INFLUENCE OF PHOSPHORUS FERTILIZER ON THE PRODUCTIVITY OF LENTIL

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INFLUENCE OF PHOSPHORUS FERTILIZER ON THE PRODUCTIVITY OF LENTIL

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CERTIFICATE

This is to certify that the thesis entitled**“ INFLUENCE OF PHOSPHORUS FERTILIZER ON THE PRODUCTIVITY OF LENTIL”** submitted to theFaculty of Agriculture**,** Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of ***MASTER OF SCIENCE IN AGRONOMY,***embodies the results of a piece of *bona fide* research work carried out by***RUKSHANA AMIN SONET***Registration. No. **08-3157,** 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

(Asstt. Prof. Sheikh Muhammad Masum)
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DEDICATED TO

MY

BELOVED PARENTS

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The Author

ABSTRACT

An experiment was carried out to evaluate the effects of phosphorus fertilizer application on growth, yield and yield components of lentil at the Agronomy Research Field ofDepartment ofSher-e-Bangla Agricultural University, Dhaka, Bangladesh during November 2013 to March 2014. Four lentil cultivars (BARI Masur 4, BARI Masur 5, BARI Masur 6 and BARI Masur 7) and four levels of phosphorus (0, 20, 40 and 60 kg P ha^{-1}) were used in this experiment as treatment variables. Cultivars showed significant difference on numbers of nodule, total dry matter and effective branch production.Significant variations due to cultivars were also found in respect of seed yield. The highest seed yield (1.76 t ha^{-1}) was observed in BARI Masur7 while the lowest in BARI Masur 5(1.37 t ha^{-1}). Phosphorus fertilizers had a significant effect on the yield of yield attributes of lentil. The highest seed yield(1.72 t ha^{-1}) was observed from 40 kg P_2O_5 ha^{-1} and the lowest (1.24 t ha^{-1}) from 0 kg P_2O_5 ha^{-1}.Interaction of cultivar and phosphorus levels showed significant influence on all the plant characters studied except plant height and branch production. The highest seed yield (1.98 t ha^{-1}) was obtained from the combination of BARI Masur 7 with 40 kg P_2O_5 ha^{-1}, and the lowest (1.08 t ha^{-1}) was from BARI Masur 5 with 0 kg P_2O_5 ha^{-1}. Addition of phosphorus fertilizer beyond 40 kg ha^{-1} decreased seed yield irrespective of varieties. Results revealed that application of phosphorus fertilizer offers a large scope for obtaining higher yield of lentil in Bangladesh. However application of phosphorus fertilizer at the rate of 40 kg P_2O_5 ha^{-1} would be the optimum for achieving higher yield irrespectiveof cultivars. BARI Masur 6 and BARI Masur 7 were found superior to BARI Masur 4 and BARI Masur 5 in respect of seed yield.

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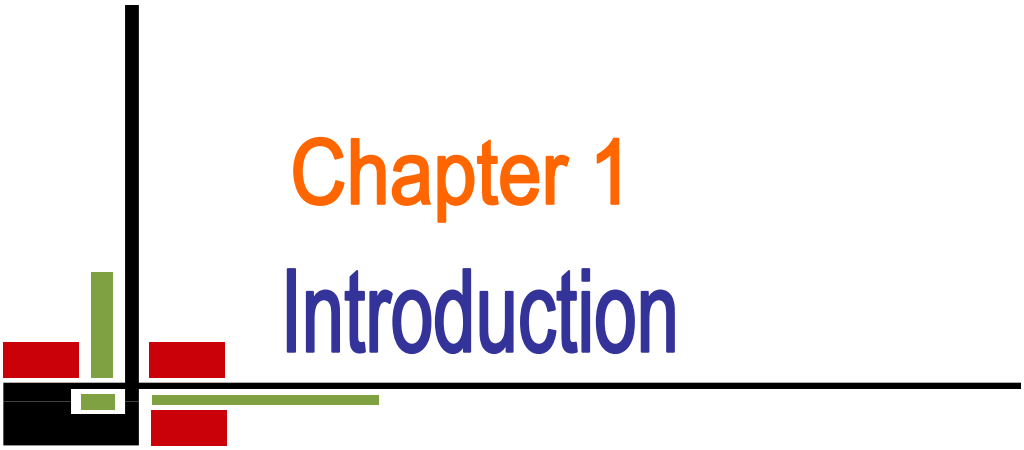
LIST OF ABBREBIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BARC	=	Bangladesh Agricultural Research Council
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau Of Statistics
^{0}C	=	Degree Centigrade
Cm	=	Centimeter
cv.	=	Cultivar
CV%	=	Percentage of coefficient of Variance
DAP	=	Di- Ammonium Phosphate
DAS	=	Days After Sowing
et al.	=	And others (at Elli)
FAO	=	Food and Agriculture Organization
G	=	gram (s)
HI	=	Harvest Index
Kg	=	Kilogram
Kg/ha	=	Kilogram/hectare
M	=	Meter
Max	=	Maximum
Min	=	Minimum
MP	=	Murate of potash
N	=	Nitrogen
no.	=	Number
NPK	=	Nitrogen, Phosphorus and Potassium
P	=	Phosphorus
P^H	=	Hydrogen ion conc.
RCBD	=	Randomized Complete Block Design
SAU	=	Sher-e-Bangla Agricultural University
SE	=	Standard errors
SRDI	=	Soil Resources and Development Institute

TSP	=	Triple Super Phosphate
UN	=	United Nations
UNDP	=	United Nations Development Program
Wt	=	Weight
%	=	Percent



Chapter 1

Introduction

INTRODUCTION

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 riot adequate to meet the national demand. Lentil (*Lens culinaris* L. Medik) is one of the most ancient annual pulse food crops that belongs to the sub family papilionaceae under the family Fabaceae ranks second in areas (4.34 million hectares) andwith annual production and productivity of 4.95 million tons and 1260 Kg ha^{-1} respectively but ranks the highest in consumer preference and total consumption (FAOSTAT, 2014). In South Asia as well as in Bangladesh it is popularly known as Masurand one of the most ancient annual food crops that have been grown as an important food source for over 8,000 years (Dhuppar*et al.*, 2012). Lentil 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. 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. It occupies a unique position in the world of agriculture by virtue of its high protein content and capacity of fixing atmospheric nitrogen. 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). The green plants can also be used as animal feed and its residues have manural value. Lentil grains contain high protein, good flavor and easily

digestible component. It may play an important role to supplement protein in the cereal based low protein diet of the people of Bangladesh but the acreage (213035 acres in 2012) and production (80125 metric tons in 2012) of lentil are steadily declining (BBS, 2012). Cultivation of high yielding varieties of wheat and boro rice has occupied considerable land suitable for lentil cultivation during rabi (winter) season of Bangladesh. Besides these, low (0.80 t ha^{-1}) yield potentiality of this crop is responsible for declining the area and production of lentil.

Being a legume crop, lentil can fix atmospheric nitrogen via symbiotic *rhizobia* in root nodules and consequently has potential in crop rotation for maintaining soil fertility (Crook *et al*., 1999). Despite holding these merits there are so many constraints in lentil production which limit the crop production by reducing their growth and yield. Out of which unavailability of promising varieties of lentil and misuse of fertilizer are the main hindering factors, which limit the economical crop growth oflentil.

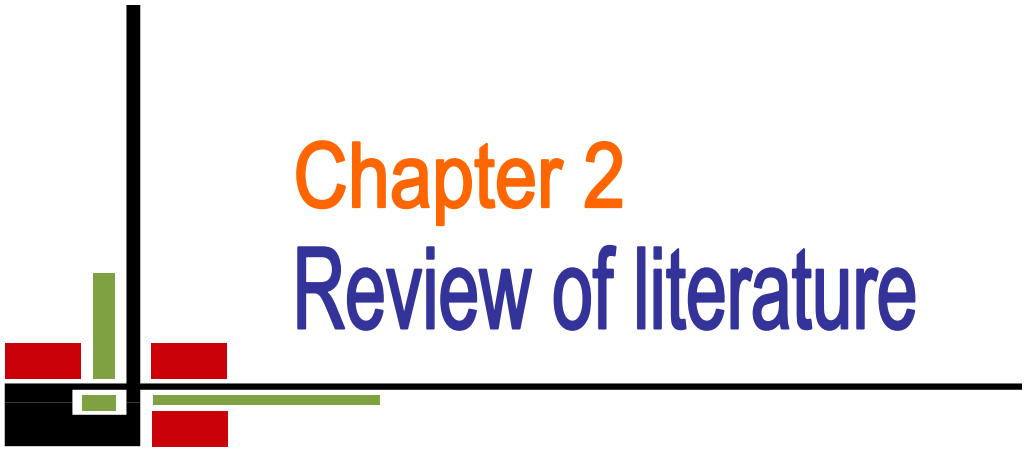
An improved variety is the first and foremost requirement for initiation and accelerated production program of any crop. Furthermore, variety plays an important role in producing high yield of lentil because different varieties responded differently for their genotypic characters; BARI has developed some varieties of lentil. 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).

There is also a wrong notion with farmers that this crop being a legume does not need any nutrition. Farmers usually grow lentil without any fertilizer.Whereas, phosphorus is a key element involved in various functions in growth and metabolism of pulses. It is classified as a major nutrient, meaning that it is frequently deficient for crop production and is required by crops in relatively large amounts. Depending on the species, stage of growth

and organ of plant the total P concentration in agricultural crops generally varies from 0.1 to 0.5 percent for optimum plant growth (Annon, 1999). Therefore, phosphorus fertilizer is important factor that greatly affects the growth development and yield of this crop.

The present study was, therefore, designed on the agronomic traits of four cultivars (BARI masur 4, BARI masur 5, BARI masur 6 BARI masur 7) of Bangladesh lentil with different phosphorus levels under irrigated conditions keeping following objectives in mind.

1. To determine the yield performance of lentil varieties,
2. To determine the effect of phosphorus fertilizer application on yield and yield attributes of lentil varieties,



Chapter 2
Review of literature

REVIEW OF LITERATURE

Variety itself is the genetical factor which contributes a lot for producing growth, yield and yield components. Different researcher reported the effect of lentil varieties on growth and yield contributing component, and grain yield. In pulse cultivation varieties play important role in increasing yield. In same environmental condition varieties may give different results. In Bangladesh, lentils are generally grown without fertilizer or manures. However, there is evidence that the yield of lentil can be increased substantially by using fertilizer. In case of phosphorus application in lentil crop give higher yield (Patra and Sahoo, 1994). Considering the above points, available literature was reviewed under phosphorus fertilizer application for lentil cultivars.

2.1 Effect of variety

Variety may have variable effects on growth, yield components and yield of lentil as well as other pulse crops.

2.1.1 Plant height

Hasan*et al*. (2015) conducted an experiment and reported that the highestplant 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 to study the effect of weeding on the growth and yield of three lentil varieties viz. BINA Masur-1, BINA Masur-2 and BINA Masur-3.The tallest plant was observed in BINA Masur-3 followed by BINA Masur-2.

Datta*et al*. (2013) conducted an experiment and reported thatthe variety BINA Masur 2 gave the highestplant height (38.18 cm)and the cultivar BARI masur 4 produced the lowestplant height (36.92 cm).

Dixit and Dubey(1986) was conducted an experiment with 20 mutants/cultivars of lentil and reported that there had wide variability in case of plant height among the studied mutants.

2.1.2 Branches plant^{-1}

Rahman *et al.* (2013) conducted a field study to evaluate the effect of nitrogen applicationon different agro-physiological traits of three lentil cultivars. They reported that branching plays a vital role in enhancing the yield of a plant. Cultivar NIAB Masurr (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.

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

2.1.3 Nodule production plant^{-1}

Datta*et al.* (2013) also reported that the variety BINA Masur2 gave the highest number of nodules plant^{-1} (17.36) and BARI Masur 4 produced the lowest number of nodules (14.72).

Haque*et al.* (2013) conducted an experiment at the research farm of Bangladesh Agricultural University, Mymensingh during rabi seasons of 2009-2010 to study the effect of *Rhizobium* inoculate in nodulation and dry matter production of lentil they reported that BARI Masur-3 performed better than other two lentil varieties (*Rhizobium* strain BINA L4 and *Rhizobium* strain TAL 640) in respect of nodule number.

2.1.4 Dry weight plant^{-1}

Hasan*et al.*(2015) reported that the highest (1.62 g) dry weight plant^{-1}was found from BARIMasur 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.

2.1.5 Pods plant^{-1}

Datta*et al.* (2013) also reported thatthe variety BINA Masur 2 gave the highest (128.5) number of pods plant^{-1}and the cultivar BARI Masur 4 produced the lowest (111.7) number of pods plant^{-1}.

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

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

Rajat and Gowda (1978) conducted an experiment on mungbeanvarieties in India and reported that the highest number of pods plant^{-1}of mungbeanwas produced by PS 7 followed by PS 16 and PS 10.

2.1.6 Seed pod^{-1}

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

Datta*et al.* (2013) also reported that BINA Masur 3 produced the highest (1.68) number of seeds pod^{-1}and the lowest (1.58) number of seeds pod^{-1}wasobserved from the cultivar BARI Masur 4.

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 seeds

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

Datta*et al*. (2013) conducted an experiment and reported thatthe cultivar BARI Masur 4 producedthe highest of 1000 seedweight(18.77 g)and the lowest (16.42 g)from the cultivar BINA Masur2.

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

Hussain *et al.* (2002) also reported that varieties vary greatly in 1000 seed weight of lentil plants.

Rajatand Gowda (1998) found that the highest 1000 grain weightof lentil was produced by PS 7 followed by PS 16 and PS 10.

2.1.8 Seed yield

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.

Datta*et al.* (2013) also found that the highestseed yield (1165 kg ha^{-1}) was observed in BARI Masur4 and the lowest (1028 kg ha^{-1}) in BINA Masur 3.

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

Rajat and Gowda (1998) found that the highest grain yield of lentil was produced by genotype PS 7 followed by PS 16 and PS 10.

2.1.9 Harvest index (%)

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%) was found in BINA Masur 2.

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 Hussain *et al.* (2002) and Shah *etal.* (2000).

2.2 Effect of phosphorus

2.2.1 Plant height

Choubey *et al*. (2013) conducted a field experiment in India and reported that. Plantheight 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 $P_20_5ha^{-1}$.

Zeidan (2007) carried out two field experiments and reported that increasing p levels from 0 to 60 kg P_20_5 ha^{-1} increased plant height of lentil.

Zafar*et al.* (2003)conducted a field trial in Dhaka, Bangladesh and reported that plant height of lentil was significantly affected by different rates of phosphorus.

Saraf and Shivakumar (1997) conducted a field experiment in India and reported that plant height of lentilincreased with the increase of phosphorus up to 60 kg P_2O_5 ha^{-1}.

Singh and Saxena (1986) also reported that phosphorus application significantly increased plant height of lentil.

2.2.2 Branches plant^{-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}.

Zeidan (2007) carried out two field experiments and reported that increasing P levels from 0 to 60 Kg P_20_5 ha^{-1} increased branches plant^{-1} of lentil.

Zafar*et al.* (2003) also reportedthat branches plant^{-1}of lentil was significantly affected by different rates of phosphorus.

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

Saraf and Shivakumar (1997) also showed that branches plant^{-1} increased with the increase of phosphorus up to 60 kg P_2O_5 ha^{-1}.

Sexenaand Varma (1996) conducted a field experiment on lentil with different levels of phosphorus in India and reported that number of branches plant^{-1}of lentil washighest with 60 kg P_2O_5 ha^{-1} in 2003 and increased up to 30 kg P_2O_5 ha^{-1} in 2005.

2.2.3 Nodule production plant^{-1}

Hassan *et al.* (2015) reported that application of 50 kg P_2O_5 ha^{-1}might be the optimum for achieving the higher nodule number.

Fatema*et al.* (2013) also reported that the phosphorus application significantly increased number of nodules plant^{-1} up to 50 kg P_2O_5 ha^{-1}.

Maqsood*et al.* (1994) reported that the highest nodulation of lentil were obtained with 60 kg P_2O_5 ha^{-1}.

2.2.4 Dry weight plant^{-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}.

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

2.2.5 Pods plant^{-1}.

Zeidan (2007) carried out two field experiments and reported that increasing P levels from 0 to 60 kg ha^{-1} increased pods plant^{-1} of lentil.

Zafar*et al(2003)* reported that pods plant^{-1} of lentil was significantly affected by different rates of phosphorus.

Sexena*and verma*(1996) conducted an experiment on lentil with different levels of P during 2003 and 2005 and reported that pod plant^{-1}of lentil was the highest with 60 kg P_2O_5 ha^{-1} in 2003 and increased up to 30 kg P_2O_5 ha^{-1} in 2005.

2.2.6 Weight of 1000 grain

Zeidan (2007) carried out two field experiments and reported that increasing P levels from 0 to 60 kg ha^{-1}increased weight of 1000 grain of lentil.

Zafar*et al.* (2003) reported that1000 grainweight of lentil was significantly affected by different rates of phosphorus.

Sexenaand Varma(1996) also reported that 1000 grain weight of lentilwas highest with 60 kg P_2O_5 ha^{-1} in 2003 and increased up to 30 kg P_2O_5 ha^{-1} in 2005.

2.2.7Seed yield

Choubey*et al.*(2013) reported that grain yield improved with the application of60 kg $P_2O_5ha^{-1}$.Datta*et al.* (2013) also reported that application of P fertilizer from 0 to 60 kg $P_2O_5ha^{-1}$increased grain yield of lentil. Fatima *et al.*(2013)

reported thatphosphorous application significantly increased grain yield up to 50 kg P_20_5 ha^{-1}.

