PERFORMANCE OF LENTIL VARIETIES UNDER DIFFERENT NITROGEN MANAGEMENT PRACTICES

MD. RAKIBUZZAMAN

DEPARTMENT OF AGRONOMY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA -1207

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By

MD. RAKIBUZZAMAN
Reg. No.: 06-01929

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Approved By:

……..……	……
(Prof. Dr. Md. Fazlul Karim)	**(Prof. Dr. Md. Hazrat Ali)**
Supervisor	**Co-supervisor**

……
Prof. Dr. A. K. M. Ruhul Amin
Chairman, Examination committee

CERTIFICATE

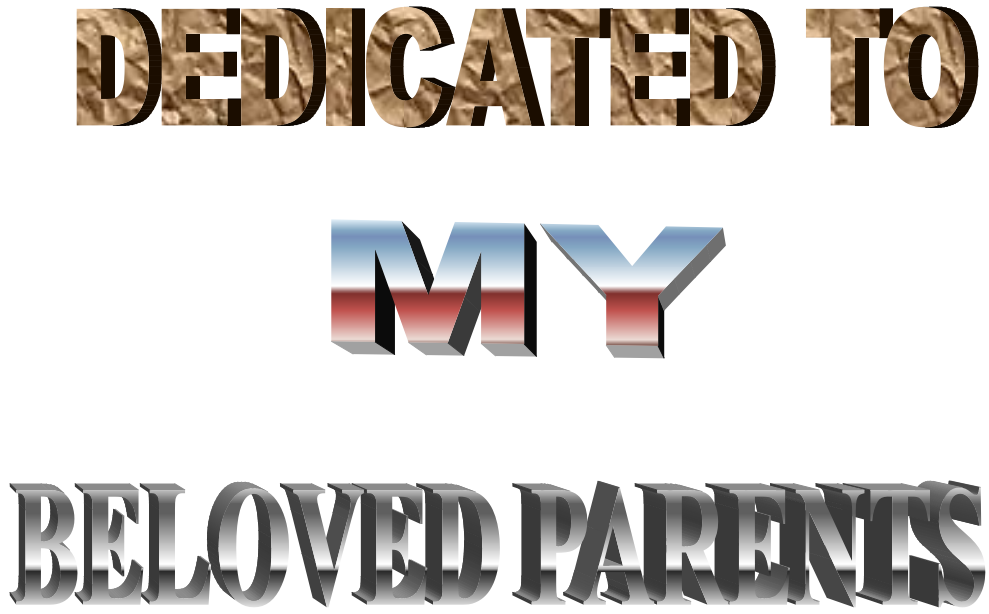
This is to certify that the thesis entitled "**Performance of lentil varieties under different nitrogen management practices**" **submitted to the** *DEPARTMENT OF AGRONOMY*, **Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of** *MASTER OF SCIENCE (M.S.) in AGRONOMY*, **embodies the results of a piece of bona fide research work carried out by** *MD. RAKIBUZZAMAN,* Registration. No. 06-01929, **under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma in any other institution.**

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

Dated: 05-12-13

Dhaka, Bangladesh

(Prof. Dr. Md. Fazlul Karim)
Supervisor
Department of Agronomy
Sher-e-Bangla Agricultural University,
Dhaka-1207


DEDICATED TO
MY
BELOVED PARENTS

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ABSTRACT

The experiment was conducted at the research field of Department of Agronomy, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during November, 2011 to March, 2012 to study the effect of N rate and appropriate schedule for high lentil yields of modern varieties. The experiment was comprised of six levels of nitrogen managements viz. N_0 (0 kg N ha^{-1}), N_1 (20 kg N ha^{-1} as basal application), N_2 (40 kg N ha^{-1} as basal application), N_3 (20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at branch initiation), N_4 (20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at flower initiation) and N_5 (20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at pod initiation) and three varieties viz. V_1 (BARI Masur 4), V_2 (BARI Masur 5), V_3 (BARI Masur 6). The experiment was laid out in a Randomized Complete Block Design under factorial arrangement with three replications. The results indicated that the tallest plant (28.83 cm), the highest branches $plant^{-1}$ (16.85) and above ground dry weight $plant^{-1}$ (14.21 g) were recorded from BARI Masur 5 at harvest. The maximum nodules $plant^{-1}$ was counted at 60 days after sowing (DAS) with BARI Masur 5. The highest pods $plant^{-1}$ (80.03), 1000 grain weight (22.72 g), seed yield (1770 kg ha^{-1}) and stover yield (2921 kg ha^{-1}) was recorded from BARI Masur 5. The highest value of growth, yield and yield contributing parameters at harvest were obtained from 40 kg N ha^{-1} as basal application (N_2). The highest values obtained were 37.93 cm, 14.41, 16.23 g, 97.89, 24.43 g, 2088 kg $ha^{-1}$and 3270 kg ha^{-1} for plant height, branches $plant^{-1}$, dry weight $plant^{-1}$, pods $plant^{-1}$, 1000 grain weight, grain yield (kg ha^{-1}) and stover yield. The maximum nodules $plant^{-1}$ (7.431) was counted at 60 DAS from 40 kg N ha^{-1} as basal application (N_2). Interaction effect variety and N management revealed that V_2N_2 (BARI Masur 5× 40 kg N ha^{-1} as basal application) showed the highest grain yield (2164 kg ha^{-1}) and stover yield (3335 kg ha^{-1}). The treatment without nitrogen either as individual or interaction had the lowest performance in respect of yield attributes and yield. The maximum seed yield was attributed due to greater production of above ground dry matter which eventually supported increased yield attributes of lentil.

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

VIII
LIST OF ACRONYMS

%	=	Percent
^{0}C	=	Degree Centigrade
AEZ	=	Agro-Ecological Zone
BARC	=	Bangladesh Agricultural Research Council
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
cm	=	Centimeter
cv.	=	Cultivar
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	=	Muriate of Potash
N	=	Nitrogen
NO	=	Number
P^H	=	Hydrogen ion concentration
RCBD	=	Randomized Complete Block Design
SAU	=	Sher-e-Bangla Agricultural Unversity
SE	=	Standard Errors
SRDI	=	Soil Resources and Development Institute
TSP	=	Triple Super Phosphate
UN	=	United Nations
UNDP	=	United Nations Development Program
Wt	=	Weight

CHAPTER I

INTRODUCTION

Lentil (*Lens culinaris* L. Medik) is an important pulse crop in Bangladesh, the commonly grown pulse crops belongs to the sub family Faboideae under the family Fabaceae, covering an area of 162 thousands hectares of land with an annual production of 211 thousands metric tons and the average yield of lentil in Bangladesh is 0.80 ton ha^{-1} (BBS, 2006). It occupies second position after mungbean in respect of area and production. Greater Faridpur, Jessore, Khustia, Pabna, and Rajshahi are the major lentil growing area in the country. In Bangladesh, lentil ranks first position in market price. Its seeds contain 59.8% CHO, 25.5% protein, 10% moisture, 4% mineral and 3% vitamins (Khan, 1981; Kaul, 1982). The green plants can also be used as animal feed and its residues have soil manural value (Sarker *et al*., 2004). Lentil grain 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. The importance of lentil in building and conserving the soil fertility has been recognized since the beginning of agriculture (Ahmed *et al*., 2008).

Lentil (*Lens culinaris* Medik), a pulse of global economic importance, has been long domesticated. Among the pulses, lentil is of special interest with 23.7% content of grain protein. In addition to protein, its seed is a rich source of minerals and vitamins as human food, while the straw serves as high-value animal feed (Rasheed *et al*., 2010).

The acreage and production of lentil are steadily declining in our country (BBS, 2008). However, the average yield of lentil is about 985 kg ha^{-1} which is very low compared to lentil growing countries of the world (BBS, 2010). There are so many reasons for lower yield of lentil. The HYVs and management of nitrogen fertilizer are the important ones that greatly affects the growth, development and yield of this crop. Pulse although fix nitrogen from the atmosphere, still there is evident that application of nitrogen fertilizer helps in increasing the yield (Patel *et al*., 1984).

The nitrogen fixation process requires a considerable amount of energy which is provided by the plant. The plant also provides energy to the *rhizobia* in the nodules and, in return, the *rhizobia* provide fixed nitrogen to the plant. (McVicar *et al*., 2007). It is believed that *rizobium* bacteria are using plants dry matter for their energy requirement that may be a back drop of pulse production. Nodules formed on the roots of plants are short-lived and is replaced constantly during growing season. However, legume plants start to support their reproductive units with dry matter rather than the rhizobia. As a result nitrogen fixation at that time is ceased (Lindermann & Glover, 2003). But the flowering and pod filling are exhausted with limited nitrogen available to the plant. Plant grown with lower basal application of nitrogen to a certain stage when vegetative stage is supported by maximum use of fixed nitrogen present in the nodules. Thus nitrogen becomes very limiting during onset of pod filling which limits seed yield (Vikman & Vessey, 1992). At this stage the plants should be given additional nitrogen to overcome plant stress for nitrogen (Lindermann & Glover, 2003). Hence, the present study was undertaken to

i. evaluate the varietal variations of lentil in relation to N rates and application schedule

ii. determine the effect of N rates and the management practices on growth and yield of three varieties of lentil.

CHAPTER II
REVIEW OF LITERATURE

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

1. Effect of variety

1.1 Plant height

Datta (2013) carried out an experiment to study the effect of variety and level of phosphorus fertilizer on the yield and yield components of lentil at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during October 2009 to March 2010. Three lentil varieties viz. BINA Masur 2, BINA Masur 3 and BARI Masur 4 and four levels of phosphorus viz. 0 kg P ha^{-1} (P_0), 15 kg P ha^{-1} (P_{15}), 30 kg P ha^{-1} (P_{30}) and 45 kg P ha^{-1} (P_{45}) were used in this experiment. He obsereved that tallest plant was obtained from BINA Masur 2 (38.18 cm).

An experiment was conducted by Zahan *et al.* (2009) at the Agronomy Field, University of Rajshahi to study the effects of potassium levels on the growth, yield and yield contributing characters of lentil. The experiment comprised of three varieties (BARI Masur 4, BARI Masur 5 and BARI Masur 6) and five potassium levels (0, 15, 25, 35 and 45 Kg K ha^{-1}). They found that the tallest plant (36.19 cm) was obtained from BARI Masur 6 and the shortest plant (33.78 cm) from BARI Masur 4 at 85 DAS.

Barman *et al.* (2009) carried out a field experiment at Mymensigh district of Bangladesh during the *Rabi* season of 2007 to 2008 on three varieties of lentil viz. BINA Masur 2, BARI

Masur 3 and BARI Masur 4. They reported that the tallest plant (42.55 cm) was obtained from BARI masur4.

1.2 Branches plant^{-1}

Zahan *et al.* (2009) conducted a field experiment at University of Rajshahi on three varieties (BARI Masur 4, BARI Masur 5 and BARI Masur 6) and five potassium levels (0, 15, 25, 35 and 45 Kg K ha^{-1}). They found that, the number of branches did not differ significantly. Numerically the highest number of branches was recorded in BARI Masur 4 at 45 and 65 DAS but 65 DAS BARI masur5 produced the highest number of branches plant^{-1}. At 45 and 85 DAS, the lowest number of branches was found in BARI Masur 6 and BARI Masur 5 produced the lowest number of branches plant^{-1} at 65 DAS.

Rahman (2007) conducted a field trial with four varieties of lentil at the Hill Agricultural Research Station, Kagrachari during the period from November 2006 to March 2007. They noted that BARI Masur 5 showed better growth and development with maximum branching.

1.3 Above ground dry weight plant^{-1} (g)

Zahan *et al.* (2009) carried out a field experiment at the Agronomy Field Laboratory, University of Rajshahi on three varieties (BARI Masur 4, BARI Masur 5 and BARI Masur 6) and five potassium levels (0, 15, 25, 35 and 45 Kg K ha^{-1}) on lentil. They reported that the highest total dry weight plant^{-1} was not significant at all sampling dates. The highest total dry weight plant^{-1} (4.40 g) was obtained from BARI Masur 4 and the lowest (4.01g) from BARI Masur 4 at 85 DAS.

Rahman (2007) conducted a field trial on four lentil varieties at the Hill Agricultural Research Station, Kagrachari during the period from November 2006 to March 2007. They found that hilly environment significantly affects the growth, development and yield of lentil

varieties. BARI Masur 5 showed better growth and development having highest total dry matter.

1.4 Nodules plant^{-1} (no.)

Datta (2013) carried out a field experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during October 2009 to March 2010 on three lentil varieties (BINA Masur 2, BINA Masur 3 and BARI Masur 4) and four levels of phosphorus (0 kg P ha^{-1} (P_0), 15 kg P ha^{-1} (P_{15}), 30 kg P ha^{-1} (P_{30}) and 45 kg P ha^{-1}). He noted that the highest number of nodules (17.36) was produced by BINA Masur 2 and the lowest (14.72) from BARI Masur 4.

Zahan *et al.* (2009) conducted a field experiment at Rajshahi district of Bangladesh on three varieties of lentil (BARI Masur 4, BARI Masur 5 and BARI Masur 6) and five potassium levels (0, 15, 25, 35 and 45 Kg K ha^{-1}). They reported that the highest number of nodules (4.40) was produced by BARI Masur 4 and the lowest number (4.01) from BARI Masur 6 at 85 DAS.

Haque *et al.* (2009) 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. We used BINA L4, TAL 640 and mixed culture of both as *Rhizobium* inoculants; BARI Masur 1, BARI Masur 2 and BARI Masur 3 as planting material. Performance of *Rhizobium* inoculants with urea at 50 kg N ha^{-1} and control was compared. They reported that both *Rhizobium* inoculants produced mentionable number of nodules with all the lentil verities. They also reported that *Rhizobium* strain BINA L4 performed better than *Rhizobium* strain TAL 640. BARI Masur 3 performed better than other two lentil varieties in respect of nodule number.

Satter (2004) conducted a field experiment on rhizobial inoculation or without inoculation on four lentil varieties (BARI Masur 1, BARI Masur 2, BARI Masur 3 and BARI Mahur 4) at

Ishurdi, Jessore and Rahmatpur and Gazipur duly 2002-2003 and 2003-2004. He reported that rhizobial inoculation significantly increased nodulation, seed and stover yield. In 2002-2003, BARI Masur 2 with inoculation and without inoculum produced higher seed yield on BARI Masur 2, BARI Masur 3. BARI Masur 2, and BARI Masur 3 were found better at Ishurdi, BARI Masur 3 at Jessore and BARI Masur 3 performed identically superior to BARI Masur 4 at Rahmatpur.

1.5 Pods plant^{-1}

Datta (2013) carried out a field experiment at Bangladesh Agricultural University, Mymensingh during October 2009 to March 2010 on three lentil varieties (BINA Masur 2, BINA Masur 3 and BARI Masur 4) and four levels of phosphorus (0, 15, 30, and 45 kg P ha^{-1}). He found that varieties showed significant influence on the all characters except plant height. He also reported that BARI Masur 4 produced maximum number of pods plant^{-1} (128.5) and BARI Masur 2 produced lowest pods plant^{-1} (111.7).

Barman *et al.* (2009) conducted a field at Bangladesh Agricultural University, Mymensigh, on lentil varieties viz. BINA Masur 2, BARI Masur 3 and BARI Masur 4. They found that the maximum number of pods plant^{-1} (97.14) was obtained from BARI Masur 4.

Zahan *et al.* (2009) carried out a field experiment at Rajshahi district of Bangladesh on three lentil varieties (BARI Masur 4, BARI Masur 5 and BARI Masur 6) and five potassium levels (0, 15, 25, 35 and 45 Kg K ha^{-1}). They noted that the effect of variety on total dry weight plant^{-1} was not significant at all sampling dates. They also found that the highest number of effective pods plant^{-1} was produced by BARI masur6 (176.77) and the lowest (158.49) from BARI Masur 4.

1.6 1000-seed weight (g)

Barman *et al.* (2009) carried out a field experiment at Bangladesh Agricultural University, Mymensigh, during the *Rabi* season of 2007 to 2008 with a view to studying the effects of

variety and compost from different sources on the yield and yield components of lentil. The varieties BINA Masur 2, BARI Masur 3 and BARI Masur 4 as well as compost of *Mimosa invisa, Sesbania rostrata, and Sesbania aculeata* were included in the study. The results revealed that the highest 1000-seed weight (25.15) was obtained from BARI Masur 4.

Zahan *et al.* (2009) conducted a field experiment at the University of Rajshahi on three lentil varieties (BARI Masur 4, BARI Masur 5 and BARI Masur 6) and five potassium levels (0, 15, 25, 35 and 45 Kg K ha^{-1}). They reported that the highest 1000-seed weight (21.54) was produced by BARI Masur 6 and the lowest 1000-seed weight (20.75) was produced by BARI Masur 4.

Khan *et al.* (2007) conducted a field experiment at the experimental farm of the Bangladesh Agriculture Research Institute, Gazipur during rabi season of 2006-07 to identify the most suitable varieties and also to understand the root dynamics of lentil under rainfed condition with four lentil varieties (BARI Masur 1, BARI Masur 2, BARI Masur 3 and BARI Masur 4). They reported that root length density, root volume and root dry weight varied greatly among varieties. BARI Masur 4 and BARI Masur 1 exerted more root length upto 20 cm depth of the soil. Those two varieties also showed greater root volume and root dry weight. They noted that but BARI Masur 4 gave the highest 1000-seed weight.

