14.01, 22.30 and 24.43 cm respectively) was recorded from control treatment. Likewise nitrogen level, more phosphorus dose could not improve plant height (Figure 2). These results agreed with those of Saraf and Shivakumar (1997) who observed that the plant height of lentil increased significantly up to 60 kg P_2O_5 ha^{-1}.



P_0= O kg P_2O_5 ha^{-1}, P_1=20 kg P_2O_5 ha^{-1}, P_2= 40 kg P_2O_5 ha^{-1}, P_3= 60 kg P_2O_5 ha^{-1}

Figure 2: The effect of different levels of phosphorus on plant height of lentil cv.'BARI masur-6' (SE = 0.0021, .0019, .0015 and .0018 at 25, 50, 75 DAS and at harvest respectively).

4.1.1.3 Interaction effect of nitrogen and phosphorus

Table 1 showed that the combination of nitrogen and phosphorus levels had significant effect on plant height at different growth stages of lentil. Nitrogen at the rate of 20 kg ha^{-1} along with 40 kg P_2O_5 ha^{-1} (N_2P_2) gave the tallest plant; 10.80, 18.25, 29.00 and 30.11 cm at 25, 50, 75 DAS and at harvest respectively which was closely followed by N_3P_2 at 25, 50, DAS and at harvest. Control treatment (N_0P_0) gave the lowest plant height at 25, 50, 75 DAS and at harvest (5.46, 11.34, 18.55 and 20.15 cm respectively).

The increase in plant height could be due to either cell elongation or cell multiplication or tissue differentiation or both of them which was influenced by optimum levels of fertilizer. The finding obtained from the present study in terms of plant height was in agreement with those of Yein *et al.* (1981).

Table 1. Interaction effect of different levels of nitrogen and phosphorus on plant height of lentil cv. 'BARI masur-6'

Treatments	Plant height (cm)			
	25 DAS	50 DAS	75 DAS	At harvest
N_0P_0	5.46 j	11.34 k	18.55 l	20.15 l
N_0P_1	7.10 i	14.01 j	21.08 k	24.21 k
N_0P_2	8.60 gh	14.70 hi	23.12 i	25.18 ij
N_0P_3	8.53 gh	14.94 gh	23.84 hi	25.62 hi
N_1P_0	8.36 h	14.20 ij	22.14 j	24.78 jk
N_1P_1	9.08 fg	15.78 ef	25.23 fg	27.51 f
N_1P_2	9.74 c-e	16.15 e	26.28 de	28.39 e
N_1P_3	9.50 d-f	16.28 e	25.89 ef	28.23 e
N_2P_0	9.34 ef	15.35 fg	24.48 gh	26.68 g
N_2P_1	10.43 ab	17.44 b-d	27.22 bc	29.04 cd
N_2P_2	10.80 a	18.25 a	29.00 a	30.11 a
N_2P_3	10.00 b-d	16.91 d	26.77 cd	28.54 de
N_3P_0	8.88 f-h	15.14 gh	24.03 h	26.12 gh
N_3P_1	10.61 ab	17.81 ab	27.92 b	29.66 a-c
N_3P_2	10.71 a	17.68 a-c	28.11 b	29.83 ab
N_3P_3	10.19 a-c	17.16 cd	27.68 b	29.42 bc
SE	0.004	0.004	0.004	0.004
CV(%)	6.58	5.04	7.02	8.12

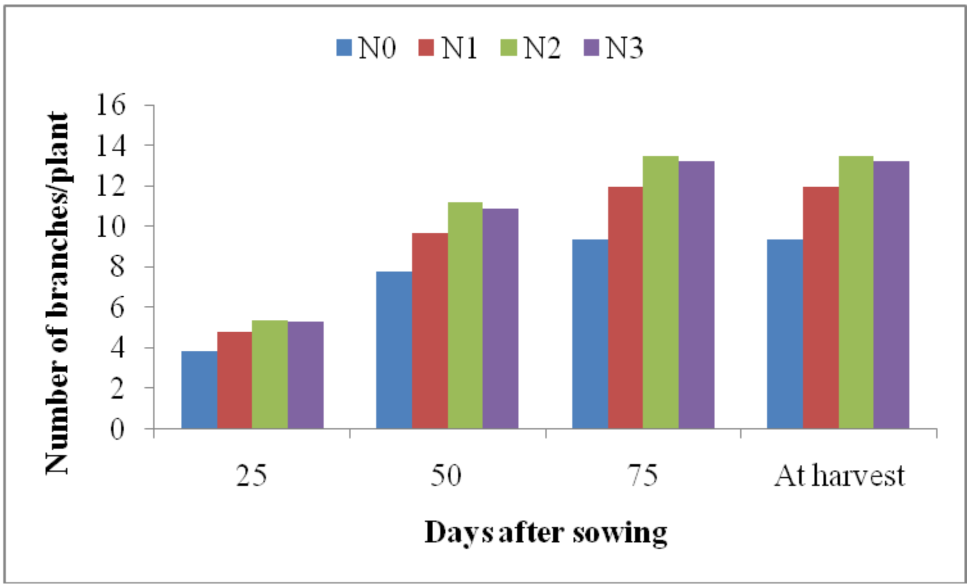
N_0 = 0 kg N ha^{-1}
N_1 = 10 kg N ha^{-1}
N_2 = 20 kg N ha^{-1}
N_3 = 30 kg N ha^{-1}

P_0 = 0 kg P_2O_5 ha^{-1}
P_1 = 20 kg P_2O_5 ha^{-1}
P_2 = 40 kg P_2O_5 ha^{-1}
P_3 = 60 kg P_2O_5 ha^{-1}

4.1.2 Branches plant^{-1}

4.1.2.1 Effect of nitrogen

Number of branches plant^{-1} was significantly influenced by different rate of nitrogen application at different days after sowing (DAS) under the present study. Application of 20 kg N ha^{-1} produced the highest number of branches plant^{-1}; 5.40, 11.17, 13.44 and 13.44 at 25, 50, 75 DAS and at harvest respectively and control treatment gave the lowest result; 3.87 , 7.76 , 9.33 and 9.33 at 25, 50, 75 DAS and at harvest respectively. Further increase in nitrogen level beyond 30 kg N ha^{-1} could not improve number of branches plant^{-1} (Figure 3). These findings were in agreement with those of Patel and Parmer (1986).

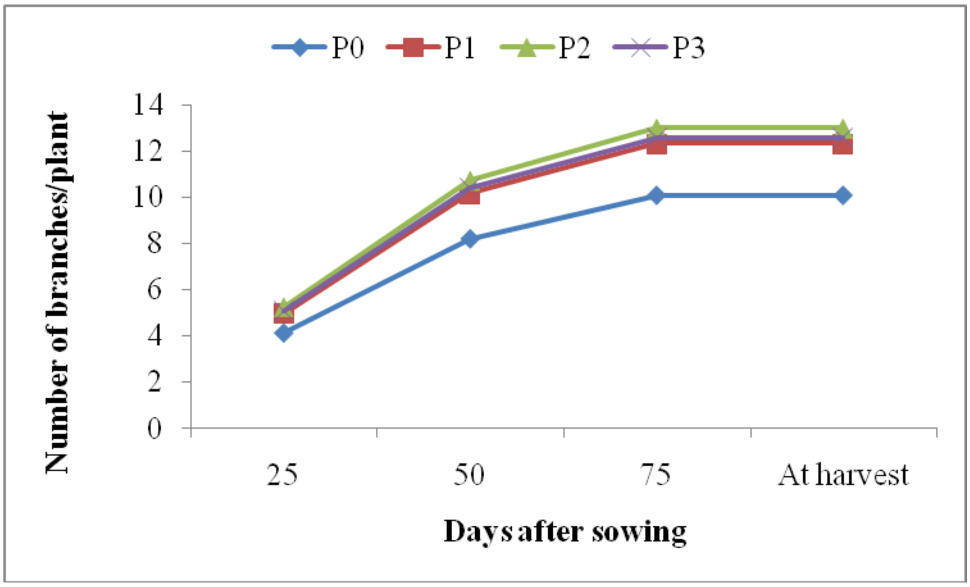


N_o= O kg N ha^{-1}, N_1= 10 kg N ha^{-1}, N_2= 20 kg N ha^{-1}, N_3= 30 kg N ha^{-1}

