INFLUENCE OF VARIETY AND PHOSPHOROUS ON GROWTH AND YIELD OF LENTIL

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INFLUENCE OF VARIETY AND PHOSPHOROUS ON GROWTH AND YIELD OF LENTIL

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CERTIFICATE

This is to certify that the thesis entitled " ***INFLUENCE OF VARIETY AND PHOSPHOROUS ON GROWTH AND YIELD OF LENTIL****" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of* ***MASTER OF SCIENCE (MS)*** *in* ***AGRONOMY,*** *embodies the results of a piece of bona fide research work carried out by* ***MD. JAHID HOSSAIN,*** *Registration. No.* ***10-03832*** *under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

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

Dated:
Dhaka, Bangladesh

(Dr. Md. Shahidul Islam)
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The Author

INFLUENCE OF VARIETY AND PHOSPHOROUS ON GROWTH AND YIELD OF LENTIL

ABSTRACT

An experiment was carried out to evaluate the influence of variety and phosphorous on growth and yield of lentil at Sher-e-Bangla Agricultural University farm, Dhaka, Bangladesh during November, 2015 to March, 2016. The experiment comprised of two factors *viz.* i) Factor A: three lentil cultivars V_1= BARI Masur 5, V_2= BARI Masur 6 and V_3= BARI Masur 7 and ii) Factor B: four levels of phosphorus 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 split-plot design with three replications where lentil varieties were assigned in the main plot and levels of phosphorous in the sub-plot. Variety of lentil showed significant influences on most of the growth, yield and yield attributes of lentil. The highest seed yield (1.44 t ha^{-1}) was observed in BARI Masur 6 while the lowest in BARI Masur 7 (1.03 t ha^{-1}). Phosphorus fertilizers had a significant effect on the growth, yield and yield attributes of lentil. The highest seed yield (1.46 t ha^{-1}) was recorded from 40 kg P_2O_5 ha^{-1} and the lowest one (0.99 t ha^{-1}) from 0 kg P_2O_5 ha^{-1}. Interaction of variety and phosphorus levels showed significant effect on most of the growth, yield and yield attributes of lentil. The highest seed yield (1.72 t ha^{-1}) was obtained from the combination of BARI Masur 6 with 40 kg P_2O_5 ha^{-1} and the lowest one (0.80 t ha^{-1}) was obtained from BARI Masur 7 with 0 kg P_2O_5 ha^{-1}. Addition of phosphorus fertilizer beyond 40 kg ha^{-1} decreased seed yield irrespective of varieties. Application of phosphorus fertilizer at the rate of 40 kg P_2O_5 ha^{-1} could be a best production package for lentil production irrespective of varieties in different lentil growing regions of Bangladesh.

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LIST OF ACRONYMS

AEZ	= Agro-Ecological Zone
BARI	= Bangladesh Agricultural Research Institute
BAU	= Bangladesh Agricultural University
BBS	= Bangladesh Bureau of Statistics
Co	= Cobalt
CV%	= Percentage of coefficient of variance
cv.	= Cultivar
DAE	= Department of Agricultural Extension
DAS	= Days after sowing
et al.	=And others
FAO	= Food and Agriculture Organization
g	= gram(s)
ha^{-1}	= Per hectare
HI	= Harvest Index
kg	= Kilogram
LSD	= Least Significant Difference
Max	= Maximum
mg	= milligram
Min	= Minimum
MoP	= Muriate of Potash
N	= Nitrogen
No.	= Number
NPK	= Nitrogen, Phosphorus and Potassium
NS	= Not significant
SAU	= Sher-e-Bangla Agricultural University
SRDI	= Soil Resources and Development Institute
TSP	= Triple Super Phosphate
wt.	= Weight
%	= Percent
^0C	= Degree Celsius

CHAPTER I

INTRODUCTION

Ecological degradation from synthetic chemicals, population pressure and poverty coupled with malnutrition are the priorities for the present day agricultural researchers. So the plant scientists are facing the challenge that how to meet the food requirement of this unchecked population (Thirtle *et al*., 2003). Hence, nutrition oriented sustainable agricultural production system is of utmost priority in the present context. In this dire context, pulses are inextricable constituent of vegetarian diet and one of the cheapest weapons for stand up to the malnutrition problem by supplying dietary protein to the people of our country. Among the major food crops in the Asia-Pacific region, particularly South, East and Southeast Asia, pulses as nutritionally rich food, play an important role in improving the diet of the people and also pulses are vital components in diversification of Bangladesh's predominantly rice-based cropping system. 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 national production of the pulse is rampage adequate to meet the national demand. Lentil (*Lens culinaris* L. Medik) is one of the most important pulse crops grown in Bangladesh. It belongs to the sub-family Papilionaceae under the family Fabaceae. In Bangladesh, it is popularly known as masur. Its grain contains 59.8% CHO, 25.8% protein, 10% moisture, 4% mineral and 3% vitamins (Gowda and Kaul, 1982). Only red cotyledon type is used as food in Bangladesh, where it is boiled into soup-like dhal and eaten with flat bread (roti) or rice. Khichuri is another popular dish, which is made from a mixture of split lentil seed and pounded wheat or rice. The Stover of the plants together with husk popularly known as bhushi is highly protein concentrated feed to cattle, horse, pig and sheep (Tomar *et al.*, 2000). It occupies a unique position in the world of agriculture by virtue of its high protein content and capacity of fixing atmospheric nitrogen. In developing countries like Bangladesh, pulse constitutes the major concentrate source of dietary protein. It is considered as 'poor man's meat' as well as cheapest source of protein for under privileged group of people who cannot afford to buy animal protein (Gowda and Kaul, 1982). Lentil being a legume crop can fix atmospheric nitrogen (101 kg ha^{-1} annum) through root nodules by *Rhizobium* bacteria, which may reduce

the pressure of nitrogenous fertilizer application to the crop (Anonymous, 1984). It is evident that pulse containing cropping pattern helped to increase the organic matter in the soil (Islam, 1988). Total production of lentil in Bangladesh during 2015-2016 was 269000 tons from an area of 249300 hectare with an average yield of 1.08 ton ha^{-1} which covers 28.15 % of the total area of pulse and ranked second position in terms of production area and yield of pulses (DAE, 2016).

There is an acute shortage of lentil in relation to its demand in Bangladesh. The average yield of the different pulses ranges from 700 to 800 kg ha^{-1}. Bangladesh faces an acute shortage of pulses. The country produces a total of 0.53 million tons against the demand of almost 2 million tons (Razzaque, 2000). In Bangladesh, the low yield of lentil may be attributed to many reasons such as lack of quality optimum seed rate, using local varieties as planting material, appropriate time of sowing, lack of judicious fertilizer application and specially decrease of organic matter in the soil. Moreover, the different doses of phosphorus will help to determine the suitable dose, thereby reducing the misuse of phosphorus fertilizer.

An improved variety is the first and foremost-requirement for initiation and accelerated production of any crop. Variety plays an important role in producing high yield of lentil because different varieties responded differently for their genotypic characters, input requirements and growth process under prevailing environment during the growing season. BARI has developed some varieties of lentil. Plant height, number of branches, number of pods, 1000 grains weight, grain yield and other contributing characters essentially differ from local variety. The use of varieties with low yield potential also limits lentil growth and yield to a considerable extent (Nazir *et al.,* 2004). High yielding cultivars usually have extensive root system, taller in height (Kasole *et al.,* 2005), relatively higher number of pods $plant^{-1}$ and grains pod^{-1} (Islam and Islam, 2006). These cultivars consequently give higher growth and biological yield (Minhas *et al*., 2007). Although varieties of a crop may exist somewhere else, but unavailability and high prices of inputs, old traditional methods of sowing, low plant population in the field, climate, soil, unawareness of the farmers about site specific production technology, marketing system and other agronomic factors may also affect lentil yield potential locally. Therefore, varieties may have to be tested for special local growing conditions (Hussain, 2002).

Phosphorous is an important macro element for growth of legumes. It increases the hardiness of crop. It also increases the growth and yield of crops. In pulse crop, phosphorus fertilizer has a significant effect on crop yield as it enhances nodulation, which helps to fix more nitrogen from air through their nodules (Sepetoglu, 2002). In vegetative growth stage, phosphorous is needed between 0.3 to 0.5 percent dry weights of plant. Phosphorous deficiency reduces the number of flowers and delay flower formation. Adding phosphate to soil increased yield of legumes. Among the three major plant nutrients, phosphorus contributes substantially to increases yield of legumes and lentil in particular by favorably affecting the physiological functions of the crop plants, root development ad nodulation (Sharma and Singh, 1989). Early experiments showed that seed and straw yields of lentil were significantly increased with increasing phosphorus up to 10, 20 and 30 ppm P_2O_5 on low, medium and high phosphorus respectively. The critical level of available phosphorus for lentil is 15 kg ha^{-1} on sandy soils (Singh *et al.*, 1981). El-Awady *et al.* (1993) revealed that phosphorus addition at 0, 30, 45 and 60 kg significantly increased seed and straw yields fed^{-1} as well as seed protein content. Recently Krishnareddy and Ahlawat (1996) concluded that application of 17.2 kg ha^{-1} P_2O_5 markedly increased number of pods $plant^{-1}$, seed number pod^{-1} and seed yield ha^{-1}. Okaz *et al.* (1994) also showed that phosphorous application induced significant increases in seed and straw yields, yield components of lentil.

Therefore, the present investigation was initiated with the following objectives:

- determining the influence of variety of phosphorous level on growth and yield of lentil
- determining the interaction effect of variety and phosphorous level on growth and yield of lentil

CHAPTER II

REVIEW OF LITERATURE

Lentil is an important pulse crop in Bangladesh. In Bangladesh lentil is generally grown without fertilizer management. However there are evidences that the yield of lentil can be increased substantially by the use of phosphorous with modern varieties. Information on variety and phosphorous application in pulse related studies are reviewed and presented in the following heads.

2.1 Effect of variety

2.1.1 Plant height

Hasan *et al*. (2015) conducted an experiment and reported that the highest plant height (45.83 cm) was found from BARI Masur 5 and the lowest (34.67 cm) from BARI Masur 7.

Awal and Roy (2015) conducted an experiment at the Field Laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh, during the period from November, 2010 to March, 2011 to study the effect of weeding on the growth and yield of three lentil varieties viz. Binamasur-1, Binamasur-2 and Binamasur-3. The experiment was laid out in a Randomized Complete Block Design with three replications. They reported that, the plant height of lentil varied significantly due to the different varieties. The tallest plants (21.50 cm) were recorded in Binamasur-3. The Binamasur-1 (19.20 cm) and Binamasur-2 (19.50 cm) showed the similar result.

A field experiment was conducted by Haque *et al.* (2014) at the farm of Bangladesh Agricultural University, Mymensingh during November 2009 to March 2010 to study the response of three lentil varieties (viz., BARI Masur-1, BARI Masur-2 and BARI Masur-3) to *Rhizobium* inoculations regarding yield. There were three *Rhizobium* inoculants (*Rhizobium* strain BINA L_4, *Rhizobium* strain TAL 640, and mixed culture) with uninoculated control and urea @ 50 kg ha^{-1}. The experiment was laid out in split-plot design having varieties in main plots and 5 inoculations in sub plots. It was observed that, the maximum plant height was produced by the variety BARI Masur-3

(11.12 cm) followed by BARI Masur-1 (11.09 cm) and BARI Masur-2 (10.93 cm). Variety BARI Masur-3 gave tallest plant (16.92 cm) at 60 days of sowing, which was statistically superior to all other varieties. At 80 days of sowing, variety BARI Masur-2 gave the maximum plant height (27.54 cm) which was statistically similar to BARI Masur-3 (27.40 cm) but significantly higher than BARI Masur-1. Variety BARI Masur-3 gave the maximum plant height (33.26 cm) at 95 days of sowing which was statistically similar to BARI Masur-2 (32.83 cm) but significantly higher than BARI Masur-1 (31.23 cm).

The effects of enzymatic biofertiliser (MOG) application at sowing time or during reproductive stage on some morphological traits and yield components of eight lentil genotypes were evaluated by Janmohammadi *et al.* (2014) under deficit-irrigation conditions at Maragheh (37°23' N; 46°16' E) in northwestern Iran. Results of the investigation revealed that, the tallest plant (29.28 cm) was obtained from the FLIP 86-35L lentil genotype whereas the shortest plant (23.03 cm) was obtained from the FLIP 96-15L.

An experiment was carried out by Datta *et al*. (2013) to study the effect of variety and level of phosphorus fertilizer on the yield and yield components of lentil at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during October 2009 to March 2010. Three lentil varieties viz. Binamasur-2, Binamasur-3 and BARI Masur-4 and four levels of phosphorus viz. 0 kg P ha^{-1} (P_0), 15 kg P ha^{-1} (P_{15}), 30 kg P ha^{-1} (P_{30}) and 45 kg P ha^{-1} (P_{45}) were used in this experiment. They reported that, the variety Binamasur-2 gave the highest plant height (38.18 cm) and the cultivar BARI Masur-4 produced the lowest plant height (36.92 cm).

Singh *et al*. (2011) conducted field experiments during *rabi* 2006-07 and 2007-08 on a loamy sand soil to study the effect of four nutrient levels involving nitrogen and phosphorus (0+0, 9.4 + 30, 12.5 + 40 and 15.6 + 50 kg N + P_2O_5 ha^{-1}) on nodulation, growth and yield of four genotypes (LL 147, LL 699, LL 875 and LL 931) of lentil. They reported that, the highest plant height (42.4 cm) was produced by lentil genotype LL 875 and the lowest (36.9 cm) by LL 931.

2.1.2 Number of branches $plant^{-1}$

Awal and Roy (2015) conducted an experiment at the Field Laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh, during the period from November 2010 to March 2011 to study the effect of weeding on the growth and yield of three lentil varieties viz. Binamasur-1, Binamasur-2 and Binamasur-3. The experiment was laid out in a Randomized Complete Block Design with three replications. They reported that, the number of branches plant^{-1} of the different lentil varieties had significant variation throughout the growing period except in 70 DAS. The highest number of branches plant^{-1} was produced in Binamasur-3 (20.32) which was statistically similar with Binamasur-2 (19.53) while the Binamasur-1 variety produced the lowest (18.50) branches plant^{-1}.

The effects of enzymatic biofertiliser (MOG) application at sowing time or during reproductive stage on some morphological traits and yield components of eight lentil genotypes were evaluated by Janmohammadi *et al.* (2014) under deficit-irrigation conditions at Maragheh (37°23' N; 46°16' E) in northwestern Iran. Results of the investigation revealed that, the maximum number of secondary branches plant^{-1} (5.91) was obtained from the FLIP 87-22L lentil genotype whereas the minimum number of secondary branches plant^{-1} (4.09) was obtained from the FLIP 96-46L.

Rahman *et al.* (2013) conducted a field study to evaluate the effect of nitrogen application on different morpho-physiological traits of three lentil cultivars. They reported that branching plays a vital role in enhancing the yield of a plant. Cultivar NIAB Masur (NM)-2006 produced the maximum number of branches per plant (11.32) followed by NM -2002 and PM-2009, producing 10.28 and 8.62 number of branches per plant, respectively.

Singh *et al*. (2011) conducted field experiments during *rabi* 2006-07 and 2007-08 on a loamy sand soil to study the effect of four nutrient levels involving nitrogen and phosphorus (0+0, 9.4 + 30, 12.5 + 40 and 15.6 + 50 kg N + P_2O_5 ha^{-1}) on nodulation, growth and yield of four genotypes (LL 147, LL 699, LL 875 and LL 931) of lentil. They reported that, the highest primary branches plant^{-1} (6.40) was produced by lentil genotype LL 875 and the lowest (5.80) by LL 931. The highest secondary branches plant^{-1} (7.00) was produced by lentil genotype LL 699 and the lowest (5.40) by LL 931.

Hussain *et al.* (2002) conducted an experiment in Faisalabad, Pakistan and reported that lentil varieties vary greatly in number of branches plant^{-1}.

2.1.3 Plant dry matter

Awal and Roy (2015) conducted an experiment at the Field Laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh, during the period from November 2010 to March 2011 to study the effect of weeding on the growth and yield of three lentil varieties viz. Binamasur-1, Binamasur-2 and Binamasur-3. The experiment was laid out in a Randomized Complete Block Design with three replications. They reported that, the maximum plant dry matter (184.7 g m^{-2}) was recorded from Binamasur-3 and minimum (161.70 g m^{-2}) from Binamasur-1.

Alam *et al*. (2015) conducted a field experiment to study dry matter production and crop growth rate of lentil as influenced by irrigation management. The experiment was laid out by split plot design and comprised of six irrigation levels viz. control irrigation, irrigation at pre-sowing, irrigation at post sowing, irrigation at vegetative stage (25-30 DAS), irrigation at pre-flowering (45-50 DAS) and irrigation at post-flowering (70 DAS) and four varieties of lentil viz. BARI Masur-3, BARI Masur-4, BARI Masur-5 and BARI Masur-6. The results of the study indicated that, at 50 DAS the highest total dry matter (TDM) (29.67 g m^{-2}) was found in V_4 (BARI Masur-6) and lowest (25.37 g m^{-2}) in V_1 (BARI Masur-3). At 60 DAS, the highest TDM (47.60 g m^{-2}) was produced by V_4 (BARI Masure-6) and lowest (41.49 g m^{-2}) by V_1 (BARI Masur-3). At 70 DAS, the highest TDM (98.03 g m^{-2}) was observed in the variety V_4 (BARI Masur-6) and the lowest (76.90 g m^{-2}) in V_1 (BARI Masur-3). The highest TDM (157.29 g m^{-2}) and the lowest (135.12 g m^{-2}) was produced by BARI Masur-6 and BARI Masur-3, respectively at 80 DAS.

Hasan *et al.* (2015) reported that the highest (1.62 g) dry weight plant^{-1}was found from BARI Masur-5 and the lowest (1.22g) from BARI Masur-7.

Haque *et al.* (2013) also reported that BARI Masur-3 performed better than other two lentil varieties (*Rhizobium* strain BINA L4 and *Rhizobium* strain TAL 640) in respect of dry matter production.

2.1.4 Days to crop maturity

Awal and Roy (2015) conducted an experiment at the Field Laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh, during the period from November 2010 to March 2011 to study the effect of weeding on the growth and yield of three lentil varieties viz. Binamasur-1, Binamasur-2 and Binamasur-3. The experiment was laid out in a Randomized Complete Block Design with three replications. They reported that, the maximum days to crop maturity (115) was recorded from Binamasur-3 and minimum days to crop maturity (105) were recorded from Binamasur-1.

2.1.5 Number of pods plant^{-1}

Awal and Roy (2015) conducted an experiment at the Field Laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh, during the period extended from November 2010 to March 2011 to study the effect of weeding on the growth and yield of three lentil varieties viz. Binamasur-1, Binamasur-2 and Binamasur-3. The experiment was laid out in a Randomized Complete Block Design with three replications. They reported that, the maximum number of pods plant^{-1} (84) was recorded from Binamasur-3 and minimum number of pods plant^{-1} (77) was recorded from Binamasur-2.

The effects of enzymatic biofertiliser (MOG) application at sowing time or during reproductive stage on some morphological traits and yield components of eight lentil genotypes were evaluated by Janmohammadi *et al.* (2014) under deficit-irrigation conditions at Maragheh (37°23' N; 46°16' E) in northwestern Iran. Results of the investigation revealed that, the maximum number of pods plant^{-1} (34.77) was obtained from the FLIP 87-22L lentil genotype whereas the minimum (19.86) from the FLIP 96-46L lentil genotype.

An experiment was carried out by Datta *et al*. (2013) to study the effect of variety and level of phosphorus fertilizer on the yield and yield components of lentil at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during October 2009 to March 2010. Three lentil varieties viz. Binamasur-2, Binamasur-3 and BARI Masur-4 and four levels of phosphorus viz. 0 kg P ha^{-1} (P_0), 15 kg P ha^{-1} (P_{15}), 30 kg P ha^{-1} (P_{30}) and 45 kg P ha^{-1} (P_{45}) were used in this experiment. They reported that, the variety Binamasur-2 gave the highest number of

pods plant^{-1} (128.5) and BARI Masur-4 produced the lowest number of pods plant^{-1} (111.70)

Haque and Khan (2012) reported that there was significant positive correlation between the numbers of pods plant^{-1}and yield plant^{-1}.

Singh *et al*. (2011) conducted field experiments during *rabi* 2006-07 and 2007-08 on a loamy sand soil to study the effect of four nutrient levels involving nitrogen and phosphorus (0+0, 9.4 + 30, 12.5 + 40 and 15.6 + 50 kg N + P O /ha) on nodulation, growth and yield 2 5 of four genotypes (LL 147, LL 699, LL 875 and LL 931) of lentil. They reported that, the highest pods plant^{-1} (59.40) was produced by lentil genotype LL 699 and the lowest pods plant^{-1} (49.80) was produced by lentil genotype LL 931.

Response of three lentil cultivars (Masoor-93, NIAB Masoor-2002 and NIAB Masoor-2006) to various NPK fertilizer combinations (25-0-0, 25-25-25, 25-50-50 and 25-75-75 kg ha^{-1}) was studied by Mahmood *et al.* (2010) during the year 2007-08 and 2008-09. The experiment was replicated thrice at Agronomic Research Area, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan. The result of the investigation revealed that, lentil cultivars produced significantly different number of pods plant^{-1}. NIAB Masoor-2006 produced the highest number of pods plant^{-1} (39.98) followed by NIAB Masoor-2002 (37.57). Lowest number of pods plant^{-1} was recorded from Masoor-93 (35.07).

Sharar *et al.* (2003) conducted an experiment on lentil in Pakistan and reported that among the cultivars, Masur-93 owing to more number of pods plant^{-1}**.**

2.1.6 Number of seed pod^{-1}

Hasan *et al.* (2015) stated that the highest seeds pod^{-1}(98) was found from BARI Masur-5 and the lowest (49) from BARI Masur-7.

Awal and Roy (2015) conducted an experiment at the Field Laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh, during the period extended from November 2010 to March 2011 to study the effect of weeding on the growth and yield of three lentil varieties viz. Binamasur-1, Binamasur-2 and Binamasur-3. The experiment was laid out in a Randomized Complete Block Design with three replications. They reported that, the maximum number of seeds pod^{-1} (1.43) was recorded from Binamasur -3 and minimum (1.33) from Binamasur-1.

The effects of enzymatic biofertiliser (MOG) application at sowing time or during reproductive stage on some morphological traits and yield components of eight lentil genotypes were evaluated by Janmohammadi *et al.* (2014) under deficit-irrigation conditions at Maragheh (37°23' N; 46°16' E) in northwestern Iran. Results of the investigation revealed that, the maximum number of seeds pod $^{-1}$ (2.30) was obtained from the FLIP 92-36L lentil genotype whereas the minimum (1.96) from the FLIP 96-46L.

An experiment was carried out by Datta *et al*. (2013) to study the effect of variety and level of phosphorus fertilizer on the yield and yield components of lentil at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during October 2009 to March 2010. Three lentil varieties viz. Binamasur-2, Binamasur-3 and BARI Masur-4 and four levels of phosphorus viz. 0 kg P ha^{-1} (P_0), 15 kg P ha^{-1} (P_{15}), 30 kg P ha^{-1} (P_{30}) and 45 kg P ha^{-1} (P_{45}) were used in this experiment. They reported that, Binamasur-3 produced the highest number of seeds pod^{-1} (1.68) and the lowest number of seeds pod^{-1} (1.58) was observed from the cultivar BARI masur-4.

Singh *et al*. (2011) conducted field experiments during *rabi* 2006-07 and 2007-08 on a loamy sand soil to study the effect of four nutrient levels involving nitrogen and phosphorus (0+0, 9.4 + 30, 12.5 + 40 and 15.6 + 50 kg N + P_2O_5 ha^{-1}) on nodulation, growth and yield 2 5 of four genotypes (LL 147, LL 699, LL 875 and LL 931) of

lentil. They reported that, the highest seeds pod^{-1} (1.97) was produced by lentil genotype LL 147 and the lowest seeds pod^{-1} (1.52) was produced by lentil genotype LL 931.

Sharar *et al*. (2003) also found that among the cultivars, Masur-93 owing to more number of seed pod^{-1}.

Hussain *et al.* (2002) reported that varieties vary greatly in number of seed pod^{-1}.

2.1.7 Weight of 1000-seed

Hasan *et al*. (2015) stated that the highest (22.02g) 1000-eed weight was found from BARI Masur-5 and the lowest (20.08) from BARI Masur-7.

Awal and Roy (2015) conducted an experiment at the Field Laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh, during the period from November 2010 to March 2011 to study the effect of weeding on the growth and yield of three lentil varieties viz. Binamasur-1, Binamasur-2 and Binamasur-3. The experiment was laid out in a Randomized Complete Block Design with three replications. They reported that, the maximum 1000-seed weight (21.30 g) was recorded from Binamasur-3 and minimum (15.50 g) from Binamasur-1.

The effects of enzymatic biofertiliser (MOG) application at sowing time or during reproductive stage on some morphological traits and yield components of eight lentil genotypes were evaluated by Janmohammadi *et al.* (2014) under deficit-irrigation conditions at Maragheh (37°23' N; 46°16' E) in northwestern Iran. Results of the investigation revealed that, the maximum 100-grain weight (4.29 g) was obtained from the FLIP 86-35L lentil genotype whereas the minimum (2.85 g) from the FLIP 96-15L.

An experiment was carried out by Datta *et al*. (2013) to study the effect of variety and level of phosphorus fertilizer on the yield and yield components of lentil at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during October 2009 to March 2010. Three lentil varieties viz. Binamasur-2, Binamasur-3 and BARI Masur-4 and four levels of phosphorus viz. 0 kg P ha^{-1} (P_0), 15 kg P ha^{-1} (P_{15}), 30 kg P ha^{-1} (P_{30}) and 45 kg P ha^{-1} (P_{45}) were used in this

experiment. They reported that, the cultivar BARI masur-4 produced the highest weight of 1000-seed (18.77 g) and the lowest weight of 1000-seed (16.42 g) was recorded from the cultivar Binamasur-2.

Singh *et al*. (2011) conducted field experiments during *rabi* 2006-07 and 2007-08 on a loamy sand soil to study the effect of four nutrient levels involving nitrogen and phosphorus (0+0, 9.4 + 30, 12.5 + 40 and 15.6 + 50 kg N + P_2O_5 ha^{-1}) on nodulation, growth and yield of four genotypes (LL 147, LL 699, LL 875 and LL 931) of lentil. They reported that, the highest 100-seed weight (2.40 g) was produced by lentil genotype LL 931 and the lowest (1.70 g) by lentil genotype LL147.

Response of three lentil cultivars (Masoor-93, NIAB Masoor-2002 and NIAB Masoor-2006) to various NPK fertilizer combinations (25-0-0, 25-25-25, 25-50-50 and 25-75-75 kg ha^{-1}) was studied by Mahmood *et al.* (2010) during the year 2007-08 and 2008-09. The experiment was replicated thrice at Agronomic Research Area, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan. The result of the investigation revealed that, the maximum 1000-seed weight (22.46 g) was produced by NIAB Masoor-2002 while the minimum (20.43 g) by Masoor-93.