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

Datta (2013) carried out a field experiment at Mymensigh district of Bangladesh three lentil varieties (BINA Masur 2, BINA Masur 3 and BARI Masur 4) and four levels of phosphorus (0, 15, 30 and 45 kg P ha^{-1}). He reported that the highest seed yield (1317 kg ha^{-1}) was obtained BARI Masur 4 when sown with 45 kg P ha^{-1} and the lowest seed yield (830 kg ha^{-1}) was observed in BARI Masur 3 with control treatment combination. He also reported that BINA Masur 2 and BARI Masur 4 were superior to BINA Masur 3 in respect of yield with 30 kg P ha^{-1}.

Mian, *et al.* (2011) conducted experiments on the selected charland of Koikunda under Ishurdi upazilla of Pabna district. Five mustard varieties viz. BARI sarisha 9, BARI sarisha 11, BARI sarisha 14, BARI sarisha 15 and BARI sarisha 16 were tested in experiment 1 and five lentil varieties namely BARI Masur 3, BARI Masur 4, BARI Masur 5, BARI Masur 6 and one local were tested in experiment 2 for two consecutive years of 2009-10 and 2010-11. Four wheat varieties like Shatabdi, Prodip, Bijoy and Sufi were grown in experiment 3 in 2010-11. They reported that all mustard varieties produced substantial yield (1314-1578 kg ha^{-1}) except BARI sarisha 9 in both the years. They also reported that BARI Masur 3 (1033-1065 kg ha^{-1}) and BARI Masur 6 (1305-1358 kg ha^{-1}) showed better yield performance as compared to others in 2009-10 and 2010-11

Four promising lentil genotypes (X95S-167(4), X95S-167(5), ILL-5134 and X95S-136), 3 local cultivars (Kushtia, Rajshahi and Rajbari local) and released varieties (BINA Masur 3, BARI Masur 3 and BARI Masur 4) were tested by Ali *et al.* (2011). They found that BARI Masur 4 performed better in yield (1708- 1750 kg ha^{-1}).

Zahan *et al.* (2009) carried out a field experiment at the University of Rajshahi on three lentil varieties (BARI Masur 4, BARI Masur 5 and BARI Masur 6) and five potassium levels (0, 15, 25, 35 and 45 Kg K ha^{-1}). They reported that BARI Masur 6 produced the highest seed yield (2.24 t ha^{-1}) and BARI Masur 4 produced the lowest seed yield (1.79 t ha^{-1}).

Rahman (2007) conducted field trial to find out the influence of hilly environment on vegetative growth and reproductive development in lentil varieties. Four varieties of lentil were tested in a RCB design with three replications. The hilly environment significantly affects the growth, development and yield of lentil varieties. He reported that BARI Masur 5 showed better growth and development, produced highest total dry matter, bear maximum branching and finally contributed highest grain yield under hilly environment.

Khan *et al.* (2007) conducted a field experiment on four lentil varieties (BARI Masur 1, BARI Masur 2, BARI Masur 3 and BARI Masur 4) at Bangladesh Agriculture Research Institute, Gazipur during rabi season of 2006-07. They found that root length density, root volume and root dry weight varied greatly among varieties. BARI Masur 4 and BARI Masur 1 exerted more root length upto 20 cm depth of the soil. These two varieties also showed greater root volume and root dry weight. Though grain yield ha^{-1} of lentil was not significantly varied but BARI Masur 4 gave the highest grain yield (1177 kg ha^{-1}) followed by BARI Masur 1 (1095 kg ha^{-1}). The lowest grain yield was obtained from BARI masur2 (958 kg ha^{-1}) under rainfed condition.

Khan *et al.* (2007) conducted a field experiment on four lentil varieties (BARI Masur 1, BARI Masur 2, BARI Masur 3 and BARI Masur 4) at Bangladesh Agriculture Research Institute, Gazipur during rabi season of 2006-07. Root length density, root volume and root dry weight varied greatly among varieties. BARI Masur 4 and BARI Masur 1 exerted more root length upto 20 cm depth of the soil. These two varieties also showed greater root volume and root dry weight. Though grain yield ha^{-1} of lentil was not significantly varied but BARI Masur 4 gave the highest grain yield (1177 kg ha^{-1}) followed by BARI Masur 1 (1095 kg ha^{-1}). The lowest grain yield was obtained from BARI Masur 2 (958 kg ha^{-1}) under rainfed condition.

Wasiq, (2006) reported that the cultivar BINA Masur 3, BARI Masur 4 and BINA Masur 2 showed significant influence on all parameters except 1000-seed weight. He also reported that BARI Masur 4 gave the highest (26.74%) harvest index and the lowest (25.62%) was found in BINA masur2. The highest straw yield (1.73 t ha^{-1}) and seed yield (0.63 t ha^{-1}) were obtained from BARI Masur 3.

BARC (2005) conducted an experiment at six agro-ecological distinct field locations in Bangladesh and reported that the uptake of macro-nutrients (K, P, Ca and Mg) as well as micro-nutrients (Fe, Mn, Zn, Cu, B and Mo) by BARI Masur 4 was significantly higher, compared to BARI Masur3. BARI Masur 4 gave significantly higher (10-20%) grain yield than BARI Masur 3.

Sarker *et al.* (2004) reported that BARI Masur 4 produced mean seed yield of 2,300 kg ha^{-1} compared to 1,800 kg ha^{-1} for BARI Masur 2. It has a 28% yield advantage over BARI Masur 2 and a 53% advantage over the standard check (Uthfala). Due to its wide adaptability, the cultivar is recommended for all lentil-growing areas in Bangladesh.

Malik *et al.* (2003) conducted an experiment four levels each of N (1, 25 and 50 kg ha^{-1}) and phosphorus (0, 50, 75 and 100 kg ha^{-1}) with mungbean cv. NM- 98. They reported that growth and yield components were significantly affected by varying levels of N and phosphorus. A fertilizer combination of 25 kg N ha^{-1}+ 75 kg P ha^{-1} resulted with maximum seed yield (1113 kg ha^{-1}).

2. Effect of nitrogen management

2.1 Plant height

Fatima *et al*. (2013) conducted an experiment on four levels each of nitrogen (N_0 ,N_{15}, N_{30} and N_{45}) and four phosphorus levels (P_0,P_{25},P_{50} and P_{75}) with lentil crop and reported that plant height showed significant and consistent increased at all growth stages up to 45 kg N ha^{-1}.

Singh *et al*. (2011) carried out field experiments during rabi 2006-07 and 2007-08 on a loamy sand soil to study the effect of four nutrient levels involving nitrogen and phosphorus (0+0, 9.4 + 30, 12.5 + 40 and 15.6 + 50 kg N + $P_2 O_5$ ha^{-1}) on nodulation, growth and yield 2 5 of four genotypes (LL 147, LL 699, LL 875 and LL 931) of lentil. They noted that nutrition is essential for proper growth and high grain yields of lentil. They also reported that plant height increased with increasing fertilizer levels.

Mohammadjanlooa *et al*. (2010) carried out an experiment was carried out in Agriculture Research Center of Ardabil, Iran in 2008 on three levels each of nitrogen (0, 25 and 50 kg ha^{-1}) and three levels of potassium (0, 30 and 60 kg ha^{-1}) and two cultivars (a local and a new cultivar named ILL180) with lentil crop. They reported that application of 40 kg N ha^{-1} fertilizer significantly increased the plant height.

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

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

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

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

Hamid (1988) conducted a field experiment to investigate the effect of Nitrogen and carbon on the growth and yield performance of Lentil (*Lens culinaris* L. Medik). He found that the plant height of lentil was found to be increased by nitrogen at 40 kg ha^{-1}.

Sardana and Varma (1987) carried out a study in New Delhi, India in 1983-84. They found that application of N phosphorus and potassium fertilizers in combination resulted in significant increase in plant height of lentil.

Trung and Yoshida (1983) reported that maximum plant height at all the stages of plant were obtained by the application of 25 ppm N; 1000- seed weight was the highest with 100 ppm N of all forms and seed yield of mungbean increased with the increase in N up to 50 ppm.

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

2.2 Branches $plant^{-1}$

Singh *et al*. (2011) carried out a field experiment on four nutrient levels involving nitrogen and phosphorus (0+0, 9.4 + 30, 12.5 + 40 and 15.6 + 50 kg N + P O ha^{-1}) with lentil crop. They reported that branches $plant^{-1}$ was increased with increasing fertilizer levels, which increased significantly up to 15.6 kg N + 50 kg P_2O_5 ha^{-1}.

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

Hamid (1988) conducted a field experiment to investigate the effect of Nitrogen and carbon on the growth and yield performance of Lentil (*Lens culinaris* L. Medik). He found that the branches $plant^{-1}$ of lentil was found to be increased by nitrogen at 40 kg ha^{-1}.

2.3 Above ground dry weight $plant^{-1}$ (g)

An experiment was conducted by Fatima *et al.* (2013) to find the effect of Nitrogen and phosphors on growth and yield of lentil. Investigation was conducted at Sher-e-Kashmir University of Agricultural Science and technology of Kashmir, Shalimar at Pulse Research Sub Station (Habak) Srinagar during rabi 2010- 11 the experiment consist of two factors viz four Nitrogen levels (N_0 ,N_{15}, N_{30} and N_{45}) and four phosphorus levels (P_0,P_{25},P_{50} and P_{75}) was laid out in a randomized block design replicated thrice. The study relieved that dry matters accumulation showed significant and consistent increased at all growth stages up to 45 kg N ha^{-1}.

Nurdilek and Kayan (2010) conducted an experiment on four nitrogen rates (0, 20, 40 and 60 kg ha^{-1}) and all of the plots received half of the N rates before sowing in October and the

remaining N rate in spring. The plants were harvested in the following stages: the first multifoliate leaf unfolding at the fifth node (V5) full seed or seed on nodes 10-13 that fill pod cavities (R6) and maturity (R8). The dry weight and N concentration of the shoot (leaf+ stem), pod wall, and seed were then measured. They found that N application significantly affected the lentil characteristics. They reported that the maximum biomass accumulation and N accumulation were obtained at R6, and the N fertilizer had a positive effect on the seed weight and N accumulation. They suggested that 20 kg N ha^{-1} will increase the per-plant dry matter and N accumulation of the seeds under rain-fed conditions.

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

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

Agbenin *et al.* (1991) carried out an experiment under glass house condition and found that nitrogen application significantly increased the dry matter yield of pulse. In another study, Leelavati *et al.* (1991) using different levels of nitrogen found a significant increase in dry matter production of lentil with 40 kg N ha^{-1}.

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

Raju and Varma (1984) carried out a field experiment during summer season of 1979 and 1980 to study the response of lentil to varying levels of nitrogen (15, 30, 45 and 60 kg N ha^{-1})

in the presence and absence of seed inoculation with *Rhizobium.* They found that maximum dry matter weight plant^{-1} was obtained by the application of 15 kg N ha^{-1}inoculated with *Rhizobium*.

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

2.4 Nodules plant^{-1} (no.)

Singh *et al*. (2011) conducted a field experiment during *rabi* 2006-07 and 2007-08 on a loamy sand soil to study the effect of four nutrient levels involving nitrogen and phosphorus (0+0, 9.4 + 30, 12.5 + 40 and 15.6 + 50 kg N + P O /ha) on nodulation, growth and yield 2 5 of four genotypes (LL 147, LL 699, LL 875 and LL 931) of lentil. They reported that number and dry weight of nodules/plant increased with increasing fertilizer levels. However nodulation was similar with application of nitrogen and phosphorus at 9.4 + 30, 12.5 + 40 and 15.6 + 50 kg N + P_2O_5 ha^{-1}.

Dhingra e*t al.* (2005) carried out an experiment at the Punjab Agricultural University, Ludhiana from 1980–1 to 1984–5 to study the response of lentil genotypes to phosphorus application and *Rhizobium* inoculation. They reported that the number and dry weight of nodules increased consistently with increasing rates of application of phosphorus from 0 to 60 kg P_2O_5 ha^{-1}. They also reported that nitrogenase activity of intact root nodules increased from 17 530 to 22 390 nmol h^{-1} per g dry weight of nodules with 20 kg P_2O_6 ha^{-1} and to 27391 and 29170 nmol h^{-1} per g with 40 and 60 kg P_2O_5 ha^{-1}, respectively. *Rhizobium* inoculation also increased nodulation, nitrogenase activity and grain yield. Interaction between phosphorus and *Rhizobium* inoculation was significant in 3 out of 5 years, indicating that the combination of *Rhizobium* and 20 kg P_2O_6 ha^{-1} gave yield equivalent to 40 kg P_2O_6 ha^{-1} without *Rhizobium*.

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

Bachchhav *et al.* (1994) conducted a field experiment on a clay soil during the summer season with lentil (*Lens culinaris* L. Medik). They observed that root nodule number per plant was highest with 30 kg N ha^{-1}.

Inthong (1987) observed that the application of 35 kg N ha^{-1} to lentil increased nodule production and enhanced nitrogen fixation while further higher rates (30, 60 and 90 kg N ha^{-1}) suppressed it.

2.5 Pods $plant^{-1}$ (no.)

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

Amanullah (2004) conducted an experiment during 2000-01 in Pesbawar, Pakistan to investigate the effect of various levels of N (0, 10 and 20 kg ha^{-1}) and P (0, 30, 60 and 90 kg ha^{-1}) on the growth and yield components of lentil cultivars masur-85, Masur-93 and Manshera-89 under rainfed conditions. P application had significantly affected the number of pods $plant^{-1}$. Lower number of pods $plant^{-1}$ (81) was recorded without P application. N applied at 20 kg ha^{-1} resulted in the highest number of pods $plant^{-1}$ (84) but had no significant effect on nodule numbers.

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

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

Sardana and Verma (1987) carried out a field experiment in New Delhi, India. They observed that application of nitrogen in combination with phosphorus and potassium fertilizers resulted the significant increase in number of pods $plant^{-1}$ of lentil.

Salimullah *et al.* (1987) reported that the number of pods $plant^{-1}$ was highest with the application of 40 kg N ha^{-1} along with 75 kg P_2O_5 ha^{-1} and 60 kg K_2O ha^{-1} in lentil.

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

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

An experiment was conducted by Amanullah (2004) in Pesbawar, Pakistan to investigate the effect of various levels of N (0 and 20 kg ha^{-1} and P (0, 30, 60 and 90 kg ha^{-1}) on the growth and yield components of lentil cultivars masur-85, Masur-93 and Manshera-89 under rainfed conditions. Lower number of seeds pod^{-1} (1.5) was recorded without P application. P applied at 60 kg ha^{-1} resulted in the highest number of seeds pod^{-1} (1.6).

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

2.7 1000-seed weight (g)

Singh *et al.* (2011) reported in a field experiment on four nutrient levels involving nitrogen and phosphorus (0+0, 9.4 + 30, 12.5 + 40 and 15.6 + 50 kg N + P O ha^{-1}) during 2006- 2007 and 2007- 2008 with of four genotypes (LL 147, LL 699, LL 875 and LL 931) of lentil. They reported that 1000- seed weight increased significantly up to 1506 kg N + 50 kg P_2P_5 ha^{-1}.

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

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

Hamid (1988) conducted a field experiment to investigate the effect of Nitrogen and carbon on the growth and yield performance of lentil (*Lens culinaris* L. Medik). He found that the plant height, 1000 seed weight and yield of lentil was found to be increased by nitrogen at 40 kg ha^{-1}.

A field trial was carried out by Sardana and Verma (1987) in New Delhi, India. In that trial, they observed that application of nitrogen in combination with phosphorus and potassium fertilizers resulted the significant increase in 1000 seed weight of lentil.

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

Islam (2007) conducted an experiment at the Sher-e-Bangla Agricultural University farm, Dhaka to study the influence of integrated nitrogen and irrigation managements on the growth parameters and yield of lentil (Lens culinaris)cv. BARI mashur-4 during the period from November 2006 to March 2007. The trial comprised of ten treatments as T_1 = no

fertilizer and no irrigation (control), T_2 = 20 kg N ha^{-1} as basal without irrigation, T_3= 20 kg N ha^{-1} as basal with one irrigation at flower initiation stage, T_4= 30 kg N ha^{-1} as basal without irrigation , T_5= 30 kg N ha^{-1} as basal with one irrigation at flower initiation stage, T_6 = 40 kg N ha^{-1} as basal without irrigation, T_7= 40 kg N ha^{-1} as basal with one irrigation at flower initiation stage, T_8= 10 kg N ha^{-1} as basal and 10 kg N ha^{-1} as split with one irrigation at flower initiation stage, T_9= 15 kg N ha^{-1} as basal and 15 kg N ha^{-1} as split with one irrigation at flower initiation stage and T_{10} = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} as split with one irrigation at flower initiation stage. Irrespective of treatment differences the lentil plant as a pulse crop showed a lag phase in early growth stage (up to 25 DAS) produced growth parameters like number of leaves, leaf dry weight and stem dry weight per plant. Application of 20 kg N ha^{-1} as basal with 20 kg N ha^{-1} as split application with one irrigation at flower initiation stage (55 DAS) of lentil improved the growth parameters significantly. Maximum dry matter eventually supported the plant to produce more number of branches and pods per plant, which resulted in maximum seed yield (1266 kg ha^{-1}).