Figure 3. The effect of different levels of nitrogen on number of branches plant^{-1} of lentil cv. BARI masur-6’ (SE = 0.0016, 0.0023, 0.0042 and 0.0046 at 25, 50, 75 DAS and at harvest respectively)

4.1.2.2 Effect of phosphorus

Application of phosphorus fertilizer significantly increased number of branches plant^{-1}. The highest number of branches plant^{-1}; 5.22, 10.72, 12.99 and 12.99 at 25, 50, 75 DAS and at harvest respectively was recorded from phosphorus at the rate of 40 kg ha^{-1}. The number of branches plant^{-1} at 25, 50, 75 DAS and at harvest (4.11, 8.19, 10.07 and 10.07 respectively) was recorded from control treatment. Likewise nitrogen level, more phosphorus dose could not improve number of branches plant^{-1} (Figure 4). These results agreed with those of Saxena *et al.* (1996) and Saraf and Shivakumar (1997). Saraf and Shivakumar (1997) also observed that the number of branches plant^{-1} of lentil increased significantly up to 30 kg P_2O_5 ha^{-1}.



P_0= O kg P_2O_5 ha^{-1}, **P_1=20 kg** P_2O_5 ha^{-1}, **P_2= 40 kg** P_2O_5 ha^{-1}, **P_3 = 60 kg** P_2O_5 ha^{-1}

Figure 4. The effect of different levels of phosphorus on number of branches plant^{-1}of lentil cv. BARI masur-6' (SE = 0.0016, 0.0023, 0.0042 and 0.0046 at 25, 50, 75 DAS and at harvest respectively).

4.1.2.3 Interaction effect of nitrogen and phosphorus

Table 2 showed that the combination of nitrogen and phosphorus levels had significant effect on number of branches plant^{-1} at different studied date of lentil. Nitrogen at the rate of 20 kg ha^{-1} along with 40 kg P_2O_5 ha^{-1} (N_2P_2) gave the highest number of branches plant^{-1}; 5.82, 12.14, 14.56 and 14.56 at 25, 50, 75 DAS and at harvest respectively which was closely followed by N_3P_1 and N_3P_2 at all stages of recording dates. Control treatment (N_0P_0) gave the lowest number of branches plant^{-1} at 25, 50, 75 DAS and at harvest (3.10, 6.00, 7.18 and 7.18 respectively).

Table 2. Interaction effect of different levels of nitrogen and phosphorus on number of branches plant^{-1} of lentil cv. BARI masur-6'

Treatments	**Number of branches plant^{-1}**			
	25 DAS	**50 DAS**	**75 DAS**	**At harvest**
N_0P_0	3.10 m	6.00 l	7.18 j	7.18 j
N_0P_1	3.92 l	7.64 k	9.45 i	9.45 i
N_0P_2	4.16 jk	8.57 ij	10.21 hi	10.21 hi
N_0P_3	4.30 j	8.85 hi	10.49 h	10.49 h
N_1P_0	4.01 kl	8.17 jk	9.88 hi	9.88 hi
N_1P_1	4.89 gh	9.85 fg	12.28 ef	12.28 ef
N_1P_2	5.18 ef	10.51 de	13.00 de	13.00 de
N_1P_3	5.04 fg	10.19 ef	12.76 de	12.76 de
N_2P_0	4.74 hi	9.47 gh	11.84 fg	11.84 fg
N_2P_1	5.44 cd	11.26 bc	13.54 b-d	13.54 b-d
N_2P_2	5.82 a	12.14 a	14.56 a	14.56 a
N_2P_3	5.32 de	11.00 cd	13.22 cd	13.22 cd
N_3P_0	4.56 i	9.13 hi	11.36 g	11.36 g
N_3P_1	5.64 ab	11.88 ab	14.05 ab	14.05 ab
N_3P_2	5.71 ab	11.66 ab	14.18 ab	14.18 ab
N_3P_3	5.58 bc	11.51 a-c	13.80 a-c	13.80 a-c
SE	0.003	0.005	0.008	0.009
CV(%)	7.11	5.08	8.05	8.32

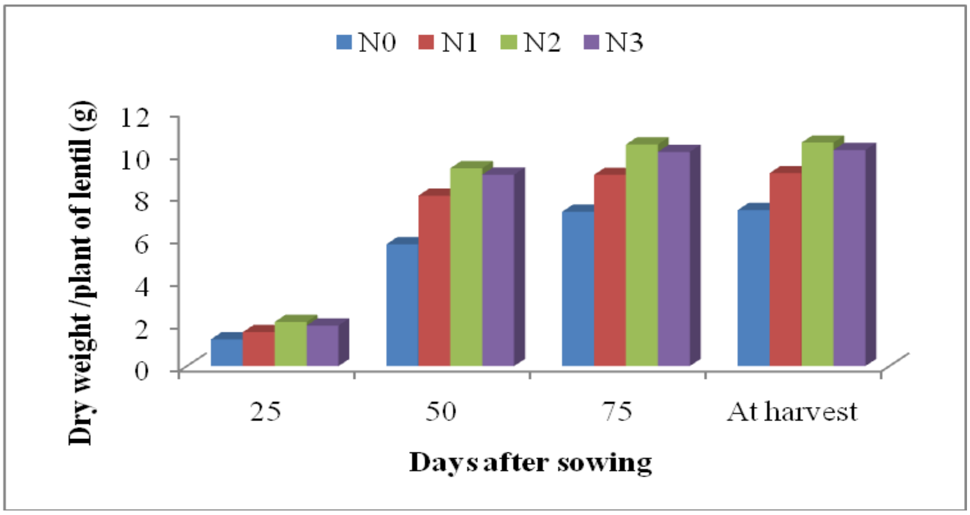
N_0 = 0 kg N ha^{-1}
N_1 = 10 kg N ha^{-1}
N_2 = 20 kg N ha^{-1}
N_3 = 30 kg N ha^{-1}

P_0 = 0 kg P_2O_5 ha^{-1}
P_1 = 20 kg P_2O_5 ha^{-1}
P_2 = 40 kg P_2O_5 ha^{-1}
P_3 = 60 kg P_2O_5 ha^{-1}

4.1.3 Dry weight plant^{-1}

4.1.3.1 Effect of nitrogen

Significant variation was observed when considering dry weight plant^{-1} by different rate of nitrogen application at different days after sowing (DAS) under the present study. Results indicated that application of 20 kg N ha^{-1} showed the highest dry weight plant^{-1} and that was 2.08, 9.32, 10.44 and 10.53 g at 25, 50, 75 DAS and at harvest respectively. Control treatment gave the lowest dry weight plant^{-1} which was 1.26, 5.74, 7.27 and 7.35 g at 25, 50, 75 DAS and at harvest respectively. Further it might be stated that dry weight plant^{-1} increased with increasing nitrogen application up to a certain level because of the highest doses of N ha^{-1}(30 kg ha^{-1}) under the present study showed lower dry weight plant^{-1} (Figure 5). These findings were in agreement with those of Srivastava and Varma (1982), Santos *et al.* (1993), Chowdhury and Rosario (1992), Agbenin *et al.* (1991), and Raju and Varma (1984).