Sharar *et al.* (2003) reported thatMasur-93 had significant effect on 1000- seed weight of lentil.

2.1.8 Seed yield

Awal and Roy (2015) conducted an experiment at the Field Laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh, during the period from November 2010 to March 2011 to study the effect of weeding on the growth and yield of three lentil varieties viz. Binamasur-1, Binamasur-2 and Binamasur-3. The experiment was laid out in a Randomized Complete Block Design with three replications. They reported that, the maximum seed weight $plant^{-1}$ (2.22 g) was recorded from Binamasur-3 and minimum (1.73 g) was recorded from Binamasur-1. The maximum seed yield (0.74 t ha^{-1}) was recorded from Binamasur-3 and minimum (0.57 t ha^{-1}) from Binamasur-1.

Hasan *et al.* (2015) conducted an experiment with three varieties of lentil (*viz.,* BARI Masur-5, BARI Masur-6 and BARI Masur-7) and they reported that variety BARIMasur-5 was the best in respect of yield.

A field experiment was conducted by Haque *et al.* (2014) at the farm of Bangladesh Agricultural University, Mymensingh during November 2009 to March 2010 to study the response of three lentil varieties (viz., BARI Masur-1, BARI Masur-2 and BARI Masur-3) to *Rhizobium* inoculations to yield. There were three *Rhizobium* inoculants (*Rhizobium* strain BINA L_4, *Rhizobium* strain TAL 640, and mixed culture) with uninoculated control and urea @ 50 kg ha^{-1}. The experiment was laid out in split-plot design having varieties in main plots and 5 inoculations in sub plots. It was observed that, BARI Masur-3 recorded the highest grain yield (1,276 kg ha^{-1}), which was statistically superior to both varieties.

The effects of enzymatic biofertiliser (MOG) application at sowing time or during reproductive stage on some morphological traits and yield components of eight lentil genotypes were evaluated by Janmohammadi *et al.* (2014) under deficit-irrigation conditions at Maragheh (37°23' N; 46°16' E) in northwestern Iran. Results of the investigation revealed that, the maximum seed yield $plant^{-1}$ (2.87 g) was obtained from the FLIP 86-35L lentil genotype whereas the minimum seed yield $plant^{-1}$ (1.37 g) was obtained from the FLIP 96-46L. The maximum seed yield (1205 kg ha^{-1}) was obtained from the FLIP 86-35L lentil genotype whereas the minimum seed yield (686 kg ha^{-1}) was obtained from the FLIP 96-46L.

An experiment was carried out by Datta *et al*. (2013) to study the effect of variety and level of phosphorus fertilizer on the yield and yield components of lentil at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during October 2009 to March 2010. Three lentil varieties viz. Binamasur-2, Binamasur-3 and BARI Masur-4 and four levels of phosphorus viz. 0 kg P ha^{-1} (P_0), 15 kg P ha^{-1} (P_{15}), 30 kg P ha^{-1} (P_{30}) and 45 kg P ha^{-1} (P_{45}) were used in this experiment. They reported that, the highest seed yield (1165 kg ha^{-1}) was recorded from cultivar BARI Masur-4 which was statistically identical with Binamasur-2 (1133 kg ha^{-1}) and the lowest seed yield (1028 kg ha^{-1}) was found in the cultivar Binamasur-3.

Singh *et al*. (2011) conducted field experiments during *rabi* 2006-07 and 2007-08 on a loamy sand soil to study the effect of four nutrient levels involving nitrogen and phosphorus (0+0, 9.4 + 30, 12.5 + 40 and 15.6 + 50 kg N + P O /ha) on nodulation, growth and yield 2 5 of four genotypes (LL 147, LL 699, LL 875 and LL 931) of lentil. They reported that, the highest seed yield (2026 kg ha^{-1}) was produced by lentil genotype LL 699 and the lowest seed yield (1433 kg ha^{-1}) was produced by lentil genotype LL875.

Response of three lentil cultivars (Masoor-93, NIAB Masoor-2002 and NIAB Masoor-2006) to various NPK fertilizer combinations (25-0-0, 25-25-25, 25-50-50 and 25-75-75 kg ha^{-1}) was studied by Mahmood *et al.* (2010) during the year 2007-08 and 2008-09. The experiment was replicated three times at Agronomic Research Area, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan. The result of the investigation revealed that, the maximum seed yield (1217 kg ha^{-1}) was produced by NIAB Masoor-2006 while the minimum (1103 kg ha^{-1}) by Masoor-93.

Hussain *et al.* (2002) also reported that varieties vary greatly in yield of lentil.

2.1.9 Stover yield

A field experiment was conducted by Haque *et al.* (2014) at the farm of Bangladesh Agricultural University, Mymensingh during November 2009 to March 2010 to study the response of three lentil varieties (viz., BARI Masur-1, BARI Masur-2 and BARI Masur-3) to *Rhizobium* inoculations to yield. There were three *Rhizobium* inoculants (*Rhizobium* strain BINA L_4, *Rhizobium* strain TAL 640, and mixed culture) with uninoculated control and urea @ 50 kg ha^{-1}. The experiment was laid out in split-plot design having varieties in main plots and 5 inoculations in sub plots. It was observed that, the highest crop residue (2,482 kg ha^{-1}) was obtained by the variety BARI Masur-3, which was statistically superior to BARI Masur-1 (2,199 kg ha^{-1}) but similar to BARI Masur-2 (2,404 kg ha^{-1}).

2.1.10 Biological yield

The effects of enzymatic biofertiliser (MOG) application at sowing time or during reproductive stage on some morphological traits and yield components of eight lentil genotypes were evaluated by Janmohammadi *et al.* (2014) under deficit-irrigation conditions at Maragheh (37°23' N; 46°16' E) in northwestern Iran. Results of the investigation revealed that, the maximum biological yield (3345 kg ha^{-1}) was obtained from the FLIP 87-22L lentil genotype whereas the minimum (2778 kg ha^{-1}) from the FLIP 96-46L.

Singh *et al*. (2011) conducted field experiments during *rabi* 2006-07 and 2007-08 on a loamy sand soil to study the effect of four nutrient levels involving nitrogen and phosphorus (0+0, 9.4 + 30, 12.5 + 40 and 15.6 + 50 kg N + P O /ha) on nodulation, growth and yield 2 5 of four genotypes (LL 147, LL 699, LL 875 and LL 931) of lentil. They reported that, the highest biological yield (5521 kg ha^{-1}) was produced by lentil genotype LL 699 and the lowest (4598 kg ha^{-1}) by lentil genotype LL875.

2.1.11 Harvest index (%)

Awal and Roy (2015) conducted an experiment at the Field Laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh, during the period from November 2010 to March 2011 to study the effect of weeding on the growth and yield of three lentil varieties viz. Binamasur-1, Binamasur-2 and Binamasur-3. The experiment was laid out in a Randomized Complete Block Design with three replications. They reported that, the maximum harvest index (40.20%) was recorded from Binamasur-3 and minimum (32.90%) from Binamasur-2.

The effects of enzymatic biofertiliser (MOG) application at sowing time or during reproductive stage on some morphological traits and yield components of eight lentil genotypes were evaluated by Janmohammadi *et al.* (2014) under deficit-irrigation conditions at Maragheh (37°23' N; 46°16' E) in northwestern Iran. Results of the investigation revealed that, the maximum harvest index (37.65%) was obtained from the FLIP 86-35L lentil genotype whereas the minimum (23.19%) from the FLIP 96-15L.

Datta *et al*. (2013) conducted an experiment and reported that BARI Masur-4 gave the highest harvest index (26.74%) and the lowest (25.62%) in Binamasur-2.

Response of three lentil cultivars (Masoor-93, NIAB Masoor-2002 and NIAB Masoor-2006) to various NPK fertilizer combinations (25-0-0, 25-25-25, 25-50-50 and 25-75-75 kg ha^{-1}) was studied by Mahmood *et al.* (2010) during the year 2007-08 and 2008-09. The experiment was replicated three times at Agronomic Research Area, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan. The result of the investigation revealed that, the maximum harvest index (42.38 %) was produced by NIAB Masoor-2002 while the minimum (38.38 %) by Masoor-93.

Singh *et al*. (2011) conducted field experiments during *rabi* 2006-07 and 2007-08 on a loamy sand soil to study the effect of four nutrient levels involving nitrogen and phosphorus (0+0, 9.4 + 30, 12.5 + 40 and 15.6 + 50 kg N + P_2O_5 ha^{-1}) on nodulation, growth and yield of four genotypes (LL 147, LL 699, LL 875 and LL 931) of lentil. They reported that, the highest harvest index (36.60 %) was produced by lentil genotype LL 699 and the lowest (31.10%) by lentil genotype LL875.

Sharar *et al.* (2003) also stated that all cultivars of lentil differed significantly from one another regarding harvest index. The Masur-93 produced significantly highest harvest index value than other cultivars. Similar results also have been reported by Shah *et al.* (2000a).

2.2 Effect of phosphorus

2.2.1 Plant height

Sixteen treatments comprising of four biofertilizer inoculations [*Rhizobium*, phosphate solubilizing bacteria (PSB), *Rhizobium* + PSB and no inoculation] and four phosphorus (0, 20, 40 and 60 kg P_20_5 ha^{-1}) levels were evaluated By Rasool and Singh (2016) at Palampur to study the interaction of biofertilizers and phosphorus on growth and yield of lentil. The result of the experiment revealed that, plant height increased with increasing level of phosphorus up to 40 kg P_2O_5 ha^{-1}. Application of 20 kg P_2O_5 ha^{-1} and control (P_0) had similar plant height at 90 and 120 DAS. At harvest the tallest plant (29.9 cm) was recorded from 60 kg P_2O_5 ha^{-1} while the shortest plant (24.80 cm) was recorded from control (P_0).

An experiment was carried out by Datta *et al*. (2013) to study the effect of variety and level of phosphorus fertilizer on the yield and yield components of lentil at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during October 2009 to March 2010. Three lentil varieties viz. Binamasur-2, Binamasur-3 and BARI Masur-4 and four levels of phosphorus viz. 0 kg P ha^{-1} (P_0), 15 kg P ha^{-1} (P_{15}), 30 kg P ha^{-1} (P_{30}) and 45 kg P ha^{-1} (P_{45}) were used in this experiment. They reported that, the highest plant height (39.32 cm) was observed in P_{45}, which was statistically identical with P_{30} and followed by P_{15} and P_0 treatment.

Choubey *et al*. (2013) conducted a field experiment in India and reported that. Plant height of lentil improved with the application of 60 kg P_20_5 ha^{-1}.

Fatima *et al.* (2013) reported that phosphorous application significantly increased plant height of lentil up to 50 kg P_20_5 ha^{-1}.

Two field experiments were carried out by Zeidan (2007) during the two winter seasons of 2003/ 2004 and 2004/2005 at the Experimental Farm of the National Research Centre at Nubariato study the effect of organic manure at 0, 10 and 20 m^3/ fed. and four phosphorus levels of 0, 30, 45 and 60 Kg P_2O_5 / fed. on growth, yield and quality of lentil grown in sandy soil. Results indicated that, the highest plant height (32.90 cm) was recorded from 45 kg P fed^{-1} and the lowest plant height (29.10 cm) was recorded from no P applied plot.

A field experiment was conducted by Zafar *et al.* (2003) to evaluate the growth and yield response of lentil to phosphorus. The experiment was laid out in a randomized complete block design with four replications. Treatments included in this study were: Control, 25, 50 and 75 kg P_2O_5 ha^{-1} at sowing. The result revealed that, the minimum plant height (34.12 cm) was recorded in case of control, whereas, maximum plant height (49.92 cm) was obtained with the application of 75 kg P_2O_5 ha^{-1}.

2.2.2 Number of branches plant^{-1}

Sixteen treatments comprising of four biofertilizer inoculations [*Rhizobium*, phosphate solubilizing bacteria (PSB), *Rhizobium* + PSB and no inoculation] and four phosphorus (0, 20, 40 and 60 kg P_20_5 ha^{-1}) levels were evaluated By Rasool and Singh (2016) at Palampur to study the interaction of biofertilizers and phosphorus on growth and yield of lentil. The result of the experiment revealed that, maximum primary branches plant^{-1} (5.30) was found from 60 kg P_2O_5 ha^{-1} and minimum primary branches plant^{-1} (3.80) was found from 0 kg P_2O_5 ha^{-1}.

Fatima *et al.* (2013) reported that phosphorous application significantly increased branches plant^{-1} of lentil up to 50 kg P_20_5 ha^{-1}.

Two field experiments were carried out by Zeidan (2007) during the two winter seasons of 2003/ 2004 and 2004/2005 at the Experimental Farm of the National Research Centre at Nubariato study the effect of organic manure at 0, 10 and 20 m^3/ fed. and four phosphorus levels of 0, 30, 45 and 60 Kg P_2O_5 / fed. on growth, yield and quality of lentil grown in sandy soil. Results indicated that, the highest no. of branches plant^{-1}(3.90) was recorded from 45 kg P fed^{-1} and the lowest no. of branches plant^{-1} (2.30) was recorded from control treatment (no phosphorous).

A field experiment was conducted by Zafar *et al.* (2003) to evaluate the growth and yield response of lentil to phosphorus. The experiment was laid out in a randomized complete block design with four replications. Treatments included in this study were: Control, 25, 50 and 75 kg P_2O_5 ha^{-1} at sowing. The result revealed that, the number of branches plant^{-1} was significantly affected by different rates of phosphorus application. Minimum number of branches per plant (6.93) was recorded in control and maximum number of branches (15.87) was recorded from 75 kg P_2O_5 ha^{-1} treatment.

2.2.3 Plant dry weight

Sixteen treatments comprising of four biofertilizer inoculations [*Rhizobium*, phosphate solubilizing bacteria (PSB), *Rhizobium* + PSB and no inoculation] and four phosphorus (0, 20, 40 and 60 kg P_20_5 ha^{-1}) levels were evaluated By Rasool and Singh (2016) at Palampur to study the interaction of biofertilizers and phosphorus on growth

and yield of lentil. The result of the experiment revealed that, plant dry matter accumulation increased with an increase in phosphorus level up to 60 kg P_2O_5 ha^{-1} at 90 and 120 DAS. At the harvest, maximum dry matter m^{-2} (201.70 g) was found from 60 kg P_2O_5 ha^{-1} and minimum dry matter m^{-2} (130.20 g) was found from 0 kg P_2O_5 ha^{-1}.

Fatima *et al.* (2013) reported that phosphorous application significantly increased dry matter accumulation of lentil up to 50 kg P_20_5 ha^{-1}.

2.2.4 Number of pods plant^{-1}

Sixteen treatments comprising of four biofertilizer inoculations [*Rhizobium*, phosphate solubilizing bacteria (PSB), *Rhizobium* + PSB and no inoculation] and four phosphorus (0, 20, 40 and 60 kg P_20_5 ha^{-1}) levels were evaluated By Rasool and Singh (2016) at Palampur to study the interaction of biofertilizers and phosphorus on growth and yield of lentil. The result of the experiment revealed that, maximum pods $plant^{-1}$ (78.40) was found from 60 kg P_2O_5 ha^{-1} and minimum pods $plant^{-1}$ (49.90) was found from 0 kg P_2O_5 ha^{-1}.

An experiment was carried out by Datta *et al.* (2013) to study the effect of variety and level of phosphorus fertilizer on the yield and yield components of lentil at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during October 2009 to March 2010. Three lentil varieties viz. Binamasur-2, Binamasur-3 and BARI Masur-4 and four levels of phosphorus viz. 0 kg P ha^{-1} (P_0), 15 kg P ha^{-1} (P_{15}), 30 kg P ha^{-1} (P_{30}) and 45 kg P ha^{-1} (P_{45}) were used in this experiment. They reported that, the highest pods $plant^{-1}$ (127.80) was observed in P_{45} treatment, which was statistically identical with P_{30} treatment (18.41) and the lowest pods $plant^{-1}$ (106.5) was observed in P_0 treatment.

A field experiment was conducted by Choubey *et al.* (2013) at Agricultural Research Farm of S.D.J. Post Graduate College, Chandeshwar, Azamgarh during Rabi season of 2010-11 and 2011-12 on a silty loam soil. The treatment consisted of 4 phosphorus levels (Control 20, 40 and 60 Kg ha^{-1}) and 3 sulphur levels (Control 20 and 40 Kg ha^{-1}) were laid-out in Randomized Block Design with 4 replications. They found that, the highest number of pods $plant^{-1}$ (136.03) was recorded from 60 kg P ha^{-1} and the lowest number of pods $plant^{-1}$ (106.91) was recorded from 0 kg P ha^{-1}.

In order to study the effect of different levels of nitrogen and phosphorus fertilizer on grain yield and protein content of lentil in dry conditions a factorial experiment based on randomized complete block with three replications was conducted by Niri *et al*. (2010) in 2007. The treatments consist of nitrogen (0, 25 and 50 kg ha^{-1}) and phosphorus (0, 40 and 60 kg ha^{-1}). The results revealed that, the maximum number of filled pods $plant^{-1}$ (20.31) was recorded from 60 kg P ha^{-1} and the minimum number of filled pods $plant^{-1}$ (15.24) was recorded from 0 kg P ha^{-1}.

Two field experiments were carried out by Zeidan (2007) during the two winter seasons of 2003/ 2004 and 2004/2005 at the Experimental Farm of the National Research Centre at Nubariato study the effect of organic manure at 0, 10 and 20 m^3/ fed. and four phosphorus levels of 0, 30, 45 and 60 Kg P_2O_5 / fed. on growth, yield and quality of lentil grown in sandy soil. Results indicated that, the highest no. of pods $plant^{-1}$(26.00) was recorded from 60 kg P fed^{-1} and the lowest no. of pods $plant^{-1}$ (14.70) was recorded from control treatment (no phosphorous).

A field experiment was conducted by Zafar *et al.* (2003) to evaluate the growth and yield response of lentil to phosphorus. The experiment was laid out in a randomized complete block design with four replications. Treatments included in this study were: Control, 25, 50 and 75 kg P_2O_5 ha^{-1} at sowing. The result revealed that, the pods per plant were significantly affected by the effect of different rates of phosphorus application. The minimum number of pods (37.50) was found in of control. The maximum number of pods per plant (62.37) was recorded with the application of 75 kg P_2O_5 ha^{-1}.

2.2.5 Number of seeds pod^{-1}

Sixteen treatments comprising of four biofertilizer inoculations [*Rhizobium*, phosphate solubilizing bacteria (PSB), *Rhizobium* + PSB and no inoculation] and four phosphorus (0, 20, 40 and 60 kg P_20_5 ha^{-1}) levels were evaluated By Rasool and Singh (2016) at Palampur to study the interaction of biofertilizers and phosphorus on growth and yield of lentil. The result of the experiment revealed that, maximum seeds pod^{-1} (1.80) was found from 60 kg P_2O_5 ha^{-1} and minimum seeds pod^{-1} (1.70) was found from 0 kg P_2O_5 ha^{-1}.

An experiment was carried out by Datta *et al.* (2013) to study the effect of variety and level of phosphorus fertilizer on the yield and yield components of lentil at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during October 2009 to March 2010. Three lentil varieties viz. Binamasur-2, Binamasur-3 and BARI Masur-4 and four levels of phosphorus viz. 0 kg P ha^{-1} (P_0), 15 kg P ha^{-1} (P_{15}), 30 kg P ha^{-1} (P_{30}) and 45 kg P ha^{-1} (P_{45}) were used in this experiment. They reported that, the highest seeds pod^{-1} (1.707) was observed in P_{45} treatment, which was statistically identical with in P_{30} treatment (1.700) and the lowest seeds pod^{-1} (1.523) was observed in P_0 treatment.

A field experiment was conducted by Choubey *et al.* (2013) at Agricultural Research Farm of S.D.J. Post Graduate College, Chandeshwar, Azamgarh during Rabi season of 2010-11 and 2011-12 on a silty loam soil. The treatment consisted of 4 phosphorus levels (Control 20, 40 and 60 Kg ha^{-1}) and 3 sulphur levels (Control 20 and 40 Kg ha^{-1}) were laid-out in Randomized Block Design with 4 replications. They found that, the highest number of seeds pod^{-1} (2.08) was recorded from 60 kg P ha^{-1} and the lowest number of seeds pod^{-1} (1.62) was recorded from 0 kg P ha^{-1}.

A field experiment was conducted by Zafar *et al.* (2003) to evaluate the growth and yield response of lentil to phosphorus. The experiment was laid out in a randomized complete block design with four replications. Treatments included in this study were: Control, 25, 50 and 75 kg P_2O_5 ha^{-1} at sowing. The result revealed that, the number of seeds per pots differed significantly by phosphorus treatments. The minimum (1.39) and maximum (1.89) number of seeds were recorded from 0 and 75 kg P_2O_5 ha^{-1} application.

2.2.6 Weight of 1000-seed

Sixteen treatments comprising of four biofertilizer inoculations [*Rhizobium*, phosphate solubilizing bacteria (PSB), *Rhizobium* + PSB and no inoculation] and four phosphorus (0, 20, 40 and 60 kg P_20_5 ha^{-1}) levels were evaluated By Rasool and Singh (2016) at Palampur to study the interaction of biofertilizers and phosphorus on growth and yield of lentil. The result of the experiment revealed that, maximum 100-seed weight (2.60g) was found from 60 kg P_2O_5 ha^{-1} and minimum 100-seed weight (2.40g) was found from 0 kg P_2O_5 ha^{-1}.

An experiment was carried out by Datta *et al*. (2013) to study the effect of variety and level of phosphorus fertilizer on the yield and yield components of lentil at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during October 2009 to March 2010. Three lentil varieties viz. Binamasur-2, Binamasur-3 and BARI Masur-4 and four levels of phosphorus viz. 0 kg P ha^{-1} (P_0), 15 kg P ha^{-1} (P_{15}), 30 kg P ha^{-1} (P_{30}) and 45 kg P ha^{-1} (P_{45}) were used in this experiment. They reported that, the highest 1000-seed weight (17.39 g) was observed in P_{30} treatment and the lowest 1000-seed weight (16.84 g) was observed in P_0 treatment.

Two field experiments were carried out by Zeidan (2007) during the two winter seasons of 2003/ 2004 and 2004/2005 at the Experimental Farm of the National Research Centre at Nubariato study the effect of organic manure at 0, 10 and 20 m^3/ fed. and four phosphorus levels of 0, 30, 45 and 60 Kg P_2O_5 / fed on growth, yield and quality of lentil grown in sandy soil. Results indicated that, the highest 1000-seed weight (29.01 g) was recorded from 60 kg P fed^{-1} and the lowest 1000-seed weight (25.40 g) was recorded from control treatment (no phosphorous).

A field experiment was conducted by Zafar *et al.* (2003) to evaluate the growth and yield response of lentil to phosphorus. The experiment was laid out in a randomized complete block design with four replications. Treatments included in this study were: Control, 25, 50 and 75 kg P_2O_5 ha^{-1} at sowing. The result revealed that, the effect of rates of phosphorus application was highly significant towards 1000-seed weight. The minimum (17.20 g) and maximum (19.38 g) 1000-seed weight was recorded in case of control and 75 kg P_2O_5 ha^{-1} application.

2.2.7 Seed yield

Sixteen treatments comprising of four biofertilizer inoculations [*Rhizobium*, phosphate solubilizing bacteria (PSB), *Rhizobium* + PSB and no inoculation] and four phosphorus (0, 20, 40 and 60 kg P_20_5 ha^{-1}) levels were evaluated By Rasool and Singh (2016) at Palampur to study the interaction of biofertilizers and phosphorus on growth and yield of lentil. The result of the experiment revealed that, maximum seed yield (794 kg ha^{-1}) was found from 60 kg P_2O_5 ha^{-1} and minimum seed yield (492 kg ha^{-1}) was found from 0 kg P_2O_5 ha^{-1}.

An experiment was carried out by Datta *et al*. (2013) to study the effect of variety and level of phosphorus fertilizer on the yield and yield components of lentil at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during October 2009 to March 2010. Three lentil varieties viz. Binamasur-2, Binamasur-3 and BARI Masur-4 and four levels of phosphorus viz. 0 kg P ha^{-1} (P_0), 15 kg P ha^{-1} (P_{15}), 30 kg P ha^{-1} (P_{30}) and 45 kg P ha^{-1} (P_{45}) were used in this experiment. They reported that, the highest seed yield (1222 kg ha^{-1}) was observed in P45 treatment, which was statistically similar with P_{30} treatment (1211 kg ha^{-1}) and the lowest seed yield (893 kg ha^{-1}) was observed in P_0 treatment.

A field experiment was conducted by Choubey *et al.* (2013) at Agricultural Research Farm of S.D.J. Post Graduate College, Chandeshwar, Azamgarh during Rabi season of 2010-11 and 2011-12 on a silty loam soil. The treatment consisted of 4 phosphorus levels (Control 20, 40 and 60 Kg ha^{-1}) and 3 sulphur levels (Control 20 and 40 Kg ha^{-1}) were laid-out in Randomized Block Design with 4 replications. They found that, he highest grain yield (21.03 q ha^{-1}) was recorded from 60 kg P ha^{-1} and the lowest grain yield (16.40 q ha^{-1}) was recorded from 0 kg P ha^{-1}.

Fatima *et al.* (2013) reported that phosphorous application significantly increased grain yield up to 50 kg P_20_5 ha^{-1}.

Barua *et al*. (2011) reported that cultivation of lentil using 85 kg P ha^{-1} with compost resulted best seed yield of lentil.

Application of 50 kg ha^{-1}phosphorus may be considered as optimum dose for higher yield of lentil (Mahmood *et al.*, 2010).

In order to study the effect of different levels of nitrogen and phosphorus fertilizer on grain yield and protein content of lentil in dry conditions a factorial experiment based on randomized complete block with three replications was conducted by Niri *et al*. (2010) in 2007. The treatments consist of nitrogen (0, 25 and 50 kg ha^{-1}) and phosphorus (0, 40 and 60 kg ha^{-1}). The results revealed that, the maximum seed yield (1466.50 kg ha^{-1}) was recorded from 40 kg P ha^{-1} and the minimum seed yield (1027.90 kg ha^{-1}) was recorded from 0 kg P ha^{-1}.

Two field experiments were carried out by Zeidan (2007) during the two winter seasons of 2003/ 2004 and 2004/2005 at the Experimental Farm of the National Research Centre at Nubariato study the effect of organic manure at 0, 10 and 20 m^3/ fed. and four phosphorus levels of 0, 30, 45 and 60 Kg P_2O_5 / fed. on growth, yield and quality of lentil grown in sandy soil. Results indicated that, the highest seed yield $plant^{-1}$ (50.8 g) was recorded from 60 kg P fed^{-1} and the lowest seed yield $plant^{-1}$ (25.70 g) was recorded from control treatment (no phosphorous). The highest seed yield fed^{-1} (3.04 ardab) was recorded from 60 kg P fed^{-1} and the lowest seed yield fed^{-1} (2.10 ardab) was recorded from control treatment (no phosphorous).