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

Application of50kg ha^{-1}phosphorus may be considered as optimum dose forhigher yield of lentil (Mahmood*et al.,* 2010).

According to Zafar*etal*. (2003) maximal does of phosphorus 75 kgP_2O_5 ha^{-1} has proved a significant dose forgetting a good grain yield of lentil.

Saraf and Shivakumar (1997) also showed that seed yield increased with the increase of phosphorus up to 60 kg P_2O_5 ha^{-1}.

Sexena and Varma(1996) conducted an experiment on lentil with different levels of P during 2003 and 2005 and reported that seed yield was the highest with 60 kg P_2O_5 ha^{-1} in 2003 and increased up to 30 kg P_2O_5 ha^{-1} in 2005.

Azad *et al.* (1991) conducted a field trial on lentil with 4 levels P viz. 0, 20, 40 and 60 kg P_2O_5 $ha^{-1}$and reported the grain yield of lentil increased significantly at all levels of phosphorus application over control.

Siag*et al.* (1990) stated that maximumgrain yield (2.68 ton ha^{-1}) of lentil was obtained with the application of 60 kg P_2O_5 ha^{-1}. The optimum P rate was calculated to be 56 kg ha^{-1}.

Prasad and Chaudhary (1984) found that minimum plant death was achieved and reduction of 60 kg P_2O_5 ha^{-1} application on lentil.Sharma *et al.* (1984) also reported the effect of levels, source and methods of P application on availability of P to lentil. Available P content in soil and shoots lentil 70 days of growth and harvest and seed yields were increased with increasing rates of applied P_2O_5 ha^{-1} (0-35.2 kg ha^{-1}).

In the field trial, Singh *et al.* (1983)reported that seed yield per plant was increased by all fertilizer treatments. The optimum treatment was 75 kg P_2O_5 ha^{-1} applied 50% to the soil at sowing and 50% as a foliar fertilizer giving seed yield of 1.9 and 1.7 t ha^{-1}respectively.

Guvisova (1981) conducted a field trial with lentil on a lime meadow soil using fertilizer @ 60 to 90 kg P_2O_5 ha^{-1} and 120 to 180 kg P_2O_5 ha^{-1} and reported that

fertilizer application did not improve seed production or yield and sometimes reduced seed yield

2.2.8 Straw yield

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

From two years field trial Zeidan (2007) reported that increasingP levels from 0 to 60 kg P_2O_5 ha^{-1} increased straw yield of lentil.

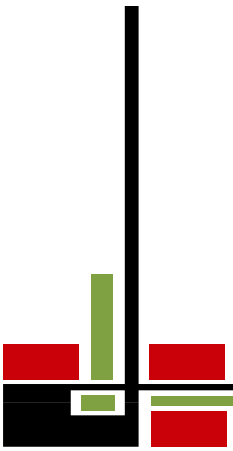
2.2.9 Harvest index (%)

According to Zafar*etal*. (2003) maximal does of phosphorus 75 kgP_2O_5 ha^{-1} has proved a significant dose forgetting highestharvest index (43.69%) of lentil.

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

Sexena 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.

From the above reviews of the effect of variety and phosphorus levels on lentil by different researchers from different locations in home and abroad it is revealed that still some observations are needed to research to find out the effect of variety and phosphorus fertilization on lentil.



Chapter 3

Materials and Methods

MATERIALS AND METHODS

The experiment was undertaken during rabiseason (November 2013 to March2014) to determine effect of phosphorus fertilizer on yield and yield attributes of lentil cultivars.

3.1 Experimental site

The experiment was conducted at the Research field of Agronomy Department of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the rabiseason (November 2013 to March2014). The location of the experimental site is $23^0$77′N latitude and $90^0$35′E longitude and at an elevation of 8.2 m from sea level (Appendix I).

3.2 Climate

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

3.3 Characteristics of soil

The soil of the experimental area belongs to the ModhupurTract under AEZ 28. It had shallow red brown terrace soil. The soil of experimental filed were analyzed in the soil testing laboratory, SRDI, Khamarbari, Dhaka and details of the recorded soil characteristic were presented in Appendix III.

3.4 Plant materials

3.4.1 Seed

Four high yielding variety of lentil viz., BARIMasur 4, BARI Masur 5, BARI Masur 6, and BARI Masur 7 developed by Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur were used in the experiment as test plant materials. These variety bear good phenotypic characters such as deep green leaf, no tendril in front of leaf, bushy type plant, 35-40 cm height, white color flower, seed size is large than local seed, deep brown color, duration of 105-110 days and seed yield of 2200-2300 kg ha^{-1}.

3.4.2 Fertilizer

In this experiment phosphorus was applied as pertreatment and nitrogen (80 kg ha^{-1}), potassium (37 kg ha^{-1}), sulphur (14 kg ha^{-1}) were used as recommended doses (BARC, 1989).

3.5 Methods

3.5.1 Experimentaltreatments

Variety and phosphorus were used as treatment. Four lentil varieties and four levels of phosphorus were used for the combination of sixteen (16) treatments of the present experiment.

The experiment consisted of two treatment factors as mentioned below:

Factor A: Fourvarieties of lentil

1) V_1= BARI Masur 4
2) V_2= BARI Masur 5
3) V_3=BARI Masur 6
4) V_4= BARI Masur 7

Factor B: Four levels of Phosphorus

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

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

1.V_1 P_0-BARI Masur 4 with0 kg P_2O_5 ha^{-1}

2. V_2P_0-BARI Masur 5 with 0 kg P_2O_5 ha^{-1}

3. V_3P_0- BARI Masur 6 with0 kg P_2O_5 ha^{-1}

4. V_4P_0-BARI Masur 7 with 0 kg P_2O_5 ha^{-1}

5.V_1P_1-BARI Masur 4 with 20 kg P_2O_5 ha^{-1}

6.V_2P_1-BARI Masur 5 with 20 kg P_2O_5 ha^{-1}

7.V_3P_1-BARI Masur 6 with 20 kg P_2O_5 ha^{-1}

8.V_4P_1-BARI Masur 7 with 20kg P_2O_5 ha^{-1}

9.V_1P_2-BARI Masur 4 with 40 kg P_2O_5 ha^{-1}

10.V_2P_2-BARI Masur 5 with 40 kg P_2O_5 ha^{-1}

11.V_3P_2-BARI Masur 6 with40 kg P_2O_5 ha^{-1}

12.V_4P_2-BARI Masur 7 with 40 kg P_2O_5 ha^{-1}

13.V_1P_3-BARI Masur 4 with 60 kg P_2O_5 ha^{-1}

14.V_2P_3-BARI Masur 5 with 60 kg P_2O_5 ha^{-1}

15.V_3P_3-BARI Masur 6 with 60 kg P_2O_5 ha^{-1}

16.V_4P_3-BARI Masur 7 with60 kg P_2O_5 ha^{-1}

3.5.2 Land preparation

The experimental plot was irrigated to remove its hard dryness before ploughing. Then it was first opened with tractor drawn disc plough after having ‘zoe’ condition. Plough soil was then brought into desirable tilth by 4 operations of ploughing, harrowing and laddering. The stubble and weeds were removed. The first ploughing and the final land preparation were done on 20 October and 30 October 2013, respectively. Experimental land was divided into plots following the design of experiment. The plot was spaded one day before planting and basal dose of fertilizers were incorporated thoroughly.

3.5.3 Fertilizer application

The rates of fertilization as mentioned in section 3.4.2 were applied in the field at the time of final land preparation. Rate of fertilizers except phosphorus P were used as mentioned in section 3.4.2. Whole amount of urea and whole amount of other fertilizers except P were applied as basal dose (during final

land preparation). Rate of P in the form of Triple Super Phosphate (TSP) was used as per treatment mentioned in section 3.5.1 and applied as basal dose.

3.5.4Design andlayout

The experiment was layout in a Split-plot design with three replications. - Different varieties of lentil were in main plot and different levels of phosphorusin sub plot. The total plot number was 16×3=48.The unit plot size was 3m×2m=6m^2.The replication were separated from one another by 1m.The distance between plot was 0.5m.

3.5.5 Sowing of seed

Sowing was done on 18th November, 2013 in rows 30 cm apart. Seeds were sown continuously in rows. The seeds were sown 35kg ha^{-1}.Seeds were treated with Bavistin before sowing to control the seed borne disease. Aftersowing the seeds were covered with soil, slightly pressed by hand.

3.5.6 Thinning

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

3.5.7 Weeding

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

3.5.8 Irrigation

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

3.5.9 Crop protection

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

3.6 Crop sampling and data collection

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

3.7 Harvesting and threshing

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

3.8 Drying and weighing

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

3.9 Data collection

Ten plants in each plot were selected and tagged. All the growth data (except dry weight) were recorded from those ten selected plants.

The following data were collected

A. Crop growth characters

1. Plant height (cm) at 15, 30, 45, 60, 75, and 90 DAS
2. Branches plant^{-1} at 15, 30, 45, 60, 75, and 90 DAS
3. Numbers of nodule plant^{-1} at 15, 30, 45, 60, 75, and 90 DAS
4. Fresh weight (g plant^{-1}) at 15, 30, 45, 60, 75, and 90 DAS
5. Dry weight (g plant^{-1}) at 15, 30, 45, 60, 75, and 90 DAS

B. Yield contributing characters

1. Effective branch plant^{-1}
2. Filled pods plant^{-1}
3. Number of seeds pod^{-1}
4. 1000-grain weight(g)

C. Yield and harvest index

1. Seed yield (t ha^{-1})
2. Straw yield (t ha^{-1})
3. Biological yield (t ha^{-1})
4. Harvest index (%)

3. 10 Methods of recording data

3.10.1 Plant height (cm)

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

3.10.2 Branches plant^{-1}

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

3.10.3 Numbers of nodule plant^{-1}

Total nodules number was taken at 15, 30, 45, 60, 75 and 90 DAS. Ten plants were collected randomly from the inner rows of each plot and counted nodule number then averaged them to have number of nodules plant^{-1}.

3.10.4 Fresh weight of plant^{-1}(g)

The fresh weight of lentil plants was recorded at 15, 30, 45, 60, 75 and 90 DAS. Ten plants were collected randomly from the inner rows of each plot. The fresh weight of the samples was taken using a sensitive digital electric balance. The mean weight was calculated and the weight was expressed in g plant^{-1}.

3.10.5Dry weight plant^{-1} (g)

Randomly selected plants from each plot excluding the harvest area and sampled plants were uprooted and oven dried separately for 72 hours in an electric oven set at 60^0C. The dry weight of the samples was taken using a sensitive digital electric balance. The mean weight was calculated and the weight was expressed in g plant^{-1}.

3.10.6 Effective branch plant^{-1}

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

3.10.7Pods plant^{-1}

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

3.10.8 Weight of 1000-grain

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

3.10.9Seed yield (t ha^{-1})

After threshing, cleaning and drying, total grain from harvested area ($3m^2$) were recorded and was converted to kg ha^{-1}.

3.10.10Straw yield (t ha^{-1})

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

3.10.11Biological yield (t ha^{-1})

The summation of grain yield and above ground straw yield was the biological yield.

Biological yield=Grain yield+Straw yield.

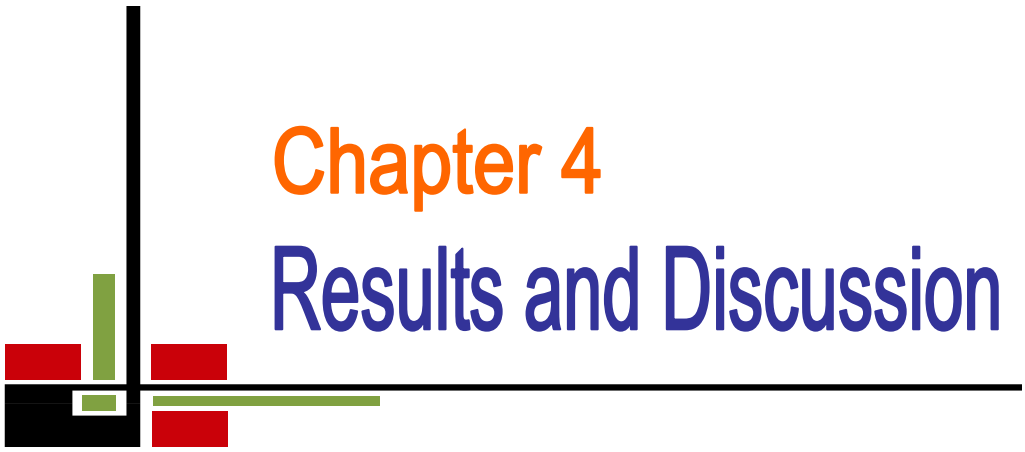
3.10.12Harvest index (%)

Harvest index was calculated by dividing the economic (grain) yield from the net plot by the total biological yield (grain+Straw) from the same area and multiplying by 100.

Harvest index (%) =grainyield (kg ha^{-1})/Biological yieldx100

3.10.13 Statistical analysis

The data obtained for different parameters were statistically analyzed to find out the significant results of phosphorus application on growth, yield and yield contributing characters of lentil. The mean values of all the characters were calculated and analysis of variance was performed by the 'F' (varianceratio) test. The significance of the difference among the treatment combinations means was estimated by the Duncan's Multiple Range Test (DMRT) at5% level of probability (Gomez and Gomez, 1984)



Chapter 4
Results and Discussion

RESULTS AND DISCUSSION

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

4.1 Crop growth parameters

4.1 .1 Plant height

4.1.1.1 Effect of variety

Plant height was significantly influenced by different varieties at different days after sowing (Fig 1). Plant height increased with increasing the age of the plant up to90 days after sowing.At 15, 30 ,45, 60, 75 and 90 days after sowing the highest plant height (11.81, 13.68, 20.52, 27.97, and 31.11 cm, respectively)was found from BARI Masur 7 and the lowest (10.52, 12.54, 27.94 and 29.02 cm) was found from BARI Masur 6.Variations in plant height due to varieties were also reported by Hasan*et al*.(2015) and Datta*et al*. (2013).

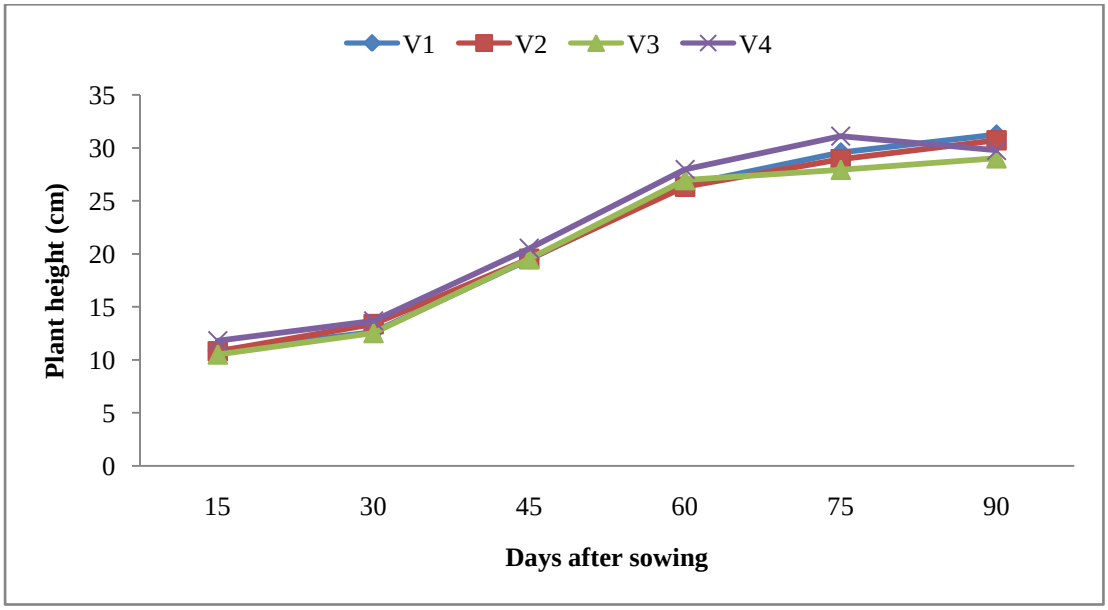


Fig.1 Plant height of lentil as influenced by varieties at different sowing days (SE=0.3066,0.5878,0.6974,1.228, 0.8719 and 0.8789 at15,30,45,60,75 and 90 DAS respectively)V_1= BARI Masur 4, V_2= BARI Masur 5, V_3= BARI Masur 6, V_4= BARI Masur 7

4.1.1.2 Effect of phosphorus

Plant height was significantly influenced by different levels of phosphorus at different days after sowing (Fig 2).At 15 days after sowing the highest plant height(11.38 cm) was found with application of 40 kg P_2O_5 ha-^{1} while the lowest (10.60 cm) was found with application of 20 kg P_2O_5 ha^{-1}. At 30, 45, 60,75, 90 days after sowing the highest plantheight (13.17, 20.51, 28.00, 30.80 and 31.44 cm) was found with application of 60 kg P_2O_5 ha^{-1}whereas the lowestplant height (12.63, 18.63, 24.42, 27.75 and 28.14cm) was found with control treatment. These result agreed with Saraf and Shivakumar (1997) who observed that the plant height of lentil increased significantly up to 60 kg P_2O_5 ha^{-1}.