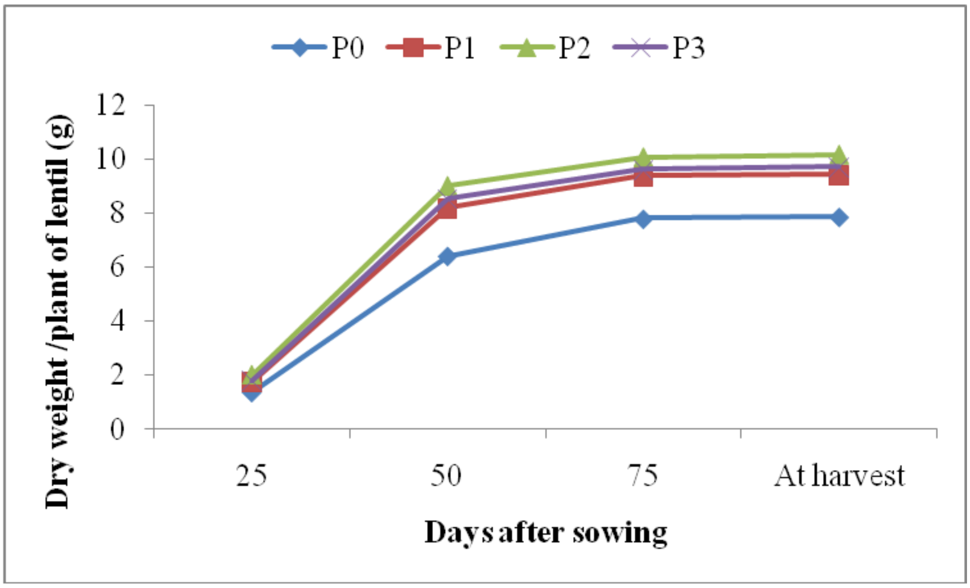


N_o= O kg N ha^{-1}, N_1= 10 kg N ha^{-1}, N_2= 20 kg N ha^{-1}, N_3= 30 kg N ha^{-1}

Figure 5. The effect of different levels of nitrogen on dry weight plant^{-1} of lentil cv. BARI masur-6' (SE = 0.0022, 0.0032, 0.0033 and 0.0049 at 25, 50, 75 DAS and at harvest respectively)

4.1.3.2 Effect of phosphorus

Phosphorus fertilizer application significantly increased dry weight plant^{-1} of lentil and it was remarked that the highest dry weight plant^{-1} (2.00, 9.01, 10.07 and 10.17 g at 25, 50, 75 DAS and at harvest respectively) was achieved with 40 kg P_2O_5 ha^{-1} where the lowest effect (1.34, 6.40, 7.78 and 7.85 g at 25, 50, 75 DAS and at harvest respectively) was recorded from the control treatment. Like nitrogen of additional phosphorus dose could not get better dry weight plant^{-1} (Figure 6). These results agreed with those of Saxena *et al.* (1996), Tomar *et al.* (1999), Sharma *et al.* (1994) and Kalita (1989) who observed that dry weight plant^{-1} significantly increased with increasing up to a certain level.



P_o= O kg P_2O_5 ha^{-1}, P_1=20 kg P_2O_5 ha^{-1}, P_2= 40 kg P_2O_5 ha^{-1}, P_3 = 60 kg P_2O_5 ha^{-1}

Figure 6. The effect of different levels of phosphorus on dry weight plant^{-1} of lentil cv. BARI masur-6' (SE = 0.0022, 0.0032, 0.0033 and 0.0049 at 25, 50, and 75 DAS and at harvest respectively).

4.1.3.3 Interaction effect of nitrogen and phosphorus

Irrespective of treatment differences accumulation of dry weight of plant started slowly at early stage then increased rapidly from 50 DAS to 75 DAS. Results obtained with the present experiment for dry weight plant^{-1} presented in Table 3 showed that the combination of nitrogen and phosphorus levels had significant effect at different growth stages of lentil. Nitrogen at the rate of 20 kg ha^{-1} along with 40 kg P_2O_5 ha^{-1} (N_2P_2) provided the highest dry weight plant^{-1} (2.58, 10.45, 11.58 and 11.67 g at 25, 50, 75 DAS and at harvest respectively) and control treatment (N_0P_0) presented the lowest at 25, 50, 75 DAS and at harvest (1.02, 4.03, 5.91 and 5.94 g respectively). Bhuiya (2005) obtained higher dry weight plant^{-1} by applying 25 kg N ha^{-1} and 45 kg P_2O_5 ha^{-1}. The present finding is also in agreement with those of Swain (2008) and Yein *et al.* (1981). The increase in dry weight plant^{-1} could be due to either availability of nutrients or optimum doses of fertilizers or both of them which influenced dry weight plant^{-1}.

Table 3. Interaction effect of different levels of nitrogen and phosphorus on dry weight plant^{-1} of lentil cv. BARI masur-6

Treatments	**Dry weight plant^{-1}** (g)			
	25 DAS	**50 DAS**	**75 DAS**	**At harvest**
N_0P_0	1.02 n	4.03 l	5.91 m	5.94 m
N_0P_1	1.24 m	5.31 k	6.90 l	6.98 l
N_0P_2	1.36 kl	6.71 i	8.01 jk	8.14 jk
N_0P_3	1.43 jk	6.91 i	8.24 ij	8.34 ij
N_1P_0	1.29 lm	6.08 j	7.84 k	7.90 k
N_1P_1	1.62 gh	8.38 f	9.15 fg	9.21 fg
N_1P_2	1.78 ef	8.78 e	9.66 e	9.71 e
N_1P_3	1.70 fg	8.88 de	9.41 ef	9.53 ef
N_2P_0	1.55 hi	7.94 g	8.86 gh	8.94 gh
N_2P_1	1.94 cd	9.12 cd	10.40 cd	10.48 cd
N_2P_2	2.58 a	10.45 a	11.58 a	11.67 a
N_2P_3	1.88 de	8.98 de	10.09 d	10.15 d
N_3P_0	1.49 ij	7.55 h	8.51 hi	8.61 hi
N_3P_1	2.18 b	9.87 b	10.94 b	11.01 b
N_3P_2	2.26 b	10.04 b	11.02 b	11.16 b
N_3P_3	2.05 c	9.41 c	10.71 bc	10.81 bc
SE	0.004	0.006	0.007	0.010
CV(%)	8.32	6.14	7.12	9.03

N_0 = 0 kg N ha^{-1}
N_1 = 10 kg N ha^{-1}
N_2 = 20 kg N ha^{-1}
N_3 = 30 kg N ha^{-1}

P_0 = 0 kg P_2O_5 ha^{-1}
P_1 = 20 kg P_2O_5 ha^{-1}
P_2 = 40 kg P_2O_5 ha^{-1}
P_3 = 60 kg P_2O_5 ha^{-1}

4.2 **Yield attributes**

The response of yield attributes considered as number of pods plant^{-1}, number of seeds pod^{-1} and 1000 seed weight of lentil cv. BARI musur-6 following individual treatment of nitrogen and phosphorus levels and their combinations were found statistically significant (Figure 7, 8 and Table 4).