A field experiment was conducted by Zafar *et al.* (2003) to evaluate the growth and yield response of lentil to phosphorus. The experiment was laid out in a randomized complete block design with four replications. Treatments included in this study were: Control, 25, 50 and 75 kg P_2O_5 ha^{-1} at sowing. The result revealed that, there was a highly significant effect of rate of different phosphorus application on the seed yield. However, highest seed yield ha^{-1} was recorded with the application of 75 kg P_2O_5 ha^{-1}.

Gan *et al*. (2003) reported that, in lentil grown in southwest Saskatchewan, Starter P at a rate of 7.4 kg P ha^{-1} increased lentil seed yield in ¾ of the trials with an average yield increase of 4% compared to the non-P (check plot).

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 P2O5 ha-1 as compared to the other levels of phosphorous.

2.2.8 Stover yield

Sixteen treatments comprising of four biofertilizer inoculations [*Rhizobium*, phosphate solubilizing bacteria (PSB), *Rhizobium* + PSB and no inoculation] and four phosphorus (0, 20, 40 and 60 kg P_20_5 ha^{-1}) levels were evaluated By Rasool and Singh (2016) at Palampur to study the interaction of biofertilizers and phosphorus on growth and yield of lentil. The result of the experiment revealed that, maximum stover yield (1397 kg ha^{-1}) was found from 60 kg P_2O_5 ha^{-1} and minimum stover yield (902 kg ha^{-1}) was found from 0 kg P_2O_5 ha^{-1}.

A field experiment was conducted by Choubey *et al.* (2013) at Agricultural Research Farm of S.D.J. Post Graduate College, Chandeshwar, Azamgarh during Rabi season of 2010-11 and 2011-12 on a silty loam soil. The treatment consisted of 4 phosphorus levels (Control 20, 40 and 60 Kg ha^{-1}) and 3 sulphur levels (Control 20 and 40 Kg ha^{-1}) were laid-out in Randomized Block Design with 4 replications. They found that, the highest stover yield (36.08 q ha^{-1}) was recorded from 60 kg P ha^{-1} and the lowest stover yield (31.97 q ha^{-1}) was recorded from 0 kg P ha^{-1}.

Field experiments were conducted by Haque and Khan (2012) to evaluate the effects of phosphatic biofertilizer with inorganic or organic sources of P on lentil (*Lens culinaris* Medikusvar. Binamasur-2). They reported that Phosphatic biofertilizer with 50% P from TSP gave the highest stover yield.

Two field experiments were carried out by Zeidan (2007) during the two winter seasons of 2003/ 2004 and 2004/2005 at the Experimental Farm of the National Research Centre at Nubariato study the effect of organic manure at 0, 10 and 20 m^3/ fed. and four phosphorus levels of 0, 30, 45 and 60 Kg P_2O_5 / fed. on growth, yield and quality of lentil grown in sandy soil. Results indicated that, the highest stover yield fed^{-1} (1.86 t) was recorded from 60 kg P fed^{-1} and the lowest stover yield fed^{-1} (0.77 t) was recorded from control treatment (no phosphorous).

2.2.9 Biological yield

Sixteen treatments comprising of four biofertilizer inoculations [*Rhizobium*, phosphate solubilizing bacteria (PSB), *Rhizobium* + PSB and no inoculation] and four phosphorus (0, 20, 40 and 60 kg P_20_5 ha^{-1}) levels were evaluated by Rasool and Singh (2016) at Palampur to study the interaction of biofertilizers and phosphorus on growth and yield of lentil. The result of the experiment revealed that, maximum biological yield (1397 kg ha^{-1}) was found from 60 kg P_2O_5 ha^{-1} and minimum biological yield (902 kg ha^{-1}) was found from 0 kg P_2O_5 ha^{-1}.

2.2.10 Harvest index (%)

Sixteen treatments comprising of four biofertilizer inoculations [*Rhizobium*, phosphate solubilizing bacteria (PSB), *Rhizobium* + PSB and no inoculation] and four phosphorus (0, 20, 40 and 60 kg P_20_5 ha^{-1}) levels were evaluated by Rasool and Singh

(2016) at Palampur to study the interaction of biofertilizers and phosphorus on growth and yield of lentil. The result of the experiment revealed that, maximum harvest index (36%) was found from 60 kg P_2O_5 ha^{-1} and minimum stover yield (34%) was found from 20 kg P_2O_5 ha^{-1}.

In order to study the effect of different levels of nitrogen and phosphorus fertilizer on grain yield and protein content of lentil in dry conditions a factorial experiment based on randomized complete block with three replications was conducted by Niri *et al*. (2010) in 2007. The treatments consist of nitrogen (0, 25 and 50 kg ha^{-1}) and phosphorus (0, 40 and 60 kg ha^{-1}). The results revealed that, the maximum harvest index (46.84%) was recorded from 40 kg P ha^{-1} and the minimum harvest index (35.52 %) was recorded from 0 kg P ha^{-1}.

A field experiment was conducted by Zafar *et al.* (2003) to evaluate the growth and yield response of lentil to phosphorus. The experiment was laid out in a randomized complete block design with four replications. Treatments included in this study were: Control, 25, 50 and 75 kg P_2O_5 ha^{-1} at sowing. The result revealed that, data showed highly significant effect of different rates of phosphorus application. Minimum harvest index (36.65%) was recorded in case of control treatment where no fertilizer was applied (F_0) whereas, maximum harvest index i.e. 43.69% was recorded with the application of 75 kg P_2O_5 ha^{-1} (F_3).

Tomar *et al.* (1999) observed that 60 kg P_2O_5 ha^{-1} gave the highest harvest index of lentil.

Saxena and Varma (1996) conducted a field trial on lentil at different levels of P during 2003 and 2005 in India. They reported that harvest index of lentil was the highest with 60 kg P_2O_5 ha^{-1} in 2003 and 30 kg P_2O_5 ha^{-1} in 2005.

2.3 Combined effect of variety and phosphorous

2.3.1 Plant height

An experiment was carried out by Yaseen *et al.* (2016) to study the influence of rock phosphorus fertilization, *Arbuscular Mycorrhizae* (AM) and *Rhizobium* inoculation on growth and yield parameters of *Lens culinaris* (NARC.2008-4). In addition,

experiments aimed to evaluate the effect of different inoculation practices on crop quality in comparison with control (no inoculation).The experiment was laid out in randomized complete block design with four replications during winter (2010-11 and 2012-13) at the Department of Botany University of Peshawar Pakistan. The result of the experiment revealed that, the tallest plant (32.26 cm) was obtained from combined application of AM+RH+P [*Arbuscular Mycorrhizae* (AM) and *Rhizobium* (RH) and Rock phosphate (RP), respectively] and the shortest plant (27.90 cm) was obtained from RP alone.

An experiment was carried out by Datta *et al*. (2013) to study the effect of variety and level of phosphorus fertilizer on the yield and yield components of lentil at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during October 2009 to March 2010. Three lentil varieties viz. Binamasur-2, Binamasur-3 and BARI Masur-4 and four levels of phosphorus viz. 0 kg P ha^{-1} (P_0), 15 kg P ha^{-1} (P15), 30 kg P ha^{-1} (P_{30}) and 45 kg P ha^{-1} (P_{45}) were used in this experiment. They reported that, the highest plant height (40.03 cm) was obtained in V_1 X P_{30} treatment combination and the lowest plant height (33.70 cm) was obtained in V_3 X P_0 treatment combination.

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

An experiment was carried out by Yaseen *et al.* (2016) to study the influence of rock phosphorus fertilization, *Arbuscular Mycorrhizae* (AM) and *Rhizobium* inoculation on growth and yield parameters of *Lens culinaris* (NARC.2008-4). In addition, experiments aimed to evaluate the effect of different inoculation practices on crop quality in comparison with control (no inoculation).The experiment was laid out in randomized complete block design with four replications during winter (2010-11 and 2012-13) at the Department of Botany University of Peshawar Pakistan. The result of the experiment revealed that, the maximum leaves $plant^{-1}$ (19.60) was obtained from combined application of AM+RH+P [*Arbuscular Mycorrhizae* (AM) and *Rhizobium* (RH) and Rock phosphate (RP), respectively] and the minimum leaves $plant^{-1}$ (18.40) was obtained from RP alone.

2.3.3 Number of pods plant^{-1}

An experiment was carried out by Yaseen *et al.* (2016) to study the influence of rock phosphorus fertilization, *Arbuscular Mycorrhizae* (AM) and *Rhizobium* inoculation on growth and yield parameters of *Lens culinaris* (NARC.2008-4). In addition, experiments aimed to evaluate the effect of different inoculation practices on crop quality in comparison with control (no inoculation).The experiment was laid out in randomized complete block design with four replications during winter (2010-11 and 2012-13) at the Department of Botany University of Peshawar Pakistan. The result of the experiment revealed that, the maximum pods plant^{-1} (74.0) was obtained from combined application of AM+RH+P [*Arbuscular Mycorrhizae* (AM) and *Rhizobium* (RH) and Rock phosphate (RP), respectively] and the minimum pods plant^{-1} (50.0) was obtained from RP alone.

An experiment was carried out by Datta *et al*. (2013) to study the effect of variety and level of phosphorus fertilizer on the yield and yield components of lentil at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during October 2009 to March 2010. Three lentil varieties viz. Binamasur-2, Binamasur-3 and BARI Masur-4 and four levels of phosphorus viz. 0 kg P ha^{-1} (P_0), 15 kg P ha^{-1} (P15), 30 kg P ha^{-1} (P_{30}) and 45 kg P ha^{-1} (P_{45}) were used in this experiment. They reported that, the highest pods plant^{-1} (137.0) was observed in V_1 X P_{30} treatment combination and the lowest pods plant^{-1} (97.60) was observed in V_3 X P_0 treatment combination.

Response of three lentil cultivars (Masoor-93, NIAB Masoor-2002 and NIAB Masoor-2006) to various NPK fertilizer combinations (25-0-0, 25-25-25, 25-50-50 and 25-75-75 kg ha^{-1}) was studied by Mahmood *et al.* (2010) during the year 2007-08 and 2008-09. The experiment was replicated three times at Agronomic Research Area, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan. The result of the investigation revealed that, the maximum pods plant^{-1} (44.46) was produced by combinations of NIAB Masoor-2006 with application of 25-75-75 kg (C_3F_4) and which showed similarity with NIAB Masoor-2006 and NPK @ 25-50-50 (43.87) combination. The minimum pods plant^{-1} (28.63) was produced by combinations of Masoor-3 with no fertilizers.

2.3.4 Number of seed pod^{-1}

An experiment was carried out by Yaseen *et al.* (2016) to study the influence of rock phosphorus fertilization, *Arbuscular Mycorrhizae* (AM) and *Rhizobium* inoculation on growth and yield parameters of *Lens culinaris* (NARC.2008-4). In addition, experiments aimed to evaluate the effect of different inoculation practices on crop quality in comparison with control (no inoculation).The experiment was laid out in randomized complete block design with four replications during winter (2010-11 and 2012-13) at the Department of Botany University of Peshawar Pakistan. The result of the experiment revealed that, the maximum seeds pod^{-1} (2.0) was obtained from combined application of AM+RH+P [*Arbuscular Mycorrhizae* (AM) and *Rhizobium* (RH) and Rock phosphate (RP), respectively] and the minimum seeds pod^{-1} (1.0) was obtained from RP alone.

An experiment was carried out by Datta *et al*. (2013) to study the effect of variety and level of phosphorus fertilizer on the yield and yield components of lentil at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during October 2009 to March 2010. Three lentil varieties viz. Binamasur-2, Binamasur-3 and BARI Masur-4 and four levels of phosphorus viz. 0 kg P ha^{-1} (P_0), 15 kg P ha^{-1} (P15), 30 kg P ha^{-1} (P_{30}) and 45 kg P ha^{-1} (P_{45}) were used in this experiment. They reported that, the highest seeds pod^{-1} (1.73) was observed in V_2 X P_{30} and V_2 X P_{45} and the lowest seeds pod^{-1} (1.47) was observed in V_3 X P_0 treatment combination.

2.3.5 Weight of 1000-seed

An experiment was carried out by Datta *et al*. (2013) to study the effect of variety and level of phosphorus fertilizer on the yield and yield components of lentil at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during October 2009 to March 2010. Three lentil varieties viz. Binamasur-2, Binamasur-3 and BARI Masur-4 and four levels of phosphorus viz. 0 kg P ha^{-1} (P_0), 15 kg P ha^{-1} (P15), 30 kg P ha^{-1} (P_{30}) and 45 kg P ha^{-1} (P_{45}) were used in this experiment. They reported that, the highest 1000-seed weight (19.01 g) was observed in V_3 X P_{30} treatment combination and the lowest 1000-seed weight (16.10 g) was observed in V_2 X P_0 treatment combination.

Response of three lentil cultivars (Masoor-93, NIAB Masoor-2002 and NIAB Masoor-2006) to various NPK fertilizer combinations (25-0-0, 25-25-25, 25-50-50 and 25-75-75 kg ha^{-1}) was studied by Mahmood *et al.* (2010) during the year 2007-08 and 2008-09. The experiment was replicated three times at Agronomic Research Area, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan. The result of the investigation revealed that, the maximum 1000-seed weight (24.35 g) was produced by combinations of NIAB Masoor-2002 with application of 25-75-75 kg (C_2F_4) and the minimum 1000-seed weight (17.65 g) was produced by combinations of Masoor-93 with no fertilizers application.

2.3.6 Seed yield

An experiment was carried out by Yaseen *et al.* (2016) to study the influence of rock phosphorus fertilization, *Arbuscular Mycorrhizae* (AM) and *Rhizobium* inoculation on growth and yield parameters of *Lens culinaris* (NARC.2008-4). In addition, experiments aimed to evaluate the effect of different inoculation practices on crop quality in comparison with control (no inoculation).The experiment was laid out in randomized complete block design with four replications during winter (2010-11 and 2012-13) at the Department of Botany University of Peshawar Pakistan. The result of the experiment revealed that, the maximum seed yield $plant^{-1}$ (42.00 g) was obtained from combined application of AM+RH+P [*Arbuscular Mycorrhizae* (AM) and *Rhizobium* (RH) and Rock phosphate (RP), respectively] and the minimum seed yield $plant^{-1}$ (12.00 g) was obtained from control treatment (no fertilizer and inoculation).

A field experiment was conducted by Haque *et al.* (2014) at the farm of Bangladesh Agricultural University, Mymensingh during November 2009 to March 2010 to study the response of three lentil varieties (viz., BARI Masur-1, BARI Masur-2 and BARI Masur-3) to *Rhizobium* inoculations to yield. There were three *Rhizobium* inoculants (*Rhizobium* strain BINA L_4, *Rhizobium* strain TAL 640, and mixed culture) with uninoculated control and urea @ 50 kg ha^{-1}. The experiment was laid out in split-plot design having varieties in main plots and 5 inoculations in sub plots. It was observed that, the highest grain yield (1,565 kg ha^{-1}) was recorded from the combination of BARI Masur-3 with mixed inoculation (V_3R_{M0}), which was statistically superior to all other treatments.

An experiment was carried out by Datta *et al*. (2013) to study the effect of variety and level of phosphorus fertilizer on the yield and yield components of lentil at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during October 2009 to March 2010. Three lentil varieties viz. Binamasur-2, Binamasur-3 and BARI Masur-4 and four levels of phosphorus viz. 0 kg P ha^{-1} (P_0), 15 kg P ha^{-1} (P15), 30 kg P ha^{-1} (P_{30}) and 45 kg P ha^{-1} (P_{45}) were used in this experiment. They reported that, the highest seed yield (1317 kg ha^{-1}) was observed in V_3 X P_{45} treatment combination, which was statistically identical with (1280 kg ha^{-1}) and (1250 kg ha^{-1}) in V_3 X P_{30} and V_1 X P_{30} treatment combination, respectively and the lowest seed yield (830 kg ha^{-1}) was observed in V_2 X P_0 treatment combination.

Response of three lentil cultivars (Masoor-93, NIAB Masoor-2002 and NIAB Masoor-2006) to various NPK fertilizer combinations (25-0-0, 25-25-25, 25-50-50 and 25-75-75 kg ha^{-1}) was studied by Mahmood *et al.* (2010) during the year 2007-08 and 2008-09. The experiment was replicated three times at Agronomic Research Area, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan. The result of the investigation revealed that, the maximum seed yield (1378 kg ha^{-1}) was produced by combinations of NIAB Masoor-2002 with application of 25-75-75 kg (C_2F_4) and the minimum seed yield (830.70 kg ha^{-1}) was produced by combinations of Masoor-93 with no fertilizers application (C_1F_1).

2.3.7 Harvest index (%)

Response of three lentil cultivars (Masoor-93, NIAB Masoor-2002 and NIAB Masoor-2006) to various NPK fertilizer combinations (25-0-0, 25-25-25, 25-50-50 and 25-75-75 kg ha^{-1}) was studied by Mahmood *et al.* (2010) during the year 2007-08 and 2008-09. The experiment was replicated three times at Agronomic Research Area, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan. The result of the investigation revealed that, the maximum harvest index (46.26 %) was produced by combinations of NIAB Masoor-2002 with application of 25-75-75 kg (C_2F_4) and the minimum harvest index (33.21 %) was produced by combinations of Masoor-93 with no fertilizers application (C_1F_1).

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the Sher-e-Bangla Agricultural University farm, Dhaka to study the influence of variety and phosphorous on growth and yield of lentil. Materials used and methodologies followed in the present investigation have been described in this chapter.

3.1 Description of the experimental site

3.1.1 Site and soil

Geographically the experimental field was located at 23° 77' N latitude and 90° 33' E longitudes at an altitude of 9 m above the mean sea level. The soil belonged to the Agro-ecological Zone - Modhupur Tract (AEZ -28). The land topography was medium high and soil texture was silty clay with pH 6.1. The morphological, physical and chemical characteristics of the experimental soil have been presented in Appendix-I and II.

3.1.2 Climate and weather

The climate of the locality is subtropical which is characterized by high temperature and heavy rainfall during Kharif season (April-September) and scanty rainfall during Rabi season (October-March) associated with moderately low temperature.

3.2 Plant materials

BARI Masur-5

BARI Masur-5 was developed by Pulses Research Centre, Ishurdi, Pabna in the year of 2006. BARI Masur-5 is a semi erect and medium statured cultivar with plant height of 38-40 cm. The leaves are dark green, with broad leaflets with small tendrils. Flowers are blue, and the pods and leaves turn to straw color during maturity stage Seed coat color is radish brown and cotyledons are bright orange It has a 1000 seed weight of 19.84 compared to 11,5 g or less for the local cultivars. It is resistant to rust/STB and Tolerant to foot rot, moderately resistant to aphid. Its duration is 110-115 days. Average yield 2200 kg ha^{-1}. It is suitable for cultivation in most of the Pulse

growing area of Bangladesh. Best sowing time is mid October to mid November and harvesting time is mid February to mid March.

BARI Masur-6

BARI Masur-6 was developed by Pulses Research Centre, Ishurdi, Pabna in the year of 2006. It is a semi erect and medium statured and bushy cultivar. Plant height is of 35-40 cm. The leaves are dark green, with broad leaflets without tendrils. Flowers are light blue, and the pods and leaves turn to straw color during maturity stage Seed coat color is deep brown and cotyledons are bright orange. It has a 1000 seed weight of 19.84 g compared to that of 11.5 g or less for the local cultivars. It is resistant to rust/STB and tolerant to foot rot, moderately resistant to aphid. Seed size is larger than the BARImasur-5. Its duration is 110-115 days. Average yield 2500 kg ha^{-1}. It is suitable for cultivation in most of the Pulse growing area of Bangladesh. Best sowing time is mid October to mid November and harvesting time is mid February to mid March.

BARI Masur-7

BARI Masur-7 was developed by Pulses Research Centre, Ishurdi, Pabna in the year of 2011. BARI masur-7 is an erect cultivar with intensive branching and podding. The leaves are light green with narrow leaflets and rudimentary tendril. The flower is bluish-purple, and the pods, leaves and stems turn a light straw color at maturity. This variety contains high micronutrient especially Iron and Zinc. Seed coat- dark grey and cotyledon is bright orange. Its duration is 115-120 days. Average yield 2200 kg ha^{-1}. Small fruit size with brownish color. It is suitable for cultivation throughout Bangladesh. Best sowing time is 1^{st} week of November and harvesting time is late February.

3.3 Treatments under investigation

There were two factors in the experiment namely variety and Phosphorous levels as mentioned below:

A. Factor-A: Variety (03)

i. V_1 = BARI Masur-5

ii. V_2= BARI Masur-6

iii. V_3= BARI Masur-7

B. Factor-B: Phosphorous levels (04)

i. P_0 = 0 kg P_2O5 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}

Treatment combination: Twelve treatment combinations

V_1P_0	**V_2P_0**	**V_3P_0**
V_1P_1	**V_2P_1**	**V_3P_1**
V_1P_2	**V_2P_2**	**V_3P_2**
V_1P_3	**V_2P_3**	**V_3P_3**

3.4 Experimental design and layout

The experiment was laid out in split-plot design with 3 replications assigning variety in the main plot and phosphorous in the sub-plot. The unit plot size was 5.25 m^2 (3.5 m × 1.5 m). The blocks and unit plots were separated by 1.0 m and 0.50 m spacing, respectively.

3.5 Land preparation

The experimental land was opened with a power tiller on 20 November, 2015. Ploughing and cross ploughing were done with power tiller followed by laddering. Land preparation was completed on 27 November, 2015 and was ready for sowing seeds.

3.6 Fertilizer application

All the fertilizers were applied as basal dose at final land preparation where Urea and MOP were applied @ 50 kg ha^{-1} and 40 kg ha^{-1}, respectively in all plots according to Afzal *et al*. (2003) to supply 23 kg N ha^{-1} and 24 kg K_2O ha^{-1}, respectively. Phosphorous fertilizer was applied from triple super phosphate (TSP) as per treatment variables where treatment P_2 followed the recommendation of Afzal *et al*. (2003).

3.7 Sowing of seeds

Seeds were sown at the rate of 35 kg ha^{-1} in the furrow on 28 November, 2015 and the furrows were covered with the soils soon after seeding. The distance between rows and between seeds in rows maintained were 30 cm and 10 cm, respectively.

3.8 Intercultural operations

3.8.1 Thinning

Thinning operation was done twice to obtain optimum plant population. 1st one was at 15 days after sowing and second one at 25 days after sowing.

3.8.2 Weed control

The crop was infested with some weeds during the early stage of crop establishment. Two hand weddings were done; first at 20 days after sowing and second at 30 days after first weeding.

3.8.3 Application of irrigation water

Irrigation water was added twice to each plot, first at 26 days after sowing and second at 45 days after sowing.

3.8.4 Plant protection measures

The crop was infested by insects and diseases. Ripcord 10 EC @ 1 ml L^{-1} was applied twice at an interval of 1 week to control aphid. On the other hand Bavistin 250 WP @ 2 g L^{-1} was also applied twice at an interval of 1 week to control foot and root rot of lentil disease as the infection was severe. Both the pesticides were first applied on the appearance of the pest incidence.

3.9 Harvesting and sampling

The crop was harvested at 97 DAS. The crop was harvested plot wise when about 80% of the pods became mature. Samples were collected from different places of each plot leaving undisturbed very small in the center. The harvested crops were tied into bundles and carried to the threshing floor. The crop bundles were sun dried by spreading those on the threshing floor. The seeds were separated, cleaned and dried in the sun for 3 to 5 consecutive days for achieving safe moisture of seed.

3.10 Threshing

The crop was sun dried for three days by placing them on the open threshing floor. Seeds were separated from the plants by beating the bundles with bamboo sticks.

3.11 Drying, cleaning and weighing

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

3.12 Recording of data

The data were recorded on the following parameters

a) Days to seedling emergence
b) Plant height (cm)
c) Number of leaves plant^{-1}
d) Number branches plant^{-1}
e) Leaf dry weight plant^{-1} (g)
f) Shoot dry weight plant^{-1} (g)
g) Total dry weight plant^{-1} (g)
h) Number of pods plant^{-1}
i) Number of seeds pod^{-1}
j) Pod length (cm)
k) Weight of 1000-seed
l) Seed weight plant^{-1} (g)
m) Seed yield (t ha^{-1})
n) Stover yield (t ha^{-1})
o) Biological yield (t ha^{-1})
p) Harvest index (%)

3.13 Procedure of recording data

i. Days to seedling emergence

An area of 1 m^2 was demarcated from each plot where emerged seedlings were observed and days required for 80% seedling emergence of the demarcated area were recorded.

ii. Plant height

The height of the selected plant was measured from the ground level to the tip of the plant at 25, 50, 75 DAS and at harvest.

iii. Number of leaves plant^{-1} (no.)

The number of leaves plant^{-1} was counted from five randomly sampled plants. It was done by counting total number of leaves of all sampled plants then the average data were recorded.

iv. Number of branches plant^{-1} (no.)

The number of branches plant^{-1} was counted from five randomly sampled plants. It was done by counting total number of branches of all sampled plants then the average data were recorded.

v. Leaf dry weight plant^{-1} (g)

Ten plants were collected randomly from each plot at 25, 50, 75 DAS and at harvest. The sample plants' leaves were separated and oven dried for 72 hours at 70°C and then leaf dry weight plant^{-1} was determined.

vi. Shoot dry weight plant^{-1} (g)

Ten plants were collected randomly from each plot at 25, 50, 75 DAS and at harvest. The sample plants' shoot were separated and oven dried for 72 hours at 70°C and then shoot dry weight plant^{-1} was determined.

vii. Total dry weight plant^{-1} (g)

The leaf and shoot dry weight plant^{-1} of lentil was added together then data was recorded.

viii. Days to 80% flowering

The days required to 80% flowering were recorded and calculated as the number of days required sowing to 80% flower initiation of plants from each plot.

ix. Days to 80% maturity

The days required to 80% maturity were recorded and calculated as the number of days required sowing to 80% physiological maturity of pod of lentil from each plot.

x. Number of pods plant^{-1} (no.)

The number of Pods plant^{-1} was counted from the 10 selected plant sample and then the average pod number was calculated.

xi. Seeds pod^{-1} (no.)

The Seeds pod^{-1} was counted from 20 selected pods of plants and then the average seed number was calculated.

xii. Pod length (cm)

The length of pod was measured by meter scale from 20 pods of plants and then the average seed number was calculated.

xiii. Weight of 1000-seed (g)

The 1000 seeds were counted, which were taken from the seeds sample of each plot separately, then weighed in an electrical balance and data were recorded.

xiv. Seed weight plant^{-1} (g)

The seed weight plant^{-1} was recorded on the basis of total harvested seeds plant^{-1} and was expressed in terms of seed weight plant^{-1} (g). Seed yield was adjusted to 12% moisture content.

xv. Seed yield (t ha^{-1})

Seed yield was recorded on the basis of total harvested seeds plot^{-1} and was expressed in terms of yield (t ha^{-1}). Seed yield was adjusted to 12% moisture content.

xvi. Stover yield (t 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 t ha^{-1}.

xvii. Biological yield (t ha^{-1})

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

xviii. Harvest index (%)

Harvest index was calculated on dry basis with the help of following formula.