A study was carried out by Togay *et al.* (2005) to determine the most suitable nitrogen forms and levels for lentil cultivar (Sazak-91) in eastern Turkey in 2000-2001 and 2001-2002 growing seasons. Four nitrogen levels (0, 20, 40 and 60 kg ha^{-1}) and four nitrogen forms (ammonium nitrate, ammonium sulphates, urea and organic N) were applied in Sazak-91 lentil cultivar to find out their effects on the yield and some yield components**.** Plant height, first pod height, number of primary branches per plant, number of secondary branches per plant, number of pods per plant, number of seeds per plant, grain yield per area, harvest index and 1000 seed weight were measured. Grain yield per area and some yield components were affected by nitrogen forms and levels significantly. Application of nitrogen up to 40 kg ha^{-1} significantly increased grain yield per area, the highest grain yield**s** per area were found to be 1422, 1632 and kg ha^{-1} in the first year and the second year, respectively. The average yield was 1527 kg ha^{-1}.

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

Malik *et al.* (2003) conducted an experiment to determine the effect of varying levels of nitrogen (0, 25 and 50 kg ha^{-1}) and phosphorus (0, 50, 75 and 100 kg ha^{-1}) on the yield and quality of mungbean cv. NM-98. Growth and yield components were significantly affected by varying levels of nitrogen and phosphorus. A fertilizer combination of 25 kg N + 75 kg P_2O_5 ha^{-1} resulted in the maximum seed yield (1112.96 kg ha^{-1}).

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

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

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

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

Patel and Patel (1999) found that 20 kg N + 40 kg P_2O_5 ha^{-1} gave the highest seed yield (1.74t ha^{-1}) which was not significantly different from foliar application of urea (1.5%) + DAP (0.5%) at 30 and 40 days after sowing (1.67 t ha^{-1}). From the reviews presented this chapter it is evident that the optimum level of N at perfect growing stage in lentil field has a great effect in achieving its yield potentiality.

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

Phimsirkul (1997) conducted a field trial on lentil variety in different soils under varying N levels. Results revealed that there was no effect of N fertilizer. He reported that seed yield of lentil was increased when the crop received N at 30 kg ha^{-1}.

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

Kumar *et al.* (1993) reported that all the growth attributes of lentil were significantly increased by 20 kg N and 50 kg P_2O_5 ha^{-1}. Yield, yield attributes and quality of lentil also exhibited the same trend, although N application did not significantly increased seed yield.

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

Lopes *et al.* (1988) conducted a field experiment on four levels of nitrogen level (0, 20, 40, and 60 kg ha^{-1}) and reported that the application of 40 kg N ha^{-1} produced 96.7% of estimated maximum yield.

Cardaso *et al.* (1988) reported that lentil production showed positive linear response to N level, the highest average yield (1890 kg ha^{-1}) was obtained from the plots receiving 40 kg N ha^{-1} .

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

Hamid (1988) conducted a field experiment to investigate the effect of Nitrogen and carbon on the growth and yield performance of lentil (*Lens culinaris* L. Medik). He found that the yield of lentil was found to be increased by nitrogen at 40 kg ha^{-1}.

Inthong (1987) observed that the application of 35 kg N ha^{-1} to lentil increased nodule production and enhanced nitrogen fixation while further higher rates (30, 60 and 90 kg N ha^{-1}) suppressed it. In another experiment he reported that application of 35 kg N ha^{-1} was found to be superior giving 23 % higher seed yield over the control. However although not significantly, 60 kg N ha^{-1} tended to produce the highest yield.

A field trial was carried out by Sardana and Verma (1987) in New Delhi, India. In that trial, they observed that application of nitrogen in combination with phosphorus and potassium fertilizers resulted the significant increase in seed yield of lentil.

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

2.9 Harvest index

Malik *et al.* (2003) conducted a field on three nitrogen levels (0, 25 and 50 kg ha^{-1}) and four phosphorus levels (0, 50, 75 and 100 kg ha^{-1}) with mungbean crop cv. NM-98. They reported that a combination of 25 kg N + 75 kg P_2O_5 ha^{-1} resulted in the maximum harvest index (41.88%).

CHAPTER III
MATERIALS AND METHODS

The experiment was undertaken during Rabi season (November to March**)** of 2011 to 2012.

3.1 Experimental site

The present research work conducted at the research field of Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka. The experimental area is located at 23.41˚ N and 90.22˚ E latitude and at an altitude of 8.6 m from the sea level.

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. Cold temperature and minimum rainfall is the main feature of the Rabi season. During October to February the average relative humidity, average max. temp, average min. temp. were 66.53%, 27.34^0C, 16.04^0C respectively. The monthly total rainfall, average relative humidity, temperature during the study period (October to March) collected from the Bangladesh Meteorological Department, Agargoan, Dhaka are presented in Appendix I.

3.3 Characteristics of Soil

The soil of the experimental field belongs to the Tejgaon series under the Agroecological Zone, Madhupur Tract (AEZ- 28) and the General Soil Type is Deep Red Brown Terrace Soils. A composite sample was made by collecting soil from several spots of the field at a depth of 0-15 cm before the initiation of the experiment. The analysis is given in Appendix II.

3.4 Planting Materials

3.4.1 Seed

Three high yielding varieties of lentil designated as 'BARI Masur 4, BARI Masur 5 and BARI Masur 6,' developed by Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur were used in the experiment as a plant material. These varieties 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 and seed size is larger than local seed, deep brown color, duration of 105-110 days and seed yield of 2200-2300 kg ha^{-1}.

3.4.2 Fertilizers

The applied fertilizers were mixed properly with soil in the plot using a spade.

Soil Analysis	Fertilizer Recommendation (kg ha^{-1})			
	N_2	P_2O_5	K_2O	S
Optimum	0—6	0—10	0—12	0—6
Medium	7—12	11—20	13—24	7—12
Low	13—18	21—30	25—36	13—18
Very low	19—28	31—40	37—48	19—24

Source: *BARC, 2005 (Fertilizer Recommended Guide)*

3.5 Methods

3.5.1 Treatments

The experiment was consisted of two treatment factors as follows:

Factor A: Variety-3

V_1= BARI Masur 4

V_2= BARI Masur 5

V_3= BARI Masur 6

Factor B: N management-6

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

N_1= 20 kg N ha^{-1} as basal application

N_2= 40 kg N ha^{-1} as basal application

N_3= 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at branch initiation

N_4= 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at flower initiation

N_5= 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at pod initiation

3.5.2 Land preparation

The experiment plot was irrigated to remove its hard dryness before ploughing. Then it was first opened with tractor drawn disc plough after having 'zoe' condition. Ploughed soil was then brought into desirable tilth by 4 operations of ploughing, harrowing and laddering. The stubble and weeds were removed. The first ploughing and the final land preparation were done on 25 October and 30 October 2011, respectively. Experimental land was divided into unit plots following the design of experiment. The plots were spaded one day before planting and the basal dose of fertilizers were incorporated thoroughly.

3.5.3 Fertilization

The amounts of fertilizer as per treatment in the forms of urea, TSP and MP were calculated and basal doses of fertilizer were applied as per respective plots. Then the calculated amount of urea was applied as split application at branch initiation, flower initiation and pod formation stages. Fertilizer of each plot was applied and incorporated into soil.

3.5.4 Design and layout

The experiment was laid out in a Randomized Complete Block Design under factorial arrangements with three replications. The total plot number was $18 \times 3 = 54$. The unit plot size was $4\ m \times 2.5\ m = 10\ m^2$. The replications were separated from one another by 1.5 m. The distance between plots was 0.75 m.

3.5.5 Sowing of seeds

Seeds @35 kg ha^{-1} were sown on 17 November, 2011 in rows 30 cm apart. Seeds were treated with Bavistin before sowing to control the seed borne disease. The lines were watered before sowing seeds. After sowing; the seeds were covered with soil, and slightly pressed by hand.

3.5.6 Thinning

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

3.5.7 Weeding

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

3.5.8 Irrigation

Three irrigations were given as plants required. First irrigation was given immediate at 15 DAS and second and third irrigations were applied at 45 and 65 DAS.

3.5.9 Crop protection

At seedling stage, fungal disease was observed in the field and some plants were died. For prevention from disease, Bavistin was sprayed. At vegetative stage, aphid (*Aphis craccivora*) attacked the young plants and at latter stage of growth, pod borer (*Maruca testulalis*) attacked the plant. For aphid control, Ripcord 2 ml l^{-1} water and for pod borer Dimacron 50 EC at the rate of 3 ml l^{-1} was sprayed respectively.

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 characters were recorded from 20 days of sowing till harvest with 20 days interval. Yield and yield contributing parameters were recorded from the central part of the plots. A brief outline of the data recording on morpho-physiological and yield contributing characters are given below.

3.7 Harvesting and threshing

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

3.8 Drying and weighing

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

3.9 Data collection

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

a. Plant height (cm)

b. Branches plant^{-1} (no.)

c. Above ground dry weight plant^{-1} (g)

d. Nodules plant^{-1} (no.)

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

a. Pods plant^{-1} (no.)

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

c. 1000-seed weight (g)

d. Seed yield (kg ha^{-1})

e. Stover yield (kg ha^{-1})

f. Biological yield (kg ha^{-1})

g. Harvest index (%)

3.9.1 Plant height (cm)

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

3.9.2 Branches plant^{-1} (no.)

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

3.9.3 Above ground dry weight plant^{-1} (g)

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

3.9.4 Nodules plant^{-1} (no.)

Nodules were collected from ten randomly selected plants. The nodules per plant were calculated from their mean values.

3.9.5 Pods plant^{-1}

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

3.9.6 Weight of 1000-seeds

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

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

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

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

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

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

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

3.9.10 Harvest index (%)

It is the ratio of economic yield (grain yield) to biological yield and was calculated with the following formula:

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

3.9.11 Statistical analysis

The data obtained for different parameters were statistically analyzed following statistical package MSTAT- C for analysis of variation. The treatment means were adjusted by the Least Significant Difference (LSD) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV
RESULTS AND DISCUSSION

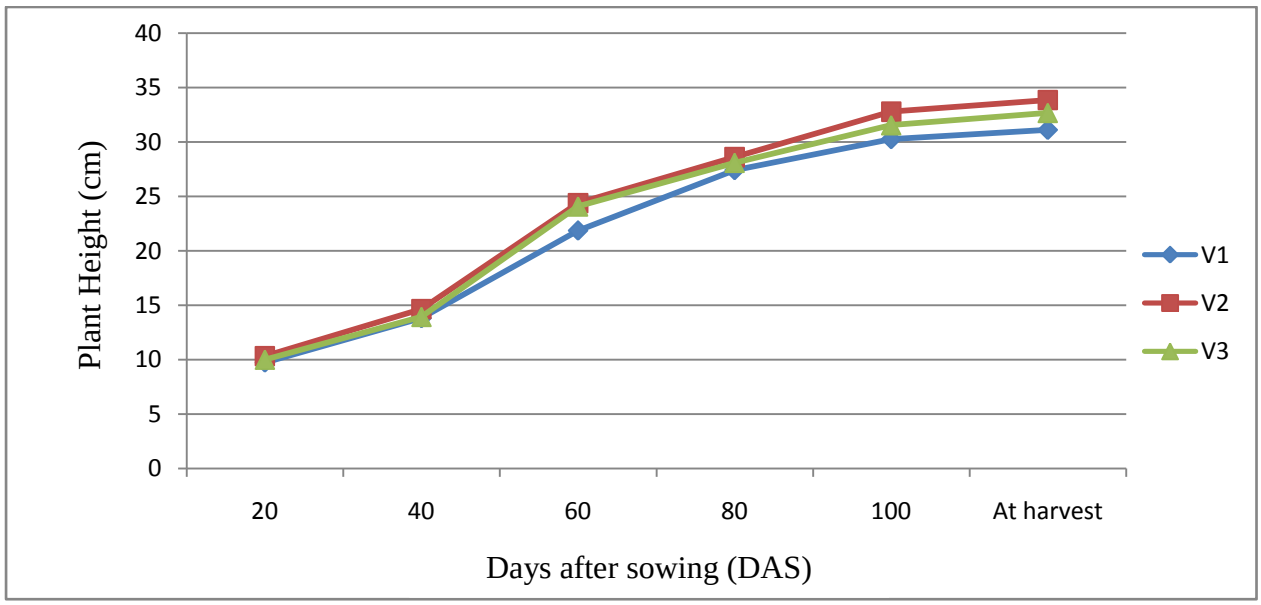
The experiment was conducted to study the response of lentil varieties to different nitrogen managements. Data on different growth, yield contributing characters and yield was recorded. The data on different parameters are presented in Appendix I to XI and Table 1 to 6. The results have been presented with the help of table and graphs and possible interpretations given under the following headings:

4.1 Growth parameters

4.1.1 Plant height

4.1.1.1 Effect of variety

Plant height was significantly influenced by different varieties of lentil at different days after sowing (DAS) (Fig. 1). Results showed that BARI Musar 5 produced the tallest plant 10.32, 14.63, 24.37, 28.59, 32.76 and 33.83 cm at 20, 40, 60, 80, 100 DAS and harvest, respectively and followed by BARI Musar 6 with similar results. The lowest plant heights 9.736, 13.81, 21.86, 27.41, 30.26 and 31.11 cm were given by BARI musar4 at 20, 40, 60, 80, 100 DAS and harvest, respectively.

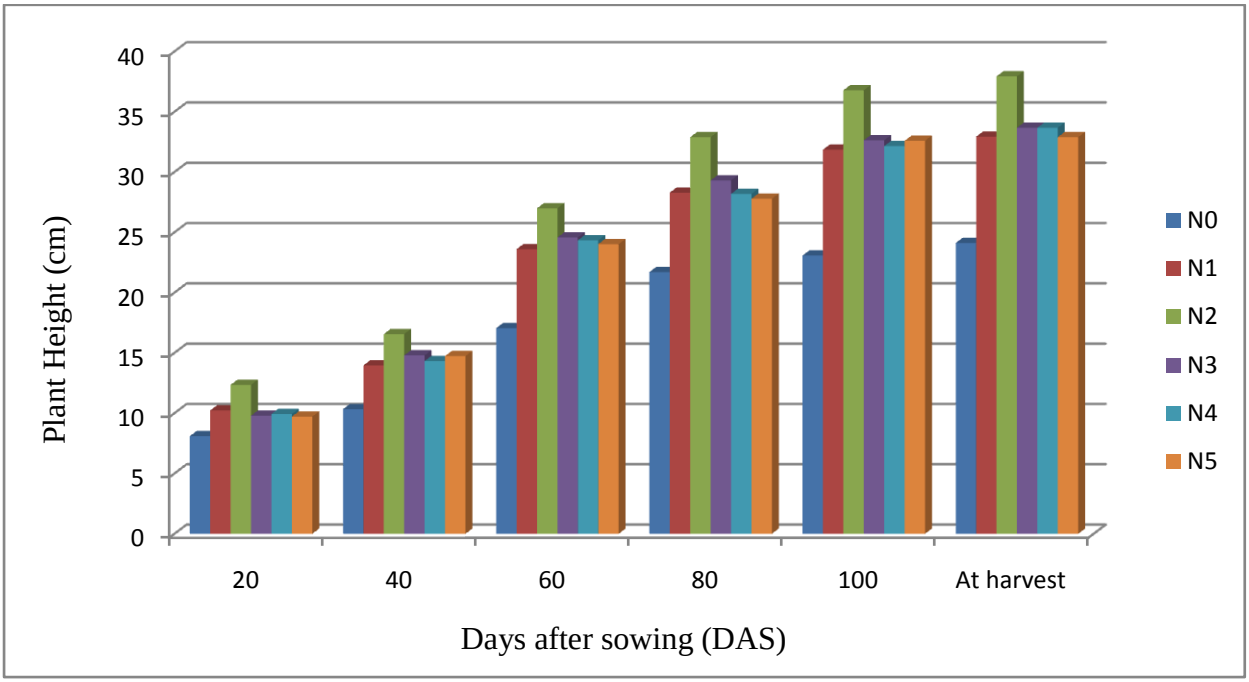


V_1= BARI Musar 4, V_2= BARI Musar 5, V_3= BARI Musar 6

Figure 1. Effect of varieties on plant height of lentil at different days after sowing ($LSD_{0.05}$ = 0.4442, 0.5024, 0.704, 1.183, 1.198, 1.217 at 20, 40, 60, 80, 100 DAS and harvest, respectively).

4.1.1.2 Effect of nitrogen management

Application of nitrogen fertilizer significantly increased plant height (Fig.2). The tallest plant; 12.35, 16.56, 26.99, 32.89, 36.78 and 37.93 cm at 20, 40, 60, 80, 100 DAS and harvest, respectively was recorded from nitrogen at the rate of 40 kg ha^{-1}. The shortest plant at 20, 40, 60, 80, 100 DAS and at harvest (8.093, 10.33, 17.05, 21.70, 23.07 and 24.11 cm, respectively) was recorded from control treatment. There was no significant difference among other treatments. These findings were in agreement with those of Quah and Jafar (1994), Hamid (1988) and Trung and Yoshida (1983).