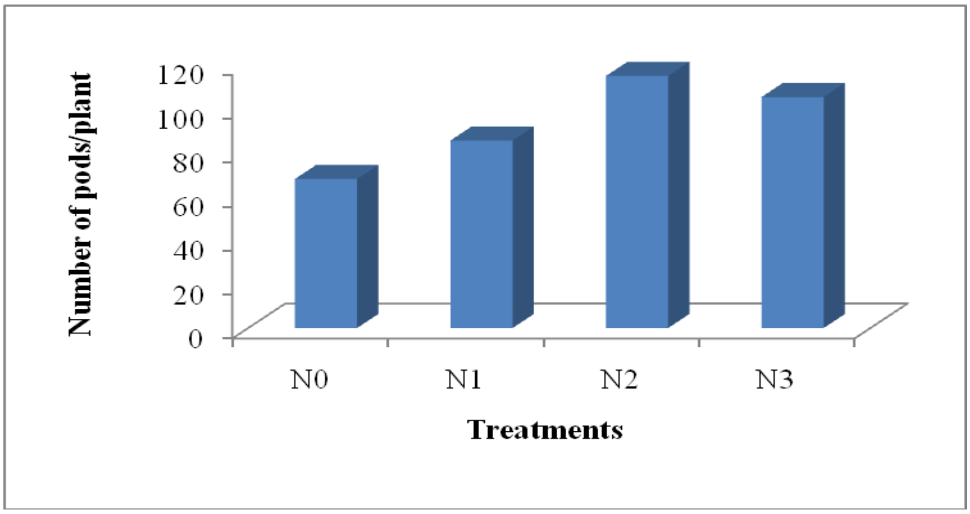
4.2.1 Pods plant^{-1}

4.2.1.1 Effect of nitrogen

Number of pods plant^{-1} is one of the most important yield contributing characters in lentil. The number of pods plant^{-1} was significantly affected by different levels of nitrogen fertilizers. The results obtained from the present experiment represented in Fig. 7 showed that the number of pods plant^{-1} increased with the increase level of nitrogen up to 20 kg ha^{-1} and then declined. The highest number of pods plant^{-1} (114.8) was recorded at 20 kg N ha^{-1} which was significantly different from other nitrogen levels. The lowest number of pods plant^{-1} (67.87) was recorded from no nitrogen application (control). Similar finding also reported by Satyanarayanamma *et al*. (1996).

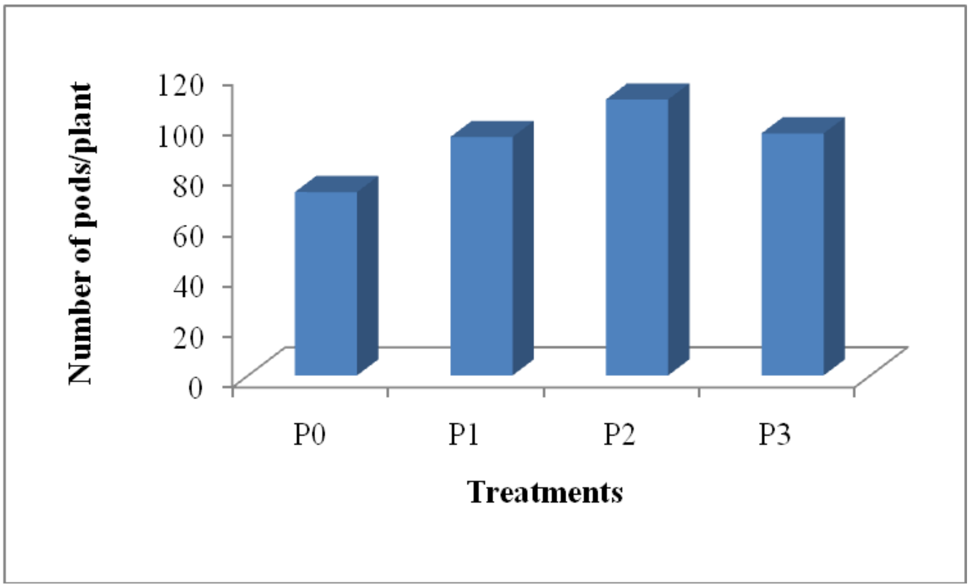
4.2.1.2 Effect of phosphorus

Significant variations were clearly evident in case of number of pods plant^{-1} with different phosphorus levels (Fig. 8). Increase in phosphorus levels to 40 kg ha^{-1} showed the highest number of pods plant^{-1}. The highest number of pods plant^{-1} (109.60) resulted from 40 kg P_2O_5 ha^{-1} and the lowest (72.83) was obtained from control treatment with a difference of 26.77 in number. Further increase in phosphorus level could not increase number of pods plant^{-1}. Similar result was found by Saxena *et al.* (1996) and they observed that seed yield of lentil was positively correlated with number of pods plant^{-1} which was close agreement with the result.



N_o= O kg N ha^{-1}, N_1= 10 kg N ha^{-1}, N_2= 20 kg N ha^{-1}, N_3= 30 kg N ha^{-1}

Figure 7. Effect of different levels of nitrogen on pods plant^{-1} of lentil cv. BARI masur-6' (SE = 0.0105).



P_o= O kg P_2O_5 ha^{-1}, P_1=20 kg P_2O_5 ha^{-1}, P_2= 40 kg P_2O_5 ha^{-1}, P_3 = 60 kg P_2O_5 ha^{-1}

Figure 8. Effect of different levels of phosphorus on pods plant^{-1} of lentil cv. BARI masur-6' (SE = 0. 0105).

4.2.1.3 Interaction effect of nitrogen and phosphorus

Pods $plant^{-1}$ is an important yield contributing character which has a great effect on final yield. The combination of 20 kg N ha^{-1} and 40 kg P_2O_5 ha^{-1} supported plant to maximum production and pods $plant^{-1}$ which could positively influenced the higher dry matter production. It was observed that under the present study, nitrogen and phosphorus showed significant effect on pods $plant^{-1}$ (Table 4). The highest number of pods $plant^{-1}$ (140.70) produced with 20 kg N ha^{-1} and 40 kg P_2O_5 ha^{-1} (N_2P_2). The lowest number of pods $plant^{-1}$ (58.44) was given by the control combination (N_0P_0). Tank *et al.* (1992), Sarkar and Banik (1991), Suhartatik (1991), Salimullah *et al.* (1987) and Yein *et al.* (1981) obtained higher number of pods $plant^{-1}$ with the interaction of N and P which were closely related with the present finding.

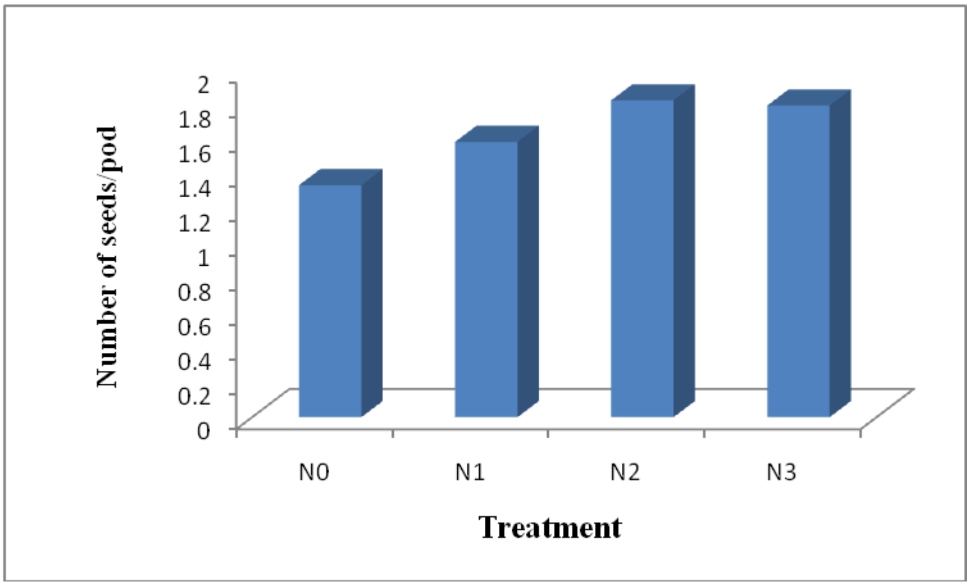
4.2.2 Seeds pod^{-1}

4.2.2.1 Effect of nitrogen

Different levels of N fertilizer had significant effect on number of seeds pod^{-1} of lentil (Fig. 9). Application of nitrogen at different levels significantly increased the number of seeds pod up to 20 kg ha^{-1} which produced maximum number of seeds pod^{-1} (1.83) which was not significantly different from N_3 where control treatment gave the lowest one (1.34) but significantly at par to N_1.