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

Here, Biological yield = Grain yield + stover yield

3.14 Data analysis technique

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program MSTAT-C and the mean differences were adjusted by Least Significance Difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISSCUSION

The experiment was conducted to study the influence of variety and phosphorous on growth and yield of lentil. Data on different growth, yield contributing characters and yield were recorded. The results have been presented with the help of table and graphs and possible interpretations have been given under the following headings.

4.1 Crop growth parameters

4.1.1 Days to 80% of seedling emergence

4.1.1.1 Effect of variety

Days to 80% emergence of seedlings of lentil was not significantly influenced by different varieties (Table 7). Numerically the maximum days to 80% emergence of seedling (6.08) were recorded from BARI Masur-5 (V_1) and BARI Masur-6 (V_2) and the minimum days to 80% emergence of seedlings (6.00) was recorded from BARI Masur-7 (V_3).

4.1.1.2 Effect of phosphorus

Days to 80% emergence of seedlings of lentil was not significantly influenced by different levels of phosphorous (Table 7). Numerically the maximum days to 80% emergence of seedlings (6.11) were recorded from 40 kg P_2O_5 ha^{-1} (P_2) and 60 kg P_2O_5 ha^{-1} (P_3) and the minimum (6.00) from 0 kg P_2O_5 ha^{-1} (P_0) and 20 kg P_2O_5 ha^{-1} (P_1).

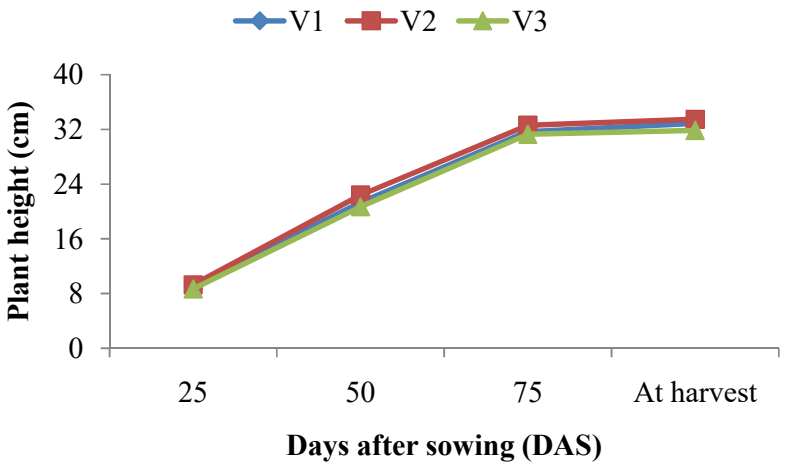
4.1.1.3 Interaction effect

Days to 80% emergence of seedlings of lentil was not significantly influenced by different variety and phosphorus levels (Table 8). Numerically the maximum days to 80% emergence of seedlings (6.33) was recorded from V_1P_3 and V_2P_2 and the minimum (6.00) from all the treatment combination except V_1P_3 and V_2P_2.

4.1 .2 Plant height

4.1.2.1 Effect of variety

Plant height of lentil was significantly influenced by different varieties only at 25 days after sowing (Fig. 1). Plant height increased with increasing the age of the plant up to 75 days after sowing. At 25 days after sowing the highest plant height (9.31 cm) was found in BARI Masur-6 (V_2) which was statistically similar with V_1 and the lowest (8.67 cm) was found in BARI Masur-7(V_3) which was also statistically similar with V_1. The plant height of lentil varied significantly for the different varieties. The results of the present study were also supported by Awal and Roy (2015); Haque *et al.* (2014); Talukder (2004) and Maola (2005) who reported that plant height of lentil varied due to varietal variation. Similar findings were also reported by Sattar and Ahmed (1995) in chickpea; by Fakir *et al.* (1998) in pigeonpea.

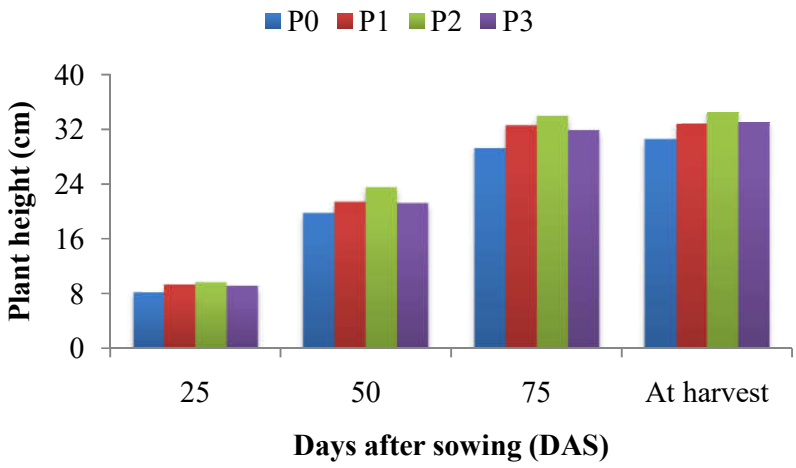


V_1 = BARI Masur-5, V_2= BARI Masur-6 and V_3= BARI Masur-7

Figure 1. Effect of variety on the plant height of lentil at different days after sowing (LSD $_{(0.05)}$ = 0.47, NS, NS and NS at 25, 50, 75 DAS and at harvest, respectively)

4.1.2.2 Effect of phosphorus

Plant height of lentil was significantly influenced by different levels of phosphorus at different days after sowing (Fig. 2). The highest plant height (9.62, 23.52, 33.87 and 34.53 cm at 25, 50, 75 DAS and at harvest, respectively) was found from 40 kg P_2O_5 ha^{-1} (P_2) which were statistically similar to P_1 and P_3 at 25, 75 DAS and at harvest, while the lowest plant height (8.17, 19.78, 29.18 and 30.59 cm at 25, 50, 75 DAS and at harvest, respectively) was found from control treatment (P_0). Maximum plant height might be due to stimulated biological activities in the presence of balanced nutrient supply. These increase might be due to that phosphorus might have improved and developed good root system of lentil plants and the capacity of root to absorb more N, P and K accordingly their contents increased by phosphorus application. This result was agreed with those obtained by Zafar *et al.* (2003); Okaz *et al*. (1994); Batten (1987); Dadson and Acquach (1984) and Saleh (1976).



P_0 = 0 kg P_2O5 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}

Figure 2. Effect of phosphorous on the plant height of lentil at different days after sowing (LSD $_{(0.05)}$ = 0.67, 1.31, 2.46 and 2.06 at 25, 50, 75 DAS and at harvest, respectively)

4.1.2.3 Interaction effect

Plant height of lentil was significantly influenced by interaction of variety and levels of phosphorus at 25, 50, 75 DAS and at harvest (Table 1). The highest plant height (9.71, 24.46, 34.59 and 35.22 cm at 25, 50, 75 DAS and at harvest, respectively) was observed from BARI Masur-6 with 40 kg P_2O_5 ha^{-1} (V_2P_2) treatment which was statistically similar with V_1P_2, V_2P_1, V_1P_1, V_3P_2, V_2P_3, V_1P_3, V_3P_1 and V_3P_3 at 25 DAS; with V_1P_2, V_3P_2 and V_2P_1 at 50 DAS; with rest of the treatment combinations except V_1P_0, V_2P_0 and V_3P_0 at 75 DAS and with rest of the treatment combinations except V_3P_0, V_1P_0 and V_2P_0 at harvest. The lowest plant height (7.80, 18.48, 28.34 and 29.49 cm at 25, 50, 75 DAS and at harvest, respectively) was observed from BARI Masur-7 with 0 kg P_2O_5 ha^{-1} (V_3P_0) treatment which was statistically similar withV_1P_0, V_2P_0, V_3P_1 and V_3P_3 at 25 DAS; with V_1P_0 and V_3P_1at 50 DAS; with V_1P_0, V_2P_0, V_1P_1, V_1P_3, V_2P_3, V_3P_1 and V_3P_3 at 75 DAS and V_1P_0, V_2P_0, V_1P_3, V_3P_1 and V_3P_3 at harvest.

Table 1. Interaction effect of variety and phosphorous on the plant height of lentil at different days after sowing

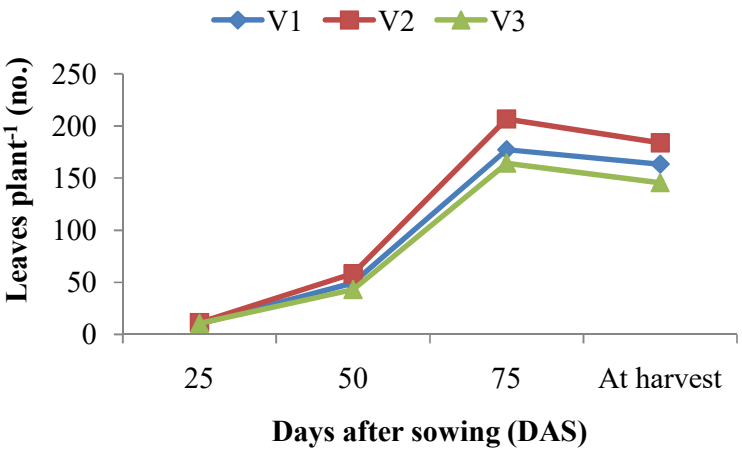
Treatments	Plant height (cm) at different days after sowing (DAS)			
	25	50	75	At harvest
V_1P_0	8.20 cd	19.85 de	28.87 c	30.66 cd
V_1P_1	9.43 ab	21.20 b-d	32.37 a-c	33.29 a-c
V_1P_2	9.66 a	23.26 ab	33.77 ab	34.96 ab
V_1P_3	9.11 a-c	20.97 cd	31.63 a-c	32.58 a-d
V_2P_0	8.50 b-d	21.01 b-d	30.33 bc	31.62 b-d
V_2P_1	9.53 ab	22.23 a-c	33.16 ab	33.32 a-c
V_2P_2	9.71 a	24.46 a	34.59 a	35.22 a
V_2P_3	9.49 ab	21.85 b-d	32.36 a-c	33.77 a-c
V_3P_0	7.80 d	18.48 e	28.34 c	29.49 d
V_3P_1	8.75 a-d	20.73 c-e	32.08 a-c	31.79 a-d
V_3P_2	9.50 ab	22.85 a-c	33.26 ab	33.41 a-c
V_3P_3	8.63 a-d	20.75 cd	31.47 a-c	32.65 a-d
LSD $_{(0.05)}$	1.16	2.27	4.27	3.57
CV (%)	7.47	6.15	7.81	6.35

V_1 = BARI Masur-5, V_2= BARI Masur-6 and V_3= BARI Masur-7; 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}

4.1.3 Number of leaves plant^{-1}

4.1.3.1 Effect of variety

Varieties had significant effect on number of leaves plant^{-1} of lentil at 25, 50, 75 DAS and at harvest (Fig. 3). At 25, 50, 75 DAS and at harvest the highest number of leaves plant^{-1} (11.40, 58.05, 206.6 and 183.70, respectively) was found from BARI Masur-6 which was statistically similar with V_3 at 25 DAS only. At 25 DAS, the lowest number of leaves plant^{-1} (10.23) was found from BARI Masur-5 (V_1) which was statistically at par with V_3. The lowest number of leaves plant^{-1} (43.00, 164.30 and 145.50 at 50, 75 DAS and at harvest, respectively) was found from BARI Masur-7 (V_3) which was statistically at par with V_1 at 75 DAS.

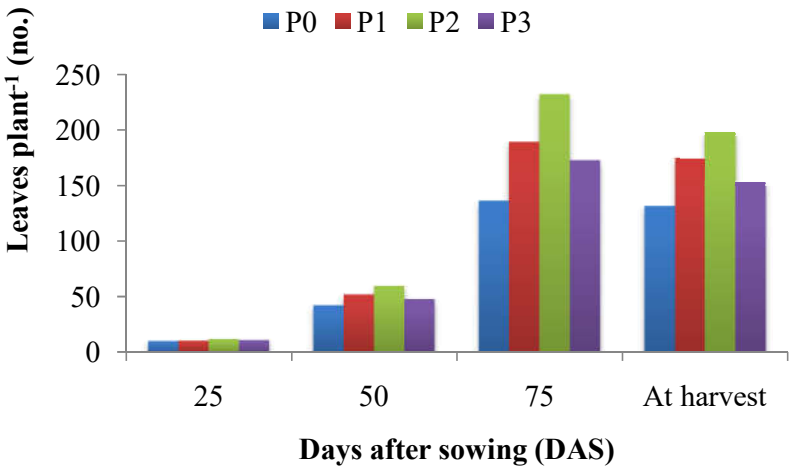


V_1 = BARI Masur-5, V_2= BARI Masur-6 and V_3= BARI Masur-7

Figure 3. Effect of variety on the number of leaves plant^{-1} of lentil at different days after sowing (LSD $_{(0.05)}$ = 1.01, 3.14, 14.88 and 8.45 at 25, 50, 75 DAS and at harvest, respectively)

4.1.3.2 Effect of phosphorus

Different levels of phosphorus had significant effect on number of leaves plant^{-1} of lentil at 25, 50, 75 DAS and at harvest (Fig. 4). The highest number of leaves plant^{-1}(11.67, 58.95, 232.30 and 197.90 at 25, 50, 75 DAS and at harvest, respectively) was found at the rate of 40 kg P_2O_5 ha^{-1} (P_2) and the lowest number of leaves plant^{-1} (9.96, 42.16, 136.50 and 131.2 at 25, 50, 75 DAS and at harvest, respectively) was found with control treatment (P_0).



P_0 = 0 kg P_2O5 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}

Figure 4. Effect of phosphorous on the number of leaves plant^{-1} of lentil at different days after sowing (LSD $_{(0.05)}$ = 0.53, 3.84, 13.60 and 15.02 at 25, 50, 75 DAS and at harvest, respectively)

4.1.3.3 Interaction effect

Interaction of variety and phosphorus had significant effect on the number of leaves plant^{-1} of lentil at 25, 50, 75 DAS and at harvest (Table 2). The highest number of leaves plant^{-1}(12.47, 69.67, 287.90 and 228.10 at 25, 50, 75 DAS and at harvest, respectively) was found from treatment combination V_2P_2. At 25 and 50 DAS, the lowest number of leaves plant^{-1} (9.47 and 37.33, respectively) was recorded from V_1P_0 which was statistically similar with V_3P_0, V_1P_1, V_1P_3 and V_3P_1 at 25 DAS and with V_3P_0, V_3P_1 and V_3P_3 at 50 DAS. At 75 DAS and at harvest, the lowest number of leaves plant^{-1} (112.70 and 113.5, respectively) was recorded from V_3P_0 which was statistically similar with V_1P_0 at 75 DAS and with V_1P_0 and V_3P_3 at harvest.

Table 2. Interaction effect of variety and phosphorous on the number of leaves plant^{-1} of lentil at different days after sowing

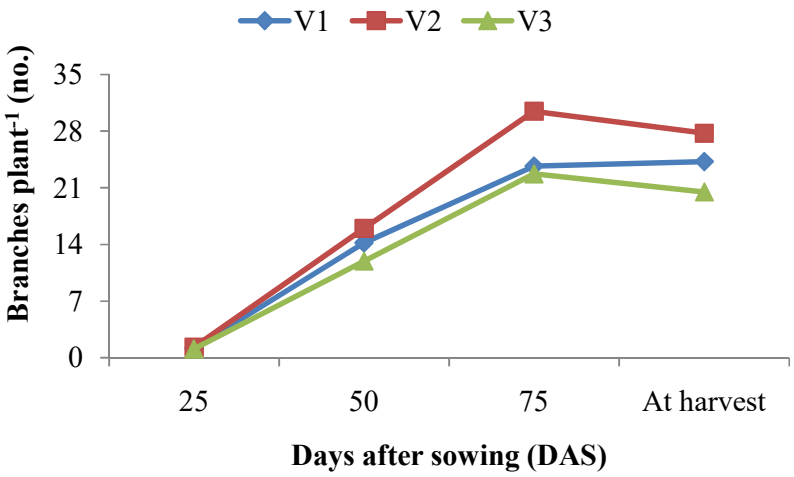
Treatments	Number of leaves plant^{-1} at different days after sowing (DAS)			
	25	50	75	At harvest
V_1P_0	9.47 f	37.33 e	135.4 g	127.0 fg
V_1P_1	10.04 d-f	56.93 b	189.6 c-e	175.9 b-d
V_1P_2	11.07 bc	56.60 b	217.6 b	194.6 b
V_1P_3	10.33 c-f	45.87 cd	166.3 ef	156.0 de
V_2P_0	10.67 b-d	50.87 bc	161.5 f	153.0 d-f
V_2P_1	11.00 bc	56.80 b	194.4 bc	186.3 bc
V_2P_2	12.47 a	69.67 a	287.9 a	228.1 a
V_2P_3	11.47 b	54.87 b	182.6 c-f	167.3 cd
V_3P_0	9.733 ef	38.27 e	112.7 g	113.5 g
V_3P_1	10.39 c-f	40.97 de	183.8 c-f	161.1 c-e
V_3P_2	11.47 b	50.59 bc	191.4 cd	170.4 b-d
V_3P_3	10.60 b-e	42.17 de	169.3 d-f	137.0 e-g
LSD $_{(0.05)}$	0.92	6.64	23.56	26.02
CV (%)	5.02	7.73	7.52	9.24

V_1 = BARI Masur-5, V_2= BARI Masur-6 and V_3= BARI Masur-7; 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}

4.1.4 Number of branches plant^{-1}

4.1.4.1 Effect of variety

The number of branch plant^{-1} of lentil was significantly affected by different varietal variation at 25, 50, 75 DAS and at harvest (Fig. 5). The highest number of branches plant^{-1} (1.28, 15.98, 30.47 and 27.74, respectively) was found from V_2 and the lowest number of branches (1.05, 11.93, 22.73 and 20.48, respectively) was found from V_3 which was statistically similar with V_1 at 25 and 75 DAS. The number of branches per plant is an important yield component of lentil (Ayub *et al*., 2001). The number of pods per plant is one of the most important yield components in lentil, and is strictly related to number of branches (Hussain *et al*., 2014). The said variability in the number of branches per plant due to varietal difference was in full agreement with Awal and Roy (2015); Janmohammadi *et al*. (2014); Sinha and Choudhary (1991); Maola (2005) and Sarker (2005).

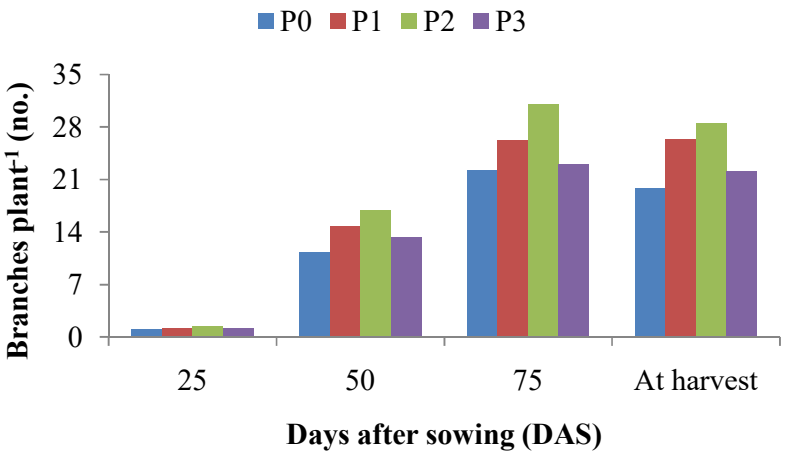


V_1 = BARI Masur-5, V_2= BARI Masur-6 and V_3= BARI Masur-7

Figure 5. Effect of variety on the number of branches plant^{-1} of lentil at different days after sowing (LSD $_{(0.05)}$ = 0.11, 1.23, 3.13 and 1.65 at 25, 50, 75 DAS and at harvest, respectively)

4.1.4.2 Effect of phosphorus

The number of branches plant^{-1} of lentil was significantly affected by different levels of phosphorous at 25, 50, 75 DAS and at harvest (Fig. 6). The highest number of branches plant^{-1}(1.42, 16.83, 30.97 and 28.47 at 25, 50, 75 DAS and at harvest, respectively) was found from P_2 and the lowest number of branches plant^{-1}(0.93, 11.26, 22.20 and 19.80 at 25, 50, 75 DAS and at harvest, respectively) was found P_0 which was statistically similar with only P_3 at 75 DAS. It may be due to the favorable effect of phosphorus on root development and root nodulation at initial stages which helped to increase number of branches plant^{-1} (Rasool and Singh, 2016). Zafar *et al.* (2003) also reported that the cumulative effect of phosphorus on the processes of cell division and balanced nutrition could trigger the number of branches plant^{-1}. The present results corroborate to the findings of Khare *et al.* (1988), Barua *et al.* (2011), Datta *et al.* (2013) and Mahmood *et al.* (2010).



P_0 = 0 kg P_2O5 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}

Figure 6. Effect of phosphorous on the number of branches plant^{-1} of lentil at different days after sowing (LSD $_{(0.05)}$ =0.09, 0.91, 1.55 and 1.88 at 25, 50, 75 DAS and at harvest, respectively)

4.1.4.3 Interaction effect

The number of branches plant^{-1} of lentil was significantly affected by interaction of variety and different levels of phosphorous at 25, 50, 75 DAS and at harvest (Table 3). The highest number of branches plant^{-1}(1.60, 19.47, 36.07 and 32.33 at 25, 50, 75 DAS and at harvest) was found from V_2P_2 which was statistically similar with V_1P_2 at 25 DAS and the lowest number of branches plant^{-1} (0.87, 9.60, 19.27 and 15.72 at25, 50, 75 DAS and at harvest, respectively) was found from V_3P_0 which was statistically similar with V_1P_0 at 25 and 50 DAS; with V_3P_3, V_1P_0 and V_1P_3 at 75 DAS and with V_3P_3 at harvest.

Table 3. Interaction effect of variety and phosphorous on the number of branches plant^{-1} of lentil at different days after sowing

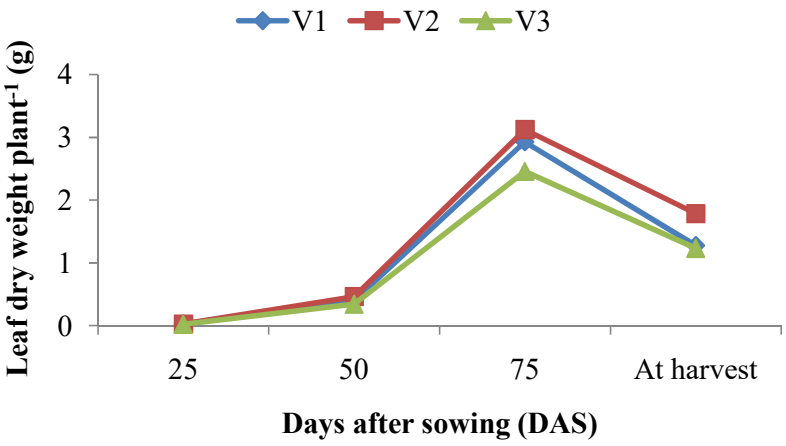
Treatments	Number of branches plant^{-1} at different days after sowing (DAS)			
	25	50	75	At harvest
V_1P_0	0.93 e	10.53 hi	21.47 f-h	19.74 ef
V_1P_1	1.13 cd	15.60 b-d	22.33 fg	25.73 cd
V_1P_2	1.47 a	16.83 b	29.51 c	28.67 bc
V_1P_3	1.00 de	13.73 ef	21.40 f-h	22.77 de
V_2P_0	1.00 de	13.63 ef	25.87 de	23.93 d
V_2P_1	1.30 b	16.07 bc	32.67 b	29.67 ab
V_2P_2	1.60 a	19.47 a	36.07 a	32.33 a
V_2P_3	1.20 bc	14.73 c-e	27.27 cd	25.03 d
V_3P_0	0.87 e	9.60 i	19.27 h	15.72 g
V_3P_1	1.00 de	12.40 fg	23.73 ef	23.53 d
V_3P_2	1.20 bc	14.20 de	27.33 cd	24.40 d
V_3P_3	1.13 cd	11.53 gh	20.60 gh	18.27 fg
LSD $_{(0.05)}$	0.15	1.58	2.68	3.26
CV (%)	8.00	6.55	6.09	7.86

V_1 = BARI Masur-5, V_2= BARI Masur-6 and V_3= BARI Masur-7; 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}

4.1.5 Leaf dry weight plant^{-1}

4.1.5.1 Effect of variety

Significant variation in leaf dry weight plant^{-1} of lentil was observed due to variety throughout the growing period except 25 DAS (Fig. 7). The highest leaf dry weight plant^{-1} (0.46, 3.12 and 1.79 g at 50, 75 DAS and at harvest, respectively) was produced by V_2 which was statistically similar to V_1 at 75 DAS whereas the lowest leaf dry weight plant^{-1} (0.34, 2.46 and 1.23 g at 50, 75 DAS and at harvest, respectively) was produced by V_3 which was statistically similar with V_1 at harvest.

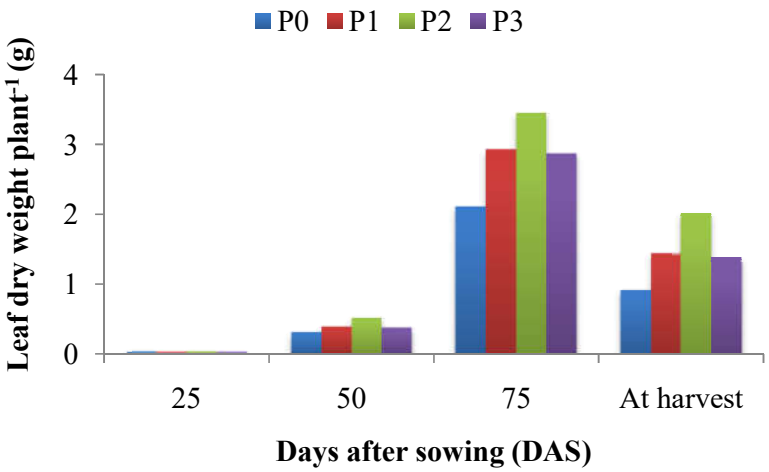


V_1 = BARI Masur-5, V_2= BARI Masur-6 and V_3= BARI Masur-7

Figure 7. Effect of variety on the leaf dry weight plant^{-1} of lentil at different days after sowing (LSD $_{(0.05)}$ = NS, 0.01, 0.33 and 0.11 at 25, 50, 75 DAS and at harvest, respectively)

4.1.5.2 Effect of phosphorus

Phosphorus had significant effect on leaf dry weight plant^{-1} of lentil throughout the growing period except at 25 DAS (Fig. 8). The highest leaf dry weight plant^{-1} (0.52, 3.44 and 2.00 g at 50, 75 DAS and at harvest, respectively) was produced by P_2 and the lowest leaf dry weight plant^{-1} (0.31, 2.11 and 0.91 g at 50, 75 DAS and at harvest, respectively) was produced by P_0 treatment. Rest of the treatments gave the intermediate value for leaf dry weight plant^{-1}.