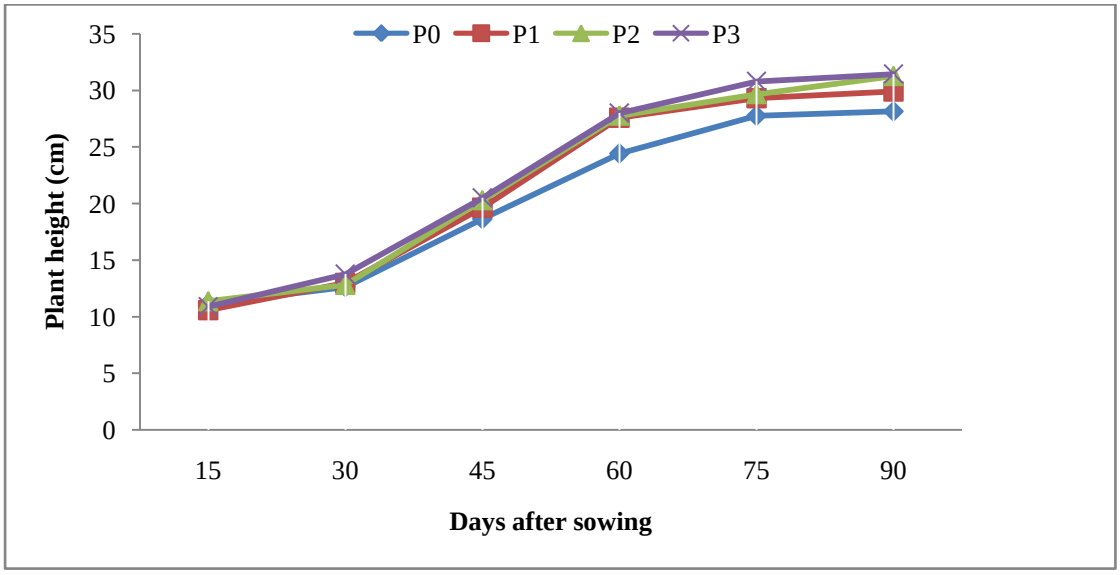


Fig.2 Plant height of lentil at different growing stages as influenced by phosphorus fertilizer (SE=0.3066, 0.5878, 0.6974, 1.228, 0.8719 and 0.8789 at 15, 30, 45, 60, 75 and 90DAS respectively)P_0= 0 kg P_2O_5 ha^{-1}, P_1= 20 kg P_2O_5 ha^{-1}, P_2=40 kg P_2O_5 ha^{-1}, P_3=60 kg P_2O_5 ha^{-1}

4.1.1.3 Interactioneffect of variety and phosphorus

Plant height was significantly influenced by different variety and different levels of phosphorus at 15 and 60 days after sowing (DAS) but showed non-significant effect at 30, 45, 75 and 90 days after sowing (Table 1). At 15 days after sowing the highest plant height (12.60 cm) was observed from V_4P_0(BARI Masur 7 with control treatment of phosphorus) treatment which was statistically similar with many other treatments. The lowestplant height (10.13 cm) was observed from V_3P_1(BARI Masur 6 with 20 kg P_2O_5 ha^{-1}) treatment which was also statistically similar with rest of the treatments except V_4P_0.At 60 days after sowing the highest plant height (31.67 cm) was observed from V_1P_3(BARI Masur 4 with 60 kg P_2O_5 ha^{-1}) andthe lowestplant height (19.47 cm) was observed from V_1P_0 (BARI Masur 4 with control treatment of phosphorus). At 30days numerically the highestplantheight (14.93cm) was found from V_2P_3 (BARI Masur 5 with 60 kg P_2O_5)and the lowest (12.30 cm) was found from V_1P_2(BARIMasur 4 with 20 kg P_2O_5 $ha^{-1)}$.At 45 and 75 days after sowing the highest plantheight (21.23 and 32.87cm, respectively) was found from V_4P_3(BARI Masur 7 with 60 kg P_2O_5 ha^{-1})and the lowest plant height (17.53and 26.87cm, respectively)was found from V_2P_0(BARI Masur 5 with 0 kg P_2O_5 ha^{-1}).At 90 days after sowingnumerically the highest plant height(32.07cm) was found from both V_1P_2(BARI Masur 4 with 40 kg P_2O_5 ha^{-1}) and V_1P_3(BARI Masur 4 with 60 kg P_2O_5 ha^{-1})and the lowestplant height (26.53cm) was found from V_4P_0 (BARI Masur 7 with 0 kg P_2O_5 ha^{-1}).

Table 1. Interaction effect of variety and phosphorus on plant height(cm) of Lentil at different days after sowing

Treatment combination	Plant height at different days after sowing (DAS)					
	15	30	45	60	75	90
V_1P_0	10.57 a-c	12.52	17.70	19.47 b	27.67	29.10
V_1P_1	10.57 a-c	12.57	19.83	27.87 ab	29.40	31.77
V_1P_2	11.55 a-c	12.30	20.43	27.07 ab	30.20	32.07
V_1P_3	10.83 a-c	13.17	20.00	31.67 a	30.97	32.07
V_2P_0	10.77 a-c	12.47	17.53	25.17 ab	26.87	29.97
V_2P_1	10.20 bc	12.53	19.27	27.63 ab	29.07	30.17
V_2P_2	10.89 a-c	13.50	20.17	26.73 ab	29.07	31.17
V_2P_3	11.33 a-c	14.93	21.13	25.77 ab	30.73	31.53
V_3P_0	10.53 a-c	12.67	19.43	25.97 ab	27.30	26.97
V_3P_1	10.13 c	12.37	19.40	27.43 ab	27.40	28.17
V_3P_2	10.77 a-c	12.67	19.63	27.30 ab	28.43	30.43
V_3P_3	10.63 a-c	12.47	19.67	27.17 ab	28.63	30.53
V_4P_0	12.60 a	12.87	19.83	27.10 ab	29.17	26.53
V_4P_1	11.50 a-c	14.50	20.07	27.40 ab	31.43	29.50
V_4P_2	12.30 ab	12.83	20.97	29.97 a	30.97	31.40
V_4P_3	10.83 a-c	14.50	21.23	27.40 ab	32.87	31.63
SE	**0.6132**	**1.176**	**1.395**	**2.455**	**1.744**	**1.758**
CV%	**9.65**	**15.60**	**12.22**	**15.78**	**10.28**	**10.09**

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by DMRT at 0.05 level of probability

V_1= BARI Masur 4, V_2= BARI Masur 5, V_3= BARI Masur 6, V_4= 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}, P_3=60 kg P_2O_5 ha^{-1}

4.1.2 Branches $plant^{-1}$

4.1.2.1 Effect of variety

Varieties play non significant effect on branch production of lentil (Fig. 3). At 15, 30, and 45 days after sowingthe highest number of branches (4.27, 4.66, and 9.17 respectively) was found from BARI Masur 6 and the lowest number of branches (3.88, 4.08, and 7.83) was found from BARI Masur 5. At 60 days

after sowing the highest number of branches (9.33) was found from BARI Masur 6 and the lowest number of branches (8.50) was found from BARI Masur 5. At 75 and 90 days the highest number of branches(9.750 and 8.917) was found from BARI Masur 7 and the lowest number of branches (8.00) was found from BARIMasur 5.Rahman*et al.* (2013) reported that basically branching is a genetic character but is also influenced byenvironmental factors. Awal and Roy (2015) also confirmed that numbers of branch production vary due to different varieties.

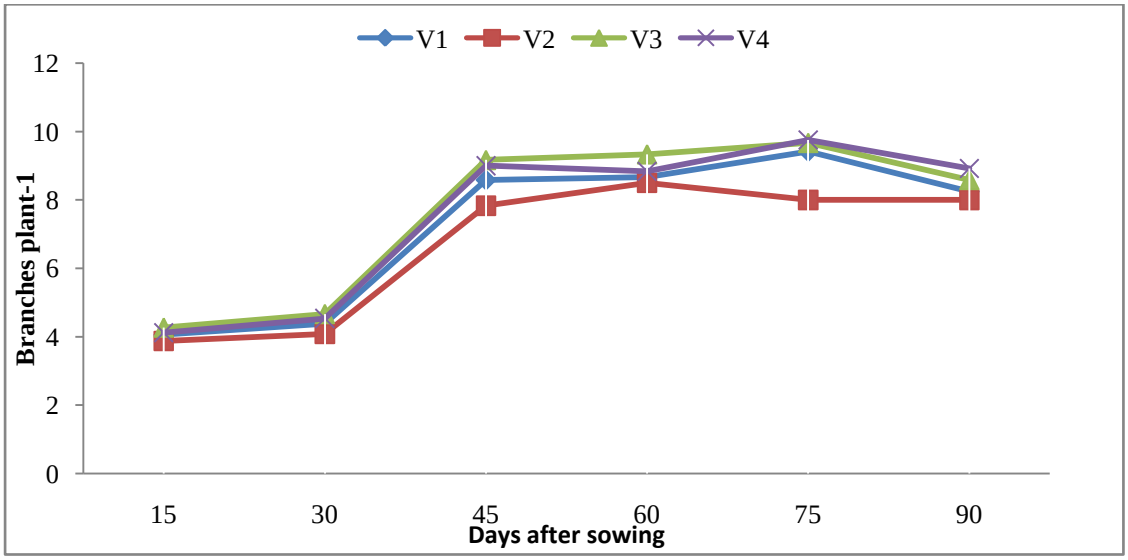


Fig. 3 Number of branches plant^{-1} of lentil as influenced by varieties at different growth stages (SE=0.2811,0.2478,0.5873,0.6597,0.8413,0.6250at 15,30,45, 60,75 and 90DAS respectively) V_1= BARI Masur 4, V_2= BARI Masur 5, V_3= BARI Masur 6, V_4= BARI Masur 7

4.1.2.2Effect of phosphorus

Different doses of phosphorus play non significant effect on branch production of lentil at 15,30 and 75 days after sowing (Fig. 4). At 45, 60, 90 days after sowing different levels of phosphorus play significant effect on branch production of lentil.At 15 days after sowing the highest number of branches plant^{-1}(4.32) was found at the rate of 20 kg P_2O_5 ha^{-1} and the lowest number of branches plant^{-1}(3.96) was found with control treatment. At 30, 45, 60, 75, and 90 days after sowing the highest number of branches plant^{-1}(4.65, 9.5, 10.17,

10.50 and 10.00respectively) was found at the rate of 60 kg P_2O_5 ha^{-1} and the lowest number of branches $plant^{-1}$(3.89, 7.58, 7.67, 7.92and 7.25respectively) was recorded from control treatment. These result agreed with those of Saxenaand Varma(1996) and Saraf and Shivakumar (1997) who observed that the number of branches $palnt^{-1}$of lentil increased significantly up to 30 kg P_2O_5 ha^{-1}.

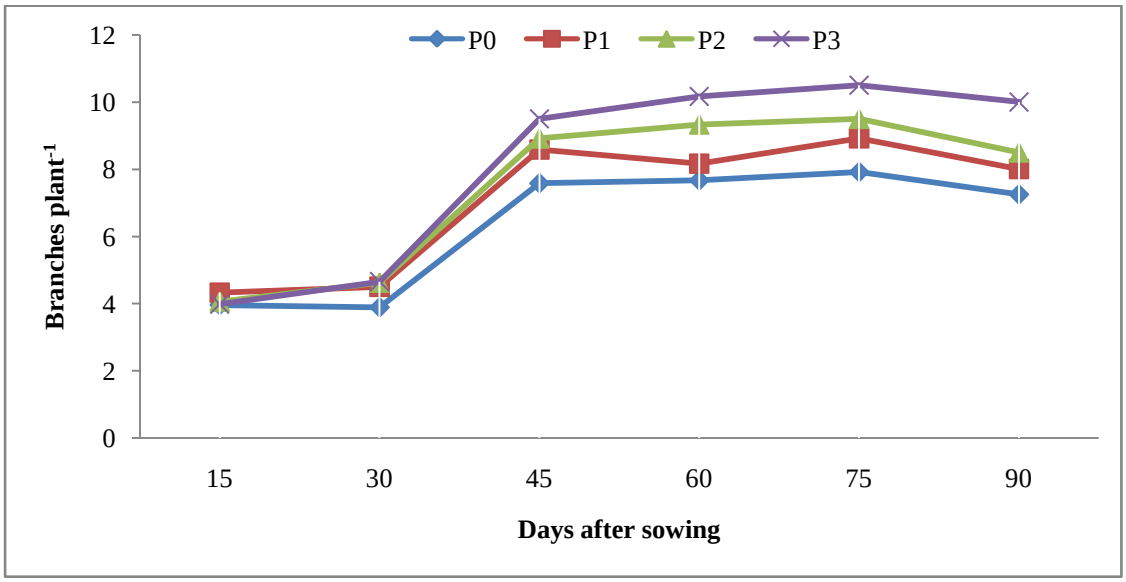


Fig.4 Branches $plant^{-1}$of lentil as influenced by phosphorus at different growth stages (SE=0.2811,0.2478,0.5873,0.6597,0.8413,0.6250 at 15,30,45,60,75,90DAS and at harvest respectively)P_0= 0 kg P_2O_5 ha^{-1}, P_1= 20 kg P_2O_5 ha^{-1}, P_2=40 kg P_2O_5 ha^{-1}, P_3=60 kg P_2O_5 ha^{-1}.

4.1.2.3Interactioneffect of verity and phosphorus

Combination of variety and phosphorus hadnosignificant effect on number of branch production of lentil at different days after sowing (Table 2). At 15 days the highest number of branches $plant^{-1}$(4.58)was found from V_4P_1(BARIMasur 7 with 20 kg P_2O_5 ha^{-1}) and the lowest number of branches (3.59)was found from V_1P_0(BARIMasur 4 with 0 kg P_2O_5 ha^{-1}). At 30 days numerically the highestnumber of branches (5.13) was found from V_4P_2 (BARI Masur 7 with 40 kg P_2O_5 $ha^{-1)}$ and the lowestnumber of branches (3.70) was found from V_2P_0

(BARI Masur 5 with control treatment of phosphorus). At 45, 60and 75 days numerically the highestnumber of branches(10.67, 11.00, and 11.67, respectively) was found from V_3P_3(BARI Masur 6 with 60 kg P_2O_5 ha^{-1}). At 45 and 75 day after sowing the lowest number of branches (7.00 and 6.67)was found from V_2P_0(BARIMasur 5 with 0 kg P_2O_5 ha^{-1}) and 60 days after sowing the lowest number of branches (7.00) was found from V_1P_0(BARIMasur 4 with control treatment of phosphorus).

Table2.Interaction effect of variety and phosphorus on branch production of lentil at different days after sowing

Treatment combination	Number of branches plant^{-1} atdifferent days after sowing					
	15	**30**	**45**	**60**	**75**	**90**
V_1P_0	3.59	3.82	7.67	7.00	8.00	7.00
V_1P_1	4.24	4.66	8.67	7.67	9.33	7.33
V_1P_2	4.40	4.53	9.00	9.67	9.67	8.00
V_1P_3	4.01	4.51	9.00	10.33	10.67	10.67
V_2P_0	3.82	3.70	7.00	7.33	6.67	7.33
V_2P_1	3.92	4.22	7.67	7.67	7.67	8.00
V_2P_2	3.88	4.00	8.00	9.00	8.67	8.00
V_2P_3	3.89	4.41	8.67	10.00	9.00	8.67
V_3P_0	4.48	4.04	8.33	8.33	8.67	7.00
V_3P_1	4.55	5.11	8.67	8.67	9.00	8.00
V_3P_2	4.28	4.83	9.00	9.33	9.33	9.00
V_3P_3	3.75	4.67	10.67	11.00	11.67	10.33
V_4P_0	3.95	4.00	7.33	8.00	8.33	7.67
V_4P_1	4.58	4.00	9.33	8.67	9.67	8.67
V_4P_2	3.68	5.13	9.67	9.33	10.33	9.00
V_4P_3	4.28	5.01	9.67	9.33	10.67	10.33
SE	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
CV%	**23.86**	**19.44**	**23.53**	**25.87**	**31.65**	**25.66**

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by DMRT at 0.05 level of probabilityV_1= BARI Masur 4, V_2= BARI Masur 5, V_3= BARI Masur 6, V_4= 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}, P_3=60 kg P_2O_5 ha^{-1}NS= Non significant.

At 90 days after sowingthe highest number of branches plant^{-1}(10.63) was found from V_1P_3 (BARI Masur 4 with 60 kg P_2O_5 ha^{-1}) and the lowest (7.00) was found from V_1P_0 (BARI Masur 4 with 0 kg P_2O_5 ha^{-1}).

4.1.3 Nodule production plant^{-1}

4.1.3.1 Effect of variety

Variety hadnonsignificant effect on nodule production of lentil at 15, 30, 45 days after sowingbut had significant effect at 60, 75 and 90 DAS (Fig. 5).Nodule number increased with age reaching a peak at around 60 DASand thereafter declined irrespective of varieties. AT 15, 30and 45 days after sowingthehighest number of nodule (1.67, 1.83, and 2.50, respectively) was found from BARI Masur 7 andthe lowestnumber of nodule(1.25 and 1.58) was found from BARI Masur 5 at 15 and 30 DAS and (2.417) from BARI Masur 4 at 45DAS. At 60 days after sowingthe highest number of nodule (11.08) was found fromBARI Masur 6 and the lowest number of nodule (5.42) was found for BARI Masur 5. At 75 and 90 days after sowing the highest number of nodule (7.33 and 5.83)was found from BARI Masur 7 and the lowest number of nodule (5.50 and 4.33) was found from BARI Masur 5. These results are conformity with Datta*et al.* (2013) and Haque*et al.* (2013) who reported that nodule production varied due to variety.