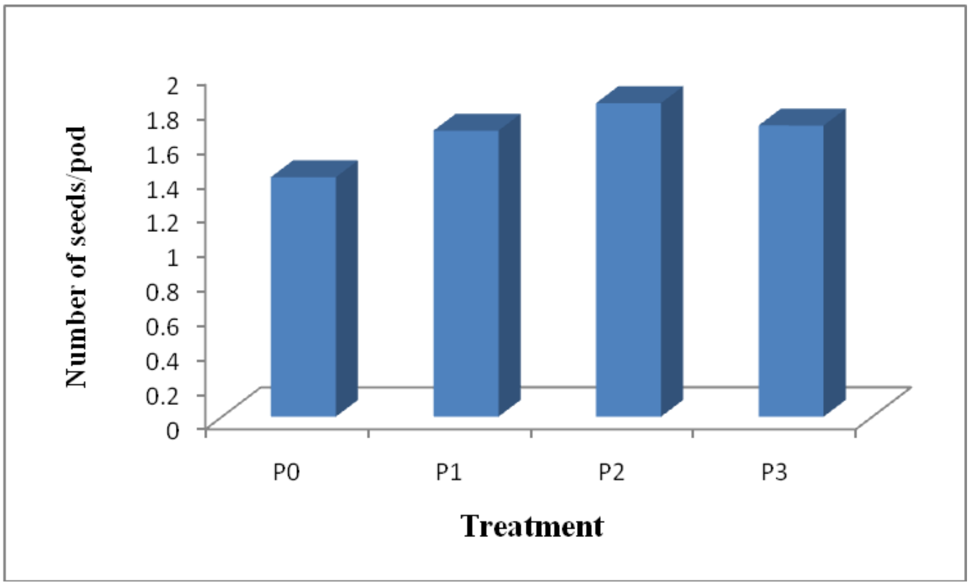
4.2.2.2 Effect of phosphorus

The results from Fig.10 revealed that phosphorus levels had significant effect on number of seeds pod^{-1}. The application of phosphorus significantly increased number of seeds pod^{-1}. Application of 40 kg P_2O_5 ha^{-1} gave the highest number of seeds pod^{-1} (1.82) where as control treatment gave the lowest (1.39) number of seeds pod^{-1}. Further increase in phosphorus level beyond 40 kg P_2O_5 ha^{-1} could not improve number of seeds pod^{-1}.



N_o= O kg N ha^{-1}, N_1= 10 kg N ha^{-1}, N_2= 20 kg N ha^{-1}, N_3= 30 kg N ha^{-1}

Figure 9. The effect of different levels of nitrogen on seeds pod^{-1} of lentil cv. BARI masur-6' (SE = 0.0118).



P_o= O kg P_2O_5 ha^{-1}, P_1=20 kg P_2O_5 ha^{-1}, P_2= 40 kg P_2O_5 ha^{-1}, P_3 = 60 kg P_2O_5 ha^{-1}

Figure 10. The effect of different levels phosphorus on seeds pod^{-1} of lentil cv. BARI masur-6' (SE = 0.0118).

4.2.2.3 Interaction effect of nitrogen and phosphorus

Number of seeds pod^{-1} is also an important yield contributing character which has a great effect on final yield. It was observed that treatment combination of nitrogen and phosphorus had significant effect on number of seeds pod^{-1} under the present study (Table 4). The combination of 20 kg N ha^{-1} with 40 kg P_2O_5 ha^{-1} (N_2P_2) supported plant to produce maximum number of seeds pod^{-1}(2.11) where the lowest one (1.12) was achieved with control treatment (N_0P_0). The results from all other treatments showed significantly different results compared to highest and lowest value regarding number of seeds pod^{-1}.

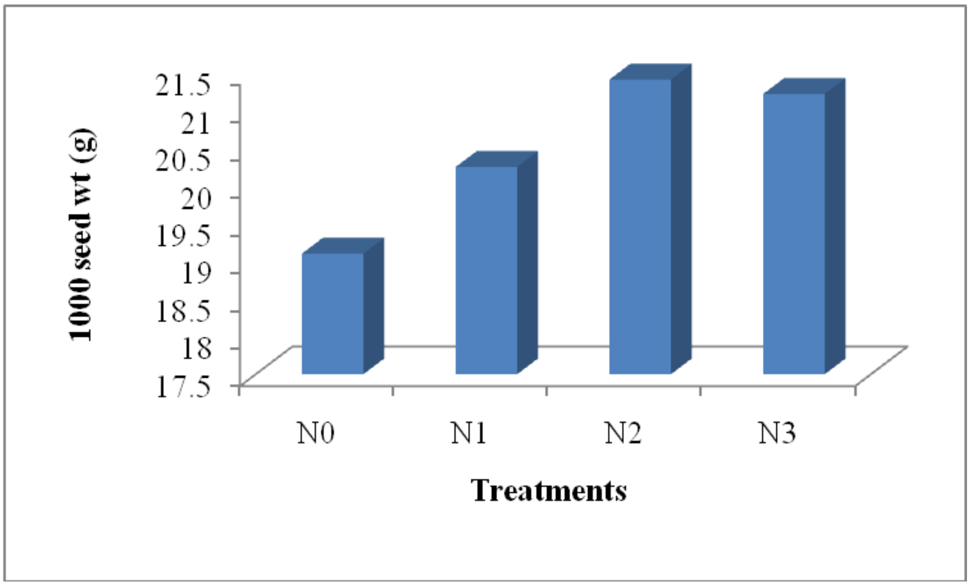
4.2.3 1000 seed weight

4.2.3.1 Effect of nitrogen

Different levels of N fertilizer had significant effect on 1000 seed weight of lentil (Fig. 11). Application of nitrogen at different levels significantly increased the 1000-seed weight up to 20 kg ha^{-1} which produced maximum seed weight (21.41 g) where control treatment gave the lowest seed weight (19.10 g). Further the highest nitrogen dose (30 kg ha^{-1}) under the present study could not improve 1000-seed weight significantly. Quah and Jafar (1994) also obtained highest 1000-seed weight of mungbean with 50 kg N ha^{-1}.

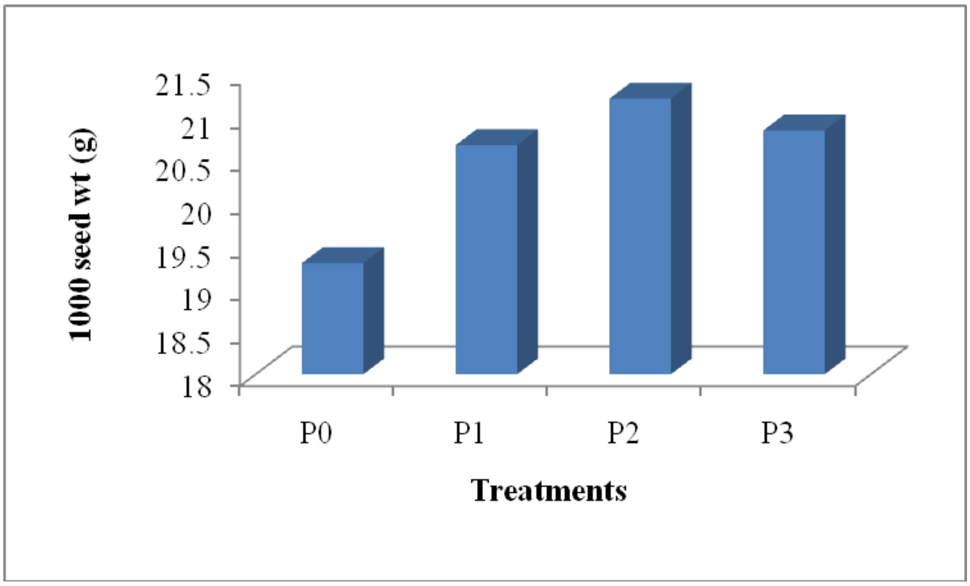
4.2.3.2 Effect of phosphorus

The results from Fig.10 reveals that phosphorus levels had significant effect on 1000-seed weight (Fig.12).The application of phosphorus significantly increased 1000-seed weight. Application of 40 kg P_2O_5 ha^{-1} gave the highest 1000-seed weight (21.20g) where as control treatment gave the lowest (19.29g) 1000-seed weight. Further increase in phosphorus level beyond 40 kg P_2O_5 ha^{-1} could not improve 1000-seed weight. Saxena *et al.* (1996) obtained significant effect on 1000-seed weight and highest was recorded from 30 to 60 kg $P_2O_5ha^{-1}$ in respective three years.