P_0 = 0 kg P_2O5 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}

Figure 8. Effect of phosphorous on the leaf dry weight plant^{-1} of lentil at different days after sowing (LSD $_{(0.05)}$ = NS, 0.03, 0.26 and 0.13 at 25, 50, 75 DAS and at harvest, respectively)

4.1.5.3 Interaction effect

Interaction of variety and phosphorus had significant effect on leaf dry weight plant^{-1} of lentil throughout the growing period except 25 DAS (Table 4). The highest leaf dry weight plant^{-1} (0.59, 3.60 and 2.67 g at 50, 75 DAS and at harvest, respectively) was produced by combination of V_2P_2 which was statistically similar with V_1P_2, V_2P_1, V_2P_3 and V_3P_2 at 75 DAS. At 50 DAS, the lowest leaf dry weight plant^{-1} (0.33 g) was produced by V_1P_0 and V_3P_3 which were statistically similar with V_3P_1, V_1P_3 and V_2P_0. The lowest leaf dry weight plant^{-1} (1.91 and 0.75 g at 75 DAS and at harvest, respectively) was produced by V_3P_0 which was statistically similar with V_1P_0, V_3P_3 and V_2P_0 at 75 DAS and with V_1P_0 at harvest.

Table 4. Interaction effect of variety and phosphorous on the leaf dry weight plant^{-1} of lentil at different days after sowing

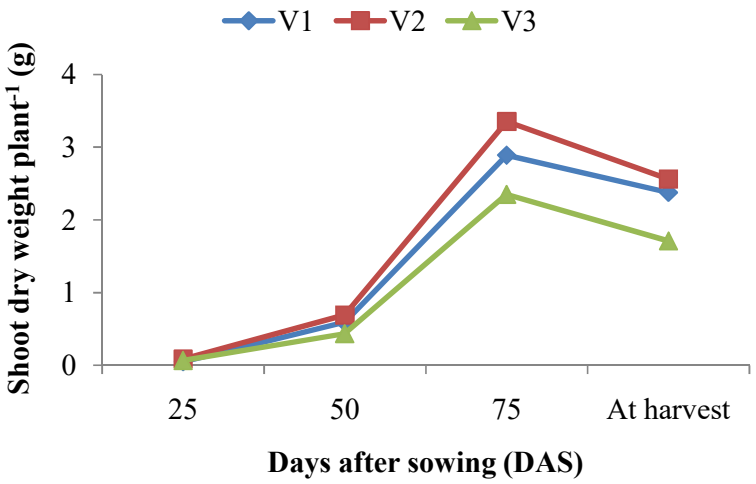
Treatments	Leaf dry weight plant^{-1} (g) at different days after sowing (DAS)			
	25	50	75	At harvest
V_1P_0	0.023	0.33 f	2.08 cd	0.76 f
V_1P_1	0.020	0.40 de	3.08 b	1.22 e
V_1P_2	0.030	0.51 b	3.50 ab	1.78 b
V_1P_3	0.020	0.35 ef	3.05 b	1.35 de
V_2P_0	0.030	0.36 ef	2.35 cd	1.22 e
V_2P_1	0.027	0.43 cd	3.28 ab	1.73 bc
V_2P_2	0.030	0.59 a	3.60 a	2.67 a
V_2P_3	0.023	0.47 bc	3.26 ab	1.52 cd
V_3P_0	0.023	0.25 g	1.91 d	0.75 f
V_3P_1	0.020	0.34 f	2.41 c	1.36 de
V_3P_2	0.027	0.45 cd	3.22 ab	1.56 cd
V_3P_3	0.020	0.33 f	2.28 cd	1.26 e
LSD $_{(0.05)}$	NS	0.05	0.46	0.22
CV (%)	14.19	9.04	9.42	8.89

V_1 = BARI Masur-5, V_2= BARI Masur-6 and V_3= BARI Masur-7; 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}

4.1.6 Shoot dry weight plant^{-1}

4.1.6.1 Effect of variety

Variety had significant effect on shoot dry weight plant^{-1} of lentil at 25, 50, 75 DAS and at harvest (Fig. 9). There was a slow increase of shoot dry weight plant^{-1} up to 50 DAS and it increased rapidly from 50 DAS to 75 DAS then there was a slow decrease up to harvest. The highest shoot dry weight plant^{-1} (0.085, 0.69, 3.36 and 2.56 g at 25, 50, 75 DAS and at harvest, respectively) was recorded from V_2. At 25 DAS, the lowest shoot dry weight plant^{-1} (0.048 g) was recorded from V_1. At 50, 75 DAS and at harvest, the lowest shoot dry weight plant^{-1} (0.43, 2.35 and 1.71 g, respectively) was recorded from V_3.

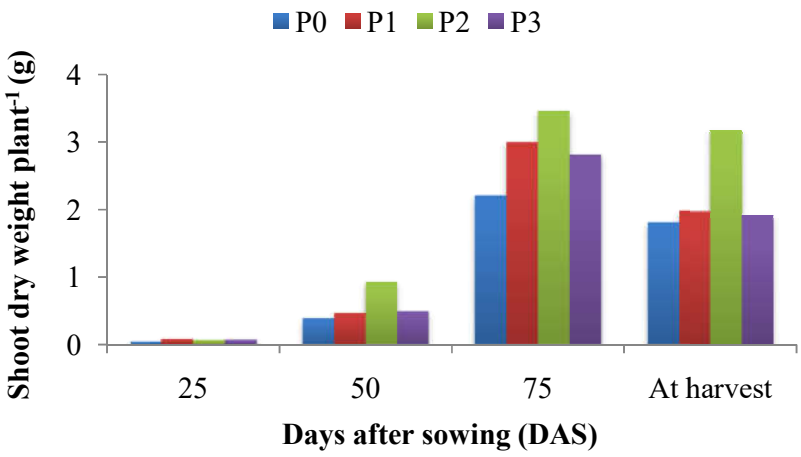


V_1 = BARI Masur-5, V_2= BARI Masur-6 and V_3= BARI Masur-7

Figure 9. Effect of variety on the shoot dry weight plant^{-1} of lentil at different days after sowing (LSD $_{(0.05)}$ = 0.01, 0.06, 0.23 and 0.19 at 25, 50, 75 DAS and at harvest, respectively)

4.1.6.2 Effect of phosphorus

Phosphorus levels exerted significant effect on shoot dry weight plant^{-1} of lentil at 25, 50, 75 DAS and at harvest (Fig. 10). There was a slow increase of shoot dry weight plant^{-1} up to 50 DAS and it increased rapidly from 50 DAS to 75 DAS then there was a slow decrease up to harvest. At 25 DAS, the highest shoot dry weight plant^{-1} (0.081 g) was recorded from P_1. The highest shoot dry weight plant^{-1} (0.93, 3.45 and 3.18 g at 50, 75 DAS and at harvest, respectively) was recorded from P_2 while the lowest shoot dry weight plant^{-1} (0.04, 0.39, 2.20 and 1.80 g, at 25, 50, 75 DAS and at harvest, respectively) was recorded from P_0 which was statistically at par with P_1 and P_3 at harvest.



P_0 = 0 kg P_2O5 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}

Figure 10. Effect of phosphorous on the shoot dry weight plant^{-1} of lentil at different days after sowing (LSD $_{(0.05)}$ = 0.01, 0.04, 0.19 and 0.21 at 25, 50, 75 DAS and at harvest, respectively)

4.1.6.3 Interaction effect

The shoot dry weight plant^{-1} of lentil was significantly influenced by varieties and different levels of phosphorus at 25, 50, 75 DAS and at harvest (Table 5). At 25 DAS, the highest total dry weight plant^{-1} (0.09 g) was recorded from the combinations of V_2P_2, V_2P_1 and V_3P_2 which were statistically similar with V_1P_1, V_2P_0, V_2P_3, V_3P_1 and V_3P_3 and the lowest total dry weight plant^{-1} (0.02 g) was recorded from the combinations of V_1P_0 and V_3P_0 which was statistically similar with V_1P_2. The highest total dry weight plant^{-1} (1.20, 3.71 and 3.60 g at 50, 75 DAS and at harvest, respectively) was recorded from the combination of V_2P_2 which was statistically similar with V_1P_2 and V_2P_3 at 75 DAS; with V_1P_2 at harvest. The lowest total dry weight plant^{-1} (0.31, 1.66 and 1.34 g at 50, 75 DAS and at harvest, respectively) was recorded from the combination of V_3P_0 which was statistically similar with V_3P_1 at 50 DAS; with V_3P_3 and V_3P_1 at harvest.

Table 5.Interaction effect of variety and phosphorous on the shoot dry weight plant^{-1} of lentil at different days after sowing

Treatments	Shoot dry weight plant^{-1} (g) at different days after sowing (DAS)			
	25	50	75	At harvest
V_1P_0	0.02 c	0.41 gh	2.08 f	1.86 de
V_1P_1	0.08 ab	0.51 d-f	3.11 cd	2.10 b-d
V_1P_2	0.03 c	0.94 b	3.51 ab	3.50 a
V_1P_3	0.06 b	0.50 d-f	2.86 d	2.05 cd
V_2P_0	0.08 ab	0.46 e-g	2.87 d	2.21 b-d
V_2P_1	0.09 a	0.56 d	3.35 bc	2.26 bc
V_2P_2	0.09 a	1.20 a	3.71 a	3.60 a
V_2P_3	0.08 ab	0.54 de	3.49 ab	2.18 b-d
V_3P_0	0.02 c	0.31 i	1.66 g	1.34 f
V_3P_1	0.07 ab	0.33 hi	2.53 e	1.55 ef
V_3P_2	0.09 a	0.64 c	3.14 cd	2.44 b
V_3P_3	0.07 ab	0.45 fg	2.07 f	1.50 ef
LSD $_{(0.05)}$	0.02	0.08	0.33	0.37
CV (%)	10.27	7.50	6.58	9.76

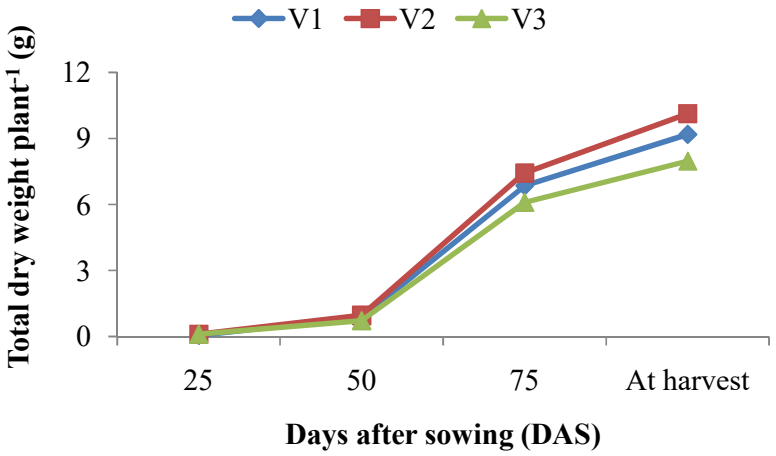
V_1 = BARI Masur-5, V_2= BARI Masur-6 and V_3= BARI Masur-7; P_0 = 0 kg P_2O_5 ha^{-1}, P_1 = 20 kg P_2O_5 ha^{-1}, P_2 = 40 kg P_2O_5 ha^{-1} and P_3 = 60 kg P_2O_5 ha^{-1}

4.1.7 Total dry weight plant^{-1}

4.1.7.1 Effect of variety

Variety had significant effect on total dry weight plant^{-1} of lentil at 25, 75 DAS and at harvest and non significant effect at 50 DAS (Fig. 11). There was a slow increase of total dry weight plant^{-1} up to 50 DAS and it increased rapidly from 50 DAS to 75 DAS then there was a slow decrease up to harvest. The highest total dry weight plant^{-1} (0.11, 7.43 and 10.13 g at 25, 75 DAS and at harvest, respectively) was recorded fromV_2 which was statistically similar with V_3 at 25 DAS and V_1 at harvest. At 25 DAS, the lowest total dry weight plant^{-1} (0.054 g) was recorded from V_1. At 75 DAS and at harvest, the lowest total dry weight plant^{-1} (6.09 and 7.97 g, respectively) was recorded from V_3. The different behavior of varieties observed in the studied characters might reflect the differential expressivity of certain genes during

autogenetic processes. Similar results also reported by Awal and Roy (2015); Alam *et al.* (2015); Dash (2005) and Wasiq (2006) in lentil; Mirza *et al.* (2007) in chickpea.

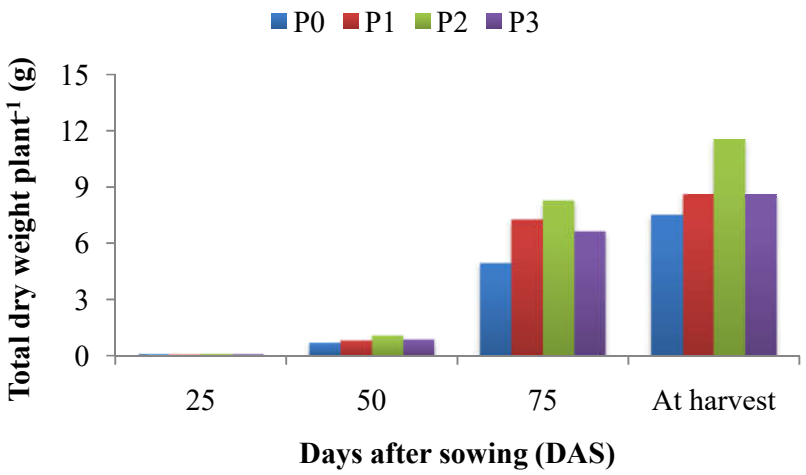


V_1 = BARI Masur-5, V_2= BARI Masur-6 and V_3= BARI Masur-7

Figure 11. Effect of variety on the total dry weight plant^{-1} of lentil at different days after sowing (LSD $_{(0.05)}$ = 0.01, NS, 0.39 and 1.07 at 25, 50, 75 DAS and at harvest, respectively)

4.1.7.2 Effect of phosphorus

Phosphorus levels exerted significant effect on total dry weight plant^{-1} of lentil at 25, 50, 75 DAS and at harvest (Fig. 12). There was a slow increase of total dry weight plant^{-1} up to 50 DAS and it increased rapidly from 50 DAS to 75 DAS then there was a slow decrease up to harvest. The highest total dry weight plant^{-1} (0.10, 1.05, 8.27 and 11.59 g at 25, 50, 75 DAS and at harvest, respectively) was recorded from P_2 which was statistically at par with P_3 at 25 DAS. At 25 DAS, the lowest total dry weight plant^{-1} (.081 g) was recorded from P_1 which was statistically at par with P_0. The lowest total dry weight plant^{-1} (0.69, 4.95 and 7.53 g, at 50, 75 DAS and at harvest, respectively) was recorded from P_0 treatment.



P_0 = 0 kg P_2O5 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}

Figure 12. Effect of phosphorous on the total dry weight plant^{-1} of lentil at different days after sowing (LSD $_{(0.05)}$ = 0.01, 0.04, 0.39 and 0.50 at 25, 50, 75 DAS and at harvest, respectively)

4.1.7.3 Interaction effect

The total dry weight plant^{-1} of lentil was significantly influenced by varieties and different levels of phosphorus at 25, 50, 75 DAS and at harvest (Table 6). The highest total dry weight plant^{-1} (0.13, 1.16, 8.54 and 12.21 g at 25, 50, 75 DAS and at harvest, respectively) was recorded from the combination of V_2P_2 which was statistically similar with V_2P_1, V_3P_2, V_3P_0 and V_2P_0 at 25 DAS; with V_1P_2 at 50 DAS; with V_1P_2, V_2P_1 and V_3P_2 at 75 DAS and V_1P_2 at harvest. At 25 DAS, the lowest total dry weight plant^{-1} (0.03 g) was recorded from the combination of V_1P_1 which was statistically similar with V_1P_0. At 50 DAS and at harvest, the lowest total dry weight plant^{-1} (0.50 and 6.10 g, respectively) was recorded from the combination of V_3P_0. At 70 DAS, the lowest total dry weight plant^{-1} (5.24 g) was recorded from the combination of V_2P_0 which was statistically similar with V_1P_0 and V_3P_3.

Table 6. Interaction effect of variety and phosphorous on the total dry weight plant^{-1} of lentil at different days after sowing

Treatments	Total dry weight plant^{-1} (g) at different days after sowing (DAS)			
	25	50	75	At harvest
V_1P_0	0.04 ef	0.69 d	5.25 g	7.99 de
V_1P_1	0.03 f	0.88 bc	7.18 cd	8.66 d
V_1P_2	0.06 e	1.10 a	8.35 a	11.78 a
V_1P_3	0.08 d	0.83 c	6.61 de	8.28 de
V_2P_0	0.11 a-c	0.89 bc	5.24 g	8.50 d
V_2P_1	0.12 ab	0.88 bc	8.31 a	9.73 c
V_2P_2	0.13 a	1.16 a	8.54 a	12.21 a
V_2P_3	0.10 b-d	0.93 b	7.61 bc	10.07 bc
V_3P_0	0.11 a-c	0.50 e	4.37 h	6.10 f
V_3P_1	0.09 cd	0.70 d	6.37 ef	7.46 e
V_3P_2	0.12 ab	0.90 bc	7.93 ab	10.78 b
V_3P_3	0.09 d	0.83 c	5.70 fg	7.55 e
LSD $_{(0.05)}$	0.02	0.08	0.68	0.87
CV (%)	8.07	5.76	5.86	5.60

V_1 = BARI Masur-5, V_2= BARI Masur-6 and V_3= BARI Masur-7; 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}

4.1.8 Days to 80% flowering

4.1.8.1 Effect of variety

The days to 80% flowering of lentil was not significantly influenced by varietal variation (Table 7). Numerically the maximum days to 80% flowering (54.58) was recorded from V_3 and the minimum days to 80% flowering (54.17) was recorded from V_2.

4.1.8.2 Effect of phosphorus

Days to 80% flowering of lentil was not significantly influenced by different levels of phosphorous (Table 7). Numerically the maximum days to 80% flowering (54.67) was recorded from P_0 and the minimum days to 80% flowering (54.11) was recorded from P_3.

4.1.8.3 Interaction effect

Days to 80% flowering of lentil was not significantly influenced by different variety and phosphorus levels (Table 8). Numerically the maximum days to 80% flowering (55.00) was recorded from V_3P_2 and the minimum days to 80% flowering (53.67) was recorded from V_1P_1 and V_2P_2.

4.1.9 Days to 80% maturity

4.1.9.1 Effect of variety

The days to 80% maturity of lentil was not significantly influenced by varietal variation (Table 7). Numerically the maximum days to 80% maturity (94.25) were recorded from V_3 and the minimum days to 80% maturity (93.75) was recorded from V_1. This finding was not similar with the findings of Awal and Roy (2015); Mamun (2006) and Karim (2006) who found variation in days to maturity in lentil varieties.

4.1.9.2 Effect of phosphorus

Days to 80% maturity of lentil was not significantly influenced by different levels of phosphorous (Table 7). Numerically the maximum days to 80% maturity (94.33) were recorded from P_0 and the minimum days to 80% maturity (93.89) was recorded from P_2 and P_3.

Table 7. Effect of variety and phosphorous on the days to 80% seedling emergence, days to 80% flowering and days to 80% maturity of lentil

Treatments Variety	Days to 80% seedling emergence	Days to 80% flowering	Days to 80% maturity
V_1	6.08	54.25	93.75
V_2	6.08	54.17	94.17
V_3	6.00	54.58	94.25
LSD $_{(0.05)}$	NS	NS	NS
CV (%)	3.35	1.50	1.31
Phosphorous			
P_0	6.00	54.67	94.33
P_1	6.00	54.22	94.11
P_2	6.11	54.33	93.89
P_3	6.11	54.11	93.89
LSD $_{(0.05)}$	NS	NS	NS
CV (%)	3.89	1.45	0.97

V_1 = BARI Masur-5, V_2= BARI Masur-6 and V_3= BARI Masur-7; 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}

4.1.9.3 Interaction effect

Days to 80% maturity of lentil was not significantly influenced by different variety and phosphorus levels (Table 8). Numerically the maximum days to 80% maturity (94.67) were recorded from V_2P_0 and V_2P_1 and the minimum days to 80% maturity (93.33) was recorded from V_1P_1.

Table 8. Interaction effect of variety and phosphorous on the days to 80% seedling emergence, days to 80% flowering and days to 80% maturity of lentil

Treatments	Days to 80% seedling emergence	Days to 80% flowering	Days to 80% maturity
V_1P_0	6.00	54.67	94.00
V_1P_1	6.00	53.67	93.33
V_1P_2	6.00	54.33	93.67
V_1P_3	6.33	54.33	94.00
V_2P_0	6.00	54.67	94.67
V_2P_1	6.00	54.33	94.67
V_2P_2	6.33	53.67	93.67
V_2P_3	6.00	54.00	93.67
V_3P_0	6.00	54.67	94.33
V_3P_1	6.00	54.67	94.33
V_3P_2	6.00	55.00	94.33
V_3P_3	6.00	54.00	94.00
$LSD_{(0.05)}$	NS	NS	NS
CV (%)	3.89	1.45	0.97

V_1 = BARI Masur-5, V_2= BARI Masur-6 and V_3= BARI Masur-7; 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}

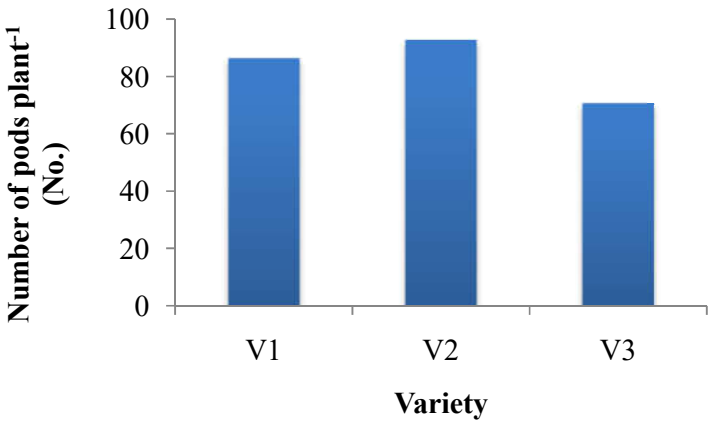
4.2 Yield attributes

4.2.1 Number of pods $plant^{-1}$

4.2.1.1 Effect of variety

Different variety had significant effect on number of pods $plant^{-1}$ of lentil (Fig. 13). The highest number of pods $plant^{-1}$ (92.60) was found from BARI Masur-6 which was statistically similar with BARI Masur-5 and the lowest numbers of pod $plant^{-1}$ (70.65) was found from BARI Masur-7. BARI Masur-6 produced 31.07% higher pod $plant^{-1}$ over BARI Masur-7. Number of pods per plant seems to be a genotypic character and cultivars differed in this trait. Number of pods per plant is considered as a criterion for selection of genotypes to develop high yielding lentil varieties (Mahmood *et al*., 2010 and Afzal, 1989). Highly significant variability in number of pods in lentil germplasm

has also been noted by some other scientists Janmohammadi *et al*. (2014); Hegazy *et al*., 2012; Hussain *et al*., 2014; Awal and Roy (2015); El-Nagar and Galal (1997), BINA (2000), Ali (2006), Mamun (2006), Rahman (2006), Wasiq (2006) and Yusuf (2006).



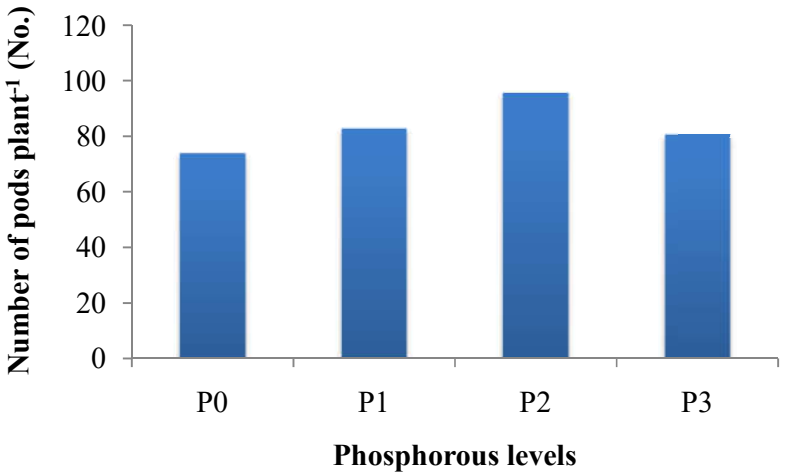
V_1 = BARI Masur-5, V_2= BARI Masur-6 and V_3= BARI Masur-7

Figure 13. Effect of variety on the number of pods plant^{-1} of lentil (LSD $_{(0.05)}$ = 7.97)

4.2.1.2 Effect of phosphorus

The results from Figure 14 showed that phosphorus levels had significant effect on number of pods plant^{-1}. The highest number of pods plant^{-1} (95.51) was found from the application of 40 kg P_2O_5 ha^{-1}. The lowest number of pods plant^{-1} (74.00) was found from the control treatment i.e. no phosphorus application plot. P_2 produced 29.07% higher pod plant^{-1} over P_0. The reason might be the liberal availability of plant nutrients which stimulated the plants to produce more pods per plant as compared to other treatments as phosphorus powerfully encourages flowering and fruiting. Zeidan (2007) and Zeidan *et al*. (2006) reported that, the application of P fertilizer with N has been found to improve pod formation in lentil. A remarkable increase in number of pods of lentil occurred with application of P Malik *et al.* (1983). It was observed that, cultivars exhibited their maximum potential for this genetically controlled trait up to certain limit of fertilizer applied and beyond that limit applied fertilizer particularly phosphorus, may restrict mycorrhizal development which adversely affects nitrogen availability to plants (Grant *et al*., 2005). Excessive phosphorus may be fixed in soil which will not available for plant. However,

Mahmood *et al*. (2010) and Zeidan (2007) recorded maximum number of pods with application of 75 kg P and 30 kg N per hectare. This finding was in accordance with the results of Saleh (1976) and Jayapaul and Ganesaraja (1990).