N_0 = Control (0 kg N ha^{-1})
N_1 = 20 kg N ha^{-1} as basal application
N_2 = 40 kg N ha^{-1} as basal application
N_3 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at branch initiation
N_4 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at flower initiation
N_5 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at pod initiation

Figure 2: Effect of nitrogen managements on plant height of lentil at different days after sowing ($LSD_{0.05}$= 0.6282, 0.7105, 0.9956, 1.673, 1.695 and 1.722 at 20, 40, 60, 80, 100 DAS and harvest, respectively).

4.1.1.3 Interaction effect of variety and nitrogen management

Interaction of variety and nitrogen management had significant effect on plant height at different growth stages of lentil (Table 1).

At 20 DAS, the highest plant height (13.29cm) was recorded from V_2N_2 (BARI Musar 5 + Basal application of nitrogen at the rate of 40 kg ha^{-1}) which was significantly different from all other treatment combinations. On the contrary, the lowest plant height (7.09 cm) was noted from V_1N_0 (BARI Musar 4 + no fertilizer) which was also significantly different from other combinations.

At 40 DAS, the highest plant height (17.53 cm) was noted from V_2N_2 (BARI musar5 + Basal application of nitrogen at the rate of 40 kg ha^{-1}) and it was statistically identical with V_3N_2 (BARI Musar 6 + Basal application of nitrogen at the rate of 40 kg ha^{-1}) (16.39 cm). The lowest plant height (9.34 cm) was noted from V_1N_0 (BARI musar4 + no fertilizer) followed by V_3N_0 (BARI Musar 6 + no fertilizer) (9.85 cm).

At 60 DAS, the highest plant height (28.58 cm) was recorded from V_2N_2 (BARI Musar 5 + Basal application of nitrogen at the rate of 40 kg ha^{-1}) and it was statistically different from other treatment combinations. The lowest plant height (15.72 cm) was noted from V_1N_0 (BARI Musar 4 + no fertilizer) and similar with V_3N_0 (BARI Musar 6 + no fertilizer) (16.89 cm).

At 80 DAS, the highest plant height (34.89 cm) was recorded from V_2N_2 (BARI Musar 5 + Basal application of nitrogen at the rate of 40 kg ha^{-1}) and it was statistically identical with V_3N_2 (BARI Musar 6 + Basal application of nitrogen at the rate of 40 kg ha^{-1}) (32.22 cm). The lowest plant height (20.22 cm) was observed from V_1N_0 (BARI Musar 4 + no fertilizer) which was statistically similar with V_2N_0 (BARI Musar 5 + no fertilizer) (23.11 cm) and V_3N_0 (BARI Musar 6 + no fertilizer) (21.78 cm).

At 100 DAS, the highest plant height (38.22 cm) was recorded from V_2N_2 (BARI musar5 + Basal application of nitrogen at the rate of 40 kg ha^{-1}) which was statistically similar with V_1N_2 (BARI Musar 4 + Basal application of nitrogen at the rate of 40 kg ha^{-1}) (36.22 cm) and V_3N_2 (BARI Musar 6 + Basal application of nitrogen at the rate of 40 kg ha^{-1}) (35.89 cm). The lowest plant height (23.11 cm) was noted from V_1N_0 (BARI Musar 4 + no fertilizer) which was statistically similar with V_2N_0 (BARI Musar 5 + no fertilizer) (23.11 cm) and V_3N_0 (BARI Musar 6 + no fertilizer) (22.78 cm).

At harvest, combination of V_2N_2 (BARI Musar 5 + Basal application of nitrogen at the rate of 40 kg ha^{-1}) produced maximum plant height (39.33 cm) and it was statistically identical with V_1N_2 (BARI Musar 4 + Basal application of nitrogen at the rate of 40 kg ha^{-1}) (37.11 cm) and V_3N_2 (BARI Musar 6 + Basal application of nitrogen at the rate of 40 kg ha^{-1}) (37.33 cm). The lowest plant height (22.89 cm) was noted from V_1N_0 (BARI Musar 4 + no fertilizer) followed by V_2N_0 (BARI Musar 5 + no fertilizer) (25.44 cm) and V_3N_0 (BARI Musar 6 + no fertilizer) (24.00 cm).

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

Table 1. Interaction effect of varieties and nitrogen management on plant height of lentil at different days after sowing

Treatments	20 DAS	40 DAS	60 DAS	80 DAS	100 DAS	At harvest
V_1N_0	7.090 f	9.34 h	15.72 h	20.22 e	23.11 g	22.89 f
V_1N_1	9.987 c	13.88 ef	21.90 f	27.22 d	29.89 f	30.78 e
V_1N_2	11.80 b	15.74 bc	25.66 bc	31.55 bc	36.22 ab	37.11 ab
V_1N_3	9.777 c	15.02 c-e	23.08 d-f	31.56 bc	31.33 d-f	32.33 c-e
V_1N_4	10.16 c	14.80 c-f	22.78 ef	27.00 d	30.11 ef	31.00 de
V_1N_5	9.603 c-e	14.05 ef	22.04 f	26.89 d	31.89 d-f	32.55 c-e
V_2N_0	8.537 e	11.80 g	18.53 g	23.11 e	23.11 g	25.44 f
V_2N_1	9.717 cd	13.73 f	25.58 bc	29.33 b-d	32.89 b-f	34.11 c
V_2N_2	13.29 a	17.53 a	28.58 a	34.89 a	38.22 a	39.33 a
V_2N_3	9.910 c	14.73 c-f	24.74 cd	27.89 d	33.67 b-e	33.55 c-e
V_2N_4	9.843 c	14.33 ef	24.55 cd	27.89 d	33.89 b-d	34.55 bc
V_2N_5	9.837 c	15.59 b-d	24.22 c-e	28.44 d	33.55 b-f	34.89 bc
V_3N_0	8.653 de	9.853 h	16.89 gh	21.78 e	22.78 g	24.00 f
V_3N_1	10.18 c	14.28 ef	23.33 d-f	28.33 d	32.78 b-f	33.89 cd
V_3N_2	11.94 b	16.39 ab	26.74 b	32.22 ab	35.89 a-c	37.33 ab
V_3N_3	9.693 cd	14.43 d-f	25.89 bc	28.44 d	32.89 b-f	34.00 c
V_3N_4	9.790 c	13.82 ef	25.67 bc	28.44 d	32.44 c-f	33.11 c-e
V_3N_5	10.51 c	14.76 c-f	25.81 bc	29.22 cd	32.33 c-f	34.67 bc
$LSD_{0.05}$	1.088	1.231	1.724	2.898	3.74	2.982
CV(%)	6.61	5.28	4.44	8.05	4.92	4.9

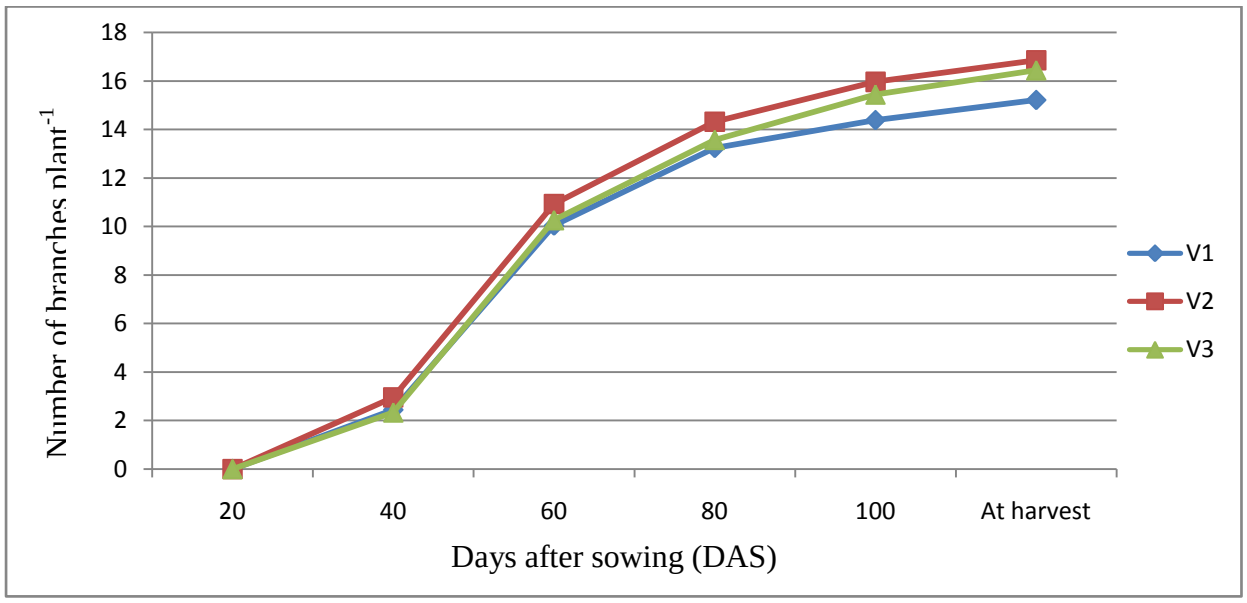
V_1 = BARI Masur 4
V_2 = BARI Masur 5
V_3 = BARI Masur 6

N_0 = Control (0 kg N ha^{-1})
N_1 = 20 kg N ha^{-1} as basal application
N_2 = 40 kg N ha^{-1} as basal application
N_3 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at branch initiation
N_4 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at flower initiation
N_5 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at pod initiation

4.1.2 Branches plant^{-1}

4.1.2.1 Effect of Variety

Number of branches plant^{-1} was significantly influenced by different rate of nitrogen application at different days after sowing (Fig. 3). Among three varieties, BARI masur5 produced the highest number of branches plant^{-1}; 0, 2.957, 10.93, 14.32, 15.96 and 16.85 at 20, 40, 60, 80, 100 DAS and harvest, respectively which was statistically different from other varieties at 20, 40, 60, 80 DAS and statistically similar with V_3 (BARI masur6) at 100 DAS and harvest. BARI Masur 4 gave the lowest result; 0, 2.333, 10.04, 13.24, 14.39 and 15.22 at 20, 40, 60, 80, 100 DAS and harvest, respectively and it was statistically similar with V_3 (BARI Masur 6) at 20, 40, 60, 80 and 100 DAS.



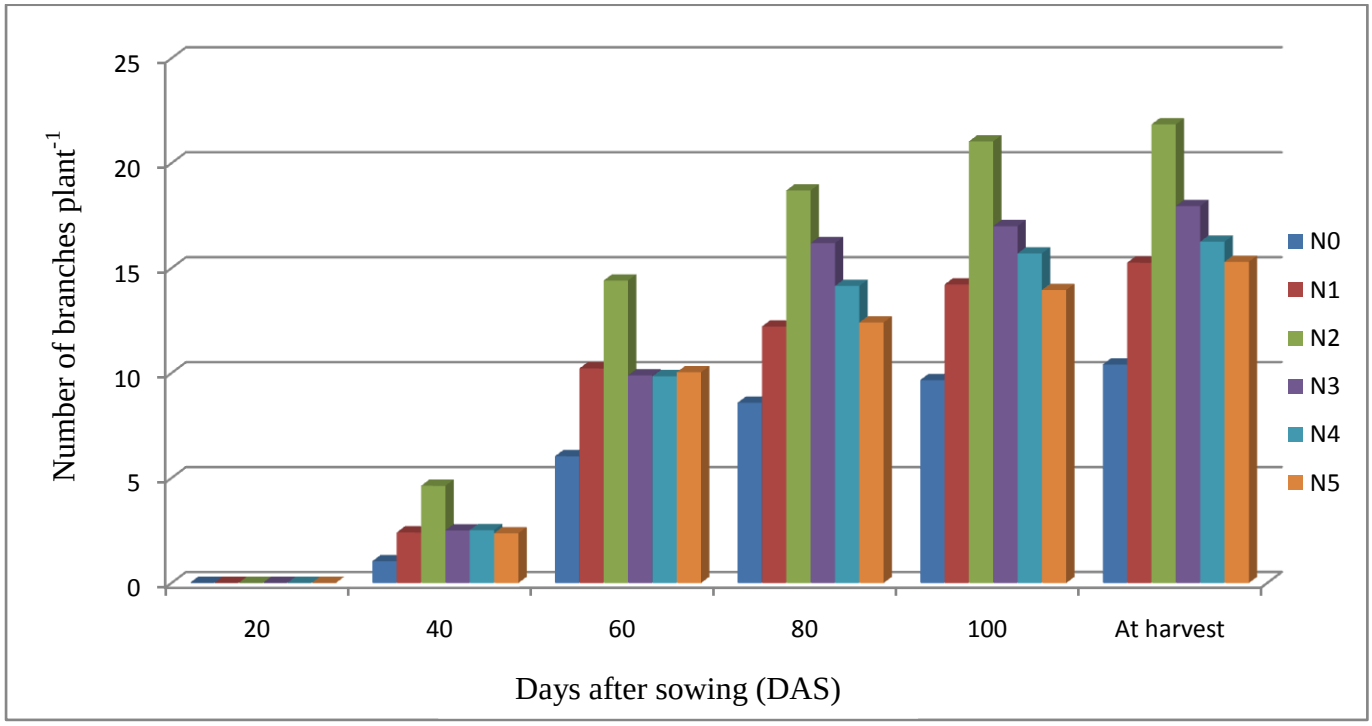
V_1= BARI Musar 4, V_2= BARI Musar 5, V_3= BARI Musar 6

Figure 3. Effect of varieties on branches plant^{-1} of lentil at different days after sowing ($LSD_{0.05}$ = 0, 0.3772, 0.5748, 0.5424, 1.113 and 1.212 at 20, 40, 60, 80, 100 DAS and harvest, respectively).

4.1.2.2 Effect of nitrogen management

Application of nitrogen fertilizer significantly influenced the number of branches plant^{-1} (Fig. 4). The highest number of branches plant^{-1} of 0, 4.629, 21.85, 18.70, 21.04 and 14.41 at 20, 40, 60, 80, 100 DAS and harvest, respectively were recorded from basal application of nitrogen at the rate of 40 kg ha^{-1}. The number of branches plant^{-1} at 20, 40, 60, 80, 100 DAS

and at harvest with 0, 1.037, 6.038, 8.588, 9.666, 10.41 respectively were recorded from control treatment. These findings were in agreement with those of Patel and Parmer (1986).



N_0 = Control (0 kg N ha^{-1})
N_1 = 20 kg N ha^{-1} as basal application
N_2 = 40 kg N ha^{-1} as basal application
N_3 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at branch initiation
N_4 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at flower initiation
N_5 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at pod initiation

Figure 4. Effect of N management on branches $plant^{-1}$of lentil at different days after sowing ($LSD_{0.05}$ = 0.5334, 0.8129, 0.767, 1.574 and 1.714 at 20, 40, 60, 80, 100 DAS and harvest, respectively).

4.1.2.3 Interaction effect of variety and nitrogen management

Interaction of variety and nitrogen management had significant effect on number of branches $plant^{-1}$ at different days after sowing (Table 2).

At 40 DAS, the highest branches $plant^{-1}$ (5.557) was recorded from treatment combination of V_2N_2 (BARI Masur 5 + Basal application with 40 kg N ha^{-1}) and it was statistically different

from all other combinations. The lowest branches plant^{-1} (0.7767) was recorded in V_1N_0 (BARI Masur 4+ No fertilizer) and found similar with V_2N_0 (BARI Masur 5 + No fertilizer) (1.223) and V_3N_0 (BARI Masur 6 + No fertilizer) (1.110).

At 60 DAS, the highest branches plant^{-1} (15.56) was recorded from V_2N_2 (BARI Masur 5 + Basal application with 40 kg N ha^{-1}) which was significantly different from all other treatment combinations. The lowest branches plant^{-1} (5.667) was recorded in V_1N_0 (BARI Masur 4+ No fertilizer) and it was statistically identical with V_2N_0 (BARI Masur5 + No fertilizer) (6.557) and V_3N_0 (BARI Masur 6 + No fertilizer) (5.890).

At 80 DAS, the highest branches plant^{-1} (19.22) was recorded from V_2N_2 (BARI masur 5 + Basal application with 40 kg N ha^{-1}) followed by V_3N_2 combination (BARI Masur6 + Basal application with 40 kg N ha^{-1}) (19.22). The lowest branches plant^{-1} (8.11) was recorded in V_1N_0 (BARI Masur 4+ No fertilizer) which was found similar with V_2N_0 (BARI masur5 + No fertilizer) (9.333) and V_3N_0 (BARI Masur 6 + No fertilizer) (8.320).

At 100 DAS, the highest branches plant^{-1} (21.33) was recorded from V_2N_2 (BARI Masur 5 + Basal application with 40 kg N ha^{-1}) which was statistically similar with V_3N_2 (BARI Masur 6 + Basal application with 40 kg N ha^{-1}) (21.22) and V_1N_2 (BARI Masur 4 + Basal application with 40 kg N ha^{-1}) (20.56). The lowest branches plant^{-1} (9.443) was recorded in V_1N_0 (BARI Masur 4+ No fertilizer) and it was statistically similar with V_3N_0 (BARI Masur 6 + No fertilizer) (9.777), V_3N_5 (BARI Masur 6 + application as basal with 50% (20 kg) N ha^{-1} and 50% (20 kg) N ha^{-1} at pod initiation stage) (9.777).