N_o= O kg N ha^{-1}, N_1= 10 kg N ha^{-1}, N_2= 20 kg N ha^{-1}, N_3 = 30 kg N ha^{-1}

Figure 11. The effect of different levels of nitrogen on 1000 seed weight of lentil cv. BARI masur-6' (SE = 0.012).



P_o= O kg P_2O_5 ha^{-1}, P_1=20 kg P_2O_5 ha^{-1}, P_2= 40 kg P_2O_5 ha^{-1}, P_3 = 60 kg P_2O_5 ha^{-1}

Figure 12. The effect of different levels phosphorus on 1000 seed weight of lentil cv. BARI masur-6' (SE = 0.012)

4.2.3.3 Interaction effect of nitrogen and phosphorus

The 1000 seed weight is an important yield contributing character which has a great effect on final yield. It was observed that treatment combination of nitrogen and phosphorus had significant effect on 1000-seed weight under the present study (Table 4). The combination of 20 kg N ha^{-1} with 40 kg P_2O_5 ha^{-1} (N_2P_2) supported plant to produce maximum 1000-seed weight (22.22 g) where the lowest one (18.00 g) was achieved with control treatment (N_2P_2). Swain (2008) also obtained highest number of 1000-seed weight with the interaction of N upto 25 kg ha^{-1} and P_2O_5 upto 45 kg ha^{-1} and Patel *et al.* (1984) obtained the highest number of 1000-seed weight with the interaction of 40 kg P_20_5 ha^{-1} along with 20 kg N ha^{-1}.

Table 4. The effect of different levels of nitrogen and phosphorus on yield contributing characters of lentil cv. BARI masur-6'

Treatments	Number of pods $plant^{-1}$	Number of seeds/pod	1000 seed wt (g)
N_0P_0	58.44 l	1.12 m	18.00 j
N_0P_1	64.11 k	1.28 l	19.04 i
N_0P_2	71.17 j	1.44 jk	19.59 h
N_0P_3	77.77 i	1.49 ij	19.77 gh
N_1P_0	66.88 jk	1.39 k	19.26 i
N_1P_1	87.41 gh	1.61 gh	20.16 f
N_1P_2	96.17 f	1.71 ef	21.02 d
N_1P_3	91.15 g	1.65 fg	20.57 e
N_2P_0	83.47 h	1.55 hi	20.01 fg
N_2P_1	106.40 e	1.80 de	21.54 c
N_2P_2	140.70 a	2.11 a	22.22 a
N_2P_3	100.40 f	1.76 e	21.33 c
N_3P_0	82.54 hi	1.51 ij	19.89 f-h
N_3P_1	120.90 c	1.95 bc	21.91 ab
N_3P_2	130.30 b	2.01 b	21.98 a
N_3P_3	115.20 d	1.86 cd	21.63 bc
SE	0.021	0.023	0.024
CV (%)	6.04	6.14	6.02

N_0 = 0 kg N ha^{-1}
N_1 = 10 kg N ha^{-1}
N_2 = 20 kg N ha^{-1}
N_3 = 30 kg N ha^{-1}

P_0 = 0 kg P_2O_5 ha^{-1}
P_1 = 20 kg P_2O_5 ha^{-1}
P_2 = 40 kg P_2O_5 ha^{-1}
P_3 = 60 kg P_2O_5 ha^{-1}

4.3 Yield parameters

4.3.1 Seed yield

4.3.1.1 Effect of nitrogen

In the present study, significant variation was found in seed yield at different nitrogen levels (Table 5). The rate of nitrogen at 20 kg ha^{-1} (N_2) produced the highest seed yield (1768 kg ha^{-1}) and control treatment gave the lowest seed yield (959.75 kg ha^{-1}) with a difference of 808.25 kg ha^{-1}. Treatment 30 kg N ha^{-1} (N_3) though produced lower seed yield (1749.75 kg ha^{-1}) but it statistically similar with N_2. The highest seed yield ha^{-1} was also obtained with Bachchhav *et al.* (1994), Inthong (1987), Srivastava and Verma (1982), Patel *et al.* (2001) and Mozumder *et al.* (2003) and they reported that increased yield was obtained with increased nitrogen level at a certain level in case of pulse crops.

4.3.1.2 Effect of phosphorus

Significant variation was remarked in seed yield among the application of different phosphorus levels represented in Table 5. Phosphorus rate at 40 kg ha^{-1} gave the highest seed yield (1695.00 kg ha^{-1}). Seed yield decreased with the decreasing or increasing application of phosphorus fertilizer than 40 kg ha^{-1}. The lowest seed yield (1114.00 kg ha^{-1}) was obtained with control treatment. The seed yield was increased with 581 kg ha^{-1} with 40 kg P_2O_5 ha^{-1} over control. Similar findings were also obtained by Dubey *et al.* (1993), Saraf and Shivakumar (1997), Saxena *et al.* (1996) and Thakur *et al.* (2000) and they reported that increased phosphorus application demonstrated higher yield of pulse crops at a certain level.

4.3.1.3 Interaction effect of nitrogen and phosphorus

It was revealed that nitrogen and phosphorus combination influenced per hectare seed yield and it was significantly superior (2145 kg ha^{-1}) at 20 kg N ha^{-1} with 40 kg P_2O_5 ha^{-1} (N_2P_2). But control treatment (N_0P_0) gave the lowest seed yield (802 kg ha^{-1}). The increased seed yield with (N_2P_2) over control (N_0P_0) was 1343 kg ha^{-1} (Table 5) and among the treatments N_2P_2 was significantly different from all other treatments. Swain (2008) observed significantly higher seed yield at N upto 50 kg ha^{-1} in combination with P_2O_5 upto 80 kg ha^{-1} for mungbean plant. But Bhuiya (2005) obtained higher yield of lentil at 25 kg N ha^{-1} in combination with 45 kg P_2O_5 ha^{-1}.

4.3.2 Stover yield

4.3.2.1 Effect of nitrogen

Stover yield was found to be significant at different levels of nitrogen application (Table 5). The rate of nitrogen at 20 kg ha^{-1} (N_2) produced the highest stover yield (3301.50 kg ha^{-1}) and control treatment gave the lowest stover yield (2552.00 kg ha^{-1}). The 30 kg N ha^{-1} (N_3) also produced stover yield (3295 kg ha^{-1}) which was significantly same with N_2. The higher stover yield with higher rate of nitrogen application might be due to cause of higher plant growth, dry matter accumulation or higher rate of nutrient availability.

4.3.2.2 Effect of phosphorus

Significant variation was remarked incase of stover yield among the application of different phosphorus levels presented in Table 5. Phosphorus rate at 40 kg ha^{-1} (P_2) gave the highest stover yield (3217.75 kg ha^{-1}). Stover yield decreased with the decreasing or increasing application of phosphorus fertilizer than 40 kg ha^{-1}. The lowest stover yield (2735.50 kg ha^{-1}) was obtained with control treatment. Similar findings were also obtained by Ahmed *et al.* (1986) and they reported that phosphorous up to 60 kg P_2O_5 ha^{-1} significantly enhanced straw production of mungbean.