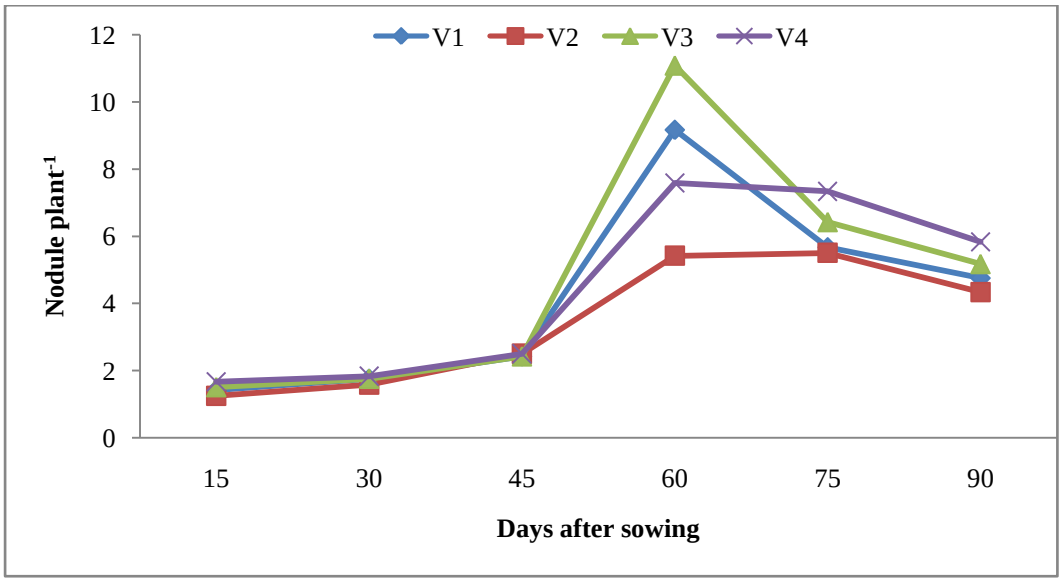


Fig.5 Number of nodules plant^{-1}of lentil as influenced by varieties at different growth stages (SE= 0.1522, 0.1180, 0.1615, 0.5210, 0.4615, 0.4173 at 15, 30, 45, 60, 75 and 90 DAS respectively)V_1= BARI Masur 4, V_2= BARI Masur 5, V_3= BARI Masur 6, V_4= BARI Masur 7.

4.1.3.2 Effect of phosphorus

Phosphorus fertilizer had significant effect on nodule production of lentil (Fig. 6). Nodule number gradually increased with increase of phosphorus levels up to 60 DAS and the yield was similar in rest of phosphorus levels. High rates of phosphorus application enhanced rhizobialactivity, raised nodule number in lentil. At 15 and 30 days after sowing the highest number of nodule (1.92 and 2.17) was found at the rate of 40 kg P_2O_5 ha^{-1} and the lowest number of nodule(0.75 and 1.33) was found with control treatment. At 45, 60, 75, and 90 days after sowing the highest number of nodule(3.00, 11.00, 8.00 and 7.17 respectively) was found at the rate of 60 kg P_2O_5 ha^{-1} and the lowest number of nodule (2.00, 5.25, 4.50 and 2.67respectively) was found with control treatment might be due to plants suffered from P stress which caused poor nodule growth. Datta*et al.* (2013) observed that numbers of nodule production in lentil increase with the increasing the phosphorus level.

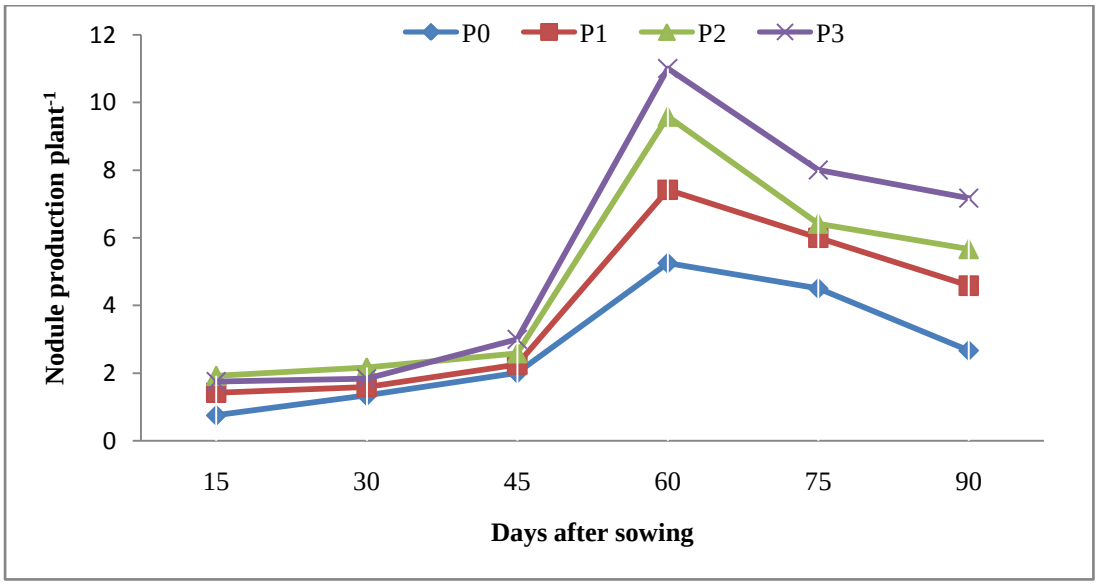


Fig.6 Nodule number of lentil as influenced by phosphorus at different growth stages (SE= 0.1522, 0.1180, 0.1615, 0.5210, 0.4615, 0.4173 at 15,30,45,60,75,90 DAS and harvest respectively)P_0= 0 kg P_2O_5 ha^{-1}, P_1= 20 kg P_2O_5 ha^{-1}, P_2=40 kg P_2O_5 ha^{-1}, P_3=60 kg P_2O_5 ha^{-1}

4.1.3.3 Interactioneffect of variety and phosphorus

Nodule production plant^{-1} was significantly influenced by varieties and different levels of phosphorus at 15, 30, 45, 60,75and 90 days after sowing (Table 3). At 15 days after sowing the highest number of nodule (2.33) was found from V_1P_2(BARI Masur 4 with 40 kg P_2O_5 ha^{-1}) which was statistically identical with most of the treatments except V_1P_0 and V_3P_0. At 15 days the lowest number of nodule (0.333) was found from V_1P_0(BARI Masur4 with 0 kg P_2O_5 ha-1) and it was statistically similar with V_1P_1, V_2P_0, V_2P_1, V_3P_0, V_3P_1, V_4P_0treatments. At 30 days, the highestnumber of nodule(2.67) was found fromV_1P_2(BARI Masur 4 with40 kg P_2O_5 ha^{-1}) while the lowest number of nodule (1.00) was found fromV_1P_0(BARIMasur 4 with 0 kg P2O5 ha-1) and V_2P_1 (BARI Masur 5 with20 kg P_2O_5 ha^{-1}). At 45 days after sowing the highest number of nodule(3.33) was found from V_3P_3(BARI Masur 6 with60 kg P_2O_5 ha^{-1}) and V_4P_3(BARI Masur 7 with60 kg P_2O_5 ha^{-1})and the lowestnumber of nodule (1.67) was found from V_3P_1(BARI Masur 6 with20 kg P_2O_5 ha^{-1}) and V_4P_0(BARI Masur 7 with0 kg P_2O_5 ha-1). At 60 days after sowing the highestnumber of nodule (13.33) was found from V_3P_3 (BARI Masur 6 with60 kg P_2O_5 ha^{-1})and the lowestnumber of nodule (2.67) was found from V_2P_0 (BARI Masur 5 with0 kg P_2O_5 ha-^{1} which was statistically similar with V_2P_1 andV_4P_0. At 75 days after sowing the highest number of nodule (8.67) was found from V_4P_3 (BARI Masur 7 with60 kg P_2O_5 ha^{-1})and the lowest number ofnodule(3.33) was found from V_2P_0 (BARI Masur 5 with0 kg P_2O_5 ha-^{1}). At 90daysthe highest number of nodule(8.67) wasfound fromV_4P_3 (BARI Masur 7 with60 kg P_2O_5 ha^{-1}and it was statistically similar with V_1P_3, V_3P_2,and V_4P_2 while the lowest number of nodule (2.33) was found from V_4P_0(BARI Masur 7 with60 kg P_2O_5 ha^{-1})and V_3P_0(BARI Masur 6 with0 kg P_2O_5 ha^{-1}) which was statistically similar with V_1P_0, V_1P_1, V_1P_2, V_2P_0, V_2P_1, V_2P_2, V_3P_1.

Table 3.Interaction effect of variety and phosphorus on nodule production of lentil at different days after sowing

Treatment combination	Number of nodule plant^{-1} atdifferent days after sowing					
	15	**30**	**45**	**60**	**75**	**90**
V_1P_0	0.33 d	1.00 c	2.00 b	6.00 cd	4.33 de	2.67 fg
V_1P_1	1.33 a-d	1.67 bc	2.33 ab	8.33 bc	5.33 b-e	4.33 c-g
V_1P_2	2.33 a	2.67 a	2.67 ab	10.67 ab	5.33 b-e	5.00 b-g
V_1P_3	1.67 a-c	1.67 bc	2.67 ab	11.67 ab	7.67 a-c	7.00 a-c
V_2P_0	0.67 cd	1.33 bc	2.00 b	2.67 e	3.33 e	3.33 e-g
V_2P_1	1.00 b-d	1.00 c	2.67 ab	3.67 de	5.00 c-e	4.00 d-g
V_2P_2	1.67 a-c	2.00 ab	2.67 ab	6.33 cd	6.33 a-e	4.67 c-g
V_2P_3	1.67 a-c	2.00 ab	2.67 ab	9.00 bc	7.33 a-d	5.33 b-f
V_3P_0	0.67 cd	1.33 bc	2.33 ab	8.33 bc	5.33 b-e	2.33 g
V_3P_1	1.33 a-d	1.67 bc	1.67 b	11.33 ab	6.00 a-e	4.33 c-g
V_3P_2	2.00 ab	2.00 ab	2.33 ab	11.33 ab	6.00 a-e	6.33 a-d
V_3P_3	2.00 ab	2.00 ab	3.33 a	13.33 a	8.33 ab	7.67 ab
V_4P_0	1.33 a-d	1.67 bc	1.67 b	4.00 de	5.00 c-e	2.33 g
V_4P_1	2.00 ab	2.00 ab	2.33 ab	6.33 cd	7.67 a-c	5.67 b-e
V_4P_2	1.67 a-c	2.00 ab	2.67 ab	10.00 ab	8.00 a-c	6.67 a-d
V_4P_3	1.67 a-c	1.67 bc	3.33 a	10.00 ab	8.67 a	8.67 a
SE	**0.3044**	**0.2359**	**0.3230**	**1.042**	**0.9230**	**0.8347**
CV%	**36.14**	**23.61**	**22.74**	**21.71**	**25.66**	**28.80**

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by DMRT at 0.05 level of probability

V_1= BARI Masur 4, V_2= BARI Masur 5, V_3= BARI Masur 6, V_4= 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}, P_3=60 kg P_2O_5 ha^{-1}

4.1.4 Total fresh weight plant^{-1}

4.1.4.1 Effect of variety

Significant variations due to varieties were found in respect of fresh weight of lentil plant at different days after sowing (Fig. 7). At 15 days after sowing the highest amount of fresh nodule weight (0.43 g) was found from BARI Masur 6 and the lowest (0.33 g) from BARI Masur 5. At 30 DAS the highest amount of fresh weight (0.62 g) was found from BARI Masur 7 and the lowest amount of fresh weight (0.89 g) was found from BARI Masur 4. At 45, 60, 75 days after sowing, the highest (3.45, 6.52and 12.09g respectively) amount of fresh weight was found from BARI Masur 6 and the lowest amount of fresh weight (2.53, 5.130, and 10.36g respectively) was found from BARI Masur 5. At 90 days after sowing the highest amount of fresh weight (14.54g) was found from BARI Masur 7 and the lowest (13.42 g) from BARI Masur 5.

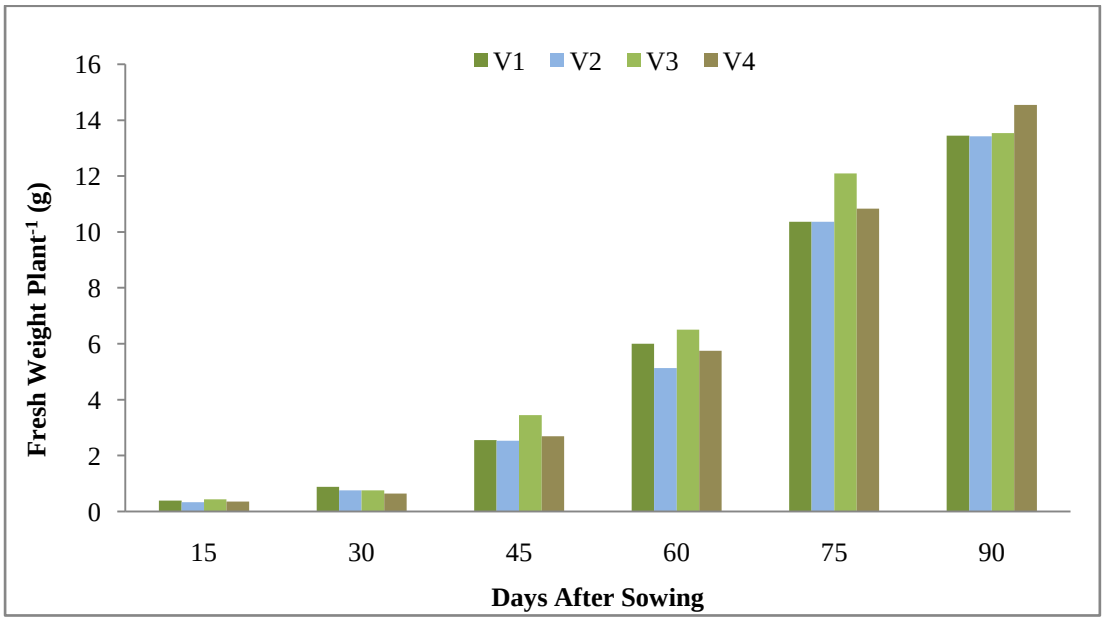


Fig.7 Fresh weight of lentil as influenced by varieties at different days after sowing. (SE= 0.01826, 0.03416, 0.1435, 0.2300, 0.499, 0.5251 at 15, 30, 45, 60, 75 and 90 DAS respectively)V_1= BARI Masur 4, V_2= BARI Masur 5, V_3= BARI Masur 6, V_4= BARI Masur 7

4.1.4.2 Effect of phosphorus

Phosphorus had significant effect on fresh weight of lentil at different days after sowing (Fig. 8). Fresh weight increased progressively with successive increase in phosphorus levels .At 15 days after sowing the highest amount of fresh weight (0.43g) wasfound at the rate of 40 kg P_2O_5 ha^{-1} and the lowest amount of fresh weight (0.35g) was found at the rate of 60 kg P_2O_5 ha^{-1}.At 30, 45, 60, 75 and 90 days after sowing the highest amount of fresh weight(0.88, 3.92, 8.17, 15.79and 17.07grespectively) was found at the rate of 60 kg P_2O_5 ha^{-1} and the lowest amount of fresh weight (0.57, 1.99, 4.39, 7.87 and 10.78g) was found with control treatment i.e. without p application .

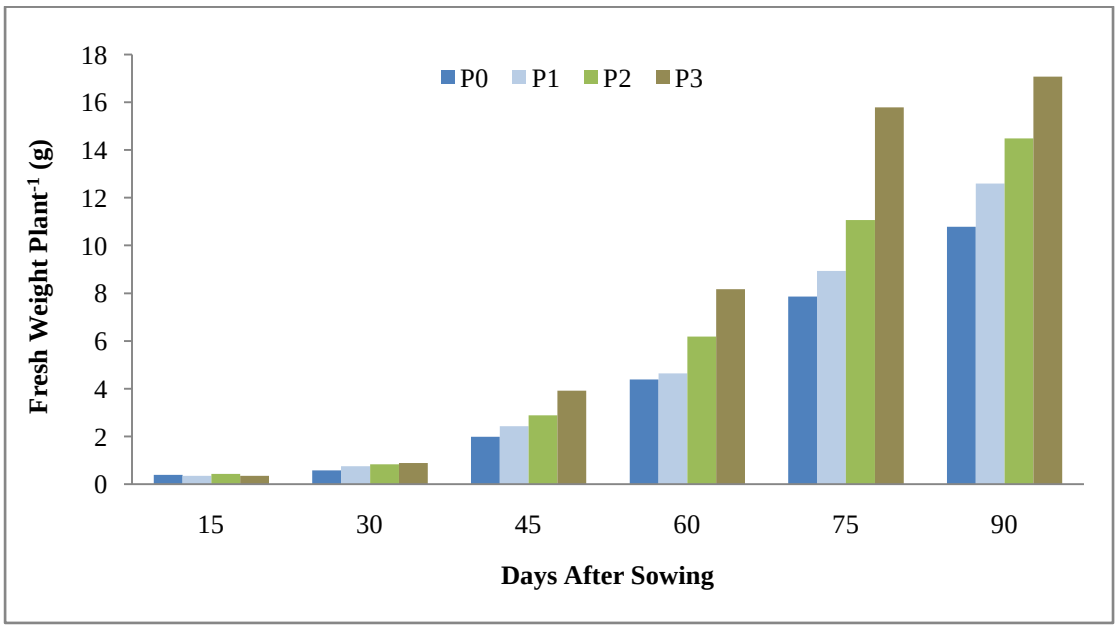


Fig.8 Fresh nodule weight of lentil as influenced by phosphorus at different days after sowing. (SE= 0.01826, 0.03416, 0.1435, 0.2300, 0.499, 0.5251 at 15, 30, 45,60,75,90 DAS respectively)P_0= 0 kg P_2O_5 ha^{-1}, P_1= 20 kg P_2O_5 ha^{-1}, P_2=40 kg P_2O_5 ha^{-1}, P_3=60 kg P_2O_5 ha^{-1}

4.1.4.3 Interaction effectof variety and phosphorus

Interaction of variety and phosphorus had significant effect on freshweight of lentil at different days after sowing (Table 4). At 15 days after sowing significantly the highest fresh weight (0.71g) was found from V_1P_2 (BARI Masur 4 with 40 kg P_2O_5 ha^{-1}) and the lowest (0.23 g) from V_2P_2 (BARI Masur 5 with 40 kg P_2O_5 ha^{-1}) treatment. At 30 days after sowing the highest amount of fresh weight (1.05 g) was found from V_1P_3 (BARI Masur 4 with 60 kg P_2O_5 ha^{-1}) and it was statistically identical with V_1P_2 treatment combination. The lowestamount of fresh weight (0.29 g) was found from V_4P_0 (BARI Masur 7with 0 kg P_2O_5 ha^{-1}). At 45 days significantly the highest amount of fresh weight (5.08 g) was found from V_3P_3 (BARI Masur 6with 60 kg P_2O_5 ha^{-1}) and the lowest amount of fresh weight (1.64 g) was found from V_4P_0 (BARI Masur 7 with 0 kg P_2O_5 ha^{-1}). At 60 days after sowing the highest amount of fresh weight (9.65 g) was found from V_3P_3 (BARI Masur 6 with 60 kg P_2O_5 ha^{-1}) and the lowest amount of fresh weight (3.43 g) was found from V_2P_0 (BARI Masur 5 with 0 kg P_2O_5 ha^{-1}). At 75 days after sowing the highest amount of fresh weight (18.81 g) was found from V_3P_3 (BARI Masur 6 with 60 kg P_2O_5 ha^{-1}) and the lowest amount of fresh weight (7.27 g) was found from V_1P_0 (BARI Masur 4 with 0 kg P_2O_5 ha^{-1}). At 90 days, the highest amount of fresh nodule weight (19.28 g) was found from V_4P_3 (BARI Masur 7 with 60 kg P_2O_5 ha^{-1}) and it was statistically identical with V_4P_4, V_2P_3 and V_3P_3. The lowest amount of fresh weight(10.10 g) was found from V_2P_0 (BARI Masur 5 with 0 kg P_2O_5 ha^{-1}).