At harvest, the highest branches plant^{-1} (22.13) was noted from V_2N_2 (BARI Masur 5 + Basal application with 40 kg N ha^{-1}) which was statistically similar with V_3N_2 (BARI Masur 6 + Basal application with 40 kg N ha^{-1}) (22.11) and V_1N_2 (BARI Masur 4 + Basal application with 40 kg N ha^{-1}) (21.33). The lowest branches plant^{-1} (10.00) was recorded in V_1N_0 (BARI Masur 4+ No fertilizer) and it was statistically identical with V_2N_0 (BARI Masur 5 + No fertilizer) (10.78), V_3N_0 (BARI Masur 6 + No fertilizer) (10.44).

Table 2. Interaction effect of varieties and N management on branches plant^{-1} of lentil at different days after sowing

Treatments	20 DAS	40 DAS	60 DAS	80 DAS	100 DAS	At harvest
V_1N_0	0	0.7767 e	5.667 e	8.110 i	9.443 f	10.00 g
V_1N_1	0	2.220 c	10.89 c	12.00 gh	13.89 de	15.11 d-f
V_1N_2	0	4.330 b	10.00 b	17.67 b	20.56 ab	21.33 ab
V_1N_3	0	2.557 c	11.22 c	11.67 h	14.67 de	15.56 d-f
V_1N_4	0	2.333 c	9.557 c	14.00 e	14.44 de	13.78 f
V_1N_5	0	1.890 cd	9.443 cd	12.22 f-h	13.33 e	15.56 d-f
V_2N_0	0	1.223 de	6.557 de	9.333 i	13.56 e	10.78 g
V_2N_1	0	2.777 c	10.11 c	13.22 e-g	15.11 de	14.55 ef
V_2N_2	0	5.557 a	15.56 a	19.22 a	21.33 a	22.13 a
V_2N_3	0	2.743 c	10.00 c	16.56 bc	18.22 bc	19.22 a-c
V_2N_4	0	2.667 c	10.11 c	14.22 de	16.33 cd	17.33 c-e
V_2N_5	0	2.777 c	10.22 c	13.34 ef	15.00 de	15.78 d-f
V_3N_0	0	1.110 de	5.890 de	8.320 i	9.777 f	10.44 g
V_3N_1	0	2.223 c	9.667 c	11.44 h	13.67 de	14.78 d-f
V_3N_2	0	4.000 b	14.22 b	19.22 a	21.22 a	22.11 a
V_3N_3	0	2.220 c	11.89 c	16.56 bc	18.11 bc	19.11 bc
V_3N_4	0	2.553 c	9.890 c	14.22 de	16.33 cd	17.67 cd
V_3N_5	0	2.443 c	10.45 c	15.45 cd	9.777 f	15.89 d-f
$LSD_{0.05}$	0	0.9239	1.408	1.328	2.727	2.968
CV(%)	0	21.75	8.16	5.84	10.86	11.2

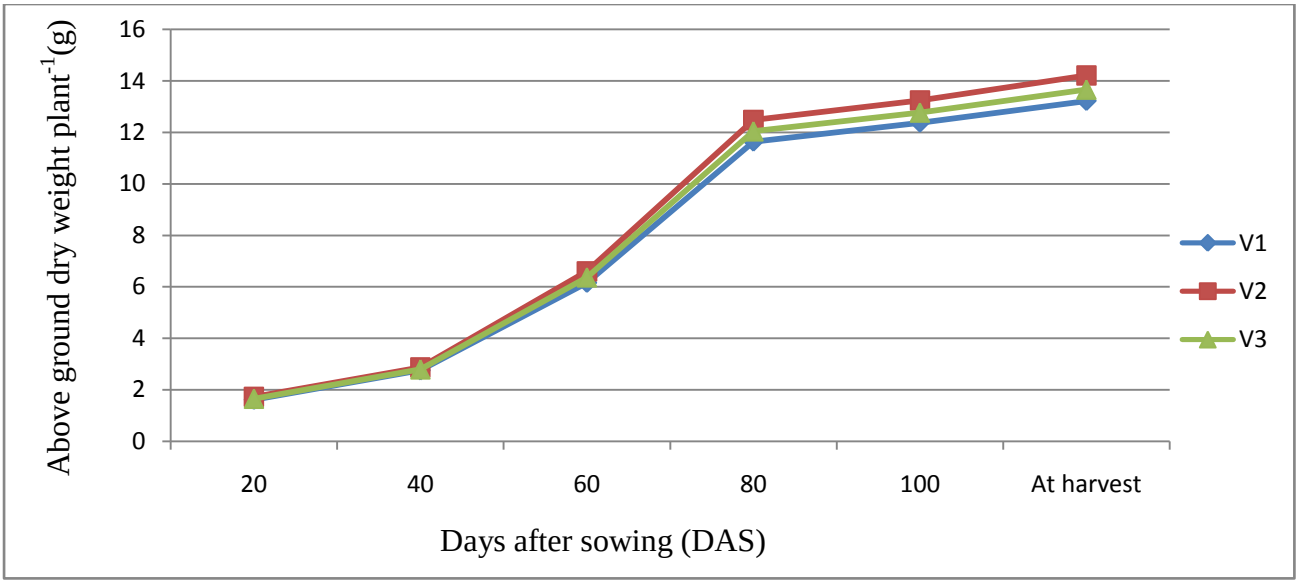
V_1 = BARI Masur 4
V_2 = BARI Masur 5
V_3 = BARI Masur 6

N_0 = Control (0 kg N ha^{-1})
N_1 = 20 kg N ha^{-1} as basal application
N_2 = 40 kg N ha^{-1} as basal application
N_3 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at branch initiation
N_4 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at flower initiation
N_5 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at pod initiation

4.1.3 Above Ground Dry weight plant^{-1}

4.1.3.1 Effect of variety

Significant variation was observed among the varieties on above ground dry weight plant^{-1} at different days after sowing (Fig. 5). Results indicated that BARI Masur 5 showed the highest dry weight plant^{-1} and that was 1.73, 2.87, 6.61, 12.48, 13.24 and 14.21 g at 20, 40, 60, 80, 100 DAS and harvest, respectively. On the other hand, BARI Masur 4 gave the lowest dry weight plant^{-1} which was 1.62, 2.75, 6.16, 11.64, 12.38 and 13.22 g at 20, 40, 60, 80, 100 DAS and harvest, respectively.



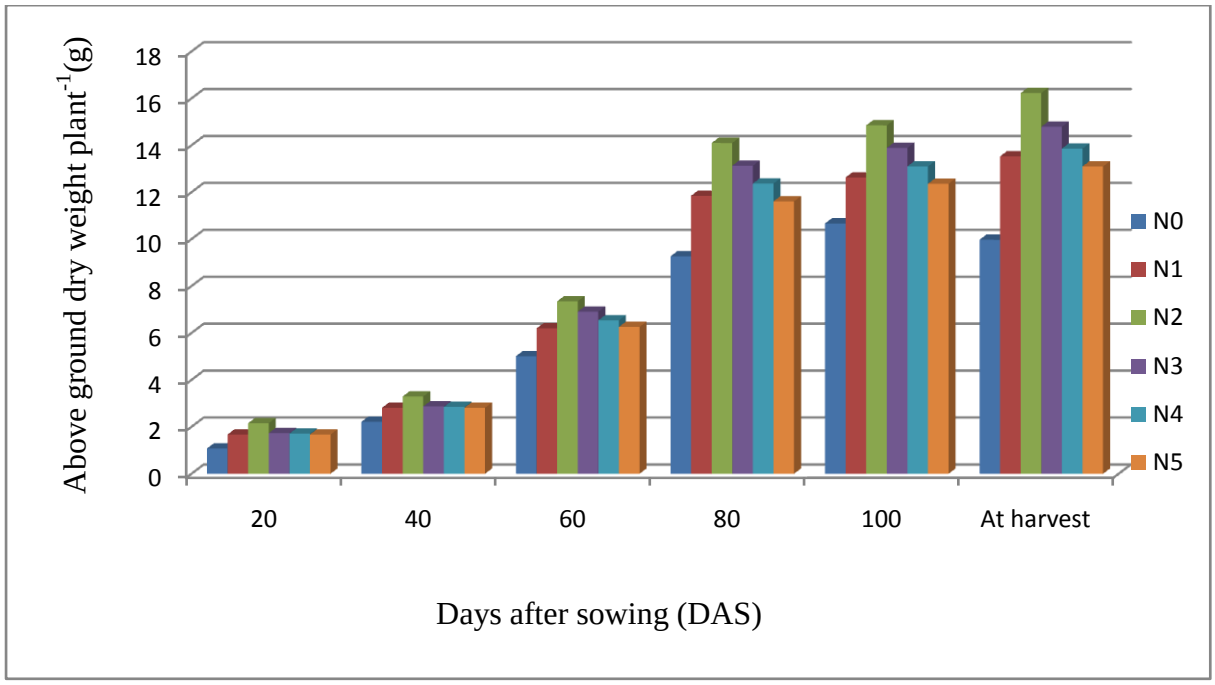
V_1= BARI Musar 4, V_2= BARI Musar 5, V_3= BARI Musar 6

Figure 5. Effect of varieties on above ground dry weight plant^{-1} of lentil at different days after sowing ($LSD_{0.05}$ = 0.44, 0.50, 0.70, 1.18, 1.20, 1.22 at 20, 40, 60, 80, 100 DAS and harvest, respectively).

4.1.3.2 Effect of nitrogen management

Irrespective of treatment difference, the dry matter production in lentil was very slow up to 40 DAS. Then it increased progressively over time attaining the height at 80 DAS. Thereafter increased slowing up to harvest (Fig. 5). Significant variation was observed dry weight plant^{-1} due to different rate of nitrogen application and varieties at different days after sowing (Fig. 6). Results indicated that basal application of 40 kg N ha^{-1} showed the highest dry weight plant^{-1} and that was 2.15, 3.29, 7.35, 14.10, 14.85 and 16.23 g at 20, 40, 60, 80, 100 DAS and harvest, respectively. On the contrary, control treatment gave the lowest dry weight

plant^{-1} which was 1.08, 2.81, 5.01, 9.27, 9.97 and 10.67 g at 20, 40, 60, 80, 100 DAS and harvest, respectively. These findings are in agreement with those of Srivastava and Varma (1982), Santos *et al.* (1993), Chowdhury and Rosario (1992), Agbenin *et al.* (1991), and Raju and Varma (1984).



N_0 = Control (0 kg N ha^{-1})
N_1 = 20 kg N ha^{-1} as basal application
N_2 = 40 kg N ha^{-1} as basal application
N_3 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at branch initiation
N_4 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at flower initiation
N_5 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at pod initiation

Figure 6. Effect of management of nitrogen on above ground dry weight plant^{-1} of lentil at different days after sowing ($LSD_{0.05}$ = 0.03029, 0.03029, 0.2142, 0.3903, 0.3985 and 0.4316 g at 20, 40, 60, 80, 100 DAS and harvest, respectively).

4.1.3.3. Interaction effect of variety and nitrogen management

There was significant variation among the results from interaction effect of variety and nitrogen managements. Results obtained with the present experiment for dry weight plant^{-1} presented in Table 3 showed that the combination of variety and nitrogen management had significant effect on above ground dry weight at different growth stages of lentil.

At 20 DAS, the highest plant dry weight (2.26 g) was recorded from V_2N_2 (BARI Masur 5 + Basal application with 40 kg N ha^{-1}) which was found different from other combinations. The lowest plant dry weight (0.98 g) was noted in V_1N_0 (BARI Masur 4 + No fertilizer) which was significantly different from all other treatment combinations.

At 40 DAS, the highest plant dry weight (3.39 g) was noted from V_2N_2 (BARI Masur 5 + basal application with 40 kg N ha^{-1}) which was observed different from other combinations. The lowest plant dry weight (2.12 g) was noted in V_1N_0 (BARI Masur 5 + No fertilizer) which was significantly different from other combinations.

At 60 DAS, the highest plant dry weight (7.57 g) was recorded from V_2N_2 (BARI Masur 5 + Basal application with 40 kg N ha^{-1}) and it was closely followed by V_3N_2 (BARI Masur 6 + Basal application with 40 kg N ha^{-1}) (7.32 g). The lowest plant dry weight (4.68 g) was noted in V_1N_0 (BARI Masur 4 + No fertilizer) followed by V_3N_0 (BARI Masur 6 + No fertilizer) (5.02 g).

At 80 DAS, the highest plant dry weight (14.31 g) was noted from V_2N_2 (BARI Masur 5 + basal application with 40 kg N ha^{-1}) and it was statistically similar with V_1N_2 (BARI Masur 4 + basal application with 40 kg N ha^{-1}) (13.93 g) and V_3N_2 (BARI Masur 6 + basal application with 40 kg N ha^{-1}) (14.05 g). The lowest plant dry weight (8.46 g) was noted in V_1N_0 (BARI Masur 4 + no fertilizer) which was registered different from other combinations.

At 100 DAS, the highest plant dry weight (15.10 g) was observed from V_2N_2 (BARI Masur 5 + basal application with 40 kg N ha^{-1}) followed by V_1N_2 (BARI Masur 4 + basal application with 40 kg N ha^{-1}) (14.69 g) and V_3N_2 (BARI Masur 6 + basal application with 40 kg N ha^{-1}) (14.77 g). The lowest plant dry weight (9.17 g) was noted in V_1N_0 (BARI Masur 4 + no fertilizer) which was significantly different from other combinations.

At harvest, the highest plant dry weight (16.66 g) was recorded from V_2N_2 (BARI masur 5 + Basal application with 40 kg N ha^{-1}) and it was statistically identical with V_3N_2 (BARI masur 6 + basal application with 40 kg N ha^{-1}) (16.31 g). On the contrary, the lowest plant dry weight (9.96 g) was found from V_1N_0 which was statistically similar with V_3N_0 (BARI Masur 6 + no fertilizer) (10.69 g)

Table 3. Combined effect of varieties and management of nitrogen on above ground dry weight plant^{-1} of lentil at different days after sowing

Treatments	20 DAS	40 DAS	60 DAS	80 DAS	100 DAS	At harvest
V_1N_0	0.9833 j	2.123 j	4.680 j	8.457 i	9.167 i	9.957 l
V_1N_1	1.677 ef	2.817 ef	6.000 h	11.27 g	12.06 g	12.71 j
V_1N_2	2.097 b	3.237 b	7.160 b	13.93 ab	14.69 a-c	15.72 bc
V_1N_3	1.687 ef	2.827 ef	6.690 c-f	12.77 cd	13.51 de	14.37 d-f
V_1N_4	1.637 fg	2.777 fg	6.340 f-h	12.00 ef	12.73 fg	13.48 g-i
V_1N_5	1.603 g	2.743 g	6.067 h	11.44 fg	12.15 g	13.07 ij
V_2N_0	1.197 h	2.337 h	5.333 i	9.973 h	10.69 h	11.38 k
V_2N_1	1.683 ef	2.823 ef	6.650 d-f	12.83 cd	13.58 de	14.89 de
V_2N_2	2.257 a	3.397 a	7.573 a	14.31 a	15.10 a	16.66 a
V_2N_3	1.793 c	2.933 c	7.000 b-d	13.22 c	14.01 cd	14.99 cd
V_2N_4	1.747 cd	2.887 cd	6.770 c-e	12.74 cd	13.49 de	14.22 e-g
V_2N_5	1.727 de	2.867 de	6.320 f-h	11.81 e-g	12.57 fg	13.14 h-j
V_3N_0	1.047 i	2.187 i	5.023 ij	9.370 h	10.06 h	10.69 kl
V_3N_1	1.657 f	2.797 f	6.123 h	11.46 fg	12.24 g	12.98 ij
V_3N_2	2.107 b	3.247 b	7.323 ab	14.05 ab	14.77 ab	16.31 ab
V_3N_3	1.710 de	2.850 de	7.040 bc	13.40 bc	14.16 b-d	15.01 cd
V_3N_4	1.747 cd	2.887 cd	6.507 e-g	12.38 de	13.07 ef	13.88 f-h
V_3N_5	1.687 ef	2.827 ef	6.207 gh	11.58 fg	12.35 g	13.10 ij
$LSD_{0.05}$	0.05247	0.05247	0.371	0.6761	0.6902	0.7476
CV (%)	2.12	1.26	3.5	3.38	3.25	3.29

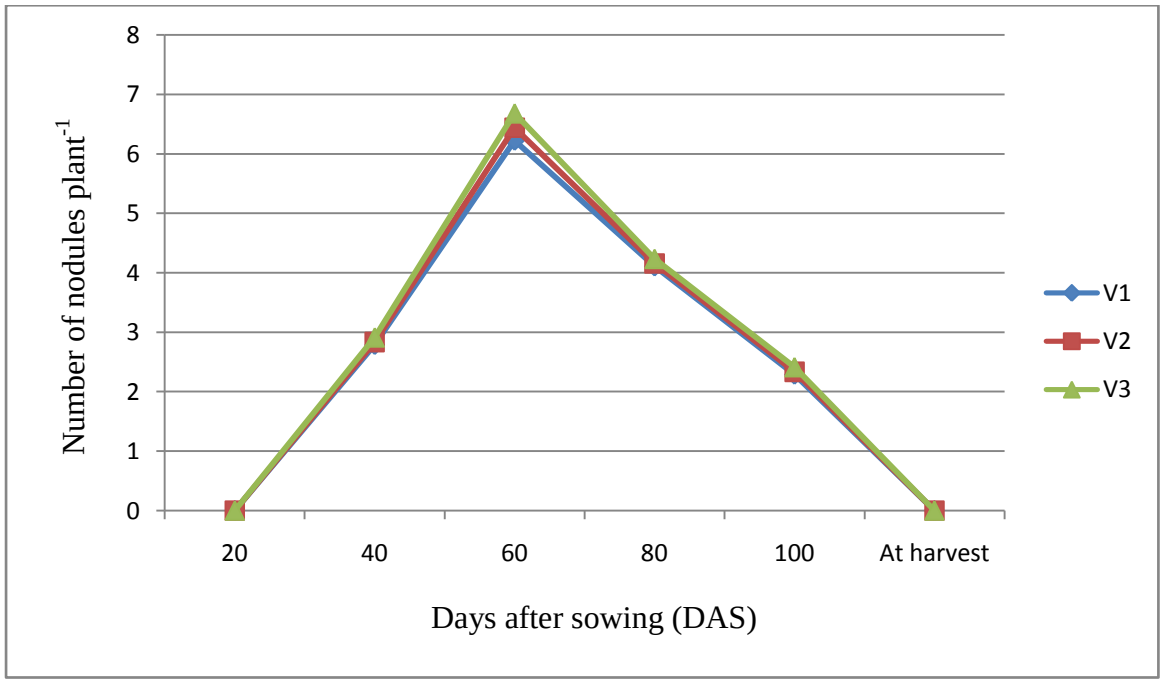
V_1 = BARI Masur 4
V_2 = BARI Masur 5
V_3 = BARI Masur 6

N_0 = Control (0 kg N ha^{-1})
N_1 = 20 kg N ha^{-1} as basal application
N_2 = 40 kg N ha^{-1} as basal application
N_3 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at branch initiation
N_4 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at flower initiation
N_5 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at pod initiation

4.1.4 Number of nodules plant^{-1}

4.1.3.1 Effect of variety

Irrespective of varietal differences in nodule started to appear after 20 DAS and had maximum value at 60 DAS and then declined sharply up to harvest (Fig. 7). Significant variation was observed among the varieties at different days after sowing (DAS). Results indicated that BARI Masur 6 showed the highest number of nodules plant^{-1} and that was 0, 2.911, 6.678, 4.231, 2.411 and 0 at 20, 40, 60, 80, 100 DAS and harvest, respectively. BARI Masur 4 gave the lowest number of nodule plant^{-1} which was 0, 2.787, 6.221, 4.107, 2.287 and 0 at 20, 40, 60, 80, 100 DAS and harvest, respectively.