P_0 = 0 kg P_2O5 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}

Figure 14. Effect of phosphorous on the number of pods plant^{-1} of lentil (LSD $_{(0.05)}$ = 4.31)

4.2.1.3 Interaction effect

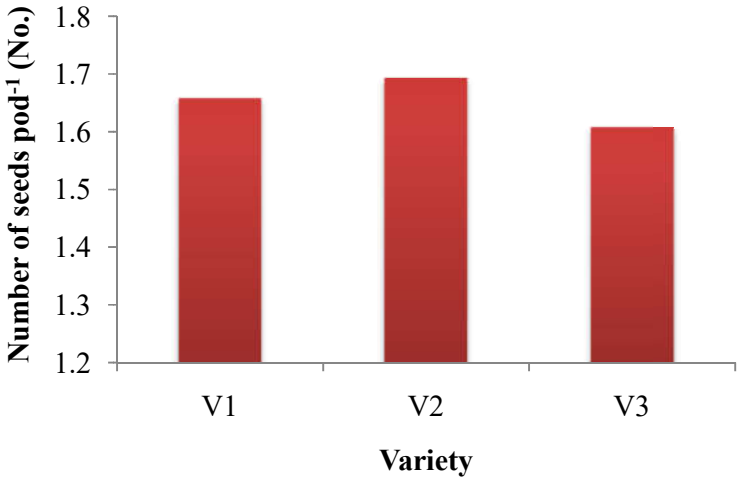
The number of pods plant^{-1} was significantly influenced by varieties and different levels of phosphorus application (Table 9). The highest number of pods plant^{-1}(103.70) was found from V_2P_2 which was statistically similar with V_1P_2 and V_2P_1 and the lowest number of pods plant^{-1} (63.53) was found from V_3P_0 which was statistically similar with V_3P_1 and V_3P_3. Treatment combination V_2P_2 produced 63.23% higher pod plant^{-1} over V_3P_0.

4.2.2 Number of seeds pod^{-1}

4.2.2.1 Effect of variety

Different variety had significant effect on number of seeds pod^{-1} of lentil (Fig. 15). The highest number of seeds pod^{-1}(1.69) was found from BARI Masur-6 which was statistically similar with BARI Masur-5 and the lowest numbers of seeds pod^{-1} (1.61) was found from BARI Masur-7 which was statistically similar with BARI Masur-5. The quantitative values of yield components found in this study for the said lentil

varieties are mostly similar to those found by Awal and Roy (2015), El-Nagar and Galal (1997), BINA (2000), Ali (2006), Mamun (2006), Rahman (2006), Wasiq (2006) and Yusuf (2006).



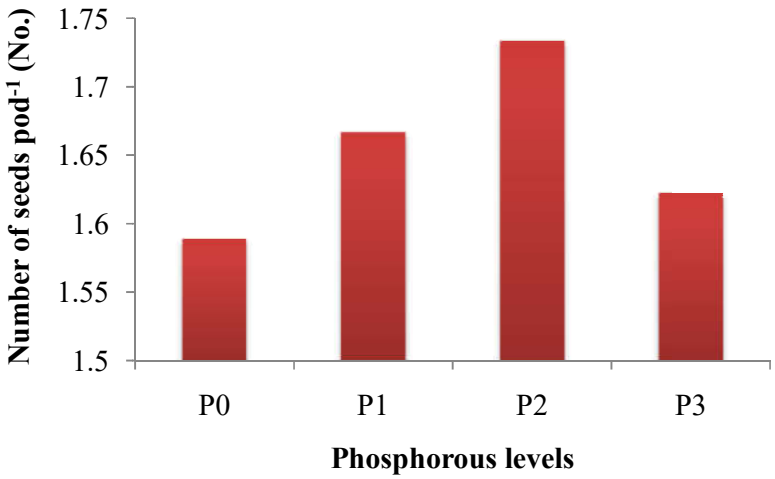
V_1 = BARI Masur-5, V_2= BARI Masur-6 and V_3= BARI Masur-7

Figure 15. Effect of variety on the number of seeds pod^{-1} of lentil (LSD $_{(0.05)}$ = 0.07)

4.2.2.2 Effect of phosphorus

The results from Figure 16 showed that phosphorus levels had significant effect on number of seeds pod^{-1}. The highest number of seeds pod^{-1}(1.73) was found from the application of 40 kg P_2O_5 ha^{-1} (P_2) which was statistically similar with P_1 and P_3. The lowest number of seeds pod^{-1} (1.59) was found from the control treatment i.e. no phosphorus application plot which was statistically similar with rest of the treatments except P_2. Due to more availability of nutrients by increasing the level of P_2O_5 ha^{-1} increased the number of seeds per pod. It appears that there was a regulatory system through which it was possible to direct and concentrate available nutrient to permit development of more number of seeds pod^{-1}. Phosphorus aids in transferring photosynthates from the stalks, leaves and other growing parts to the economically important organs like seed making them plump and bold. These results are strongly in agreement with the findings of Subramanian and Radhak (1981); Jayapaul and Ganesaraja (1990) who reported that application of 80-120 P_2O_5 kg ha^{-1} increased the number of seeds pod^{-1}. Similar findings also reported by Mahmood *et al*. (2010);

Malik *et al.* (1991) and Zeidan (2007) who reported a significant increase in number of seeds per pod with increase in P from 25 to 75 kg per hectare.



P_0 = 0 kg P_2O5 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}

Figure 16. Effect of phosphorous on the number of seeds pod^{-1} of lentil (LSD $_{(0.05)}$ = 0.11)

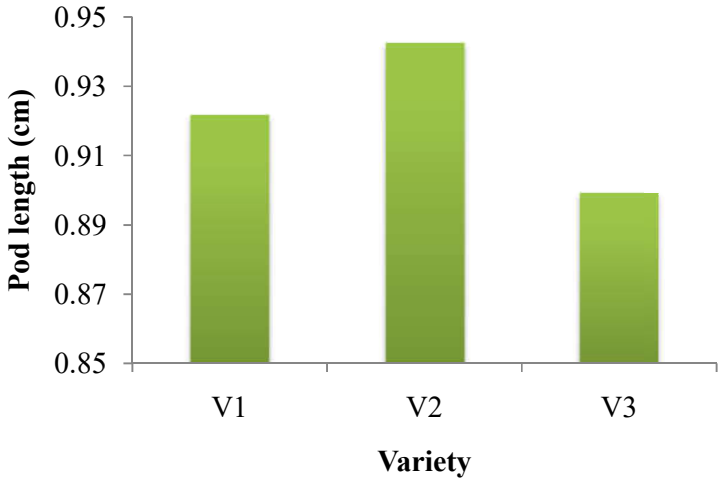
4.2.2.3 Interaction effect

The number of seeds pod^{-1} was significantly influenced by varieties and different levels of phosphorus application (Table 9). The highest number of seeds pod^{-1} (1.77) was found from V_2P_2 which was statistically similar with rest of the treatment combinations except V_3P_0 and V_3P_3 and the lowest number of seeds pod^{-1} (1.53) was found from V_3P_0 which was statistically similar with rest of the treatment combinations except V_2P_2 and V_1P_2.

4.2.3 Pod length

4.2.3.1 Effect of variety

Different variety had significant effect on pod length of lentil (Fig. 17). The highest pod length (0.94 cm) was recorded from BARI Masur-6 which was statistically similar with BARI Masur-5 and the lowest pod length (0.90 cm) was recorded from BARI Masur-7 which was statistically similar with BARI Masur-5.

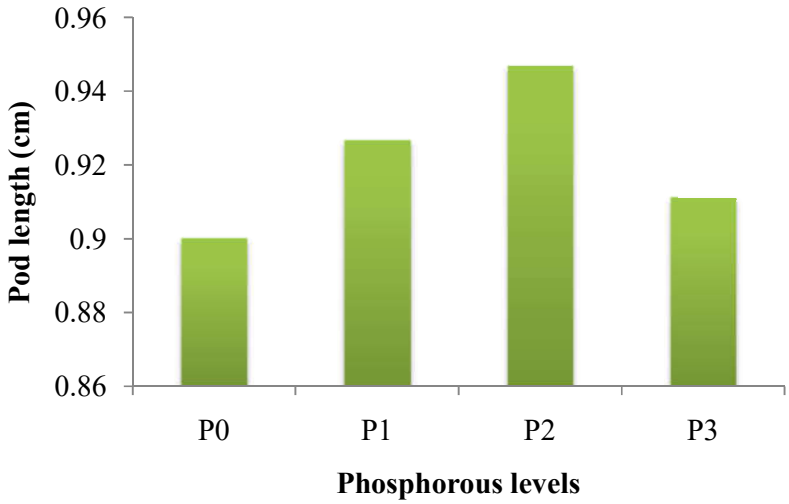


V_1 = BARI Masur-5, V_2= BARI Masur-6 and V_3= BARI Masur-7

Figure 17. Effect of variety on the pod length of lentil (LSD $_{(0.05)}$ = 0.04)

4.2.3.2 Effect of phosphorus

Pod length of lentil significantly affected by different phosphorus levels (Fig. 18). The highest pod length (0.95 cm) was found from the application of P_2 which was statistically similar with P_1 and P_3. The lowest pod length (0.90 cm) was recorded from the P_0 which was statistically similar with rest of the treatments except P_2. Optimum amount of phosphorous might be enhanced the plant growth which attributed to increase the length of pod of lentil.



P_0 = 0 kg P_2O5 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}

Figure 18. Effect of phosphorous on the pod length of lentil (LSD $_{(0.05)}$ = 0.04)

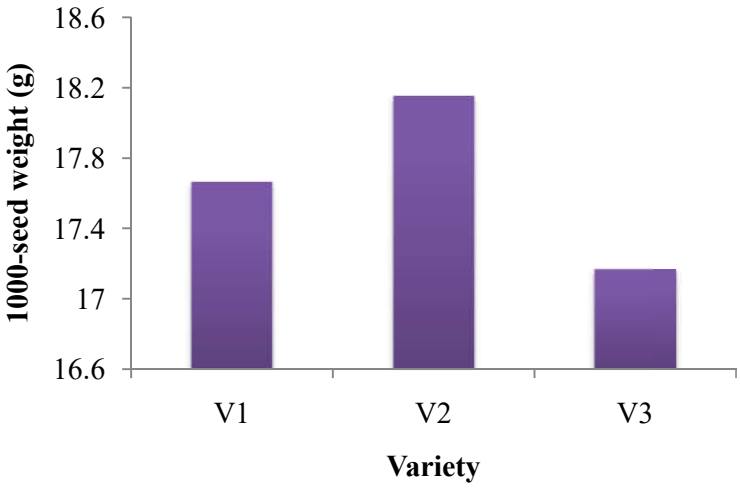
4.2.3.3 Interaction effect

The pod length was significantly influenced by varieties and different levels of phosphorus application (Table 9). The highest pod length (0.96 cm) was found from V_2P_2 which was statistically similar with rest of the treatment combinations except V_3P_0 and the lowest pod length (0.87 cm) was found from V_3P_0 which was statistically similar with rest of the treatment combinations except V_2P_2.

4.2.4 1Weight of 1000-seed

4.2.4.1 Effect of variety

Variety had no significant effect on 1000-seed weight of lentil (Fig. 19). However, numerically the highest 1000-seed weight (18.15 g) was produced by V_2 and the lowest one (17.17 g) was produced by V_3. This finding was not similar to those findings of Awal and Roy (2015), El-Nagar and Galal (1997), BINA (2000), Ali (2006), Mamun (2006), Rahman (2006), Wasiq (2006); Yusuf (2006); Singh *et al.* (2010) and Joshi *et al.* (2005).

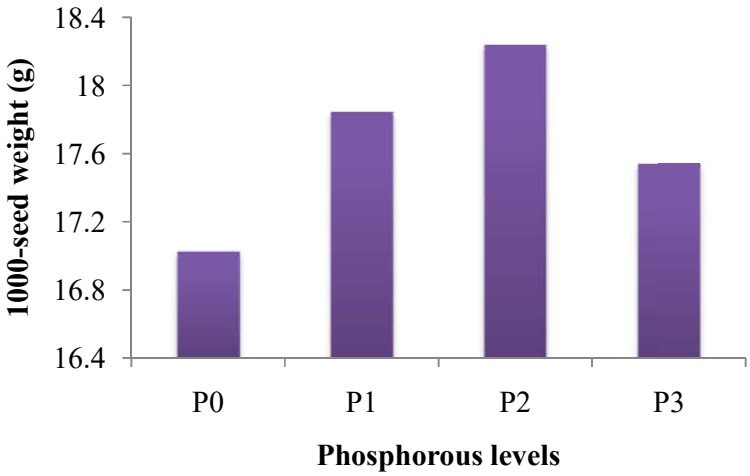


V_1 = BARI Masur-5, V_2= BARI Masur-6 and V_3= BARI Masur-7

Figure 19. Effect of variety on the 1000-seed weight of lentil (LSD $_{(0.05)}$ = NS)

4.2.4.2 Effect of phosphorus

Phosphorus levels had significant effect on 1000-seed weight of lentil (Fig. 20). The highest 1000-seed weight (18.24 g) was produced by P_2 which showed similarity with P_1 and P_3 and the lowest 1000-seed weight (17.02 g) was produced by P_0 which also showed similarity with P_1 and P_3. Increase in 1000-seed weight might be due to the influence of cell division, phosphorus contents in the seed as well as the formation of fat and albumin. Mahmood *et al*. (2010) reported that, increase in 1000-seed weight manifests that phosphorus plays a significant role in grain filling and seed size. Absence of adequate available phosphorus may result in slow growth and reduced grain filling. Fertilizers side drilled at sowing near the seed ensured an abundant supply of phosphorus for crop uptake early in growing season and caused an increased seed weight. Increased seed weight may be due to the role of P in energy transfer (Rashid, 2002) essentially required by cell division and portioning of assimilates. The results are in line with those of Hussain, (2002); Subrmanian and Radhak (1981); Shamim and Naimat (1987) and Ali (1979) who reported that seed yield of good quality lentil by the application of 60 P_2O_5 ha^{-1}.



P_0 = 0 kg P_2O5 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}

Figure 20. Effect of phosphorous on the 1000-seed weight of lentil (LSD $_{(0.05)}$ = 1.07)

4.2.4.3 Interaction effect

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 variety and phosphorus had significant effect on 1000-seed weight under the present study (Table 9). The highest 1000-seed weight (18.94 g) was produced by combination of V_2P_2 which was statistically similar with rest of the treatment combinations except V_1P_0, V_3P_0 and V_3P_3 whereas the lowest 1000-seed weight (16.47 g) was produced by combination of V_3P_0 which was statistically similar with rest of the treatment combinations except V_2P_2.

Table 9. Interaction effect of variety and phosphorous on the yield contributing characters of lentil

Treatments	Pods plant^{-1} (No.)	Seeds pod^{-1} (No.)	Pod length (cm)	1000 seed weight (g)
V_1P_0	78.25 d	1.60 a-c	0.90 ab	17.06 b
V_1P_1	83.93 cd	1.67 a-c	0.94 ab	17.81 ab
V_1P_2	98.60 a	1.73 ab	0.94 ab	18.19 ab
V_1P_3	84.27 cd	1.63 a-c	0.91 ab	17.60 ab
V_2P_0	80.20 d	1.63 a-c	0.93 ab	17.52 ab
V_2P_1	96.40 ab	1.70 a-c	0.94 ab	18.19 ab
V_2P_2	103.7 a	1.77 a	0.96 a	18.94 a
V_2P_3	90.13 bc	1.67 a-c	0.93 ab	17.94 ab
V_3P_0	63.53 e	1.53 c	0.87 b	16.47 b
V_3P_1	67.47 e	1.63 a-c	0.90 ab	17.51 ab
V_3P_2	84.27 cd	1.70 a-c	0.94 ab	17.60 ab
V_3P_3	67.33 e	1.57 bc	0.90 ab	17.09 b
LSD $_{(0.05)}$	7.47	0.20	0.08	1.85
CV (%)	5.24	6.99	5.40	6.11

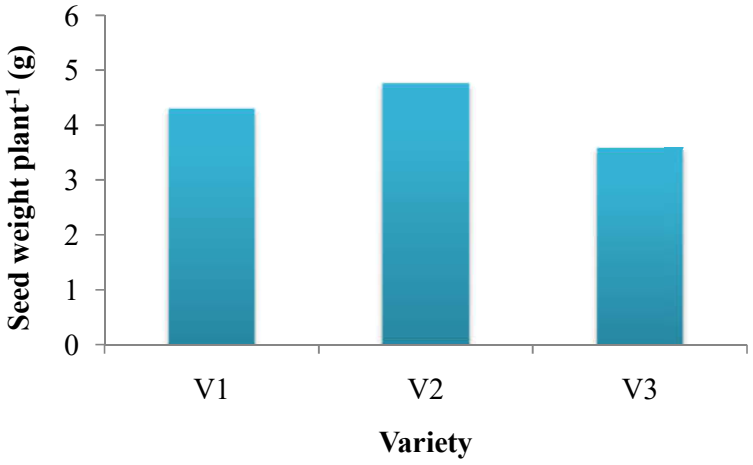
V_1 = BARI Masur-5, V_2= BARI Masur-6 and V_3= BARI Masur-7; P_0 = 0 kg P_2O_5 ha^{-1}, P_1 = 20 kg P_2O_5 ha^{-1}, P_2 = 40 kg P_2O_5 ha^{-1} and P_3 = 60 kg P_2O_5 ha^{-1}

4.3 Yield parameters

4.3.1 Seed weight plant^{-1}

4.3.1.1 Effect of variety

Variety exerted significant effect on seed weight plant^{-1} of lentil (Fig. 21). The highest seed weight plant^{-1} (4.77 g) was recorded from BARI Masur-6. The lowest seed weight plant^{-1} (3.59 g) was recorded from BARI Masur-7.

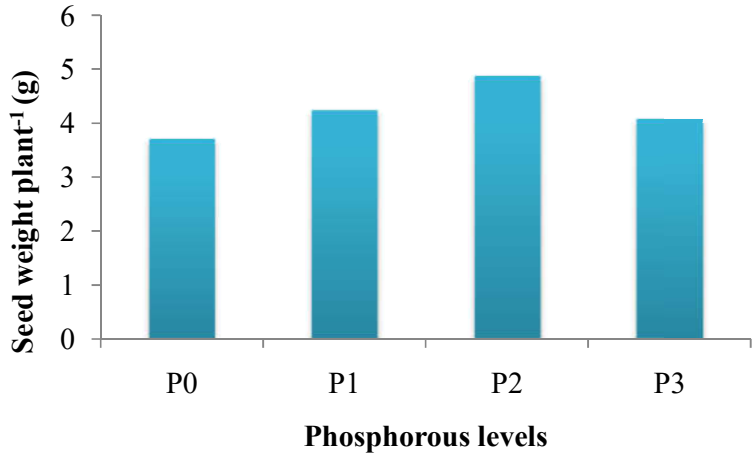


V_1 = BARI Masur-5, V_2= BARI Masur-6 and V_3= BARI Masur-7

Figure 21. Effect of variety on the seed weight plant^{-1} of lentil (LSD $_{(0.05)}$ = 0.31)

4.3.1.2 Effect of phosphorus

Phosphorus had significant effect on seed weight plant^{-1} of lentil (Figure 22). The highest seed weight plant^{-1} (4.87 g) was recorded from P_2 followed by P_1 and P_3 and the lowest seed weight plant^{-1} (3.69 g) was recorded from P_0 treatment.



P_0 = 0 kg P_2O5 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}

Figure 22. Effect of phosphorous on the seed weight plant^{-1} of lentil (LSD $_{(0.05)}$ = 0.31)

4.3.1.3 Interaction effect

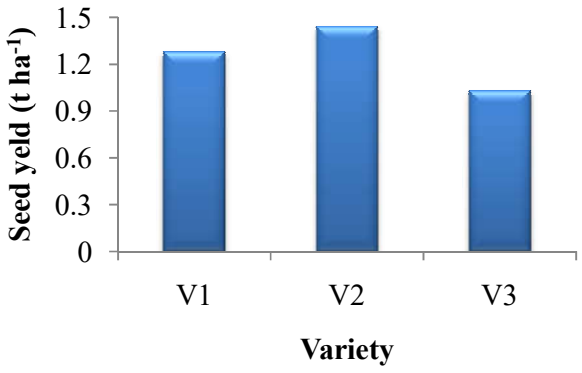
A significant interaction between variety and phosphorus levels was observed in respect of seed weight plant^{-1} of lentil (Table 10). The highest seed weight plant^{-1} (5.90 g) was recorded from V_2P_2 and the lowest seed weight plant^{-1} (2.91 g) was recorded from V_3P_0.

4.3.2 Seed yield

Seed yield ha^{-1} is the output of different treatment applied as well as the effect of different agronomic practices and environment. Thus, seed yield is controlled by large number of internal and external factors and any variation in them is liable to bring about variations in total seed yield.

4.3.2.1 Effect of variety

Variety exerted significant effect on seed yield of lentil (Fig. 23). The highest seed yield (1.44 t ha^{-1}) was recorded from BARI Masur-6. The lowest seed yield (1.03 t ha^{-1}) was recorded from BARI Masur-7. BARI Masur-6 produced 39.81% higher seed yield than BARI Masur-7. These results suggest that genotype improvement efforts for higher seed yield can be achieved through higher growth rate during the early growth stages and better allocation of photo-assimilate to reproductive organs. The findings of the current study were consistent with the results of Janmohammadi *et al*. (2014), Hussain *et al*. (2014). Datta *et al.* (2013), Wasiq (2006), Awal and Roy (2015), FAO (1999), Sinha and Singh (2002) who reported that seed yield of lentil varied due to varietal difference. Mahmood *et al*. (2010); Shah *et al.* (2000b); Singh *et al.* (2010); Joshi *et al.* (2005); Chowdhury *et al.* (1998) and Hussain *et al*. (2002) also reported that, the difference in seed yield occurred mainly due to different genetic potential of various genotypes.



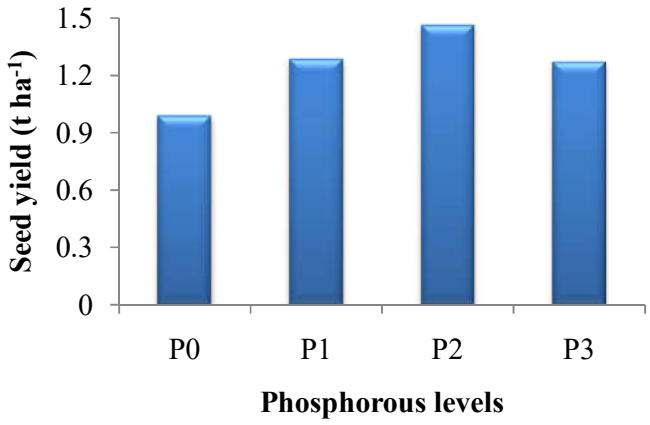
V_1 = BARI Masur-5, V_2= BARI Masur-6 and V_3= BARI Masur-7

Figure 23. Effect of variety on the seed yield of lentil (LSD $_{(0.05)}$ = 0.06)

4.3.2.2 Effect of phosphorus

Phosphorus had significant effect on seed yield of lentil (Figure 24). The highest seed yield (1.46 t ha^{-1}) was recorded from P_2 followed by P_1 and P_3 and the lowest seed yield (0.99 t ha^{-1}) was recorded from P_0 treatment. P_2 produced 47.48% higher seed yield than P_0. This result might be due to more availability of phosphorus to the plants and more synthesis of proteins, fats and carbohydrates. Phosphorus is an essential element for photosynthesis, root development and seed formation as well as nitrogen uptake (Zeidan, 2007). Phosphorus is known to take part in carbohydrate metabolism and it also acts as energy carrier derived from the metabolism which is stored as phosphate molecules for subsequent use in growth, development and production in plants. This may be due to better nutrition of the plants during reproductive period (Rasool and Singh, 2016). Mosali *et al.* (2006) stated that the positive response of lentil plants to phosphorus fertilization may be due to the meristemic activity caused by P application; phosphorus caused an increase in the amounts of metabolites by plants as dry matter weight of different parts of the plant become great and phosphorus caused an increase in number of flowers and fruit setting percentage $plant^{-1}$. The response of P application over control increased content of soil P (Datta *et al.,* 2013 and Azad *et al.,* 1991). According to Zafar *et al*. (2003) maximal does of phosphorus 75 kg P_2O_5 ha^{-1} has proved a significant dose for getting a good seed yield of lentil (1250 kg ha^{-1}). Barua *et al*. (2011) reported that cultivation of lentil using 85 kg P ha^{-1} with compost resulted best seed yield. Application of phosphorus 50 kg ha^{-1} may be considered as optimum dose for higher yield of lentil (Mahmood *et al.*, 2010).

Singh *et al*. (1999) and Chaubey *et al*. (1999) also reported that with application of 0-90 kg P_2O_5 ha^{-1} seed yield increased significantly. Zeidan (2007); El-Awady *et al.* (1993) and Rathore *et al.* (1992) found that, the increase in seed yield by application of 60 kg P_2O_5 fed^{-1} might be associated with high number of pods $plant^{-1}$, 1000 seed weight and seed yield $plant^{-1}$. Similar results were reported by El-Awady *et al.* (1993); Singh *et al*., (1981) and Ojha *et al.* (1977) who found that phosphorus fertilization at 50 kg P_2O_5 ha^{-1} increased seed yield as compared with control. Batten (1987) reported that net CO_2 assimilation, N concentration, and Chlorophyll content decreased when wheat leaf P concentration falls below a critical level. It was observed that cultivars exhibited their maximum potential for this genetically controlled trait up to certain limit of fertilizer applied and beyond that limit applied fertilizer particularly phosphorus, may restrict mycorrhizal development which adversely affects nitrogen availability to plants (Grant *et al.*, 2005). Excessive phosphorus may be fixed in soil which will not available for plant. Similar findings were also observed by Singh *et al. (*2011); Singh *et al*. (2003); Khan *et al.* (2006); Gwal *et al.* (1995); Ali *et al*. (1981); Dadson and Acquach (1984); Chiezey *et al*. (1992); Paricha and Aulakh (1992); Singh *et al*. (1992) and Chandra (1991).



P_0 = 0 kg P_2O5 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}

Figure 24. Effect of phosphorous on the seed yield of lentil (LSD $_{(0.05)}$ = 0.08)

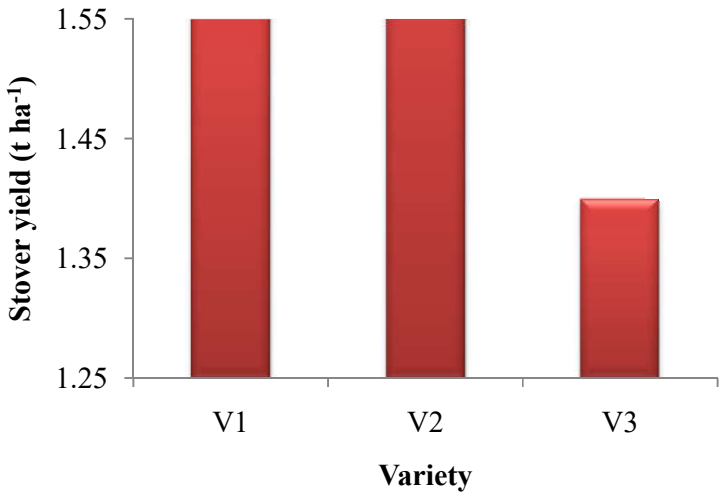
4.3.2.3 Interaction effect

A significant interaction between variety and phosphorus levels was observed in respect of seed yield of lentil (Table 10). The highest seed yield (1.72 t ha^{-1}) was recorded from V_2P_2 and the lowest seed yield (0.80 t ha^{-1}) was recorded from V_3P_0. V_2P_2 produced 115% higher seed yield than the combination of V_3P_0.