4.3.2.3 Interaction effect of nitrogen and phosphorus

It was revealed that nitrogen and phosphorus combination influenced per hectare stover production and it was significantly superior (3545 kg ha^{-1}) at 20 kg N ha^{-1} with 40 kg P_2O_5 ha^{-1} (N_2P_2). But control treatment (N_0P_0) gave the lowest stover production (2394 kg ha^{-1}). The increased stover yield with N_2P_2 over control (N_0P_0) was 1151 kg ha^{-1} (Table 5) and among the treatments N_2P_2 was significantly different from all other treatments. Bhuiya (2005) observed straw yield performance of lentil was higher with 25 kg N ha^{-1} and 45 kg P_2O_5 ha^{-1}.

4.3.3 Biological yield

4.3.3.1 Effect of nitrogen

The results obtained incase of biological yield was found to be significant at different levels of nitrogen application (Table 5). The rate of nitrogen at 20 kg ha^{-1} (N_2) produced the highest biological yield (5069.50 kg ha^{-1}) and control treatment gave the lowest biological yield (3511.75 kg ha^{-1}). The results obtained from all other nitrogenous effect were significantly different. The higher biological yield with higher rate of nitrogen application might be due to cause of higher vegetative growth with higher nitrogen application.

4.3.3.2 Effect of phosphorus

Different phosphorus levels produced significant variation in biological yield of lentil (Table 5). The highest biological yield (4912.75 kg ha^{-1}) was obtained from the rate at 40 kg P_2O_5 ha^{-1} and biological yield decreased with the decreasing or increasing application of phosphorus fertilizer than 40 kg P_2O_5 ha^{-1}. The lowest biological yield (3849.50 kg ha^{-1}) was obtained with control treatment. Similar finding was obtained by Ahmed *et al.* (1986) incases of mungbean.

4.3.3.3 Interaction effect of nitrogen and phosphorus

The results from Table 5 showed that the biological yield was significantly varied among all the treatment combinations. The highest biological yield (5690 kg ha^{-1}) was achieved by 20 kg N ha^{-1} with 40 kg P_2O_5 ha^{-1} (N_2P_2). But control treatment (N_0P_0) gave the lowest biological yield (3196 kg ha^{-1}). Similar result was obtained by Bhuiya (2005).

4.3.4 Harvest index

4.3.4.1 Effect of nitrogen

Harvest index is an important measurement of yield performance. The harvest index was significantly affected by different levels of nitrogen fertilizers. The results obtained from the present experiment presented in Table 5 showed that the highest harvest index (34.54%) was recorded at (N_2) which was statistically similar with N_3 (30 kg N ha^{-1}). The lowest harvest index (27.22%) was recorded from no nitrogen application (control). The result obtained by Mozumder *et al.* (2003) was not similar and he stated that higher rate of nitrogen had negative effect on the harvest index.

4.3.4.2 Effect of phosphorus

Significant variations were observed for harvest index with different phosphorus levels (Table 5). Increase in phosphorus levels to 40 kg ha^{-1} showed higher harvest index. The highest harvest index (33.87%) resulted from 40 kg P_2O_5 ha^{-1} and the lowest (28.70%) was obtained from control treatment. Further decrease or increase in phosphorus level could not increase harvest index. Saxena *et al.* (1996) and Tomar *et al.* (1999) observed that harvest index increased significantly with increased P application to at a certain level.

4.3.4.3 Interaction effect of nitrogen and phosphorus

Combination between nitrogen and phosphorus levels may be important determining factor for harvest index and it was significantly influenced by N & P combination (Table 5). Significantly higher of harvest index was 37.70 % when applied 20 kg N ha^{-1} in combination with 40 kg P_2O_5 ha^{-1} (N_2P_2) which was significantly similar with N_3P_1 and N_3P_2 but significantly different from all other treatments. The lowest harvest index (25.09 %) was given by the control combination (N_0P_0). Similar result was also obtained by Malik *et al.* (2003) for mungbean crop.

Table 5. The effect of different levels of nitrogen and phosphorus on yield characters of lentil cv. BARI masur-6'

Treatments	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
Effect of nitrogen				
N_0	959.75 d	2552.00 c	3511.75 d	27.22 c
N_1	1418.50 c	3063.75 b	4482.25 c	31.50 b
N_2	1768.00 a	3301.50 a	5069.50 a	34.54 a
N_3	1749.75 ab	3295.00 a	5044.75 b	34.45 a
SE	0.036	0.044	0.041	0.0342
Effect of phosphorus				
P_0	1114.00 d	2735.50 d	3849.50 d	28.70 c
P_1	1518.00 c	3084.75 c	4602.75 c	32.35 b
P_2	1695.00 a	3217.75 a	4912.75 a	33.87 a
P_3	1569.00 b	3174.25 b	4743.25 b	32.79 b
SE	0.036	0.044	0.041	0.0342
Interaction effect of nitrogen and phosphorus				
N_0P_0	802 p	2394 p	3196 p	25.09 k
N_0P_1	892 o	2444 o	3336 o	26.74 j
N_0P_2	1003 n	2580 n	3583 n	27.99 ij
N_0P_3	1142 l	2790 l	3932 l	29.04 hi
N_1P_0	1100 m	2716 m	3816 m	28.83 hi
N_1P_1	1426 i	3081 i	4507 i	31.64 e-g
N_1P_2	1618 g	3266 g	4884 g	33.13 de
N_1P_3	1530 h	3192 h	4722 h	32.40 ef
N_2P_0	1332 j	2970 j	4302 j	30.96 fg
N_2P_1	1808 e	3362 e	5170 e	34.97 bc
N_2P_2	2145 a	3545 a	5690 a	37.70 a
N_2P_3	1714 f	3303 f	5017 f	34.16 cd
N_3P_0	1222 k	2862 k	4084 k	29.92 gh
N_3P_1	1946 c	3452 c	5398 c	36.05 ab
N_3P_2	2014 b	3480 b	5494 b	36.66 ab
N_3P_3	1890 d	3412 d	5302 d	35.65 bc
SE	0.072	0.088	0.082	0.068
CV(%)	8.942	7.582	9.116	6.89

N_0 = 0 kg N ha^{-1}
N_1 = 10 kg N ha^{-1}
N_2 = 20 kg N ha^{-1}
N_3 = 30 kg N ha^{-1}

P_0 = 0 kg P_2O_5 ha^{-1}
P_1 = 20 kg P_2O_5 ha^{-1}
P_2 = 40 kg P_2O_5 ha^{-1}
P_3 = 60 kg P_2O_5 ha^{-1}

CHAPTER V

SUMMARY AND CONCLUSION

An experiment was conducted at the Agronomy Farm of Sher-e-Bangla Agricultural University, Dhaka to evaluate the response of lentil to different levels of nitrogen and phosphorous. The experiment comprised two different factors; (1) four levels of nitrogen application viz. N_0 (0 kg N ha^{-1}), N_1 (10 kg N ha^{-1}), N_2 (20 kg N ha^{-1}) and N_3 (30 kg N ha^{-1}) (2) Four levels of phosphorus application viz. P_0 (0 kg P_2O_5 ha^{-1}), P_1 (20 kg P_2O_5 ha^{-1}), P_2 (40 kg P_2O_5 ha^{-1}), and P_3 (60 kg P_2O_5 ha^{-1}).

The experiment was set up in Randomized Complete Block Design (factorial) with three replications. There were 16 treatment combinations. The experimental plot was fertilized as per treatment with nitrogen and phosphatic fertilizers. Data on different growth and yield parameters were recorded and analyzed statistically.

Data were collected on plant height (cm), number of branches $plant^{-1}$, dry weight $plant^{-1}$(g), number of pods $plant^{-1}$,1000 seed weight (g), seed yield (t ha^{-1}), stover yield, biological yield and harvest index (%). Three effects have been considered to evaluate the experiment such as (i) Effect of nitrogen, (ii) Effect of phosphorus and (iii) Interaction effect of nitrogen and phosphorus.