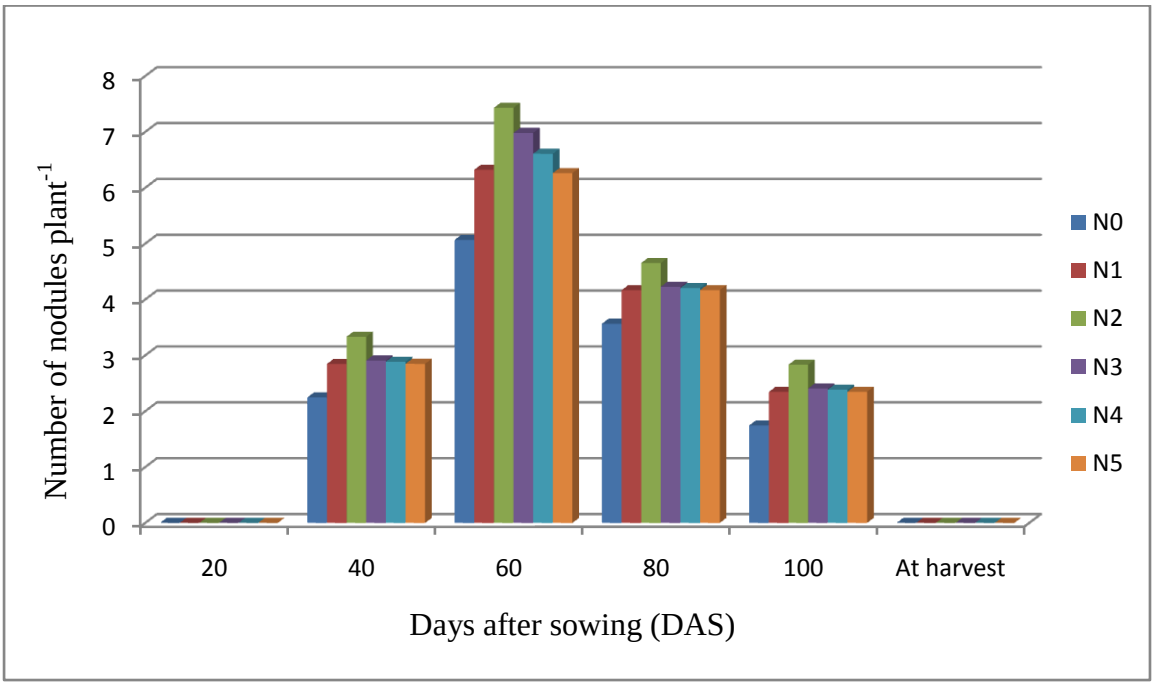
V_1= BARI Musar 4, V_2= BARI Musar 5, V_3= BARI Musar 6

Figure 7. Effect of varieties on nodules plant^{-1} of lentil at different days after sowing ($LSD_{0.05}$ = 0, 0.02142, 0.153, 0.02142, 0.02142 and 0 at 20, 40, 60, 80, 100 DAS and harvest, respectively).

4.1.3.2 Effect of nitrogen management

Significant variation was observed when considering number of nodule plant^{-1} by different rate of nitrogen application at different days after sowing (Fig. 8). Results indicated that basal application of 40 kg N ha^{-1} showed the highest number of nodule plant^{-1} and that was 0, 3.333, 7.431, 4.653, 2.833 and 0 at 20, 40, 60, 80, 100 DAS and at harvest respectively.

Control treatment gave the lowest dry weight plant^{-1} which was 0, 2.246, 5.066, 3.566, 1.746 and 0 at 20, 40, 60, 80, 100 DAS and harvest, respectively.



N_0 = Control (0 kg N ha^{-1})
N_1 = 20 kg N ha^{-1} as basal application
N_2 = 40 kg N ha^{-1} as basal application
N_3 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at branch initiation
N_4 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at flower initiation
N_5 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at pod initiation

Figure 8. Effect of management of nitrogen on number of nodule plant^{-1} of lentil at different days after sowing ($LSD_{0.05}$ = 0, 0.03029, 0.2163, 0.03029, 0.03029 and 0 at 20, 40, 60, 80, 100 DAS and harvest, respectively).

4.1.3.3 Interaction effect of variety and nitrogen management

Combination of variety and nitrogen levels had significant effect at different growth stages of lentil (Table 4).

At 40 DAS, the maximum number of nodule plant^{-1} (3.44) was recorded from V_3N_2 (BARI Masur 6 + basal application with 40 kg N ha^{-1}) which was found different from other combinations. The minimum number of nodule plant^{-1} (2.15) was noted in V_1N_0 (BARI Masur 4 + no fertilizer) which was significantly different from other combinations.

At 60 DAS, the maximum number of nodule plant^{-1} (7.65) was obtained from V_3N_2 (BARI Masur 6 + basal application with 40 kg N ha^{-1}) which was followed by V_2N_2 (BARI Masur 5 + basal application with 40 kg N ha^{-1}) (7.40). The minimum number of nodule plant^{-1} (4.73) was noted in V_1N_0 (BARI Masur 4 + no fertilizer) and it was statistically identical with V_2N_0 (BARI Masur 5 + No fertilizer) (5.07).

At 80 DAS, the maximum number of nodule plant^{-1} (4.76) was recorded from V_3N_2 (BARI Masur 6 + basal application with 40 kg N ha^{-1}) which was significantly different from other combinations. The minimum number of nodule plant^{-1} (3.47) was noted in V_1N_0 (BARI Masur 4 + no fertilizer) which was registered different from other combinations.

At 100 DAS, the maximum number of nodule plant^{-1} (2.94) was recorded from V_3N_2 (BARI Masur 6 + basal application with 40 kg N ha^{-1}) which was noted different from other combinations. On contrary, the minimum number of nodule plant^{-1} (1.65) was noted in V_1N_0 (BARI Masur 4 + no fertilizer) which was observed different from other combinations.

Table 4. Interaction effect of varieties and nitrogen management on nodules plant^{-1} of lentil at different days after sowing

Treatments	20 DAS	40 DAS	60 DAS	80 DAS	100 DAS	At harvest
V_1N_0	0	2.153 l	4.730 j	3.473 l	1.653 l	0
V_1N_1	0	2.85 f-h	6.060 h	4.17 f-h	2.350 f-h	0
V_1N_2	0	3.277 b	7.237 b	4.597 b	2.777 b	0
V_1N_3	0	2.86 e-g	6.76 c-f	4.18 e-g	2.360 e-g	0
V_1N_4	0	2.807 hi	6.407 f-h	4.127 hi	2.307 hi	0
V_1N_5	0	2.777 i	6.130 h	4.097 i	2.277 i	0
V_2N_0	0	2.217 k	5.073 ij	3.537 k	1.717 k	0
V_2N_1	0	2.83 g-i	6.187 h	4.147g-i	2.327 g-i	0
V_2N_2	0	3.287 b	7.403 ab	4.607 b	2.787 b	0
V_2N_3	0	2.890 d-f	7.113 bc	4.210 d-f	2.390 d-f	0
V_2N_4	0	2.927 cd	6.577 e-g	4.247 cd	2.427 cd	0
V_2N_5	0	2.860 e-g	6.273 gh	4.180 e-g	2.360 e-g	0
V_3N_0	0	2.367 j	5.393 i	3.68 j	1.867 j	0
V_3N_1	0	2.860 e-g	6.720 d-f	4.180 e-g	2.360 e-g	0
V_3N_2	0	3.437 a	7.653 a	4.757 a	2.937 a	0
V_3N_3	0	2.973 c	7.073 b-d	4.293 c	2.473 c	0
V_3N_4	0	2.923 cd	6.840 c-e	4.243 cd	2.423 cd	0
V_3N_5	0	2.907 de	6.387 f-h	4.227 de	2.407 de	0
$LSD_{0.05}$	0	0.05247	0.3747	0.05247	0.05247	0
CV(%)	0	1.32	3.51	0.9	1.6	0

V_1 = BARI Masur 4
V_2 = BARI Masur 5
V_3 = BARI Masur 6

N_0 = Control (0 kg N ha^{-1})
N_1 = 20 kg N ha^{-1} as basal application
N_2 = 40 kg N ha^{-1} as basal application
N_3 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at branch initiation
N_4 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at flower initiation
N_5 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at pod initiation

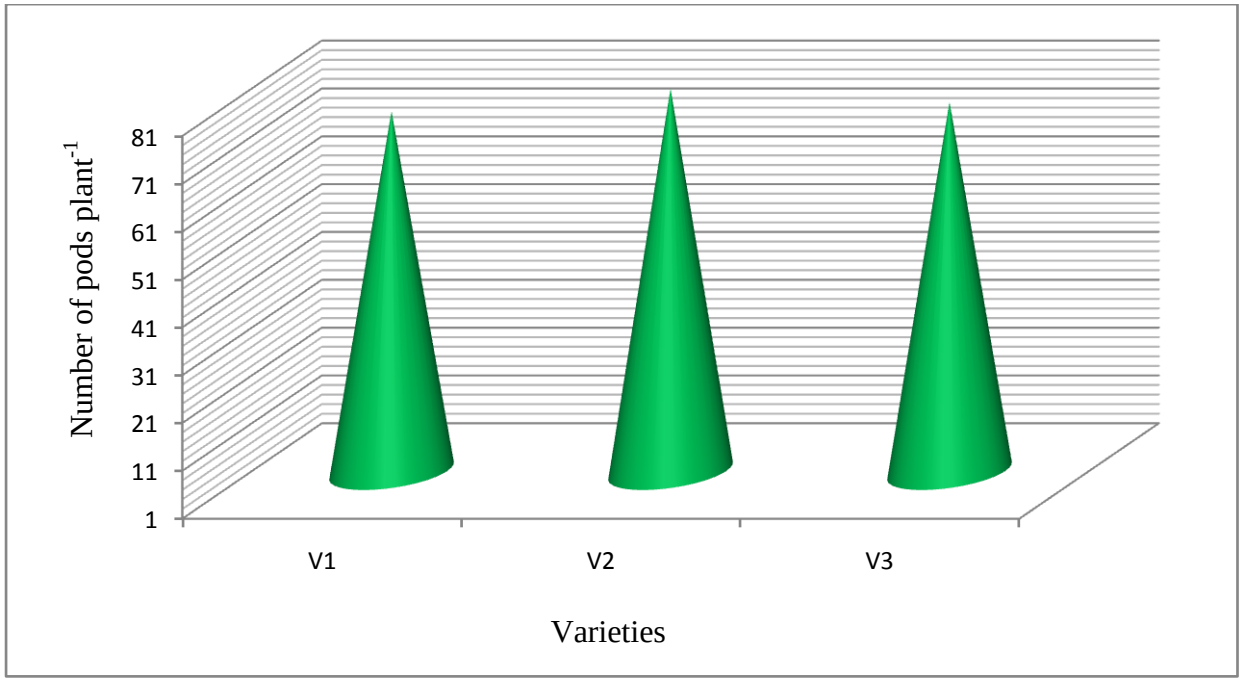
4.2 **Yield attributes**

The response of yield attributes, pods plant^{-1}, number of seeds pod^{-1} and 1000 seed weight of lentil were found statistically significant due to varieties on N management (Figures 9, 10, 11, 12, 13, 14 and Table 5).

4.2.1 Pods plant^{-1}

4.2.1.1 Effect of variety

Number of pods plant^{-1} is one of the most important yield contributing characters in lentil. The number of pods plant^{-1} was significantly affected by different management of nitrogen fertilizers (Fig. 9). The highest number of pods plant^{-1} (80.03) was recorded in V_2 (BARI Masur 5) which was significantly different from other varieties. The lowest number of pods plant^{-1} (70.37) was recorded in V_1 (BARI Masur 4). Variety BARI Masur 5 gave 13.73% higher pods plant^{-1} than BARI Masur 4.



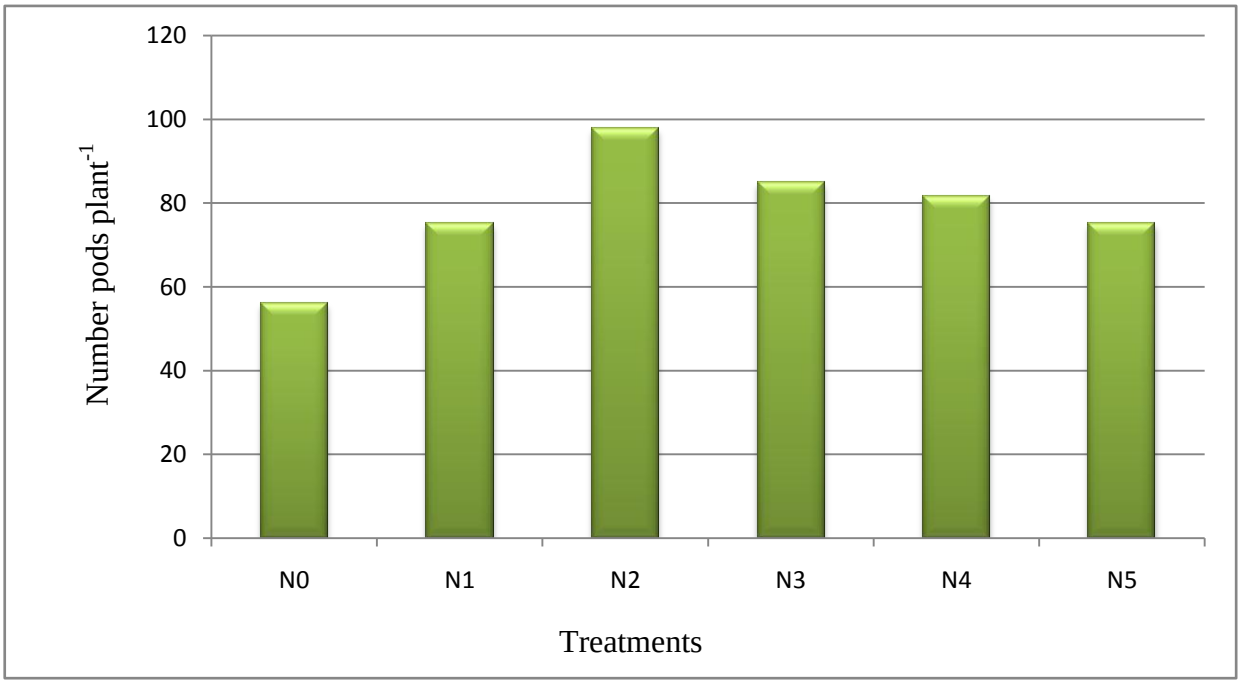
V_1= BARI Musar 4, V_2= BARI Musar 5, V_3= BARI Musar 6

Figure 9. Effect of varieties on pods plant^{-1} of lentil ($LSD_{0.05}$ = 3.891).