Table 4. Interaction effect of Variety and phosphorus on fresh weight (g) of lentil at different days after sowing

Treatment combination	Fresh weight of lentil atdifferent days after sowing					
	15	30	45	60	75	90
V_1P_0	0.33 d-h	0.72 cd	1.87 f-h	4.85e-g	7.27 g	11.57 e-h
V_1P_1	0.26 f-h	0.77 cd	2.70 d-g	4.88 e-g	7.69fg	12.29 d-h
V_1P_2	0.71 a	1.00ab	2.79 c-f	6.36c-e	10.95 c-f	15.59 b-d
V_1P_3	0.26 gh	1.05 a	2.88 c-e	7.91b	15.59 b	14.34 b-f
V_2P_0	0.30e-h	0.64cd	1.77 gh	3.43 g	7.91 e-g	10.10 h
V_2P_1	0.44 b-d	0.72 cd	2.00 e-h	3.44g	7.96 e-g	12.68 d-h
V_2P_2	0.23 h	0.78b-d	2.63 d-g	5.83 ef	11.93 cd	13.47 d-h
V_2P_3	0.35 c-g	0.87 a-c	3.71 bc	7.81 bc	13.67 bc	17.42 ab
V_3P_0	0.45 bc	0.62d	2.69 d-g	4.91 e-g	7.85 e-g	10.61 gh
V_3P_1	0.38 b-f	0.78 b-d	2.77 d-f	5.28ef	11.10 ce	11.35 f-h
V_3P_2	0.42 b-e	0.82b-d	3.27 b-d	6.19de	10.60 c-g	14.95 b-e
V_3P_3	0.48 b	0.82b-d	5.08 a	9.65a	18.81 a	17.26 a-c
V_4P_0	0.45 bc	0.29 e	1.64 h	4.36fg	8.43 e-g	10.85 f-h
V_4P_1	0.33 c-h	0.73cd	2.27 e-h	4.95e-g	9.01d-g	14.10 b-g
V_4P2	0.35c-h	0.75 cd	2.85 c-e	6.37 de	10.80 c-f	13.93 c-g
V_4P_3	0.30e-h	0.80b-d	4.02 b	7.32b-d	15.09 b	19.28 a
SE	**0.03651**	**0.06831**	**0.2869**	**0.4601**	**0.9998**	**1.050**
CV%	**16.86**	**15.34**	**17.70**	**13.63**	**15.87**	**13.24**

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by DMRT at 0.05 level of probabilityV_1= BARI Masur 4, V_2= BARI Masur 5, V_3= BARI Masur 6, V_4= 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}, P_3=60 kg P_2O_5 ha^{-1}

4.1.5Total dry weight plant^{-1}

4.1.5.1 Effect of variety

Variety had significant effect on totaldry weight plant^{-1}at different days after sowing (Fig. 9). At 15 days after sowing thehighest amountof dry weight (0.147g)was found from BARI Masur 6and thelowest (0.10g) amountwas found from BARI Masur 4. At 30 after sowing the highest amount of dry weight (0.25g)was found from BARI Masur 4 and thelowest (0.23g) amount was found from BARI Masur 5. At 45, 60 and 75 daysafter sowing the highest

amount of dry weight (1.19, 2.03and 4.62g respectively)was found from BARI Masur 6 and thelowest (0.79, 1.60and 4.08g accordingly) amount was found from BARI Masur 5. At 90 days aftersowing the highest amount of dry weight (7.39g) was found from BARI Masur 7 and thelowest (6.20g) amount was found from BARI Masur 5.Variation of plant dry matter due to varieties was also reported byDatta*et al.* (2013), and Farghali and Hossain(1995) in lentil.

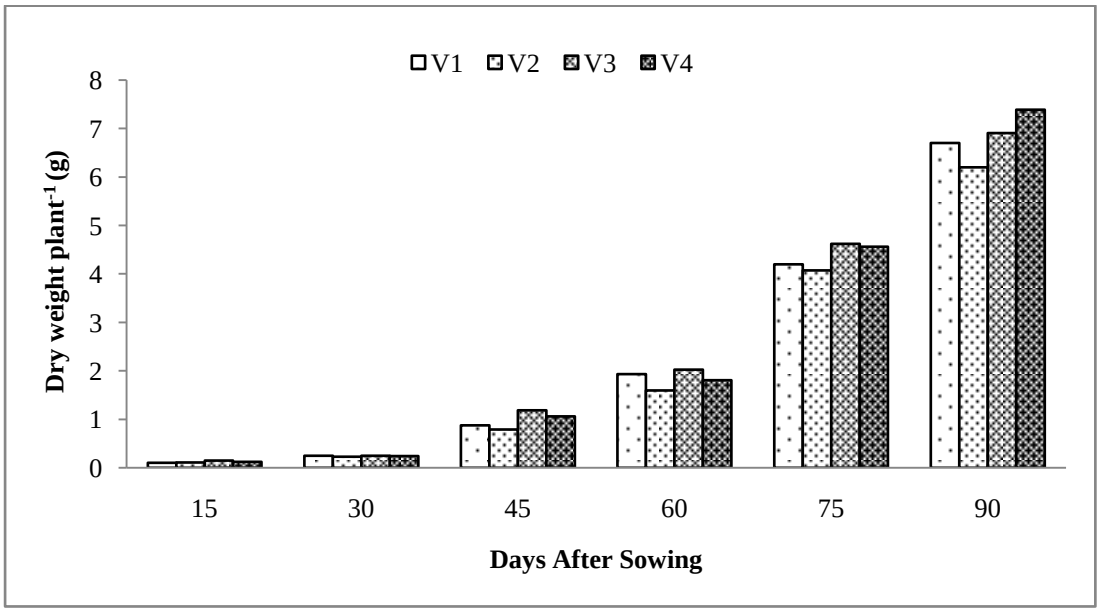


Fig.9 Dry weight plant^{-1} of lentil as influenced by varieties at different DAS (SE= 0.009129, 0.01291, 0.08010, 0.1242, 0.1514, 0.2739 at 15, 30, 45, 60,75 and 90 DAS respectively)V_1= BARI Masur 4, V_2= BARI Masur 5, V_3= BARI Masur 6, V_4= BARI Masur 7.

4.1.5.2 Effect of phosphorus

Phosphorus had significant effect on total dry weight plant^{-1} of lentil (Fig. 10). Total dry matter plant^{-1} increased progressively with successive increase in P levels irrespective of growth stage. At 15 days after sowing the highest amount of total dry weight (0.13g) was found at the rate of 20 kg P_2O_5 ha^{-1} and the lowest amount of total dry weight (0.12g)was found at the rate of 40 kg P_2O_5 ha^{-1}. At 30, 45, 60, 75and 90 days after sowing the highest amount of total dry weight (0.29, 1.29, 2.40, 6.25and 8.91grespectively) was found at the rate of 60 kg P_2O_5 ha^{-1} and the lowest amount of total dry weight (0.19, 0.78, 1.46,

2.98 and 4.82g respectively)was found from control treatment.These results agreed with those of Tomar*et al.* (1999), Kalita (1998), Saxena and Varma(1996), and Sharma *et al.* (1984) who observed that dry weight plant^{-1} significantly increased with increasing phosphorus level up to a certain level in lentil.

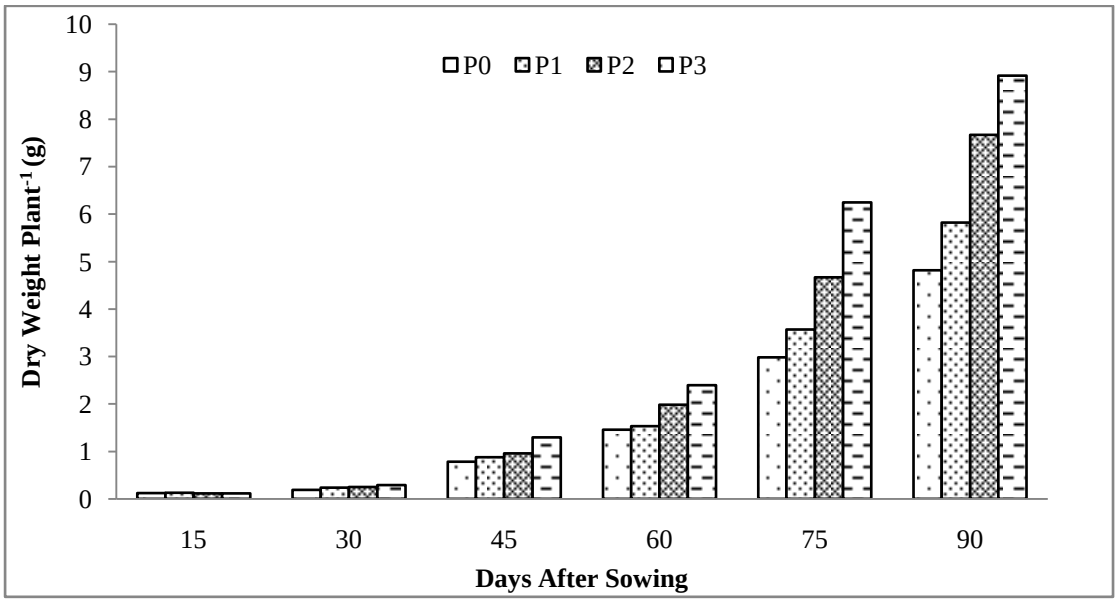


Fig.10 Total dry weight plant^{-1} of Lentil as influenced by P fertilizer at different DAS (SE= 0.009129, 0.01291, 0.08010, 0.1242, 0.1514, 0.2739 at 15, 30, 45, 60,75and90 DAS respectively)P_0= 0 kg P_2O_5 ha^{-1}, P_1= 20 kg P_2O_5 ha^{-1}, P_2=40 kg P_2O_5 ha^{-1}, P_3=60 kg P_2O_5 ha^{-1}

4.1.5.3Interactioneffect of variety and phosphorus

Dry weight (g) of lentil was significantly influenced by the combination ofvariety and different levels of phosphorus at 15, 30,45,60, 75 and 90 days after sowing (Table 5). At 15 days highestamount of dry weight (0.16 g)was found from V_4P_1(BARI Masur 7 with 20 kg P_2O_5 ha^{-1})and the lowest dry weight(0.08 g)was found from V_1P_3(BARIMasur 4 with 60 kg P_2O_5 ha^{-1}). At 30 days after sowing thehighest dryweight (0.32g)was found fromV_1P_3(BARIMasur 4 with 60 kg P_2O_5 ha^{-1})and thelowest dry weight (0.11 g) was found from V_2P_0(BARI Masur 5 with 0 kg P_2O_5 ha^{-1}). At 45 days after sowing the highestdry weight (1.80 gm) was found from V_4P_3(BARIMasur 7

with 60 kg P_2O_5 ha^{-1})and the lowestdry weight (0.63 g) was found for the variety of V_4P_2(BARI Masur 7 with 40 kg P_2O_5 ha^{-1}). At 60 days after sowing the highest dry weight(2.59 g) was found for the variety of V_1P_3(BARIMasur 4 with 60 kg P_2O_5 ha^{-1})and the lowestdry weight (1.20 g) was found from V_2P_0(BARI Masur 5 with 0 kg P_2O_5 ha^{-1}). At 75 days after sowing thehighest dry weight (6.10gm) was found for the variety of V_3P_3(BARI Masur 6 with 60 kg P_2O_5 ha^{-1}) and the lowest dry weight (2.85 g) was found from the variety of V_4P_0(BARI Masur 7 with 0 kg P_2O_5 ha^{-1}). At 90 days after sowing thehighest dry weight(9.66 g) was found for the variety of V_1P_3 (BARIMasur 4 with 60 kg P_2O_5 ha^{-1})and the lowest dry weight (4.29 g)was found from the variety of V_2P_0(BARIMasur 5 with 0 kg P_2O_5 ha^{-1}).

Table 5.Interaction effect of Variety and Phosphorus on total dry weight (g) of Lentil at different days after sowing

Treatment combination	Dry weight (g) of Lentil atdifferent days after sowing					
	15	**30**	**45**	**60**	**75**	**90**
V_1P_0	0.13 a-c	0.20 c	0.80 c	1.56 de	2.95 e	4.70 f-h
V_1P_1	0.10 a-c	0.24 a-c	0.89 bc	1.58c-e	3.17 e	6.01 d-h
V_1P_2	0.10 bc	0.24 a-c	0.67 c	2.01 a-d	4.65 c	6.45 c-f
V_1P_3	0.08 c	0.32 a	1.15 bc	2.59 a	6.04 b	9.66 a
V_2P_0	0.10 a-c	0.11 d	0.69 c	1.12 e	3.09 e	4.28 h
V_2P_1	0.12 a-c	0.23 bc	0.77 c	1.12 e	3.14 e	5.17 f-h
V_2P_2	0.11 a-c	0.26 a-c	0.87 bc	1.74 b-e	4.25 cd	7.32 b-e
V_2P_3	0.11 a-c	0.30ab	0.82 c	2.41 a-c	5.83 b	8.04 a-c
V_3P_0	0.15ab	0.21 c	0.76 c	1.76 a-e	3.03 e	5.76 e-h
V_3P_1	0.14 a-c	0.23bc	0.94 bc	1.82 a-e	4.35 cd	5.80 d-h
V_3P_2	0.15ab	0.24 a-c	1.67 a	2.06 a-d	4.11 cd	7.58 b-d
V_3P_3	0.15 ab	0.31ab	1.39 ab	2.47 ab	7.00 a	8.50 ab
V_4P_0	0.11 a-c	0.24 a-c	0.89 bc	1.39 de	2.85 e	4.52 gh
V_4P_1	0.16 a	0.24 a-c	0.92 bc	1.61 c-e	3.61 de	6.27 c-g
V_4P_2	0.10 bc	0.25 a-c	0.63 c	2.12 a-d	5.66 b	9.33 a
V_4P_3	0.13 a-c	0.25 a-c	1.80 a	2.12 a-d	6.12 ab	9.46 a
SE	**0.01826**	**0.02582**	**0.1602**	**0.2483**	**0.3028**	**0.5477**
CV%	**25.14**	**19.69**	**28.33**	**23.32**	**12.01**	**13.95**

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by DMRT at 0.05 level of probability

V_1= BARI Masur 4, V_2= BARI Masur 5, V_3= BARI Masur 6, V_4= 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}, P_3=60 kg P_2O_5 ha^{-1}

4.2 Yield attributes

The response of yield attributes considered as number of effective branches $plant^{-1}$, numbersof filledpod $plant^{-1}$and numbers of seed pod^{-1} and 1000 grain weight of lentil varieties. BARI Masur 4, BARI Masur 5, BARI Masur 6, and BARIMasur 7.Following individual treatment of variety and phosphorus levels and their combinations are represented in Table 6.

4.2.1 Effective branch palnt^{-1}

4.2.1.1 Effect of variety

Number of effective branches plant^{-1} is one of the most important yield contributing characters in lentil. The number of branches plant^{-1} was significantly affected by different variety (Table 6). The highest number of effective branches (7.08)was found from BARI Masur 7 which was statistically similar with BARI Masur 6 (6.67).The lowestnumber of effective branches (5.17)was found from BARI Masur 5.Patil*et al.* (2003) and Hussain*et al*. (2002) also reported that effective branches plant^{-1} also vary with variety.