4.3.3 Stover yield

4.3.3.1 Effect of variety

Variety had significant effect on stover yield of lentil (Fig. 25). The highest stover yield (1.68 t ha^{-1}) was recorded from BARI Masur-6 which was statistically similar with BARI Masur-5 (1.59 t ha^{-1}). The lowest stover yield (1.40 t ha^{-1}) was found from BARI Masur-7 which was statistically similar with BARI Masur-5. Similar results were observed by Haque *et al.* (2014); Dziamba and Miroslaw (1994) who reported that, stover yield of lentil differed due to varietal variation.

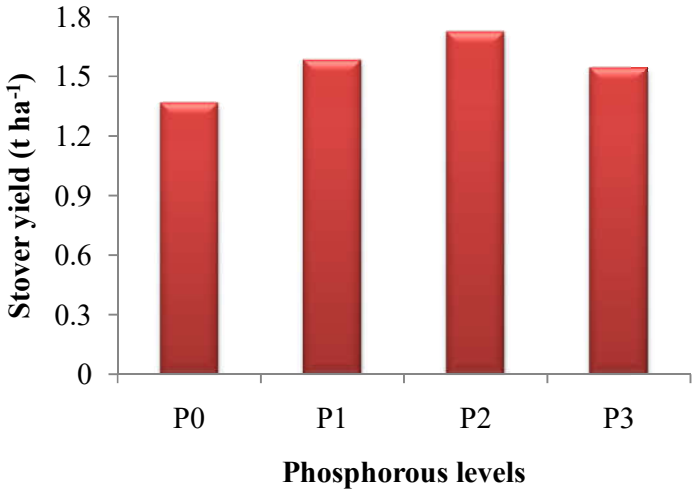


V_1 = BARI Masur-5, V_2= BARI Masur-6 and V_3= BARI Masur-7

Figure 25. Effect of variety on the stover yield of lentil (LSD $_{(0.05)}$ = 0.22)

4.3.3.2 Effect of phosphorus

Phosphorus had significant effect on stover yield of lentil (Fig. 26). The highest stover yield (1.72 t ha^{-1}) was recorded from the application of 40 kg P_2O_5 and the lowest stover yield (1.37 t ha^{-1}) was found with control treatment. Rest of the phosphorous treatments gave the intermediate stover yield. Rathore *et al*. (1992) pointed out that increased phosphorus levels from 0, 20, 40 and 60 kg P_2O_5 ha^{-1} significantly increased straw yield ha^{-1}. El-Awady *et al*. (1993) revealed that phosphorus addition at 60 kg P_2O_5 fed^{-1} significantly increased straw yields fed^{-1}.



P_0 = 0 kg P_2O5 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}

Figure 26. Effect of phosphorous on the stover yield of lentil (LSD $_{(0.05)}$ = 0.08)

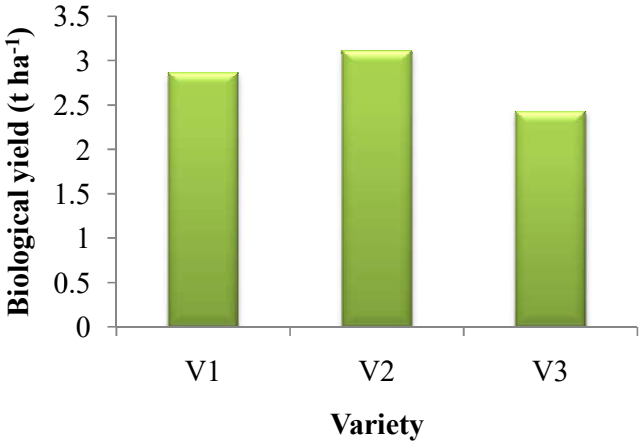
4.3.3.3 Interaction effect

Stover yield was significantly influenced by variety and phosphorus combinations (Table 10). The highest of stover yield (1.87 t ha^{-1}) was recorded from V_2P_2 which was statistically identical with V_2P_1 and V_1P_2. The lowest stover yield (1.30 t ha^{-1}) was recorded from V_3P_0 which was statistically identical with V_3P_3, V_3P_1, V_2P_0 and V_1P_0.

4.3.4 Biological yield

4.3.4.1 Effect of variety

The biological yield of lentil significantly varied due to varietal variation (Fig. 27). The highest biological yield (3.12 t ha^{-1}) was observed from BARI Masur-6 whereas, the lowest biological yield (2.43 t ha^{-1}) was found from BARI Masur-7.

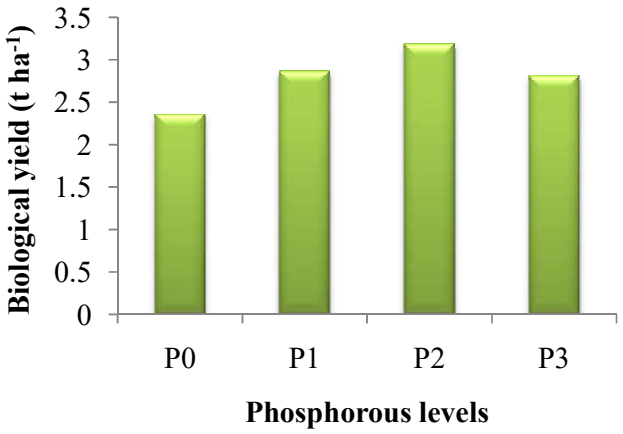


V_1 = BARI Masur-5, V_2= BARI Masur-6 and V_3= BARI Masur-7

Figure 27. Effect of variety on the biological yield of lentil (LSD $_{(0.05)}$ = 0.06)

4.3.4.2 Effect of phosphorus

Different phosphorus levels produce significant variation in terms of biological yield of lentil (Fig. 28).The highest biological yield (3.19 t ha^{-1}) was observed from the application of 40 kg P_2O_5 and the lowest biological yield (2.36 t ha^{-1}) was observed from control treatment (P_0). These results were in conformity with those of Rasool and Singh (2016); Azad *et al.* (1991); Ali *et al.* (2004); Haque and Khan (2012) and Singh *et al.* (2010).



P_0 = 0 kg P_2O5 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}

Figure 28. Effect of phosphorous on the biological yield of lentil (LSD $_{(0.05)}$ = 0.12)

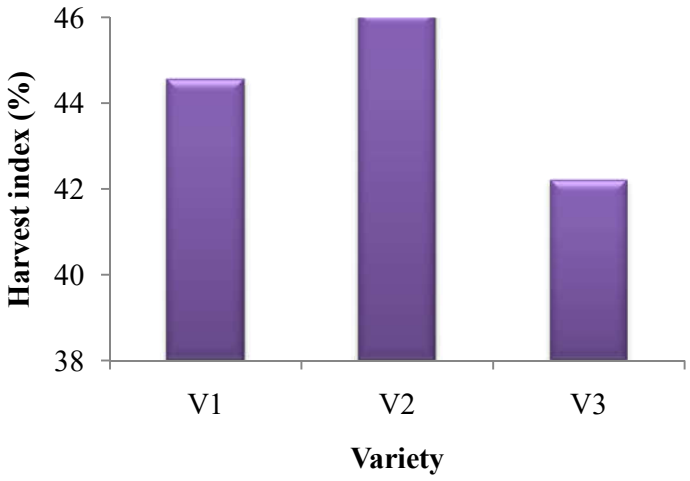
4.3.4.3 Interaction effect

Interaction of variety and phosphorus levels had significant influence on biological yield of lentil (Table 10). The highest biological yield (3.53 t ha^{-1}) was observed from V_2P_2 and the lowest biological yield (2.10 t ha^{-1}) was observed from V_3P_0.

4.3.5 Harvest index

4.3.5.1 Effect of variety

Harvest index of lentil significantly varied due to different varieties (Fig. 29). The highest harvest index (46.13%) was recorded from V_2 which was statistically at par with V_1 and the lowest one (42.21%) was recorded from V_3 which was statistically at par with V_1. Harvest index is an important physiological character that reflects dry matter partitioning of a given genotype to the economic part. Higher harvest index results higher crop yield probably due to more partitioning of dry matter to reproductive sink (Plainiappan, 1985). Different genotypes had different genetic potential to convert photosynthates into economically important parts of the plant Mahmood *et al*. (2010). Awal and Roy (2015); Dey (2002) and Rahman (2006) also observed the large variation of harvest index in the different genotypes of lentil.

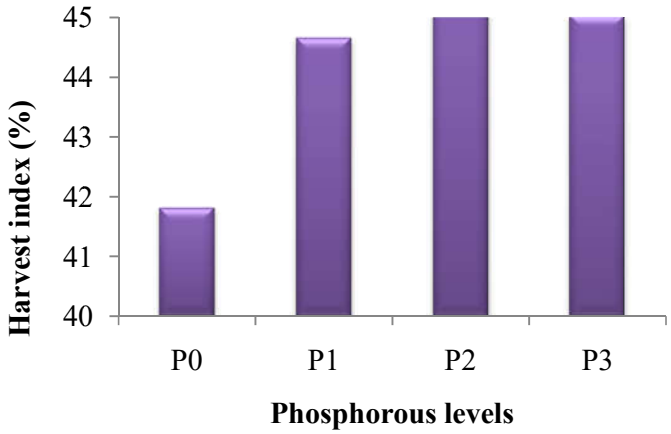


V_1 = BARI Masur-5, V_2= BARI Masur-6 and V_3= BARI Masur-7

Figure 29. Effect of variety on the harvest index of lentil (LSD $_{(0.05)}$ = 3.56)

4.3.5.2 Effect of phosphorus

Different levels of phosphorus exerted significant effect on the harvest index of lentil (Fig. 30). The highest harvest index (45.72%) was recorded from P_2 which was statistically at par with rest of the treatments except P_0 and the lowest one (41.80%) was recorded from control treatment. Higher harvest index value may be due to balanced nutrition. The low harvest index at low level of P_2O_5 ha^{-1} might be due to poor development of plant at different growth stages. These results are supported by the findings of previous investigators (Sadiq *et al*., 2002; Zeidan, 2007 and Mahmood *et al*., 2010).



P_0 = 0 kg P_2O5 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}

Figure 30. Effect of phosphorous on the harvest index of lentil (LSD $_{(0.05)}$ = 2.23)

4.3.5.3 Interaction effect

Combination between variety and phosphorus had significant effect on harvest index of lentil (Table 10). The highest harvest index (47.93%) was recorded from V_2P_2 which was statistically at par with rest of the treatment combinations except V_3P_0, V_3P_1, V_3P_2 and V_1P_0 and the lowest harvest index (38.19 %) was given by the V_3P_0 combination.

Table 10. Interaction effect of variety and phosphorous on the yield of lentil

Treatments	Seed weight plant^{-1} (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
V_1P_0	3.96 c-e	1.07 g	1.42 de	2.49 d	42.85 bc
V_1P_1	4.38 bc	1.31 c-e	1.60 c	2.91 c	45.04 a-c
V_1P_2	4.60 b	1.45 bc	1.75 ab	3.20 b	45.37 a-c
V_1P_3	4.21 b-d	1.29 de	1.58 c	2.88 c	44.97 a-c
V_2P_0	4.21 b-d	1.10 fg	1.38 e	2.48 d	44.36 a-c
V_2P_1	4.53 b	1.52 b	1.76 ab	3.28 b	46.40 ab
V_2P_2	5.90 a	1.72 a	1.87 a	3.53 a	47.93 a
V_2P_3	4.42 bc	1.43 b-d	1.69 bc	3.12 b	45.85 a-c
V_3P_0	2.91 f	0.80 h	1.30 e	2.10 e	38.19 d
V_3P_1	3.78 de	1.02 g	1.38 e	2.41 d	42.50 c
V_3P_2	4.10 b-e	1.21 ef	1.56 cd	2.77 c	43.86 bc
V_3P_3	3.57 e	1.08 fg	1.36 e	2.44 d	44.28 a-c
LSD $_{(0.05)}$	0.53	0.14	0.14	0.20	3.87
CV (%)	7.38	6.80	5.47	4.19	5.09

V_1 = BARI Masur-5, V_2= BARI Masur-6 and V_3= BARI Masur-7; 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}

CHAPTER V

SUMMARY AND CONCLUSION

An experiment was conducted at the Sher-e-Bangla Agricultural University farm, Dhaka, Bangladesh during November 2015 to March 2016 to evaluate the influence of variety and phosphorous on growth and yield of lentil . The experiment comprised of two factors; (A) three varieties of lentil *viz.,* V_1 = BARI Masur-5, V_2 = BARI Masur-6, V_3= BARI Masur-7 and (B) four levels of phosphorus fertilizer i.e., 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 consists with 12 treatment combinations which were set up in split plot design with three replications. Varieties were in main plot and different levels of fertilizer were in sub-plot. The experimental plot was fertilized as per treatment with phosphatic fertilizers and other fertilizers were applied as recommended dose for lentil.

Data were collected for Number of 80% seedling emergence m^{-2}, plant height (cm), number of leaves $plant^{-1}$, number of branches $plant^{-1}$, leaf dry weight $plant^{-1}$ (g), shoot dry weight $plant^{-1}$ (g), total dry weight $plant^{-1}$ (g), days to 80% flowering, days to 80% maturity, number of pods $plant^{-1}$, number of seeds pod^{-1}, pod length (cm), 1000-seed weight (g), seed weight $plant^{-1}$ (g), seed yield (t ha^{-1}), stover yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index(%).

Different varieties of lentil significantly affected most of the growth, yield and yield attributes of lentil with some exceptions. The highest plant height (33.48 cm) was found from BARI Masur-6 and the lowest one (31.84 cm) was recorded from BARI Masur-7. The highest number of leaves $plant^{-1}$ (206.6) was found from BARI Masur-6 (V_1) and the lowest number of leaves $plant^{-1}$ (164.30) was found from BARI Masur-7 (V_3). The highest number of branches $plant^{-1}$ (30.70) was recorded from BARI Masur-6 and the lowest number of branches $plant^{-1}$ (22.73) was recorded from BARI Masur-7. The highest leaf dry weight $plant^{-1}$ (3.12 g) was produced by V_2 whereas the lowest leaf dry weight $plant^{-1}$ (2.46 g) was produced by V_3. The highest shoot dry weight $plant^{-1}$ (3.36 g) was recorded from V_2 and the lowest shoot dry weight $plant^{-1}$ (2.35 g) was recorded from V_3. The highest total dry weight $plant^{-1}$ (10.13 g) was recorded fromV_2 and the lowest total dry weight $plant^{-1}$ (7.97 g) was recorded from was

recorded from V_3. The highest number of pods plant^{-1} (92.60). The highest number of seeds pod^{-1}(1.69), pod length (0.94 cm), 1000 seed weight (18.15 g), seed weight plant^{-1} (4.77 g), seed yield (1.44 t ha^{-1}), stover yield (1.68 t ha^{-1}), biological yield (3.12 t ha^{-1}) and harvest index (46.13%) was found from BARI Masur-6 and the lowest numbers of pod plant^{-1} (70.65), numbers of seeds pod^{-1} (1.61), pod length (0.90 cm), 1000-seed weight (17.17 g), seed weight plant^{-1} (3.59 g), seed yield (1.03 t ha^{-1}), stover yield (1.40 t ha^{-1}), biological yield (2.43 t ha^{-1}) and harvest index (42.21%) was recorded from BARI Masur-7. BARI Masur-6 produced 39.81% higher seed yield than BARI Masur-7.

Different levels of phosphorus significantly affected the growth yield and yield attributes of lentil. The highest plant height (34.53 cm), number of leaves plant^{-1} (232.3), number of branches plant^{-1} (30.97), leaf dry weight plant^{-1} (3.44 g), shoot dry weight plant^{-1} (3.45 g), total dry weight plant^{-1} (11.59 g), number of pods plant^{-1} (95.51), number of seeds pod^{-1} (1.73), pod length (0.95 cm), 1000 seed weight (18.24 g), seed weight plant^{-1} (4.87 g), seed yield (1.46 t ha^{-1}), stover yield (1.72 t ha^{-1}), biological yield (3.19 t ha^{-1}) and harvest index(45.72%) was recorded from 40 kg P_2O_5 ha^{-1} (P_2) and the lowest plant height (30.59 cm), number of leaves plant^{-1} (136.5), number of branches plant^{-1} (22.20), leaf dry weight plant^{-1} (2.11 g), shoot dry weight plant^{-1} (2.20 g), total dry weight plant^{-1} (7.53 g), number of pods plant^{-1} (74), number of seeds pod^{-1} (1.59), pod length (0.90 cm), 1000-seed weight (17.02 g), seed weight plant^{-1} (3.69 g), seed yield (0.99 t ha^{-1}), stover yield (1.37 t ha^{-1}), biological yield (2.36 t ha^{-1}) and harvest index(41.80%) was recorded from 0 kg P_2O_5 ha^{-1} (P_0). P_2 produced 47.48% higher seed yield than P_0.

Combined effect of variety and phosphorous levels had profound significant effect on the growth, yield and yield contributing characters of lentil. The highest plant height (35.22 cm), number of leaves plant^{-1} (287.90), number of branches plant^{-1} (36.07), leaf dry weight plant^{-1} (3.60 g), shoot dry weight plant^{-1} (3.71 g), total dry weight plant^{-1} (12.21 g), number of pods plant^{-1} (103.70), number of seeds pod^{-1} (1.77), pod length (0.96 cm), 1000-seed weight (18.94 g), seed weight plant^{-1} (5.90 g), seed yield (1.72 t ha^{-1}), stover yield (1.87 t ha^{-1}), biological yield (3.59 t ha^{-1}) and harvest index(47.93 %) was recorded from BARI Masur-6 in combination with 40 kg P_2O_5 ha^{-1} and the lowest plant height (29.49 cm), number of leaves plant^{-1} (112.70),

number of branches plant^{-1} (19.27), leaf dry weight plant^{-1} (1.91 g), shoot dry weight plant^{-1} (1.66 g), total dry weight plant^{-1} (4.37 g), number of pods plant^{-1} (63.53), number of seeds pod^{-1} (1.53), pod length (0.87 cm), 1000 seed weight (16.47 g), seed weight plant^{-1} (2.91 g), seed yield (0.80 t ha^{-1}), stover yield (1.30 t ha^{-1}), biological yield (2.10 t ha^{-1}) and harvest index (38.19%) were obtained from the combination of BARI Masur-7 with 0 kg P_2O_5 ha^{-1}. V_2P_2 produced 115% higher seed yield than the combination of V_3P_0.

It could be concluded that using new developed Bangladesh lentil variety has shown promising performance for higher lentil yield. Among the three varieties, BARI Masur-6 performed better for most of the growth and yield parameters of lentil. On the other hand phosphorus application (40 kg P_2O_5 ha^{-1}) increased lentil yield compared to no application of phosphatic fertilizer. It can be therefore, concluded from the above study that the treatment combination of BARI Masur-6 with the application of 40 kg P_2O_5 ha^{-1} was found to the most suitable combination for the highest yield of lentil.

However, to reach a specific conclusion and recommendation, more research works regarding lentil should be done in different Agro-ecological zones of Bangladesh to fit in cropping system for rich diet and improve the soil health.

REFERENCES

Afzal, M. (1989). Effect of Potassium in different Proportions with Nitrogen and Phosphorus on Yield and Quality of Lentil. M. Sc. Thesis, Deptt. Agronomy, Univ. Agric., Faisalabad.

Afzal, M. A., Bakar, M. A., Luna, N. K., Rahman, M. M., Hamid, A., Haque, M. M. and Shanmungasudaram, S. (2003). Registration of 'Barimungs' Mungbean. *Crop Sci*. **43**: 930-931.

Alam, M. S., Ferdous, J., Sharmin, F., Khan, T. A., Mollah, M. D. A. and Hoque, A. (2015). Dry matter production and crop growth rate of lentil as influenced by irrigation management *Intl. J. Biosci.* **6**(7): 66-72.

Ali, A. (1979). Effect of plant nutrition on seed yield, mineral composition an cooking quality of lentil (*Lens culinaris*). *M.Sc. Thesis*, Dept. Agron., Uni. Agri., Faisalabad, Pakistan.

Ali, M. A., Hussain, M., Malik, W. H. and Tahir, M. (2004). Evaluation of the effect of *Rhizobium* inoculation and phosphorus on grain yield and nodulation behaviour of *Lens culinaris. Pakistan J. Life Social Sci.* **2**(2)**:** 112-114.

Ali, M. I., Phuiya, E. H., Rehman, M. M. and Badruddin, B. (1981). Effect of phosphorus on dry matter production and P uptake by lentils in different soils using P 32 as tract. *Thailand J. Agri. Sci.* **14**: 143-147.

Ali, M. M. (2006). Growth and yield assessment of some lentil genotypes. Master's Thesis. Department of Crop Botany, Bangladesh Agricultural University, Mymensingh. pp. 1-30.

Anonymous (1984). A guide book on production of pulses in Bangladesh. FAO/UNDP Project on strengthening the agriculture extension service. Khamarbari, Farmgate, Dhaka, Bangladesh.

Awal, M. A. and Roy, A. (2015). Effect of weeding on the growth and yield of three varieties of lentil (*Lens culinaris* L.). *American J. Food Sci. Nutr. Res.* **2**(2): 26-31.

Ayub, K., Rahim, M. and Khan, A. (2001). Performance of exotic lentil varieties under rainfed conditions in Mingora, (NWFP) Pakistan. *Online J. Biol. Sci.* **1**(5): 343-344.

Azad, A. S., Gill, A. S. and Dhaliwal, H. S. (1991). Response of phosphorus and *Rhizobium* culture on grain yield of lentil. *Lens Newsl*. **18**(1-2): 14: 14-19.

Barua, R., Bhuiya, M. S. U., Kabir, M. M., Maniruzzaman, S. and Ahmed, Z. (2011). Effect of Mimosa (*Mimosa invisia*) compost and phosphorus on the yield and yield components of lentil (*Lens culinaris* L.). *The Agriculturists.* **9**(1-2): 63-72.

Batten, G. D. (1987). Senescence of the flag leaf and grain yield following late foliar application of phosphate on plants of differing phosphorus status. *J. Plant Nutr.* **10**: 735-740.

BBS (Bangladesh Bureau of Statistics). (2008). Statistical Year Book of Bangladesh. Bangladesh Bur. Stat. Stat. Div. Min. Plan. Govt. People's Repub. Bangladesh, Dhaka. p.200.

BINA (Bangladesh Institute of Nuclear Agriculture). (2000). Annual Report. Bangladesh Institute of Nuclear Agriculture, Mymensingh. pp. 121-139.

Chandra, R. (1991). Influence of different levels of *Rhizobium* inoculation and phosphoruson nodulation, dry matter and yield of lentil. *Legumes Res.* **14**(3): 145-149.

Chaubey, A. K., Kushik, M. K. and Singh, S. B. (1999). Response of lentil to phosphorus and zinc sulphate nutrition. *Crop Res. Hasar.* **17**: 309-12.

Chiezey, U. F., Yayock, J. and Shebayan, J. A. Y. (1992). Response of soybean to N and P fertilizer levels. *Tropical Sci. Zaria.* **32**: 361-368.

Choubey, S. K., Dwivedi, V. P. and Srivastava, N. K. (2013). Effect of different levels of phosphorus and sulphur on growth, yield and quality of lentil (*Lens culinaris*). *Indian J. Sci. Res*. **4**(2): 149-150.

Chowdhury, A. K., Newaz, M. A., Samanta, S. C., Huda, S. and Ali, M. (1998). Response of lentil genotypes to cultural management on nodulation, growth and yield. Bangladesh. *J. Sci. Ind. Res*. **33**: 258-262.

Dadson, R. B. and Acquach, G. (1984). Nitrogen and phosphorus effect on nodulation, symbiotic N fixation and yield of soybean. *Field Crop Res.* **9**: 101-108.

DAE (Department of Agricultural Extension). (2016). Field Service Wing, Department of Agricultural Extension, Ministry of Agriculture, Government of the Peoples Republic of Bangladesh, Khamarbari, Farmgate, Dhaka.

Dash, P. C. (2005). Evaluation of lentil mutants with respect of yield, yield attributes and seed protein content. M. S. Thesis. Department of Agronomy, Bangladesh Agricultural University, Mymensingh. pp. 26-35.

Datta, S. K., Sarkar, M. A. R. and Uddin, F. M. J. (2013). Effect of variety and level of phosphorus on the yield and yield components of lentil. *Intl. J. Agril. Res. Innov. Technol.* **3**(1): 78-82.

Dey, S. K. (2002). Effect of cultivar and seed rate on weed infestation and crop performance of lentil (*Lens culinaris* L. Medik). M. S. Thesis. Department of Agronomy, Bangladesh Agricultural University, Mymensingh. pp. 17-52.

Dziamba, S. and Microslaw, H. (1994). Effect of inoculating lentil seeds with *Rhizobium* strains on yield. Biuletyn Instytutu Hodowli-i Aklimatyzacji Roslin. **189**: 85-90:11.

El-Awady, R. M., Gendy, E. N. and Montaser, S. Y. (1993). Effect of phosphate and Zinc application on lentil plants and some chemical composition of alluvial soils. *Egypt. J. Agric. Res*. **71**(4): 873-882.

El-Nagar, G. R. and Galal, A. H. (1997). Effect of sowing date, seeding rate and harvesting time on yield, yield components and quality of lentil. *Assuit. J. Agric*. **28**(2): 135-144.

Fakir, M. S. A., Mushi, A. A. A. and Alam, S. M. M. (1998). Effects of *Rhizobium* inoculation, nitrogen and phosphorus on yield contributing characters of soybean. *Bangladesh J. Agril. Sci.* **15**(2): 211-215.

FAO (Food and Agriculture Organization). (1999). FAO Production year book. Basic Data Unit. Statistic Division, FAO. Rome, Italy.

Fatima, K., Hussain, N., Pir, F. A. and Mehedi, M. (2013). Effect of nitrogen and phosphorus on growth and yield of Lentil (*lens culinaris). Elixir Appl. Bot.* **57**: 14323-14325.

Gan, Y., Selles, F., Hanson, K. G., Zentner, R. P., McConkey, B. G., Angadi, S. V. and McDonald, C. L. (2003). *Rhizobium* Inoculant formulation and placement in lentil and chickpea in the semiarid Canadian prairies. *In* Proc. (CD-ROM) Soils and Crops Workshop 2003, Saskatoon, SK. Feb 17-18, 2003.