Data recorded on growth parameters; plant height (cm), number of branches $plant^{-1}$ and dry weight $plant^{-1}$(g) as influenced by nitrogen were highest with N_2 (20 kg N ha^{-1}) and the highest results were 28.83 cm, 13.44 and 10.53 g respectively at the time of harvest. Again the highest results as influenced by phosphorus application on plant height (cm), number of branches plant and dry weight/plant were 28.38 cm, 12.99 and 10.17 g respectively with P_2 (40 kg P_2O_5 ha^{-1}). In both cases control treatments (N_0 = 0 kg N ha^{-1} and P_0 = 0 kg P_2O_5 ha^{-1}) showed the lowest results on growth parameters. Again, significant effect was also observed on plant height (cm), number of branches $plant^{-1}$ and dry weight $plant^{-1}$ by the combined effect of nitrogen and phosphorus and the highest values were 30.11 cm, 14.56 and 11.67 g respectively which was achieved by N_2P_2 (20 kg N ha^{-1} and 40 kg P_2O_5 ha^{-1}) where N_0P_0 (0 kg N ha^{-1} and 0 kg P_2O_5 ha^{-1}) showed the lowest results (20.15 cm, 7.18 and 5.94 g respectively).

In terms of yield contributing parameters; number of pods $plant^{-1}$, 1000 seed weight (g), and harvest index (%) were significantly affected by nitrogen and phosphorus individually and/or their interaction. Nitrogen level of 20 kg ha^{-1} (N_2) showed the highest number of pods $plant^{-1}$ (114.80), 1000 seed weight (21.41 g) and harvest index (34.54%). Higher nitrogen level at 30 kg N ha^{-1} could not show better performance in above three yield contributing characters. The phosphorus level of 40 kg ha^{-1} (P_2) showed the highest number of pods $plant^{-1}$(109.60), 1000 seed weight (21.20 g) and harvest index (33.87%). With the interaction effect of nitrogen and phosphorus; N_2P_2 (20 kg N ha^{-1} and 40 kg P_2O_5 ha^{-1}) represented the highest number of pods $plant^{-1}$ (140.70), 1000 seed weight (22.22 g) and harvest index (37.70%) where the lowest (58.44, 18.00 g and 24.15% respectively) was with N_0P_0 (0 kg N ha^{-1} and 0 kg P_2O_5 ha^{-1}).

The yield parameters of the study; grain yield, stover yield and biological yield were significantly influenced by nitrogen, phosphorus and their interaction. Nitrogen application at 20 kg ha^{-1} (N_2) showed the highest grain yield (2145.75 kg ha^{-1}), stover yield (3301.50 kg ha^{-1}) and biological yield (5069.50 kg ha^{-1}) where N_3 (30 kg ha^{-1}) showed the results which were closely related to N_2 in terms of grain yield and stover yield. Control treatment, N_0 (no nitrogen application) showed the lowest results of yield parameters. The phosphorus level of 40 kg ha^{-1} (P_2) showed the highest grain yield (1695.00 kg ha^{-1}), stover yield (3217.75 kg ha^{-1}) and biological yield (4912.75 kg ha^{-1}) where the lowest were obtained from control treatment, P_0. The combined effect of nitrogen and phosphorus, N_2P_2 (20 kg N ha^{-1} and 40 kg P_2O_5 ha^{-1}) showed the highest grain yield (2145 kg ha^{-1}), stover yield (3545 kg ha^{-1}) and biological yield (5690 kg ha^{-1}) where the lowest grain yield (802 kg ha^{-1}), stover yield (2394 kg ha^{-1}) and biological yield (3196 kg ha^{-1}) were obtained by control combination N_0P_0 (0 kg N ha^{-1} and 0 kg P_2O_5 ha^{-1}).

It may be concluded from the results that nitrogen and phosphorus application is very much promising for higher lentil yield. Comparing control treatment, nitrogen (10-30 kg ha^{-1}) and phosphorus application (20-60 kg ha^{-1}) at any rate showed better performance for lentil yield. However, the best nitrogen dose was 20 kg ha^{-1} and phosphorus dose was 40 kg ha^{-1} under the present study. The combination of N_2P_2 (20 kg N ha^{-1} with 40 kg P_2O_5 ha^{-1}) performed best in producing higher yield than other treatments comprised with other nitrogen and phosphorus levels under the present study.

The present research work was carried out at the Sher-e-Bangla Agricultural University and in one season only. Further trial of this work in different locations of the country is needed to justify the result for higher return of yield.

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APPENDICES

Appendix I. Monthly average air temperature, relative humidity and total rainfall of the experimental site during the period from October 2008 to March 2009

Month	RH (%)	Max. Temp. (ºC)	Min. Temp. (ºC)	Rainfall (mm)
October	73.36	29.46	19.19	Trace
November	71.15	26.98	14.88	Trace
December	68.30	25.78	14.21	Trace
January	69.53	25.00	13.46	0
February	50.31	29.50	18.49	0
March	44.95	33.80	20.28	0

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix II. Physical characteristics and chemical composition of soil of the experimental plot.

Soil Characteristics	Analytical results
Agroecological Zone	Madhupur Tract
P^H	5.47 – 5.63
Total N (%)	0.43
Available phosphorous	22 ppm
Exchangeable K	0.42 meq / 100 g soil
Sand	27%
Silt	43%
Clay	30%
Textural Class	Silty clay

Source: Soil Resource Development Institute, Khamarbari, Dhaka.

Appendix III. The effect of different levels of nitrogen and phosphorus on plant height of lentil cv. 'BARI masur-6'

Sources of variation	Degrees of freedom	Mean square of Plant height			
		25 DAT	50 DAT	75 DAT	At harvest
Replication	2	0.001	0.000	0.004	0.002
Factor A	3	19.382*	28.010*	14.353*	3.937*
Factor B	3	8.548*	17.976*	4.563*	2.911*
AB	9	0.809*	0.642*	1.394*	1.205*
Error	30	0.123	0.106	0.224	0.136

Appendix IV: The effect of different levels of nitrogen and phosphorus on number of branches plant^{-1} of lentil cv. BARI masur-6

Sources of variation	Degrees of freedom	Mean square of number of branches plant^{-1}			
		25 DAT	50 DAT	75 DAT	At harvest
Replication	2	0.001	0.001	0.004	0.004
Factor A	3	5.890*	28.434*	42.600*	42.600*
Factor B	3	3.001*	15.561*	20.572*	20.572*
AB	9	0.054*	0.377*	0.437*	0.437*
Error	30	0.012	0.134	0.023	0.023

Appendix V: The effect of different levels of nitrogen and phosphorus on dry weight plant^{-1} of lentil cv. BARI masur-6

Sources of variation	Degrees of freedom	Mean square dry weight plant^{-1}			
		25 DAT	50 DAT	75 DAT	At harvest
Replication	2	0.000	0.001	0.002	0.001
Factor A	3	1.542	31.560*	4.368*	24.491*
Factor B	3	0.892	15.488*	1.822*	12.174*
AB	9	0.068	0.697**	0.477*	0.482*
Error	30	0.004	0.032	0.046	0.054

Appendix VI: The effect of different levels of nitrogen and phosphorus on yield contributing characters of lentil cv. BARI masur-6

Sources of variation	Degrees of freedom	Mean square of	
		number of pods plant^{-1}	1000 seed wt
Replication	2	0.001	0.001
Factor A	3	5.239*	13.445*
Factor B	3	4.386*	8.354*
AB	9	2.271**	0.218**
Error	30	8.236	0.034

Appendix VII: The effect of different levels of nitrogen and phosphorus on yield characters of lentil cv. BARI masur-6

Sources of variation	Degrees of freedom	Mean square of			
		yield (kg ha^{-1})	stover yield	biological yield	harvest index
Replication	2	6.25	4.87	5.470	1.096
Factor A	3	366.04*	298.66*	216.917*	14.368*
Factor B	3	188.14*	121.39*	110.54*	6.433*
AB	9	32.17*	27.89*	22.877*	3.697*
Error	30	11.25	9.931	11.687	1.976