4.2.1.2 Effect of phosphorus

Significant variations were clearly evident in case of effective branches plant $^{-1}$ with different phosphorus levels (Table 6). Increase in phosphorus levels up to 40 kg P_20_5 ha^{-1} showed the highest number of effective branches plant^{-1}(6.92) which was statistically similar with application of 20kg P_2O_5ha^{-1} (6.08) and 60 kg P_2O_5ha^{-1} (6.67). The lowest number of effective branches (4.83)was found with 0 kg P_2O_5 ha^{-1} i.e. control treatment. Zafar*et al*. (2003) also reported that branches plant^{-1} also vary with different levels of phosphorus.

4.2.1.3Interaction effect of variety and phosphorus

Effective branches plant^{-1} was significantly influenced by variety and different levels of phosphorus applications (Table 6). The highest number of effective branches plant^{-1}(8.00) was found from V_4P_2(BARI Masur 7 with 40 kg P_2O_5 ha^{-1}) which was statistically similar with V_1P_2, V_1P_3, V_3P_1, V_3P_2, V_3P_3, V_4P_1 and V_4P_3 combination. The lowest number of effective branches (4.00) was found from V_2P_0 (BARI Masur 5 with 0 kg P_2O_5 ha^{-1}) and it was statistically identical with V_1P_0, V_1P_1, V_2P_1, V_2P_3, V_3P_0, V_4P_0 combinations.

4.2.2 Filled pods plant^{-1}

4.2.2.1 Effect of variety

Different variety had no significant effect on number of filled pods plant^{-1} of lentil (Table 6). However, numerically the highest number of filled podplant^{-1} (53.83) was found from BARI Masur 7 and the lowest numbers of filled pod (48.17) plant^{-1} was found from BARI Masur 5.Datta*et al.* (2013) also found that numbers of filled pod differ due to different varieties.

4.2.2.2 Effect of phosphorus

The results from Table 6showed that phosphorus levels had significant effect on filled pod plant^{-1}. The highest number of filled pod^{-1}(66.33) was found from the application of 40 kg P_2O_5 ha^{-1}. The lowest number of filled pod plant^{-1}(32.50) was found from the control treatment i.e. without phosphorus. Similar result was found by Datta*et al.* (2013) and Saxena and Varma (1996) and they observed that seed yield of lentil was positively correlated with number of pods plant^{-1} which was close agreement with the result.

4.2.2.3 Interaction effect of variety and phosphorus

Number of filled pod plant^{-1} was significantly influenced by varieties and different level of phosphorus application (Table 6). The highest number of filled pod plant^{-1}(73.0) was found from V_4P_2 (BARI Masur 7 with 40 kg P_2O_5 ha^{-1}) and the no. of lowest filled pod plant^{-1}(26.33) was found from V_2P_0(BARI Masur 5 with 0 kg P_2O_5 ha^{-1}). Datta*et al.* (2013) mentioned that numbers of pod in lentil significantly varied due to variations of variety and Plevels.

4.2.3 Number of seed pod^{-1}

4.2.3.1 Effect of variety

Variety plays non significant effect on number of seed pod^{-1} (Table 6). However, numerically the highest number of seed pod^{-1}(1.87) was found from BARI Masur 7 and the lowest (1.76) number was from BARI Masur 5. Hussain*et al.* (2002) reported that number of seed pod^{-1} vary greatly with varieties in lentil.

4.2.3.2 Effect of phosphorus

Phosphorus levels had significant effect on number of seed pod^{-1} (Table 6). The highestnumber of seed pod^{-1}(1.94) was found at the rate of 40 kg P_2O_5 ha^{-1} while the lowest number of seed pod^{-1}(1.68) was found with control treatment i.e. without P fertilizer. Zeidan (2007) reported that increasing phosphorus levels from 0 to 60 kg increases seed pod^{-1}.

4.2.3.3 Interaction effect of variety and phosphorus

Number of grain pod^{-1} is also 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 number of grain pod^{-1} under the present study (Table 6). The highest number of grain pod^{-1}(1.97) was found for the treatment V_3P_2(BARI Masur 6 with 40 kg P_2O_5 ha^{-1}) and V_4P_2(BARI Masur 7 with 40 kg P_2O_5 ha^{-1}) while the lowest number of grain pod^{-1}(1.64) was found from V_1P_0(BARI Masur 4 with 0 kg P_2O_5 ha^{-1}). The used plant materials are the modern variety of lentil in Bangladesh therefore variation mainly due to application different phosphorus level.

4.2.4 1000 grain weight

4.2.4.1 Effect of variety

Effect of variety on 1000 grain weight was non significant (Table 6). However, numerically the highest amount of 1000 grainweight (23.83g) was found from BARI Masur 7 and the lowest (22.42g) was found from BARI Masur 5. Variation in 1000-grain weight in different variety was also reported by Rajat and Gowda (1998) in lentil.

4.2.4.2 Effect of phosphorus

The results from Table 6showed that phosphorus levels had significant effect on 1000 grain weight. The highest amount of 1000grainweight(26.08 gm) was found from the application of 40 Kg P_2O_5 $ha^{-1}$and the amount of 1000-seed weight lowest (21.17 gm)was found with control treatment of phosphorus. Saxenaand Varma(1996) obtained significant effect on 1000-grain weight and highest was recorded from 30 to 60 kg P_2O_5 ha^{-1} in respective three years which is conformity with the present experiment results.

Table 6. Effect of variety and phosphorus and their interaction effect on yield contributing characters of lentil

Treatment combination	Effective branch plant^{-1} (no.)	Filled pods plant^{-1} (no.)	Seed pod^{-1} (no.)	1000-grain weight (g)
Effect of Variety				
V_1	5.58 b	51.17	1.78	22.92
V_2	5.17 b	48.17	1.76	22.42
V_3	6.67 a	51.75	1.84	23.67
V_4	7.08 a	53.83	1.87	23.83
SE	**0.2843**	**NS**	**NS**	**NS**
Effect of Phosphorus				
P_0	4.83 b	32.50 c	1.68 c	21.17 c
P_1	6.08 a	51.50 b	1.83 ab	22.00 bc
P_2	6.92 a	66.33 a	1.94 a	26.08 a
P_3	6.67 a	54.58 b	1.79bc	23.58 b
SE	**0.2843**	**2.867**	**0.04743**	**0.7862**
Combination effect of variety and phosphorus				
V_1P_0	4.33fg	35.00 d-f	1.64 b	20.33 c
V_1P_1	5.33d-g	53.00 b-d	1.77 ab	21.33 a-c
V_1P_2	6.33 a-e	61.00 a-c	1.91 ab	26.33 ab
V_1P_3	6.33 a-e	55.67 a-c	1.78 ab	23.67 a-c
V_2P_0	4.00 g	26.33 f	1.66ab	21.33 a-c
V_2P_1	5.00 e-g	48.67 c-e	1.74ab	21.67 a-c
V_2P_2	6.00 b-f	62.67 a-c	1.90 ab	25.33 a-c
V_2P_3	5.67 c-g	55.00 a-c	1.75ab	21.33 a-c
V_3P_0	5.67 c-g	33.00 ef	1.74ab	21.00 bc
V_3P_1	6.67 a-e	51.33 b-e	1.93 ab	23.00 a-c
V_3P_2	7.33 a-c	68.67 ab	1.97 a	26.67 a
V_3P_3	7.00 a-d	54.00 a-d	1.71 ab	24.00 a-c
V_4P_0	5.33 d-g	35.67 d-f	1.69 ab	22.00 a-c

V_4P_1	7.33 a-c	53.00 b-d	1.89 ab	22.00 a-c
V_4P_2	8.00 a	73.00 a	1.97 a	26.00 ab
V_4P_3	7.67 ab	53.67 b-d	1.91 ab	25.33 a-c
SE	**0.5686**	**5.734**	**0.09487**	**1.572**
CV%	**16.08**	**19.39**	**9.02**	**11.73**

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by DMRT at 0.05 level of probability

V_1= BARI Masur 4, V_2= BARI Masur 5, V_3= BARI Masur 6, V_4= 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}, P_3=60 kg P_2O_5 ha^{-1}

4.2.4.3 Interactioneffect of variety and phosphorus

The 1000-grain weight is an important yield contributing character which has a great effect on final yield. It is observed that treatment combination of variety and phosphorus had significant effect on 1000 -grain weight under the present study (Table 6). The highest 1000-grain weight (26.67 gm) was found from V_3P_2(BARI Masur 6 with 40 kg P_2O_5 ha^{-1})whereas the lowest 1000-grainweight (20.33 gm)was found from V_1P_0(BARI Masur 4 with 0 kg P_2O_5 ha^{-1}). The used plant materials are the modern variety of lentil in Bangladesh therefore variation mainly due to application different phosphorus level.

4.3 Yield parameters

4.3.1 Seed yield

4.3.1.1 Effect of variety

Variety exerted significant effect on grain yield of lentil (Fig. 11). The highest amount of seed yield(1.76 t ha^{-1}) was found fromBARI Masur 7 which was statistically similar with BARIMasur 6 (1.67 t ha^{-1}). The lowestgrainyield (1.37 t ha^{-1}) was found from BARI masur 5 which was statistically similar with BARIMasur 4 (1.41 t ha^{-1}).Hasan*et al.* (2015), Mandal*et al*., (2015), Datta *et al.* (2013) and Haque*et al*. (2013) reported that grainyield vary with variety in case of lentil.

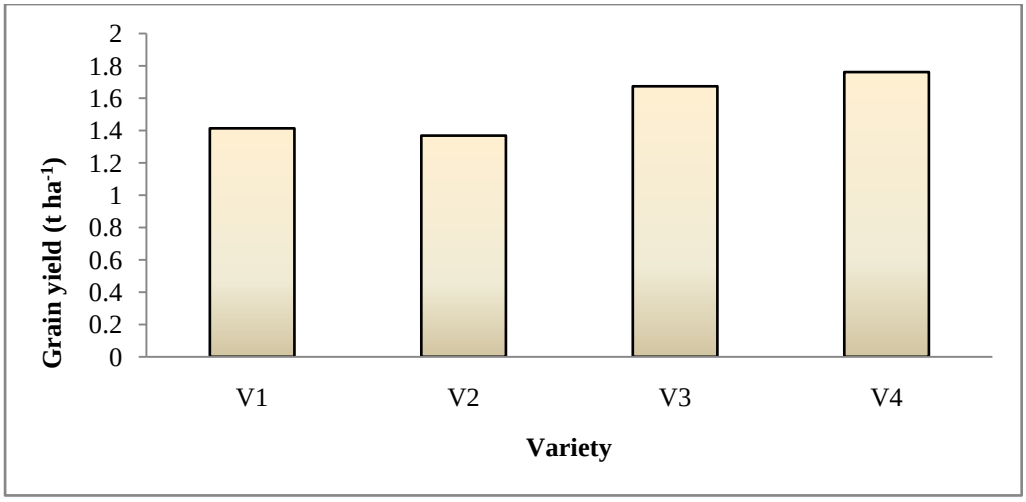


Fig.11 Effect of variety on grain yield of lentil at different DAS (SE=0.06191)

V_1= BARI Masur 4, V_2= BARI Masur 5, V_3= BARI Masur 6, V_4= BARI Masur 7

4.3.1.2 Effect of phosphorus

Phosphorus had significant effect on grain yield of lentil (Figure 12). The highest grain yield(1.72 t ha^{-1}) was obtain from the application of 40 kg P_2O_5 ha^{-1}which was statistically similar with application of 20 P_2O_5 ha^{-1}(1.59 t ha^{-1}) and 60 kg P_2O_5 ha^{-1} (1.67 t ha^{-1}).Similar findings were also obtained by Thakur *et al*. (2000),Saraf and Shivakumar (1997), Saxena and Varma (1996),and Dubey*et al.* (1993)they reported that increased phosphorus application demonstrated higher yield of pulse crops at a certain level. The maximum grain yield ha^{-1} produced by 40 kg P_2O_5 ha^{-1} was mainly due to cumulative effects of number of seeds paod-1 and 1000-grain weight. Plants grown without phosphorus fertilizer produced the lowest grain yield (1.24 t ha-1)

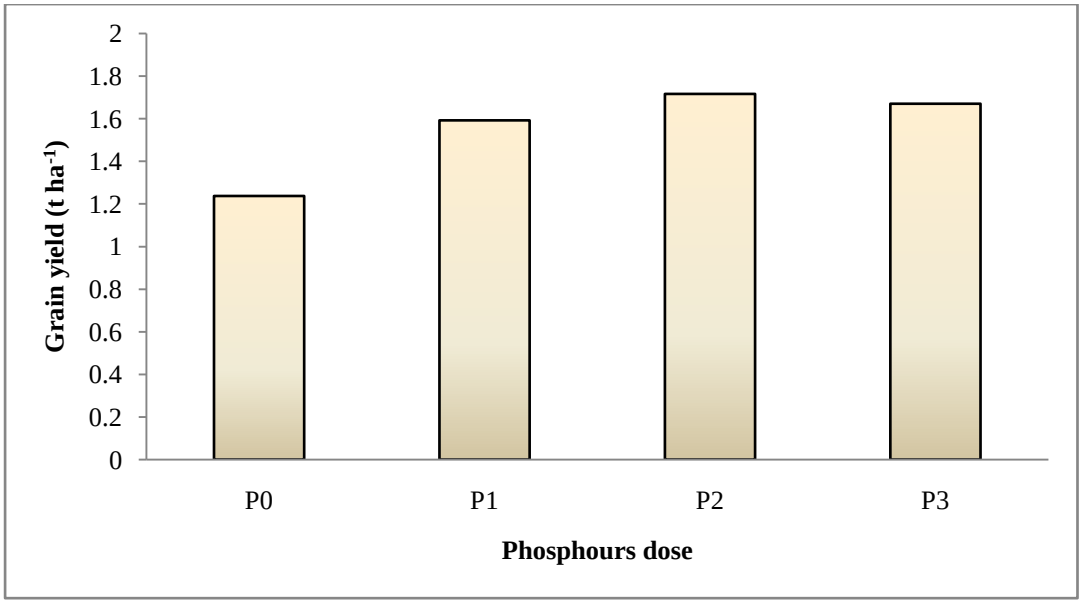


Fig.12 Effect of phosphorus on seed yield of lentil at different DAS (SE=0.06191)

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

4.3.1.3Interaction effect of variety and phosphorus

A significant interaction between variety and phosphorus levels in respect of grain yield of lentil (Table 7).The yield varied from 1.08 to 1.98 t ha^{-1} due to different levels of P and varieties .Thehighest grainyield (1.98) t ha^{-1}) was found from V_4P_2(BARI Masur 7 with 40 kg P_2O_5 ha^{-1}) and it was statistically identical with V_3P_1, V_3P_2, V_3P_3, V_4P_1 and V_4P_4treatment combinations. The highest grain yield at V_4P_2 and V_4P_3 treatment combinations may be attributed to favorable growth, higher number of pod $plant^{-1}$, seed pod^{-1} and 1000-grain weight. Increase in phosphorus fertilizer beyond 40 kg ha^{-1}tended to decrease grain yield irrespective of varieties. This might be due to the imbalance of other nutrients. The lowest grainyield (1.08 t ha^{-1}) was obtained from 0 kg P_2O_5 ha^{-1} irrespective of varieties.

4.3.2 Straw yield

4.3.2.1 Effect of variety

Variety had significant effect on straw yield of lentil (Fig. 13). Thehighest amount of straw (2.94 t ha^{-1}) was found from BARI Masur 7 which was statistically similar with BARI Masur 5 (2.80 t ha^{-1}) and BARI Masur 6 (2.83 t ha^{-1}). The lowest amount of straw (2.51 t ha^{-1}) was found from BARI Masur 4. This result is conformity with Mandal*et al.* (2015) who reported that straw yield also varied significantly among the varieties.

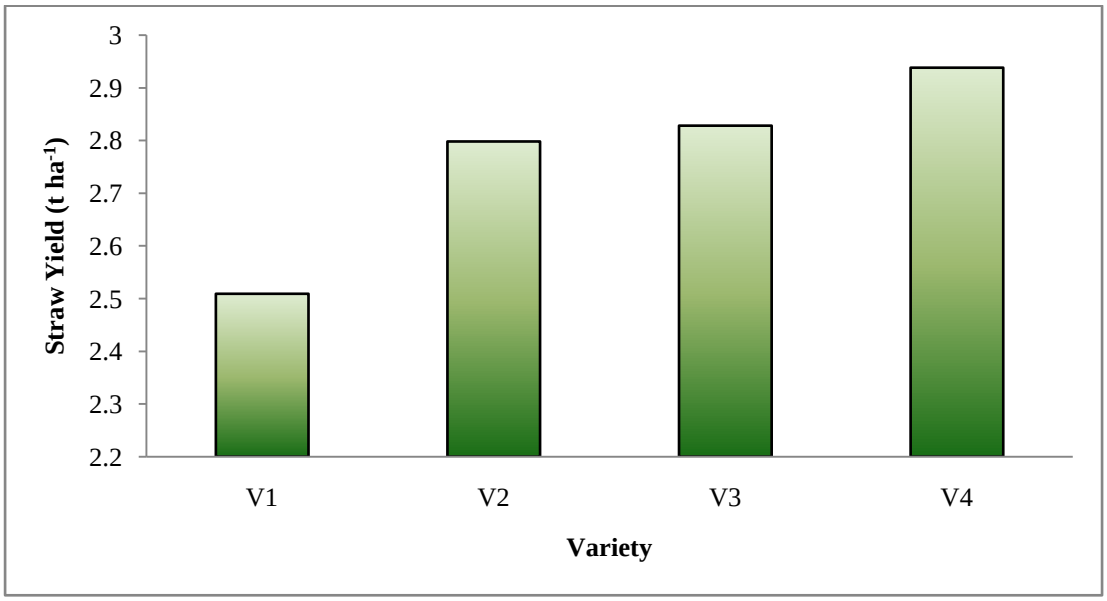


Fig.13 Effect of variety on straw yield of lentil (SE= 0.1288)V_1= BARI Masur 4, V_2= BARI Masur 5, V_3= BARI Masur 6, V_4= BARI Masur 7

4.3.2.2 Effect of phosphorus

Phosphorus had significanteffect on straw yield of lentil (Fig. 14). Thehighest amount of straw yield (3.45 t ha^{-1}) was found from the application of 60 kg P_2O_5 which was statistically similar with 20 kg P_2O_5 ha^{-1}(3.30 t ha^{-1}) and 40 kg P_2O_5 ha^{-1} (3.33 t ha^{-1}). The lowest amount of straw yield (3.01 t ha^{-1}) was found with control treatment. Similar findings were also obtained byZeidan (2007) and reported that phosphorus up to 60 kg P_2O_5 ha^{-1} significantly enhanced straw yield.