Gomez, K. A. and Gomez, A. A. (1984). Statistical procedures for Agricultural Research. Jhon Wiley and Sons, New York.

Gowda, C. L. L. and Kaul, A. K. (1982). Pulses in Bangladesh, BARI publication. **6**(1): 27-29.

Grant, C., Bittman, S., Montreal, M., Plenchette, C. and Morel, C. (2005). Soil and fertilizer phosphorus: Effects on plant P supply and mycorrhizal development. *Canadian J. Plant Sci*. **85**: 3-14.

Gwal, I. B., Tiwari, R. J. and Gupta, D. K. (1995). Fertilizer management of lentil under rainfed conditions in MP. *Lens Newsl.* **22**(1-2): 11-12.

Haque, M. A., Bala, P. and Azad, A. K. (2014). Performance of lentil varities as influenced by different *Rhizobium* inoculations. *Bangladesh Agron. J.* **17**(1): 41-46.

Haque, M. A., Bala, P., Azad, A. K., Parvin, N. and Nessa, B. (2013). Nodulation and dry matter of lentil influenced by genotype and inoculants. *Eco-friendly Agril. J.* **6**(10): 211- 214.

Haque, M. and Khan, A. (2012). Effects of phosphatic biofertilizer with inorganic and organic sources of phosphorus on growth and yield of lentil. *J. Environ. Sci. Natural Res.* **5**(2): 225-230.

Hasan, A. K., Ashiquzzaman, M., Quadir, Q. F. and Ahmed, I. (2015). Phosphorus use efficiency of different varieties of lentil and grass pea. *Res. Agric. Livest. Fish.* **2**(2): 271-277.

Hegazy, S. R., Selim T. and El-Emam, E. A. (2012). Correlation and path co-efficient analysis of yield and some yield components in lentil. *Egyptian J. Plant Breed.* **16**(3): 147-159.

Hussain, M. (2002). Effect of soil phosphorus and foliar application of calcium-cu-magnesium on agroqualitative traits of three cultivars of lentil (*Lens culinaris* L. Medik.). Ph.D. Thesis, Dept. of Agronomy, University of Agriculture, Faisalabad, Pakistan.

Hussain, M., Shah, S. H. and Nazir, S. M. (2002). Differential genotypic response to phosphorus application in lentil (*Lens culinaris* L.). *Intl. J. Agric. Biol.* **4**: 61-63.

Hussain, N., Yaqoob, M. and Rashid, A. (2014). Genetic competition among lentil (*Lens culinaris*) candidate lines for yield and yield components under rainfed conditions. *J. Agr. Res.* **52**: 53-62.

Islam, M. F. and Islam, M. S. (2006). Response of chickpea to nitrogen, phosphate, potash,sulfur an zinc fertilization in calcareous dark gray flood plain soils of Bengladesh,11th Ann. Bengladesh Conference, Dhaka, BAAS. **1**: 26.

Islam, M. S. (1988). Nutrient status of Bangladesh soils. Annual report for 1988. Bangladesh Agril. Res. Inst., Gazipur, Bangladesh. pp. 82-85.

Janmohammadi, M., Mostafavi, H. and Sabaghnia, N. (2014). Effects of enzymatic biofertilizer on growth and yield of lentil genotypes under deficit irrigation proceedings of the latvian academy of sciences. **68**(3/4): 174-179.

Jayapaul, P. and Ganesaraja, V. (1990). Studies on response of soybean varieties to nitrogen and phosphorus. *Indian J. Agri.* **35**: 329-330.

Joshi, N., Singh, S. and Singh, I. (2005). Variability and association studies in 25 lentil genotypes. *Indian J. Pulses Res*. **18**: 144-146.

Karim, M. M. A. (2006). Effect of spacing and harvesting time on the performances of lentil. M.S. Thesis. Department of Agronomy, Bangladesh Agricultural University, Mymensingh. pp. 26-45.

Kasole, K. E., Kalke, S. D., Kareepa, S. M. and Khade, K. K. (2005). Response of chickpea to different fertilizer levels, plant population and weed management on cultivators field in north eastern part of Kohlapur, Maharashtara. *Indian J. Agron.* **40**(2): 217-219.

Khan, H., Ahmad, F., Ahmad, S. Q., Sherin, M. and Bari, A. (2006). Effect of phosphorus fertilizer on grain yield of lentil. *Sarhad J. Agric*. **22**: 433-436.

Khare, J. P., Tomar, G. S., Tiwari, U. K. and Sharma, H. L. (1988). Response of lentil to nitrogen and phosphorus levels under rainfed conditions in central India. *Lens Newsl.* **15**(2): 12-14.

Krishnareddy, S. V. and Ahlawat, I. P. S. (1996). Growth and yield response of lentil cultivars to phosphorus, zinc and bio-fertilizers. *J. Agric. Crop. Sci.* **177**(1): 49-59.

Mahmood, I., Razzaq, A., Bukhari, S. A. H. and Naveed, T. M. (2010). Optimization of lentil (*Lens culinaris* L.) cultivars response to NPK under rainfed condition. *J. Agric. Res.* **48**(3): 343-351.

Malik, B. A., Haqqani, A. M. and Bashir, M. (1983). Yield potential of lentil cultivars in Pakistan. *Lens Newsl.* **10**(1): 15-16.

Malik, M. A., Tanveer, A., Hayee, M. A. and Ali, A. (1991). Seed yield and protein contents of lentil (*Lens culinaris* L.) as influenced by NPK application. *J. Agric. Res.* **29**(3): 333-338.

Mamun, A. A. (2006). Variation in growth and yield performance of ten lentil genotypes. Master's Thesis. Department of Crop Botany, Bangladesh Agricultural University, Mymensingh. pp. 15-22.

Maola, M. M. (2005). Effect of gamma radiation on some important morphophysiological and yield attributes in M_2 generation lentil. M. S. Thesis. Department Crop Botany, BAU, Mymensingh.

Minhas, R. S., Jaggi, R. S. and Sharma, P. (2007). Response of gram to NPK application in wet temperature zone of Himachal Pradesh. *Indian J. Agril. Chem.* **20**: 95-99.

Mirza, H. F., Quazi, K. M. A. and Kamrun, N. **(**2007). Yield performance of chickpea varieties following application of growth regulator. *American-Eurasian J. Sci. Res.* **2**(2): 117-120.

Mosali, J., Desta, K., Roger, K.T., Kyle, W. F., Kent, L. M., Janson, W. L. and William, R. R. (2006). Effect of foliar application of phosphorus on winter wheat grain yield, phosphorus uptake and use efficiency. *J. Plant Nutr.* **29**: 2147-2163.

Nazir, M. S., Akhtar, M. N. and Ali, G. (2004). Nutritional studies on chickpea. *Pakistan J. Agril. Res.* **5**: 179-182.

Niri, H. H., Tobeh, A., Gholipouri, A., Zakaria, R. A., Mostafaei, H. and Jamaati-e-Somarin, S. (2010). Effect of nitrogen and phosphorous on yield and protein content of lentil in dryland condition. *American-Eurasian J. Agric. Environ. Sci.* **8**(2): 185-188.

Ojha, S. N., Roy, R. K. and Jha, J. N. (1977). Effect of nitrogen, phosphorus and *Rhizobium* inoculation on grain yield of lentil under irrigated condition. *Indian J. Agron.* **22**(4): 250-253.

Okaz, A. M. A., El-Ghareib, E. A., Kadry, W., Negm, A. Y. and Zahran, F. A. F. (1994). Response of lentil plants to potassium and phosphorus application in newly reclaimed sandy soils. Proc. 6th Conf. Agron., Al-Azhar Univ., Cairo, Egypt, Sept. 1994. **2**: 753-771.

Paricha, N. S. and Aulakh, M. S. (1992). Effect of phosphorus, sulphur interrelationship on their availability from fertilizer and soil to soybean and linseed. *In: Proc. Middle East Sulphur Symp.* 12–16 Feb., Cario, Egypt.

Plainiappan, S. P. (1985). Cropping Systems in the Tropic: Principles and Management. Wiley Eastern Ltd., New Delhi.

Rahman, M. H. ,Wajid, S. A., Ahmad, A., Khaliq, T., Malik, A. U., Awais, M., Talha, M., Hussain, F. and Abbas, G. (2013) Performance of promising lentil cultivars at different nitrogen rates under irrigated conditions. *Sci. Int. (Lahore).* **25**(4): 905-909.

Rahman, M. J. (2006). Effect of source and rate of compost on the yield and yield component of lentil. M. S. Thesis. Department of Agronomy, Bangladesh Agricultural University, Mymensinh. pp. 23-36.

Rashid, A. (2002). Growth and Yield Response of Three Cultivars of Gram (*Cicer arietinum* L.) to NPK Levels. M.Sc. Thesis, Deptt. Agronomy, Univ. Agric., Faisalabad.

Rasool, S. and Singh, J. (2016). Effect of biofertilizers and phosphorus on growth and yield of lentil (*Lens culinaris* L.). *Intl. J. Adv. Agril. Sci. Technol*. **3**(7): 35-42.

Rathore, R. S., Khandwe, R., Khandwe, N., and Singh, P. P. (1992). Effect of irrigation schedules, phosphorus levels and phosphate solubilizing organisms on lentil yield. *Lens.* **19**(1): 17-19

Razzaque, M. A. (2000). Annual Report 1998-99. Lentil, Blackgram, Mungbean Development Pilot Project, Bangladesh Agricultural Research Institute. Gazipur, Bangladesh.

Sadiq, M. S., Sarwar, G., Saleem, M. and Abbas, G. (2002). NIAB Masoor 2002 - A short duration and high yielding lentil variety. *J. Agric. Res*. **40**(3-4): 187-192.

Saleh, S. A. (1976). Response of six soybean varieties to phosphorus fertilizer at Wadi Jizan region, Saudi Arabia. *Ann. Agric. Sci. Moshtohor.* **5**: 3-10.

Sarker, D. K. R. (2005). Study on the growth, yield and yield attributes of advanced mutants of lentil. Master's Thesis. Department Crop Botany, BAU, Mymensingh.

Sattar, M. A. and Ahmed, S. U. (1995). Response of mungbean (*Vigna radiata* L. Wilczek) to inoculation with *Bradyrhizobium* as affected by phosphorus levels. Proc. Intl. Cong. Comm. IV. pp. 419-423.

Saxena, K. K. and Varma, V. S. (1996). Effect of N, P and K on the growth of yield of lentil (*Lens culinaris*). *Indian J. Agron.* **40**(2): 249-242.

Sepetoglu, H. (2002). Grain legume. Department of Field crops, Faculty of Agriculture, university of Ege publication, 24/4, lzmin, Turkey.

Shah, N. H., Hafeez, F. Y., Arshad, M. and Malik, K. A. (2000a). Response of lentil to *Rhizobium leguminosarumbv. viciae* strains at different levels of nitrogen and phosphorus. *Australian J. Exp. Agri.* **40**: 93-98.

Shah, S. H., Mahmood, M. Y. and Zameer, M. S. I. (2000b). Qualitative and quantitative response of three cultivars of lentil (*Lens culinaris* Medic.) to phosphoric application. *Intl. J. Agri. Biol*. **2**(3): 248-250.

Shamim, M. and Naimat, A. (1987). Effect of seed inoculation with Rhizobium and N.P. fertilizer level on the yield of gram. *Pakistan J. Agric. Res.* **8**: 383-385.

Sharar, M. S., Ayub. M., Nadeem, M. A. and Naeem, M. (2003). Effect of different combinations of nitrogen and phosphorus on the growth and yield of three varieties of Lentil (*Lens culinaris*Medik). *Pakistan J. life Soc. Sci.* **1**(1): 54-56.

Sharrna, M. C. and Singh, M. P. (1989). Uptake pattern of N, P and K in lentil under various seed rates, row spacings and fertilizer levels. *J. Agric. Sci.* **59**(10): 634-639.

Singh, B., Marok, A. S. and Singh, B. (1981). Response of lentil to phosphorus application on soils differing in available phosphorus status. *Indian J. Ecol.* **8**(2): 163-166.

Singh, G., Ram, H., Sekhon, H. S., Aggarwal, N. and Khanna, V. (2011). Effect of Nutrient Management on Nodulation, Growth and Yield of Lentil (*Lens culinaris* Medik.) Genotypes. *American-Eurasian J. Agron.* **4**(3): 46-49.

Singh, O. B., Shama, H. B. and Singh, V. K. (1999). Effect of nitrogen, phosphorus and rhizobium culture on yield and yield attributes of lentil under dry land conditions. Dept., Agron., G.B. Pant University Agri. and Tech., Pantnagar, Distt. Udham Singh Nagar 263 145, India. *Indian J. Pulses Res.* **12**: 260-262.

Singh, O. N., Sharma, M. and Dash, R. (2003). Effect of seed rate, phosphorus and FYM application on growth and yield of bold seeded lentil. *Indian J. Pulses Res.* **16**: 116-118.

Singh, T., Singh, K. N. and Baba, H. (1992). Response of lentil (*Lens culinaris*) to different levels of nitrogen and phosphorus under rainfed conditions of Kashmir. *Indian J. Agri. Sci.* **62**: 830-841.

Singh, Y. P., Chauhan, C. P. S. and Gupta, R. K. (2010). Effect of sulphur, phosphorus and inoculation on growth, yield and sulphur utilization by lentil (*Lens culinaris*). *Indian J. Agril. Sci.* **70**(7): 491-493.

Sinha, R. P. and Choudhary, S. K. (1991). Induced co-dominant mutation for dwarfness in lentil. *Indian J. Genet. Plant Breed.* **51**: 370-372.

Sinha, R. P. and Singh, R. N. (2002). Correlation of seed yield with other traits in lentil. *J. Appl. Biol*. **12** (1/2): 1-3.

Subramanian, A. and Radhak, A. (1981). Effect of foliar spray on black gram pulse crop. *Newsl. India.* **1**: 39.

Talukder, M. S. (2004). Effect of gamma rays on large seeded lentil. M. S. Thesis. Department of Genetics and Plant Breeding, BAU, Mymensingh.

Thirtle, C., Lin, L. and Piesse, J. (2003). The impact of research-led agricultural productivity and growth on poverty reduction in Africa, Asia and Latin America. *World Develop*. **3**: 1959-1976.

Tomar, S. K., Tripathi, P. and Rajput, A. L. (1999). Effect of genotype, seeding method and diammonium phosphate on yield and protein and nutrient uptake of lentil (*Lens culinaris* L. Medik). *Indian J. Agron.* **45**(1): 148-152.

Tomar, S. S., Srivastava, U. K., Sharma, R. K., Bhadouria, S. S. and Tomar, A. S. (2000). Physiological parameters of summer mungbean (*Vigna radiata*) as affected by seed rate, moisture regime and phosphorous levels. *Legume Res.* **18**(2):125-128.

Wasiq, I. (2006). Effect of plant density and cultivar on the performance of lentil. M. S. Thesis. Department of Agronomy, Bangladesh Agricultural University, Mymensingh. pp. 24-41.

Yaseen, T., Ali, K., Munsif, F., Rab, A., Ahmad, M., Israr, M. and Baraich, A. (2016). Influence of *Arbuscular* mycorrhizal fungi, *Rhizobium* inoculation and rock phosphate on growth and quality of lentil. *Pakistan J. Bot*. **48**(5): 2101-2107.

Yusuf, M. A. (2006). Effect of row spacing and weeding regime on the performance of late sown lentil cv. BARI-4. M. S. Thesis. Department of Agronomy, Bangladesh Agricultural University, Mymensingh. pp. 27-43.

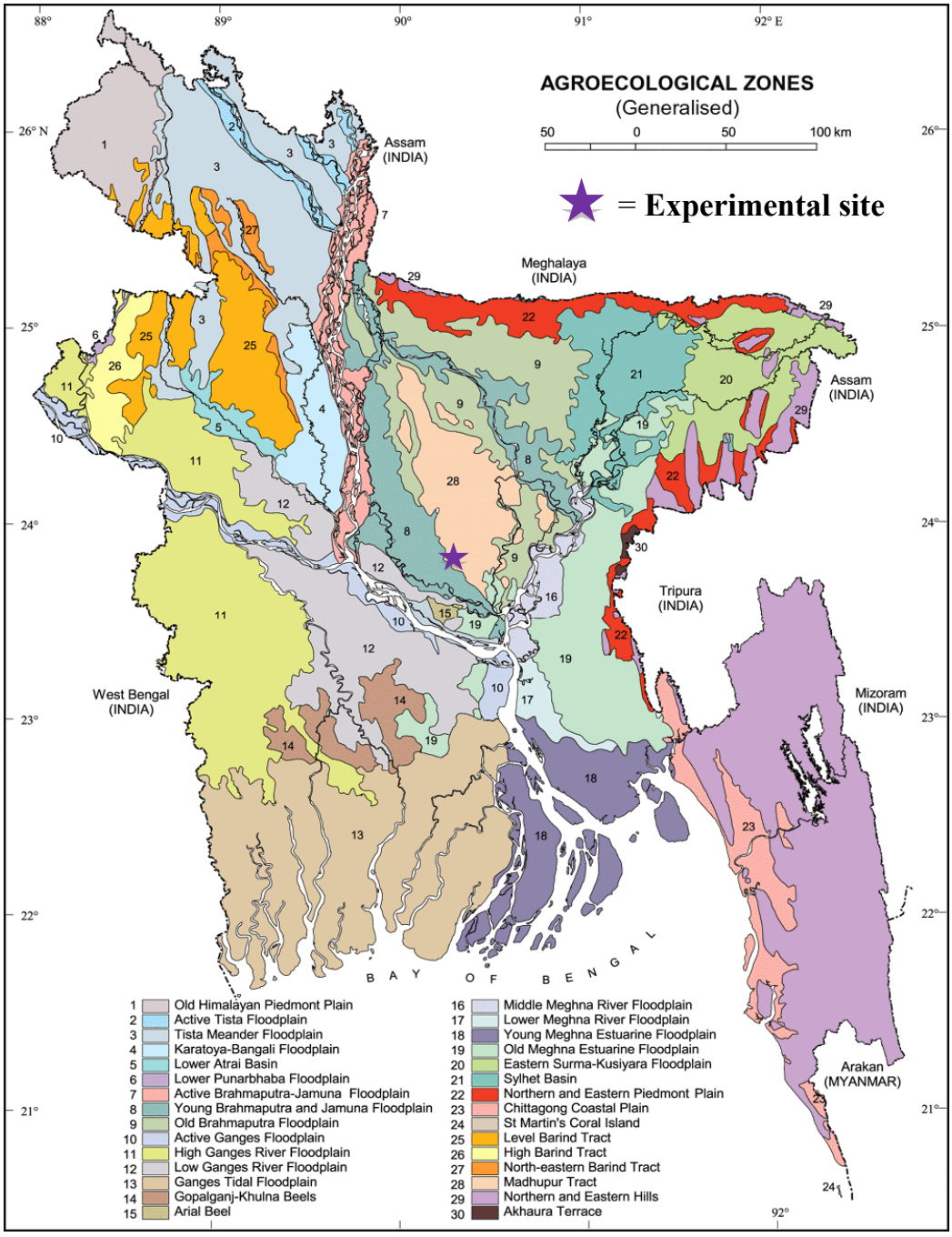
Zafar, M., Maqsood, M., Ansar, M. R. and Zahid, A. (2003). Growth and yield of lentil as affected by phosphorus. *Intl. J. Agric. Biol.* **5**(1): 98-100.

Zeidan, M. S. (2007). Effect of organic manure and phosphorus fertilizers on growth, yield and quality of lentil plants in sandy soils. *Res. J. Agri. Biol*. **38**(6-7): 745-752.

Zeidan, M. S., Hozayn, M. and Abd El-Salam, M. E. E. (2006). Yield and quality of lentil as affected by micronutrient deficiency in sandy soils. *J. Appl. Sci. Res*. **2**(12): 1342-1345.

APPENDICES

Appendix I. Map showing the experimental site under study



Appendix II. Characteristics of soil of the experimental field

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Sher-e-Bangla Agricultural University Research Farm, Dhaka
AEZ	AEZ-28, Modhupur Tract
General Soil Type	Deep Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. The initial physical and chemical characteristics of soil of the experimental site (0 - 15 cm depth)

Physical characteristics	
Constituents	**Percent**
Sand	26
Silt	45
Clay	29
Textural class	Silty clay

Chemical characteristics	
Soil characters	**Value**
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.03
Available P (ppm)	20.54
Exchangeable K (me/100 g soil)	0.10

Source: Soil Resource and Development Institute (SRDI), Farmgate, Dhaka

Appendix III. Mean square value of plant height of lentil as influenced by combined effect of variety and phosphorous levels

Source of variation	df	Plant height at different days after sowing			
		25	50	75	At harvest
Replication	2	0.23	0.61	5.20	24.10
Variety (A)	2	1.26*	8.75^{NS}	5.59^{NS}	8.32^{NS}
Error	4	0.17	6.34	2.73	4.35
Phosphorous (B)	3	3.42*	21.45*	35.08*	23.66*
Variety (A) X Phosphorous (B)	6	0.08*	0.32*	0.19*	0.53*
Error	18	0.45	1.74	6.19	4.32

*Significant at 5% level of significance

^{NS} Non significant

Appendix IV. Mean square value of number of leaves plant^{-1} of lentil as influenced by variety, phosphorous level and their interactions

Source of variation	df	Number of leaves plant^{-1} at different days after sowing			
		25	50	75	At harvest
Replication	2	1.55	6.97	200.84	221.17
Variety (A)	2	4.41*	686.85*	5645.46*	4382.08*
Error	4	0.79	7.66	172.38	55.6
Phosphorous (B)	3	4.64*	449.19*	14202.60*	7301.73*
Variety (A) X Phosphorous (B)	6	0.03*	50.22*	1310.30*	177.85*
Error	18	0.29	15.00	188.58	230.02

*Significant at 5% level of significance

^{NS} Non significant

Appendix V. Mean square value of number of branches plant^{-1} of lentil as influenced by variety, phosphorous level and their interactions

Source of variation	df	Number of branches plant^{-1} at different days after sowing			
		25	50	75	At harvest
Replication	2	0.01	4.87	7.53	0.65
Variety (A)	2	0.16*	49.20*	213.56*	158.25*
Error	4	0.01	1.17	7.60	2.11
Phosphorous (B)	3	0.37*	49.43*	141.38*	140.29*
Variety (A) X Phosphorous (B)	6	0.03*	1.66*	5.44*	1.40*
Error	18	0.01	0.84	2.44	3.61

*Significant at 5% level of significance

^{NS} Non significant

Appendix VI. Mean square value of leaf dry weight plant^{-1} of lentil as influenced by variety, phosphorous level and their interactions

Source of variation	df	Leaf dry weight plant^{-1} at different days after sowing			
		25	50	75	At harvest
Replication	2	0.0001	0.004	0.03	0.00
Variety (A)	2	0.0001^{NS}	0.043*	1.41*	1.13*
Error	4	0.0001	0.0001	0.09	0.01
Phosphorous (B)	3	0.0001^{NS}	0.064*	2.70*	1.81*
Variety (A) X Phosphorous (B)	6	0.0001^{NS}	0.002*	0.09*	0.12*
Error	18	0.0001	0.001	0.07	0.02

*Significant at 5% level of significance

^{NS} Non significant

Appendix VII. Mean square value of shoot dry weight plant^{-1} of lentil as influenced by variety, phosphorous level and their interactions

Source of variation	df	Shoot dry weight plant^{-1} at different days after sowing			
		25	50	75	At harvest
Replication	**2**	0.0001	0.001	0.03	0.001
Variety (A)	**2**	0.004*	0.20*	3.03*	2.42*
Error	**4**	0.0001	0.003	0.04	0.03
Phosphorous (B)	**3**	0.003*	0.52*	2.42*	3.77*
Variety (A) X Phosphorous (B)	**6**	0.001*	0.03*	0.13*	0.06*
Error	**18**	0.0001	0.002	0.04	0.05

*Significant at 5% level of significance

^{NS} Non significant

Appendix VIII. Mean square value of total dry weight plant^{-1} of lentil as influenced by variety, phosphorous level and their interactions

Source of variation	df	Total dry weight plant^{-1} at different days after sowing			
		25	50	75	At harvest
Replication	**2**	0.000	0.02	0.19	0.21
Variety (A)	**2**	0.01*	0.17^{NS}	5.37*	13.98*
Error	**4**	0.0001	0.004	0.12	0.89
Phosphorous (B)	**3**	0.001*	0.20*	17.52*	27.35*
Variety (A) X Phosphorous (B)	**6**	0.001*	0.022*	0.43*	0.44*
Error	**18**	0.0001	0.002	0.16	0.26

*Significant at 5% level of significance

^{NS} Non significant

Appendix IX. Mean square value of days to 80% seedling emergence, 80% flowering and 80% maturity of lentil as influenced by variety, phosphorous level and their interactions

Source of variation	df	Days to 80% seedling emergence	Days to 80% flowering	Days to 80% maturity
Replication	**2**	0.03	5.08	8.53
Variety (A)	**2**	0.03^{NS}	0.58^{NS}	0.86^{NS}
Error	**4**	0.07	0.67	1.53
Phosphorous (B)	**3**	0.04^{NS}	0.52^{NS}	0.41^{NS}
Variety (A) X Phosphorous (B)	**6**	0.07^{NS}	0.55^{NS}	0.49^{NS}
Error	**18**	0.06	0.62	0.82

*Significant at 5% level of significance

^{NS} Non significant

Appendix X. Mean square value of yield contributing characters of lentil as influenced by variety, phosphorous level and their interactions

Source of variation	df	Pods plant^{-1}	Seeds pod^{-1}	Pod length	1000 seed weight	Seed weight plant^{-1}
Replication	**2**	59.00	0.002	0.006	1.91	0.06
Variety (A)	**2**	1531.46*	0.02*	0.006*	2.88^{NS}	4.20*
Error	**4**	49.48	0.004	0.001	0.78	0.08
Phosphorous (B)	**3**	730.55*	0.04*	0.004*	2.40*	2.15*
Variety (A) X Phosphorous (B)	**6**	24.58*	0.0001*	0.0001*	0.07*	0.29*
Error	**18**	18.96	0.01	0.002	1.17	0.10

*Significant at 5% level of significance

^{NS} Non significant

Appendix XI. Mean square value of yield of lentil as influenced by variety, phosphorous level and their interactions

Source of variation	df	Seed yield	Stover yield	Biological yield	Harvest index
Replication	**2**	0.01	0.004	0.01	1.61
Variety (A)	**2**	0.52*	0.24*	1.46*	46.86*
Error	**4**	0.003	0.04	0.03	9.86
Phosphorous (B)	**3**	0.34*	0.20*	1.05*	26.83*
Variety (A) X Phosphorous (B)	**6**	0.01*	0.01*	0.04*	3.50*
Error	**18**	0.01	0.01	0.01	5.08

*Significant at 5% level of significance

^{NS} Non significant