4.2.1.2 Effect of Nitrogen management

Significant variation was evident in case of number of pods plant^{-1} with different nitrogen management (Fig. 10). Application of 40 kg N ha^{-1} as basal (N_2) showed the highest number of pods plant^{-1} (97.89). But split application of nitrogen could not increase number of pods

plant^{-1}. The lowest number of pods plant^{-1} (56.03) was obtained from N_0 (No fertilizer). From the study it was observed that 74.71% higher pods plant^{-1} was given by N_2 (Basal application with 40 kg N ha^{-1}) over N_0 (No fertilizer) treatment.



N_0 = Control (0 kg N ha^{-1})
N_1 = 20 kg N ha^{-1} as basal application
N_2 = 40 kg N ha^{-1} as basal application
N_3 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at branch initiation
N_4 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at flower initiation
N_5 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at pod initiation

Figure 10. Effect of management of nitrogen on pods plant^{-1} of lentil ($LSD_{0.05}$ = 5.503).

4.2.1.3 Combined effect of variety and nitrogen management

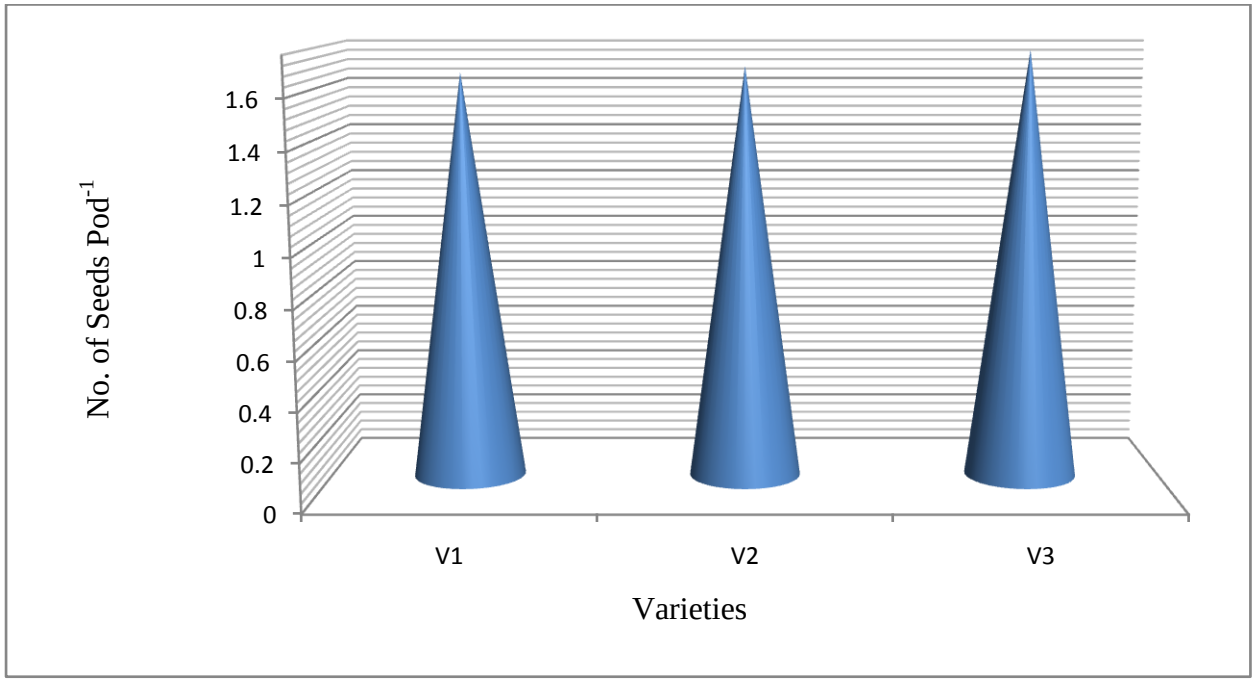
Pods plant^{-1} is an important yield contributing character which has a great effect on final yield. It was observed that variety and nitrogen management showed significant effect on pods plant^{-1} (Table 5). It was found that V_2N_2 (BARI Masur 5 + basal application of 40 kg N ha^{-1}) supported plant to produce maximum pods plant^{-1} (102.3) which was statistically similar with V_3N_2 (BARI Masur 6 + basal application of 40 kg N ha^{-1}) (97.89). The lowest number of pods plant^{-1} (54.33) was given by the combination of V_1N_0 (BARI Masur 4 + no fertilizer) and it was statistically similar with V_2N_0 (BARI Masur 5 + no fertilizer) and V_3N_0 (BARI

Masur 6 + no fertilizer). It was noted that V_2N_2 (BARI Masur 5 + Basal application of 40 kg N ha^{-1}) produced 87.85% higher pods $plant^{-1}$ than V_1N_0 (BARI Masur 4 + no fertilizer).

4.2.2 Seeds pod^{-1}

4.2.2.1 Effect of variety

Different varieties had significant effect on number of seeds pod^{-1} of lentil (Fig. 11). It was found that V_3 (BARI Masur 6) produced maximum number of seeds pod^{-1} (1.75) which was significantly different from V_1 (BARI Masur 4) and V_2 (BARI Masur 5). Variety BARI Masur 4) gave minimum number of seeds pod^{-1} (1.66) followed by V_2 (BARI Masur 5) (1.69). BARI Masur 6 gave 5.42% higher seeds pod^{-1} than BARI Masur 4.



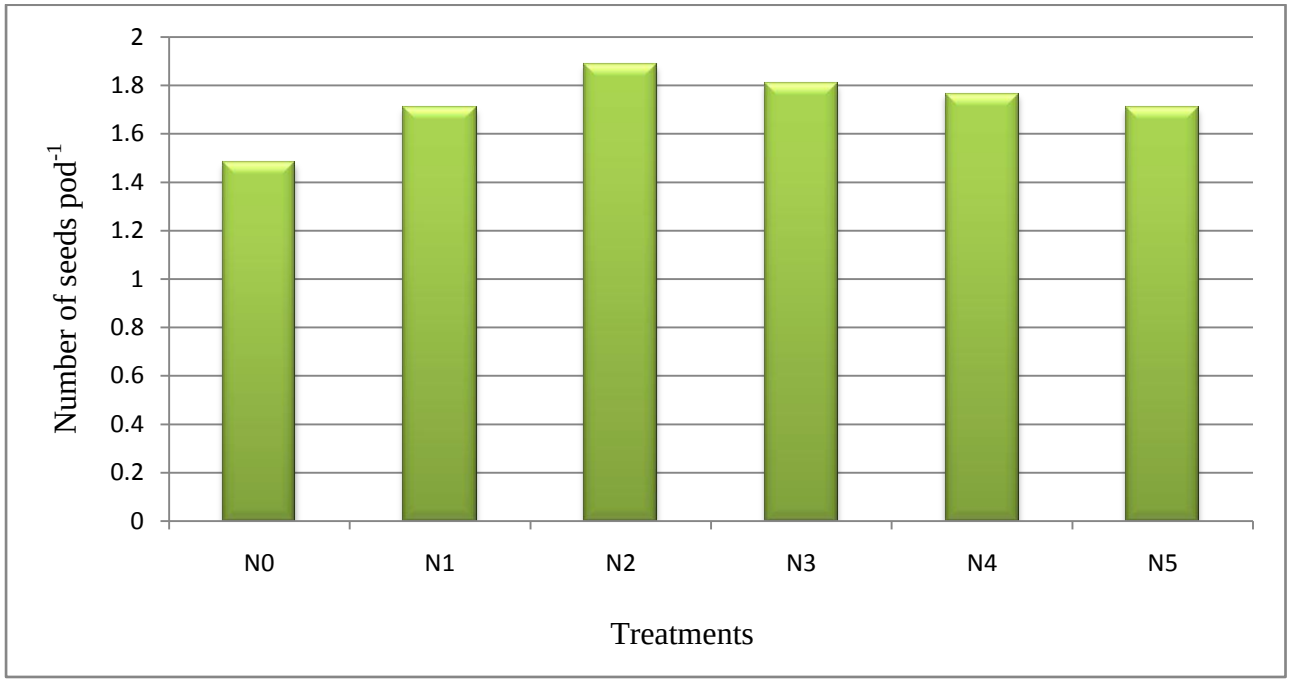
V_1= BARI Musar 4, V_2= BARI Musar 5, V_3= BARI Musar 6

Figure 11. Effect of varieties on seeds pod^{-1} of lentil ($LSD_{0.05}$ = 0.02142).

4.2.2.2 Effect of nitrogen management

Nitrogen management had significant effect on number of seeds pod^{-1} (Fig. 12). It was found that N_2 (Basal application of 40 kg N ha^{-1}) gave the maximum number of seeds pod^{-1} (1.886) which was statistically different from others. It was noted that N_0 (No fertilizer) gave the minimum number of seeds pod^{-1} (1.481) and it found statistically different from others. Number of seed pod^{-1} (1.707) obtained by N_1 (Basal application of 20 kg N ha^{-1}) (1.707) and N_5 (1.709) with 20 kg N ha^{-1} as basal and additional 20 kg N ha^{-1} at pod initiation stage was

statistically same. It was noted that N_2 (Basal application of 40 kg N ha^{-1}) gave 27.35% higher result over N_0 (No fertilizer) treatment.



N_0 = Control (0 kg N ha^{-1})
N_1 = 20 kg N ha^{-1} as basal application
N_2 = 40 kg N ha^{-1} as basal application
N_3 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at branch initiation
N_4 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at flower initiation
N_5 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at pod initiation

Figure 12. Effect of management of nitrogen on seeds pod^{-1} of lentil ($LSD_{0.05}$ = 0.03029).

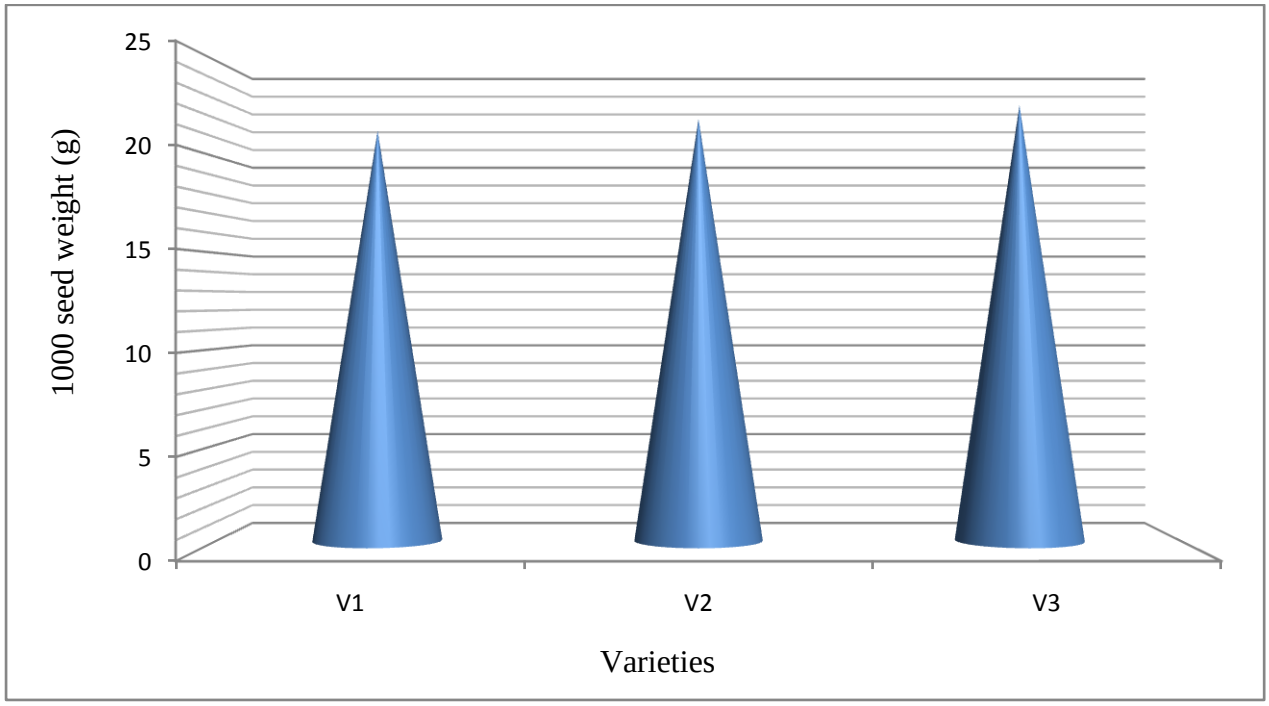
4.2.2.3 Interaction effect of variety and nitrogen management

It was observed from the study that treatment combination of variety and nitrogen had significant effect on number of seeds pod^{-1} (Table 5). The combination of basal application of 40 kg N ha^{-1} on BARI masur6 (V_3N_2) supported plant to produce maximum number of seeds pod^{-1} (1.90). The lowest number of seeds pod^{-1} (1.437) was achieved by control treatment (V_1N_0). The results from all other treatments showed significantly different results compared to highest and lowest value regarding number of seeds pod^{-1}.

4.2.3 1000- seed weight

4.2.3.1 Effect of variety

Different varieties had significant effect on 1000- seed weight of lentil (Fig. 13). Variety BARI Masur 6 produced the highest seed weight (22.72 g) which was statistically similar with BARI Masur 5 (22.00 g). On the contrary, BARI Masur 4 gave the lowest seed weight (21.38 g) and it was statistically similar with BARI Masur 5 (22.00 g). It was found that V_3 (BARI Masur 6) gave 6.27% higher 1000- seed weight over V_1 (BARI Masur 4).

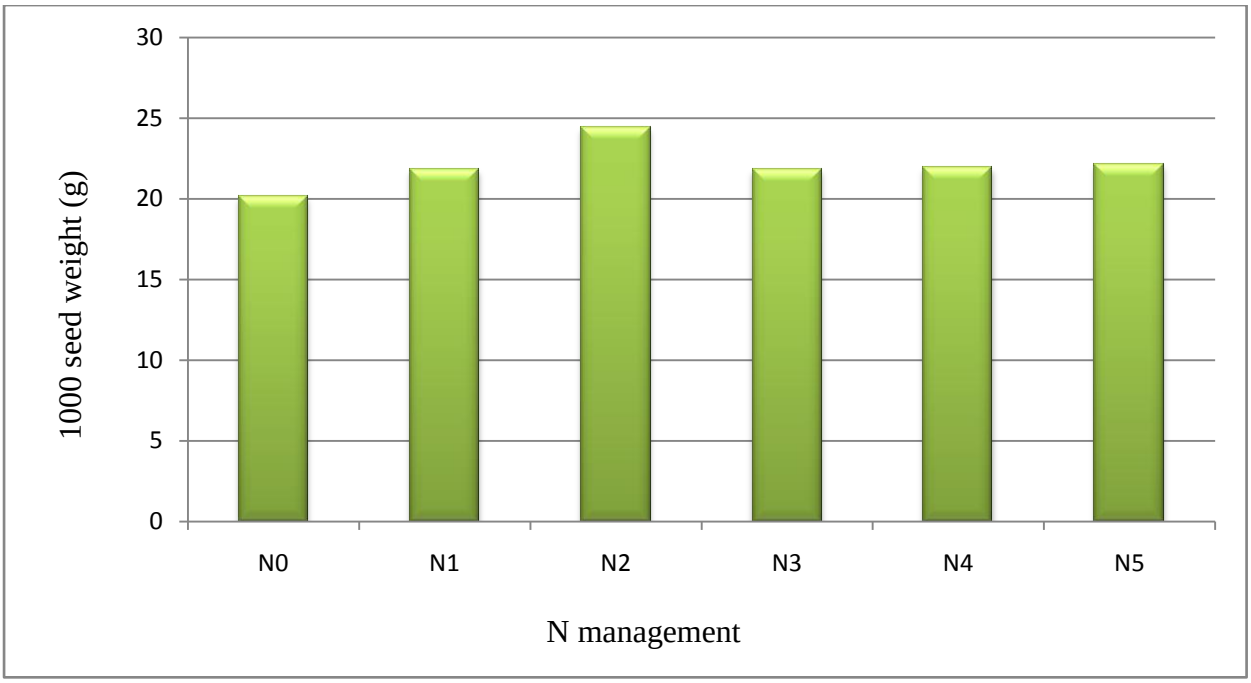


V_1= BARI Musar 4, V_2= BARI Musar 5, V_3= BARI Musar 6

Figure 13. Effect of varieties on 1000- seed weight of lentil ($LSD_{0.05}$ = 1.208).

4.2.3.2 Effect of nitrogen management

Nitrogen management levels had significant effect on 1000-seed weight. It was found that, N_2 (Basal application of 40 kg N ha^{-1}) gave the highest 1000-seed weight (24.43 g) which was statistically different from others. Plant grown without nitrogen (No fertilizer) gave the lowest 1000-seed weight (20.13 g) which was registered different from others.



N_0 = Control (0 kg N ha^{-1})
N_1 = 20 kg N ha^{-1} as basal application
N_2 = 40 kg N ha^{-1} as basal application
N_3 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at branch initiation
N_4 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at flower initiation
N_5 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at pod initiation

Figure 14. Effect of nitrogen management on 1000-seed weight of lentil ($LSD_{0.05}$ = 1.708).