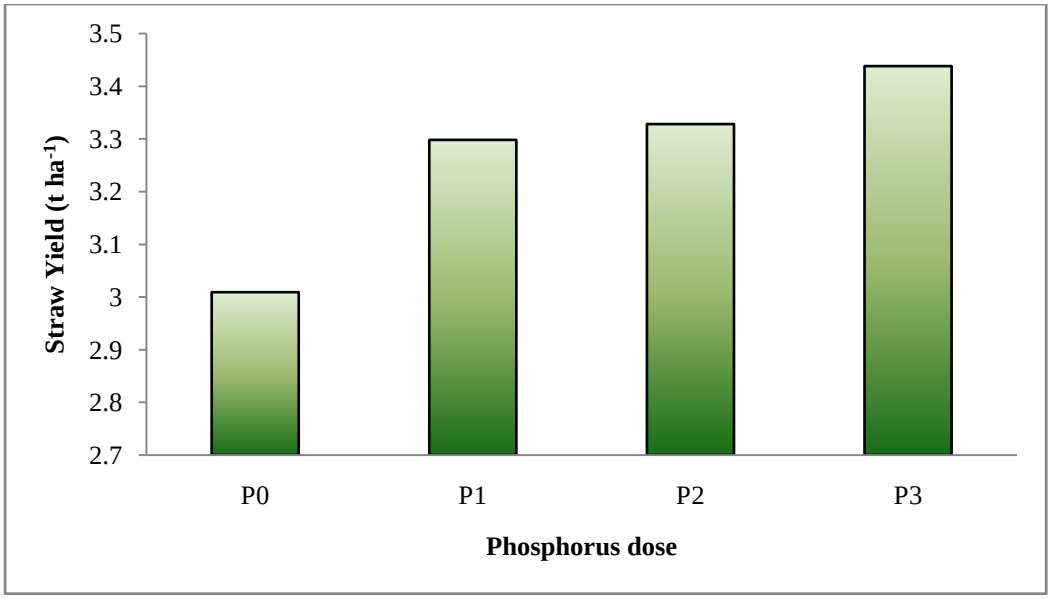


Fig.14 Effect of phosphorus on straw yield of lentil (SE= 0.1288)P_0= 0 kg P_2O_5 ha^{-1}, P_1= 20 kg P_2O_5 ha^{-1}, P_2=40 kg P_2O_5 ha^{-1}, P_3=60 kg P_2O_5 ha^{-1}

4.3.2.3 Interactioneffect of varietyand phosphorus

Straw yield was significantly influenced by variety and phosphorus combinations (Table 7). Thehighest of straw yield (3.40 t ha^{-1}) was found from V_4P_3(BARI Masur 7 with 60 kg P_2O_5 ha^{-1}) which was statistically identical with V_1P_1, V_1P_2, V_1P_3, V_3P_0, V_3P_2, V_3P_3, V_4P_0 and V_4P_2 treatment combinations.The lowest straw yield (2.31 t ha^{-1}) was found from V_2P_0(BARI Masur 5 with 0 kg P_2O_5 ha^{-1}).

4.3.3 Biological yield

4.3.3.1 Effect of variety

Variety had significant effect on biological yield of lentil (Fig. 15). The highest biological yield (4.83 t ha^{-1}) was found from BARIMasur 7 which was statistically similar with BARIMasur 6 (4.55 t ha^{-1}) whereas, the lowest biological yield (3.71 t ha^{-1}) was found from BARI Masur 5.Variations in biological yield due to variety were also reported by Patil*et al.*(2003).

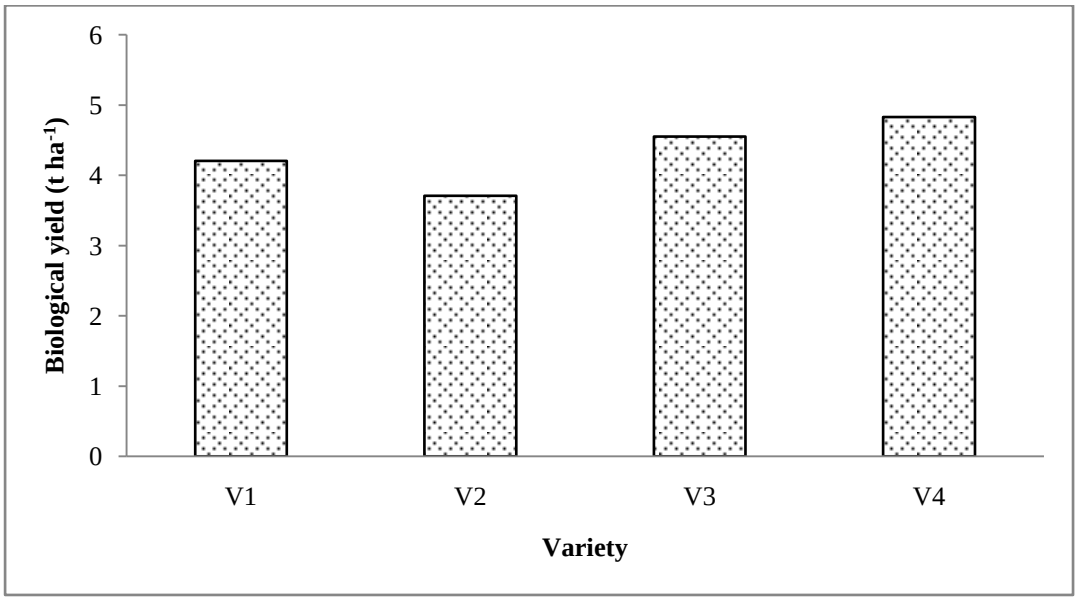


Fig.15 Effect of variety on biological yield of lentil (SE=0.1372) V_1= BARI Masur 4, V_2= BARI Masur 5, V_3= BARI Masur 6, V_4= BARI Masur 7

4.3.3.2 Effect of phosphorus

Different phosphorus levels produce significant variation in terms of biological yield of lentil (Fig. 16).The highest biological yield (4.61 t ha^{-1}) was found from the application of 60 kg P_2O_5 which was statistically similar with 20 kg $P_2O_5ha^{-1}$(4.39 t ha^{-1}) and 40 kg $P_2O_5ha^{-1}$(4.54 t ha^{-1}). The lowest biological yield (3.74 t ha^{-1}) was found from control treatment.

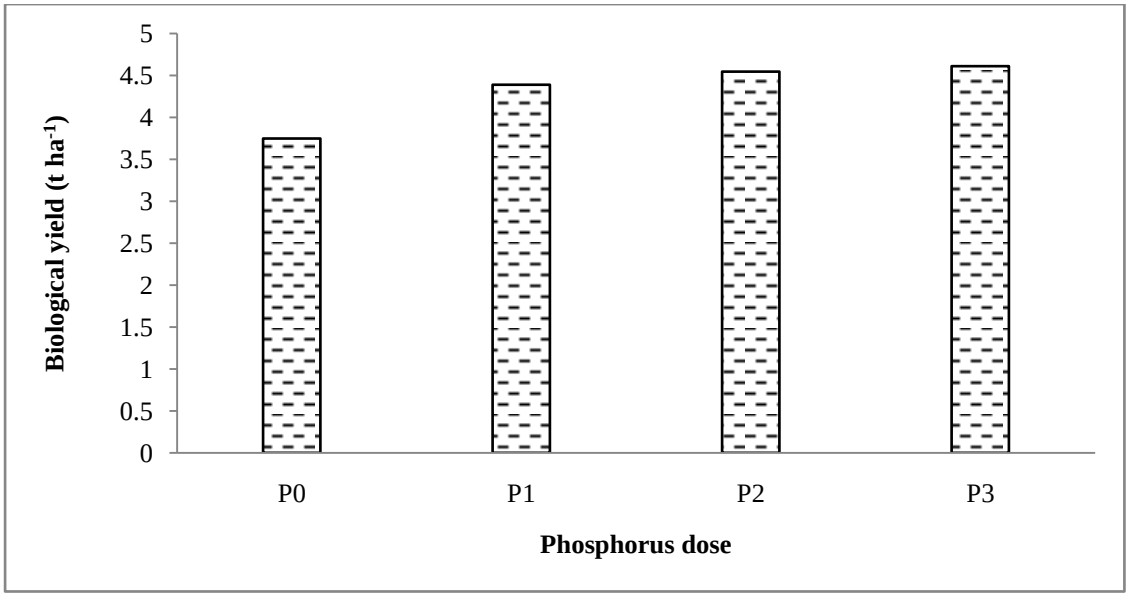


Fig.16 Effect of phosphorus on biological yield of lentil varieties (SE= 0.1372)

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

4.3.3.3Interactioneffect of variety and phosphorus

Interaction or combination of variety and phosphorus levels should significant influence on biological yield and it varied from 3.38 to 5.35 t ha^{-1} (Table 7). The highest biological yield (5.35 t ha^{-1}) was found from V_4P_3(BARI masur 7 with 60 kg P_2O_5 ha^{-1}) and it was statistically identical with V_1P_2, V_1P_3, V_3P_2, V_3P_3, V_4P_1 and V_4P_2 treatment combinations.The lowest biological yield (3.38 t ha^{-1}) was found from V_2P_0(BARI Masur 5 with 0 kg P_2O_5 ha^{-1}) which was statistically identical with V_1P_0, V_2P_1, V_2P_2, V_2P_3, V_3P_0 and V_4P_0 treatment combinations.

Table 7.Interaction effect of variety and phosphorus on grain yield, straw yield, biological yield and harvest index of lentil

Treatment combination	Seed yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
V_1P_0	1.11 de	2.38 b	3.49 fg	33.73
V_1P_1	1.48 c-e	2.92 ab	4.40 b-f	33.56
V_1P_2	1.56 bc	2.92ab	4.48 a-e	34.73
V_1P_3	1.51 cd	2.93 ab	4.44 a-e	33.74
V_2P_0	1.08 e	2.30 b	3.38 g	32.48
V_2P_1	1.42 c-e	2.31 b	3.73 e-g	38.59
V_2P_2	1.54 bc	2.35 b	3.89 c-g	40.00
V_2P_3	1.44 c-e	2.39 b	3.83 d-g	37.50
V_3P_0	1.37 c-e	2.53 ab	3.90 c-g	36.67
V_3P_1	1.74 a-c	2.95ab	4.69 a-d	37.24
V_3P_2	1.79 a-c	3.01 ab	4.80 a-c	37.16
V_3P_3	1.79 a-c	3.02 ab	4.81 a-c	37.15
V_4P_0	1.39 c-e	2.82 ab	4.21 b-g	32.96
V_4P_1	1.73 a-c	3.01ab	4.74 a-d	36.57
V_4P_2	1.98 a	3.04ab	5.01 ab	39.30
V_4P_3	1.95ab	3.40 a	5.35 a	36.27
SE	**0.1238**	**0.2576**	**0.2745**	**NS**
CV%	**13.73**	**16.10**	**10.99**	**16.87**

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by DMRT at 0.05 level of probability

V_1= BARI Masur 4, V_2= BARI Masur 5, V_3= BARI Masur 6, V_4= 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}, P_3=60 kg P_2O_5 ha^{-1}

4.3.4 Harvest index

4.3.4.1 Effect of variety

Harvest index is an important measurement of yield performance. Different variety had non significant effect on harvest index of lentil in the present experiment (Fig. 17). However, numerically the highest harvest index (37.14%) was found from BARI Masur 5 and the lowest (33.94%) was found from BARI Masur 4.

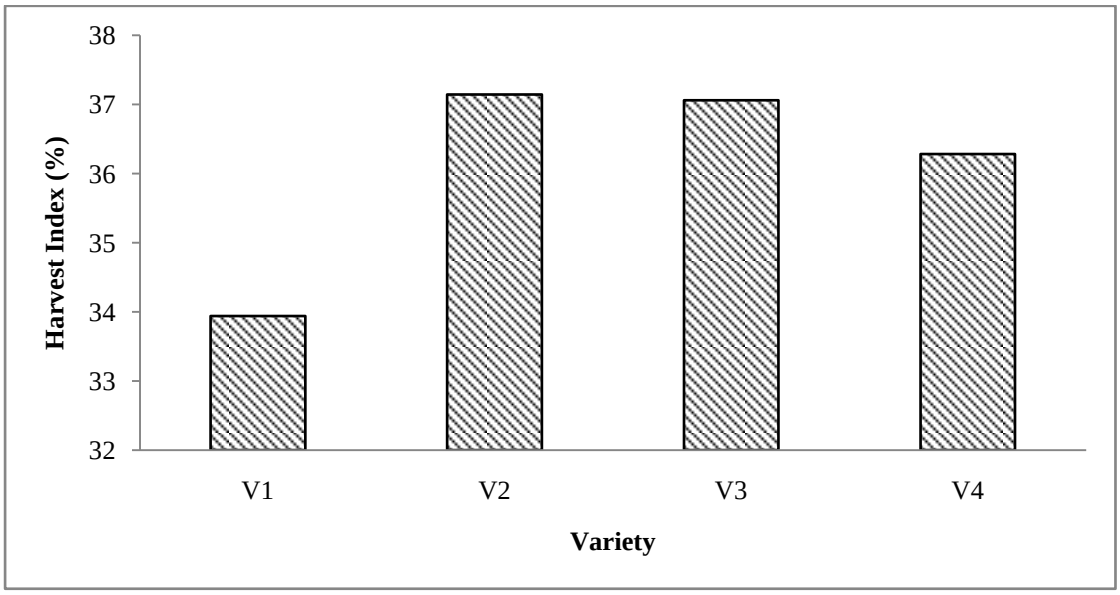


Fig.17 Effect of variety on harvest index of lentil (SE=1.758)V_1= BARI Masur 4, V_2= BARI Masur 5, V_3= BARI Masur 6, V_4= BARI Masur 7

4.3.4.2 Effect of phosphorus

Different levels of phosphorus did not exert significant effect on the harvest index of lentil. The harvest index ranged from 33.96 to 37.80 % across the P application. The highestharvest index (37.80%) was found from 40 kg P_2O_5 ha^{-1} and the lowest (33.96%) from control treatment. Tomar*et al.* (1999) and Saxena and Varma(1996) observed that harvest index increased with increased P application up to a certain level.

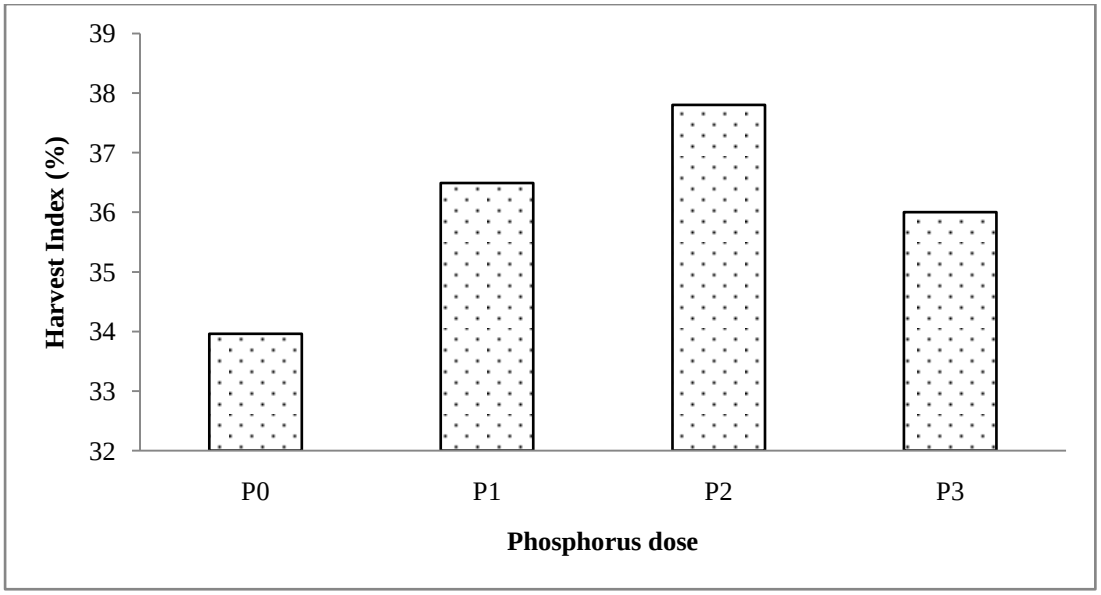
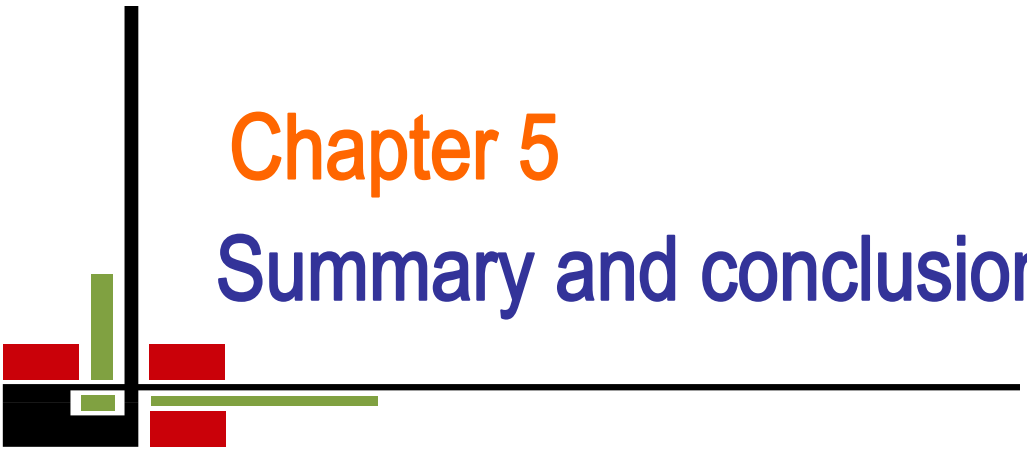


Fig.18 Effect of phosphorus on harvest index of lentil (SE=1.758)P_0= 0 kg P_2O_5 ha^{-1}, P_1= 20 kg P_2O_5 ha^{-1}, P_2=40 kg P_2O_5 ha^{-1}, P_3=60 kg P_2O_5 ha^{-1}

4.3.4.3 Interactioneffect of variety and phosphorus

Combination between variety and phosphorus had non significant effect on harvest index of lentiland it is varied from 32.48 to 40.00 % (Table 7). Numerically higher of harvest index was 40.00% when applied 40 kg $P_2O_5ha^{-1}$ in combination with BARI Masur 5 and the lowest harvest index 32.48 % was given by the V_2P_0 (BARI Masur 5 with 0 kg P_2O_5 ha^{-1}) treatment combination.



Chapter 5

Summary and conclusion

SUMMARY AND CONCLUSION

An experiment was conducted at the Agronomy Farm of Sher-e-Bangla Agricultural University, Dhaka to evaluate the response on different variety of lentil at different levels of Phosphorus. The experiment comprised two different factors; (A) four varieties of lentil *viz.,* V1 = BARI Masur 4,V_2 = BARIMasur 5, V_3= BARIMasur 6, V_4= BARIMasur 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 16 treatment combinations which were set up in split plot design with three replications. Different levels of fertilizer were in sub-plot and varieties were in main plot.The experimental plot was fertilized as per treatment with phosphaticfertilizers and other fertilizers were applied as recommended dose for lentil.

Data were collected for plant height (cm), number of branches $plant^{-1}$, number of nodules $plant^{-1}$, fresh weight $plant^{-1}$(g), dry weight $plant^{-1}$(g), numbers of effective branch $plant^{-1}$, number of pods $plant^{-1}$,1000- grain weight (g), seed yield (t ha^{-1}), straw yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index(%).

The highest (31.25 cm)plant height was found fromBARI Masur 4and the lowest (29.02 cm) was fromBARI Masur 6.The highest number of branches(8.92) was found from BARI Masur 7 and the lowest(8.00) from BARI Masur 5.In case of nodule formation the highest number of nodule (5.83) was found from BARI Masur 7 and the lowest (4.33) from BARI Masur 5.The highest dry weight (7.39 g) was found from BARI Masur 7 and the lowest(6.20 g) from BARIMasur 5.BARI Masur 7 showed the highest no. of effective branches (7.08), filled pods $plant^{-1}$(53.83), no of seed pod^{-1}(1.87), 1000-seed weight (23.83 g) which contributed the highest seed yield (1.76 tha^{-1}), straw yield (2.94 t ha^{-1}), biological yield (4.83 t ha^{-1})whereas BARI Masur 5 sowed the lowest number of effective branches $plant^{-1}$(5.17),filled pod $plant^{-1}$(48.17), no of seed pod^{-1} (1.76), and 1000-seed weight (22.42 g) which showed the

lowest seed yield (1.368 t ha^{-1}), straw yield (2.509 t ha^{-1}), and also biological yield (3.71 t ha^{-1}).

Different doses of phosphorus plays also important role in increasing growth parameters of lentil. The highest number of plant height (31.44 cm), number of branches(10.00), number of nodule (7.17), fresh weight $plant^{-1}$ (17.07 g) and dry weight (8.91 g)were found from the application of 60 kg P_2O_5 ha^{-1} whereas the lowest from the control treatment of phosphatic fertilizer. Application of 40 kg P_2O_5 ha^{-1} showed highest number of effective branches $plant^{-1}$ (6.92), filled pod $plant^{-1}$ (66.33), number of seed pod^{-1} (1.94) and 1000-grain weight (26.08 g) which contributed the highest seed yield (1.98 t ha^{-1}) whereas the lowest number of effective branches (4.83), filled pod $plant^{-1}$(32.50), number of seed pod^{-1}(1.68), 1000-grain weight (21.17 g) was found from the control treatment of phosphetic which ultimately produced the lowest seed yield (1.24 t ha^{-1}).Application 60 kg ha^{-1} showed the highest straw yield (3.44 t ha^{-1}) and biological yield (4.61 t ha^{-1}).

The highest plant height (32.07 cm) was found from BARI Masur 4 in combination with 40 kg and 60 kg P_2O_5 ha^{-1}.Maximum number (10.67) of branches was found from BARI Masur 4 in combination with 60 kg P_2O_5 ha^{-1} whereas the minimum number (8.67) of nodule was found from BARI Masur 7 in combination with 60 kg P_2O_5 ha^{-1}.The highest (9.66 g) dry weight was found from BARI Masur 4 with 60 kg $P_2O_5ha^{-1}$application.BARI Masur 7 with 40 kg $P_2O_5ha^{-1}$showed the highest number of effective branches (8.00), filled pods $plant^{-1}$ (73.00) and number of seed pod^{-1} (1.97). Although the highest (26.67 g) 1000 seed-weight was obtained from the combination of BARI Masur 6 and 40 kg P_2O_5 $ha^{-1}$and BARI Masur 7 with 40 kg $P_2O_5ha^{-1}$ also gave statistically similar 1000-seed weight (26.00 g). Thehighest seed yield (1.98 t ha^{-1}) was obtained from the combination of BARI Masur 7 with 40 kg $P_2O_5ha^{-1}$whereas the highest straw yield (3.40 t ha^{-1}) and biological yield (5.35 t ha^{-1}) were obtained from the combination of BARI Masur 7 with 60 kg P_2O_5 ha^{-1}. The highest (40.00%) harvest index was obtained from the combination of BARI Masur5 with 40 kg $P_2O_5ha^{-1}$.

It could be suggested that using new developed Bangladesh lentil variety is very much promising for higher lentil yield. On the other hand phosphorus application(20-60 kg P_2O_5 ha^{-1}) increased lentil yield compared to no application of phosphetic fertilizer. The combination effect reveled that BARI Masur 7 with 40 kg P_2O_5 ha^{-1} performed best in producing higher yield.Therefore, it could be recommended that BARI Masur 7 with 40 kg P_2O_5 $ha^{-1}$to be a promising practice for lentil cultivation in Bangladesh.

However, to reach a specific conclusion and recommendation, more research work on different variety and the application of phosphetic fertilizer in lentil cultivation should be done over different Agro-ecological zones of Bangladesh.

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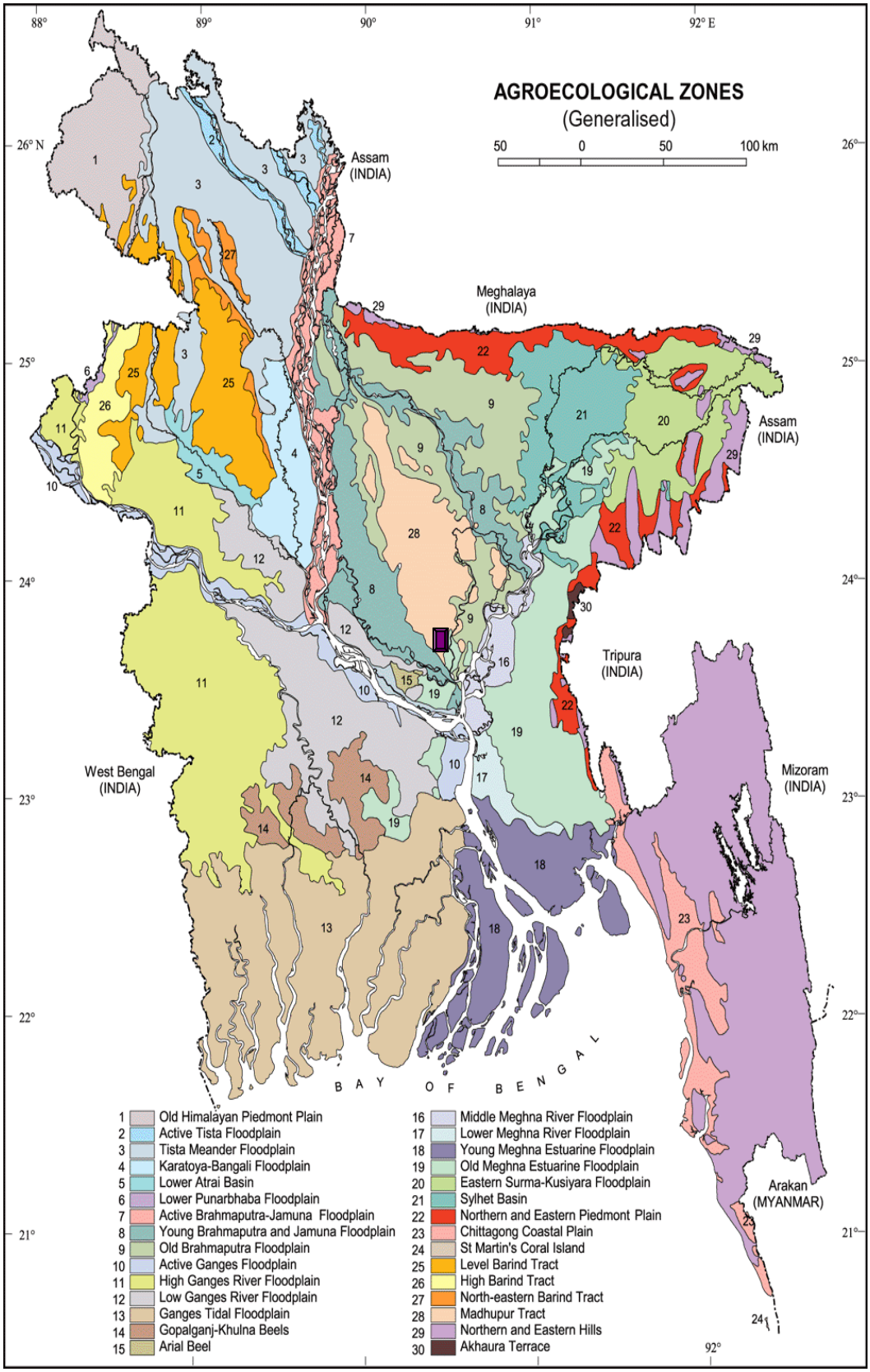
Appendices

APPENDICES



Appendix I. Map showing the experimental site under study

Appendix II. Weather data, 2013-2014, Dhaka

Month	Average RH (%)	Average Temperature (ºC)		Total Rainfall (mm)
		Min.	Max.	
November'13	65%	0	32	Trace
December'13	54.30	5.21	25.36	0.21
January'14	64.02	15.46	21.17	0.00
February'14	53.07	19.12	24.30	2.34
March'14	48.66	22.37	29.78	0.12

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

Appendix III. Physiochemical properties of the initial soil

Characteristics	Value
Particle size analysis	
% Sand	26
% Silt	45
% Clay	29
Textural class	SiltyClay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/ 100 g soil)	0.10
Available S (ppm)	45

Source: Soil Resources Development Institute (SRDI), Dhaka-1207

Appendix IV. Means square values for plant height (cm) of lentil at different days after sowing

Sources of variation	DF	Means square					
		Plant height at					
		15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS
Replication	2	0.296	0.857	5.018	7.298	18.184	8.157
Variety (V)	3	3.771*	3.654^{NS}	3.054^{NS}	6.449^{NS}	21.149*	11.715^{NS}
Error (a)	6	0.592	3.701	6.042	16.989	7.196	8.701
Phosphorus (P)	3	1.296^{NS}	2.976^{NS}	8.614^{NS}	34.184^{NS}	19.034*	28.022*
V x P	9	0.716*	1.401^{NS}	1.444^{NS}	18.153*	0.975^{NS}	1.948^{NS}
Error (b)	24	1.128	4.146	5.837	18.082	9.123	9.269

**: Significant at 0.01 level of probability *: Significant at 0.05 level of probability NS: Non-significant

Appendix V. Means square values forbranch number of lentilat different days after sowing

Sources of variation	DF	Mean square					
		Number of branches plant^{-1} at					
		15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS
Replication	2	2.524	0.473	0.771	0.896	2.333	19.000
Variety (V)	3	0.314^{NS}	0.751^{NS}	4.243^{NS}	1.556^{NS}	8.028^{NS}	1.910^{NS}
Error (a)	6	0.971	1.199	5.743	3.035	12.361	3.806
Phosphorus (P)	3	0.337^{NS}	1.535^{NS}	7.743*	15.333*	14.028^{NS}	16.188*
V x P	9	0.298^{NS}	0.321^{NS}	0.632^{NS}	0.741^{NS}	0.565^{NS}	0.910^{NS}
Error (b)	24	0.948	0.737	4.139	5.222	8.493	4.688

**: Significant at 0.01 level of probability *: Significant at 0.05 level of probability NS: Non-significant

Appendix VI. Means square values for nodule number of lentil at different days aftersowing

Sources of variation	DF	Means square					
		Number of nodule plant^{-1} at					
		15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS
Replication	2	0.271	1.021	0.521	0.438	4.333	1.271
Variety (V)	3	0.361^{NS}	0.132^{NS}	0.028^{NS}	69.299*	8.410*	4.910*
Error (a)	6	0.465	1.215	0.729	1.049	2.556	3.993
Phosphorus (P)	3	3.194*	1.521*	2.250*	76.076*	24.854*	43.021*
V x P	9	0.361*	0.354*	0.417*	2.095*	1.039*	2.058*
Error (b)	24	0.278	0.167	0.313	3.257	2.556	2.090

**: Significant at 0.01 level of probability*: Significant at 0.05 level of probability

Appendix VII. Means square values for fresh weight (g plant-1) of lentil at different days after sowing

Sources of variation	DF	Means square					
		fresh weight (g plant-^{1}) at					
		15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS
Replication	2	0.001	0.007	0.797	0.173	1.520	2.031
Variety (V)	3	0.024*	0.120*	2.262*	3.934*	7.905*	3.457^{NS}
Error (a)	6	0.004	0.010	0.238	0.239	4.714	13.777
Phosphorus (P)	3	0.015*	0.229*	8.213*	36.473*	147.995*	86.824*
V x P	9	0.056*	0.023*	0.503*	0.917*	5.051*	5.615*
Error (b)	24	0.004	0.014	0.247	0.635	2.999	3.309

**: Significant at 0.01 level of probability *: Significant at 0.05 level of probability

Appendix VIII. Means square values for total dry weight (g plant^{-1}) of lentilat different days after sowing

Sources of variation	DF	Means square					
		dry weight (g plant-1) at					
		15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS
Replication	2	0.000	0.000	0.059	0.004	0.129	5.589
Variety (V)	3	0.004*	0.001^{NS}	0.392*	0.415*	0.850*	2.922*
Error (a)	6	0.000	0.004	0.080	0.222	0.372	0.336
Phosphorus (P)	3	0.001^{NS}	0.022*	0.584*	2.280*	24.743*	40.517*
V x P	9	0.001*	0.004*	0.286*	0.089*	0.797*	1.728*
Error (b)	24	0.001	0.002	0.077	0.185	0.275	0.900

**: Significant at 0.01 level of probability*: Significant at 0.05 level of probability NS: Non-significant

Appendix IX. Means square values for effective branches plant^{-1}, filled pods plant^{-1} ,number of seeds pod^{-1},1000 seed weight oflentil.

Sources of variation	DF	Means square			
		Effective branch plant^{-1}	Filled pods plant^{-1}	Number of seeds pod^{-1}	1000 seed weight
Replication	2	0.328	111.396	0.040	8.771
Variety (V)	3	9.694*	65.743^{NS}	0.03^{0NS}	5.250^{NS}
Error (a)	6	0.481	42.535	0.010	6.188
Phosphorus (P)	3	10.361*	2360.965*	0.135*	56.139*
V x P	9	0.194*	31.891*	0.010*	2.343*
Error (b)	24	0.970	98.639	0.027	7.417

**: Significant at 0.01 level of probability*: Significant at 0.05 level of probabilityNS: Non-significant

Appendix X.Means square values forseed yield, straw yield, biological yield and harvest index of lentil

Sources of variation	DF	Means square values			
		Seed yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield(t ha^{-1})	Harvest index(%)
Replication	2	0.018	0.111	0.207	7.751
Variety (V)	3	0.444*	1.142*	2.798*	26.837^{NS}
Error (a)	6	0.026	0.277	0.408	15.077
Phosphorus (P)	3	0.565*	0.401*	1.864*	30.488^{NS}
V x P	9	0.008*	0.055*	0.075*	7.666^{NS}
Error (b)	24	0.046	0.199	0.226	37.075

**: Significant at 0.01 level of probability *: Significant at 0.05 level of probability NS: Non-significant