4.2.3.3 Combined effect of variety and nitrogen management

The 1000 seed weight is an important yield contributing character which has a great effect on yield. Interaction of variety and nitrogen management had significant effect on 1000- seed weight under the present study (Table 5). It was noted that, V_3N_2 (BARI Masur 6 + basal application with 40 kg N ha^{-1}) gave the highest 1000- seed weight (25.18 g) which was statistically similar with V_1N_2 (BARI Masur 4 + basal application with 40 kg N ha^{-1}) (22.80 g), V_2N_4 (BARI Masur 5 + application as basal with 50% (20 kg) N ha^{-1} and 50% (20 kg) N ha^{-1} at flower initiation stage) (22.62 g)), V_2N_5 (BARI Masur 5 + application as basal with 50% (20 kg) N ha^{-1} and 50% (20 kg) N ha^{-1} at pod initiation stage) (22.62 g)) and V_3N_2 (BARI Masur 6 + basal application with 40 kg N ha^{-1}) (25.18 g). On the other hand, V_1N_0 (BARI Masur 4 + no fertilizer) gave the lowest 1000-seed weight (18.07 g) which was

statistically similar with V_2N_3 (BARI Masur 4 + application as basal with 20 kg N ha^{-1} and additional 20 kg N ha^{-1} at branch initiation stage) (20.95 g).

Table 5. Effect of varieties and nitrogen management on pods $plant^{-1}$, seeds pod^{-1} and 1000- seed weight of lentil

Treatments	No. of pods $plant^{-1}$	No. of seeds pod^{-1}	1000- seed weight (g)
V_1N_0	54.33 i	1.437 l	18.07 d
V_1N_1	73.01 h	1.673 j	22.20 bc
V_1N_2	93.33 bc	1.877 ab	22.80 ab
V_1N_3	83.56 de	1.800 cd	22.14 bc
V_1N_4	79.33 e-g	1.770 d-g	21.08 bc
V_1N_5	73.78 gh	1.677 ij	22.01 bc
V_2N_0	58.78 i	1.490 k	19.34 cd
V_2N_1	76.89 f-h	1.727 g-i	21.25 bc
V_2N_2	102.3 a	1.880 ab	25.31 a
V_2N_3	87.44 cd	1.787 c-e	20.95 b-d
V_2N_4	83.67 de	1.743 e-h	22.62 ab
V_2N_5	76.67 f-h	1.710 h-j	22.54 ab
V_3N_0	55.11 i	1.517 k	22.98 ab
V_3N_1	75.56 f-h	1.727 g-i	21.93 bc
V_3N_2	97.89 ab	1.900 a	25.18 a
V_3N_3	84.00 de	1.833 bc	22.36 ab
V_3N_4	81.45 d-f	1.783 c-f	22.03 bc
V_3N_5	75.00 gh	1.733 f-h	21.80 bc
$LSD_{0.05}$	6.164	0.05247	2.959
CV(%)	4.75	1.95	8.1

V_1 = BARI Masur 4
V_2 = BARI Masur 5
V_3 = BARI Masur 6

N_0 = Control (0 kg N ha^{-1})
N_1 = 20 kg N ha^{-1} as basal application
N_2 = 40 kg N ha^{-1} as basal application
N_3 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at branch initiation
N_4 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at flower initiation
N_5 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at pod initiation

4.3 Yield parameters

4.3.1 Seed yield

4.3.1.1 Effect of variety

Significant variation was found in seed yield among the varieties (Table 6). Variety BARI Masur 5 produced the highest seed yield (1770 kg ha^{-1}) which was significantly different from other varieties. On the contrary, V_1 (BARI Masur 4) gave the lowest seed yield (1609 kg ha^{-1}) and it was statistically similar with V_2 (BARI Masur 5) (1770.27 kg ha^{-1}). It was observed that V_2 (BARI Masur 5) gave 10.03% higher yield than V_1 (BARI Masur 4).

4.3.1.2 Effect of nitrogen management

Significant variations due to N management were found in respect of seed yield (Table 6). It was found that N_2 (Basal application with 40 kg N ha^{-1}) gave the highest seed yield (2088 kg ha^{-1}) which was significantly different from all other treatments. On the other hand, N_0 (No fertilizer) gave the lowest seed yield (1047 kg ha^{-1}) which was significantly different from other treatments. It was found that 99.48% higher yield was obtained by N_2 (Basal application with 40 kg N ha^{-1}) over N_0 (No fertilizer).

4.3.1.3 Combined effect of variety and nitrogen management

Combination of variety and nitrogen management showed significant influence on seed yield (Table 6). It was found that, V_2N_2 (BARI Masur 4 + basal application with 40 kg N ha^{-1}) gave the highest seed yield (2164 kg ha^{-1}) and it was statistically similar with V_1N_2 (BARI Masur 4 + Basal application with 40 kg N ha^{-1}) (2015 kg ha^{-1}) and V_3N_2 (BARI Masur 6 + basal application with 40 kg N ha^{-1}) (2084 kg ha^{-1}) and V_2N_1 (BARI Masur 5 + basal application with 20 kg N ha^{-1}). On the contrary, it was noted that, V_1N_0 (BARI Masur 4 + no fertilizer) gave the lowest seed yield (903 kg ha^{-1}) which was statistically similar with V_3N_0 (BARI Masur 6 + no fertilizer) (1030.1 kg ha^{-1}). It was found that 139.65% higher yield was noted from V_2N_2 (BARI Masur 4 + basal application with 40 kg N ha^{-1}) over V_1N_0 (BARI Masur 4 + no fertilizer).

4.3.2 Stover yield

4.3.2.1 Effect of variety

Stover yield was found to be significant among different varieties (Table 6). From the study, it was revealed that, V_2 (The BARI Masur 5) produced the highest stover yield (2921 kg ha^{-1}) which was statistically similar with V_2 (The BARI Masur 5) (2889 kg ha^{-1}). Variety BARI Masur 4 gave the lowest stover yield (2755 kg ha^{-1}) and it was significantly different from other varieties.

4.3.2.2 Effect of nitrogen management

Significant variation due to different management of nitrogen was found in respect of stover yield (Table 6). Application of 40 kg N ha^{-1}as basal N_2 treatment gave the highest stover yield (3270 kg ha^{-1}) which was significantly different from all other treatments. On the contrary, N_0 (No fertilizer) gave the lowest stover yield (2478 kg ha^{-1}) it was statistically different from other treatments. Treatments N_1 and N_5 gave statistically identical stover yield.

4.3.2.3 Combined effect of variety and nitrogen management

Combination of variety and nitrogen management showed significant differences for stover yield (Table 6). Combination of V_2N_2 (BARI Masur 5 + basal application with 40 kg N ha^{-1}) gave the highest stover yield (3301 kg ha^{-1}) and it was statistically similar with V_1N_2 (BARI Masur 4 + basal application with 40 kg N ha^{-1}) (3174.53 kg ha^{-1}), V_3N_2 (BARI Masur 6 + basal application with 40 kg N ha^{-1}) (3301.2 kg ha^{-1}) and V_3N_3 (BARI Masur 6 + application as basal with 50% (20 kg) N ha^{-1} and 50% (20 kg) N ha^{-1} at branch initiation stage) (3133 kg ha^{-1}). On the contrary, V_1N_0 (BARI Masur 4 + no fertilizer) gave the lowest stover production (2385 kg ha^{-1}) which was statistically similar with V_2N_0 (BARI Masur 5 + no fertilizer) (2549 kg ha^{-1}) and V_3N_0 (BARI Masur 6 + no fertilizer) (2500.3 kg ha^{-1}).

4.3.3 Biological yield

4.3.3.1 Effect of variety

Biological yield was found significant in respect of variety (Table 6). The results revealed that V_2 (BARI masur5) produced the highest biological yield (4692 kg ha^{-1}) which was significantly different from other varieties. Variety BARI Masur 4 gave the lowest biological yield (4364 kg ha^{-1}) and it was significantly different from other varieties.

4.3.3.2 Effect of nitrogen management

Significant variation in biological yield of lentil was found in case of different management of nitrogen (Table 6). It was found that, N_1 (basal application with 40 kg N ha^{-1}) gave the highest biological yield (4692 kg ha^{-1}) which was significantly different from other treatments. The lowest biological yield (3525 kg ha^{-1}) was obtained from control treatment and it was statistically different from other treatments. The higher biological yield with higher rate of nitrogen application might be due to cause of higher vegetative growth with higher nitrogen application.

4.3.3.3 Combined effect of variety and nitrogen management

Interaction or combination of variety and N management showed significant influence on biological yield (Table 6). The highest biological yield (5499 kg ha^{-1}) was achieved by V_2N_2 (BARI Masur 5 + basal application with 40 kg N ha^{-1}) and it was statistically similar with V_3N_2 (BARI Masur 6 + basal application with 40 kg N ha^{-1}) (5385 kg ha^{-1}). Combination of V_1N_0 (BARI Masur 4 + no fertilizer) gave the lowest biological yield (3288 kg ha^{-1}) which was statistically similar with V_3N_0 (BARI Masur 6 + no fertilizer).

4.3.4 Harvest index

4.3.4.1 Effect of variety

Harvest index is an important measurement of yield performance. The harvest index was found significant among the varieties (Table 6). The highest harvest index (37.459 %) was recorded for V_2 (BARI Masur 5) which was statistically similar with V_1 (BARI Masur 4). The lowest harvest index (35.613 %) was recorded from V_3 (BARI Masur 6).

4.3.4.2 Effect of nitrogen management

There were no significant variations observed for harvest index due to different nitrogen management except control treatment (Table 6). Among the treatments, N_2 (Basal application with 40 kg N ha^{-1}) gave the highest harvest index (38.98 %) which was followed by other treatments except N_0 (No fertilizer). The lowest harvest index (29.58 %) was obtained from N_0 (No fertilizer) (29.57%) which was significantly different from other treatments. Saxena *et al.* (1996) and Tomar *et al.* (1999) observed that harvest index increased significantly with increased N_2 application up to a certain level/ limit.

4.3.4.3 Combined effect of variety and nitrogen

Combination of variety and nitrogen management may be important determining factor for harvest index. Lentil varieties and N management showed significant differences for harvest index (Table 6). The highest harvest index (39.77 %) was obtained from V_2N_2 (BARI Masur 5 + basal application with 40 kg N ha^{-1}) combination. The lowest harvest index (27.43 %) was given by V_1N_0 (BARI Masur 4 + no fertilizer) which was statistically similar with V_3N_0 (BARI Masur 6 + no fertilizer).

Table 6. The effect of different varieties, nitrogen management and their combination on the yields and harvest index

Treatments	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
Effect of variety				
V_1	1609 b	2755 b	4364 c	36.399 ab
V_2	1770 a	2921 a	4692 a	37.459 a
V_3	1621 b	2889 a	4510 b	35.613 b
$LSD_{0.05}$	93.76	84	100.8	1.496
Effect of nitrogen				
N_0	1047 d	2478 e	3525 e	29.576 b
N_1	1711 bc	2754 cd	4465 cd	37.832 a
N_2	2088 a	3270 a	5358 a	38.977 a
N_3	1835 b	3048 b	4883 b	37.598 a
N_4	1704 bc	2872 c	4576 c	37.246 a
N_5	1618 c	2707 d	4326 d	37.416 a
$LSD_{0.05}$	132.60	118.80	142.50	2.116
Interaction effect of variety and nitrogen				
V_1N_0	903 h	2385 i	3288 l	27.43 c
V_1N_1	1588 f	2606 f-h	4195 j	37.87 a
V_1N_2	2015 a-c	3175 ab	5190 bc	38.83 a
V_1N_3	1822 c-e	2922 de	4744 d-f	38.40 a
V_1N_4	1693 ef	2758 ef	4451 g-i	38.03 a
V_1N_5	1633 ef	2683 f-h	4316 ij	37.83 a
V_2N_0	1206 g	2550 g-i	3756 k	32.10 b
V_2N_1	1970 a-d	2946 c-e	4916 de	39.40 a
V_2N_2	2164 a	3335 a	5499 a	39.77 a
V_2N_3	1860 b-e	3090 b-d	4950 cd	37.62 a
V_2N_4	1763 d-f	2930 c-e	4693 e-g	37.60 a
V_2N_5	1657 ef	2679 f-h	4336 h-j	38.27 a
V_3N_0	1030 gh	2500 hi	3530 kl	29.19 bc
V_3N_1	1575 f	2710 fg	4286 ij	36.77 a
V_3N_2	2084 ab	3301 a	5385 ab	38.69 a
V_3N_3	1822 c-e	3133 a-c	4955 cd	36.77 a
V_3N_4	1654 ef	2760 c-e	4582 f-h	36.11 a
V_3N_5	1564 f	2928 ef	4324 ij	36.17 a
$LSD_{0.05}$	229.70	205.8	246.8	3.666
CV(%)	8.30	4.34	3.29	6.06

V_1 = BARI Masur 4
V_2 = BARI Masur 5
V_3 = BARI Masur 6

N_0 = Control (0 kg N ha^{-1})
N_1 = 20 kg N ha^{-1} as basal application
N_2 = 40 kg N ha^{-1} as basal application
N_3 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at branch initiation
N_4 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at flower initiation
N_5 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at pod initiation

CHAPTER V
SUMMARY AND CONCLUSION

An experiment was conducted at the Agronomy Farm of Sher-e-Bangla Agricultural University, Dhaka to evaluate the response of three lentil varieties to different nitrogen management. The experiment comprised of two factors; (A) Three varieties viz. V_1 (BARI masur4), V_2 (BARI masur5), and V_3 (BARI masur6). (B) six nitrogen managements viz. N_0 (0 kg N ha^{-1}), N_1 (Basal application with 20 kg N ha), N_2 (Basal application with 40 kg N ha) and N_3 (Application as basal with 20 kg N ha^{-1} and additional 20 kg N ha^{-1} at branch initiation stage) N_4 (Application as basal with 20 kg N ha^{-1} and additional 20 kg N ha^{-1} at flower initiation stage) N_5 (Application as basal with 20 kg N ha^{-1} and additional 20 kg N ha^{-1} at pod initiation stage).

The experiment was set up in Randomized Complete Block Design under factorial arrangement with three replications. There were 18 treatment combinations. The experimental plot was fertilized as per treatment with nitrogen, phosphorous, gypsum and MP fertilizers. Data on different growth and yield parameters were recorded and analyzed statistically.

Data were collected on plant height, branches $plant^{-1}$, above ground dry weight $plant^{-1}$, nodules $plant^{-1}$, number of pods $plant^{-1}$, 1000 seed weight (g), seed yield (Kg ha^{-1}), stover yield(Kg ha^{-1}), biological yield, and harvest index.

Plant height (cm), branches $plant^{-1}$ and above ground dry weight $plant^{-1}$(g) as influenced by varieties was highest with V_2 (BARI Musar 5) and the highest results were 28.83 cm, 16.85 and 14.21 g respectively at the time of harvest. Number of nodules $plant^{-1}$ was also influenced by variety. The highest nodules $plant^{-1}$ was obtained from BARI Musar 6 (6.221) at 60 DAS. Nitrogen managements showed the highest plant height (37.93 cm), branches $plant^{-1}$ (14.41), dry weight $plant^{-1}$ (16.23 g) and nodules $plant^{-1}$ (7.43) with N_2 (basal application of 40 kg N ha^{-1}). Control treatment with BARI Musa r4 showed the lowest results on growth parameters. Significant effect was also observed on plant height (cm), number of branches $plant^{-1}$ and dry weight $plant^{-1}$ by the combined effect of variety and nitrogen. The highest values were 39.33 cm, 22.11 and 16.66 g respectively which was achieved by V_2N_2 (Basal application

with 40 kg N ha^{-1} and BARI musar5) while V_1N_0 (BARI Musar 4 and 0 kg N ha^{-1}) showed the lowest values (22.89 cm, 10.00 and 9.957 g respectively).

Number of pods $plant^{-1}$, 1000- seed weight (g), and harvest index (%) were significantly affected by variety and nitrogen individually and/or their interaction. The V_2 (BARI Masur 5) showed the highest number of pods $plant^{-1}$(80.03), harvest index (33.87%) and the V_2 (BARI Masur 5) showed the highest 1000 seed weight (37.46 g). Basal application with 40 kg N ha^{-1} (N_2) showed the highest pods $plant^{-1}$ (97.89), 1000 seed weight (24.43 g) and harvest index (38.98 %). Treatment combined of V_2N_2 (Basal application of 40 Kg N ha^{-1} in BARI Masur 5) represented the highest pods $plant^{-1}$ (102.3), harvest index (39.77 %) and 1000 seed weight (25.18 g) by basal application with 40 kg N ha^{-1} in BARI masur6 (V_3N_2) and the lowest (54.33, 18.07 g and 27.43 %, respectively) from V_1N_0 (BARI Masur 4 and 0 kg N ha^{-1}).

Grain yield, stover yield and biological yield were significantly influenced by varieties, nitrogen and their interaction. BARI Masur 5 showed the highest grain yield (1770 kg ha^{-1}), stover yield (2921 kg ha^{-1}) and biological yield (4692 kg ha^{-1}) and the lowest from BARI Masur 4. Application at 40 kg N ha^{-1} (N_2) showed the highest grain yield (2088 kg ha^{-1}), stover yield (3270 kg ha^{-1}) and biological yield (5357 kg ha^{-1}). Control treatment, (no nitrogen application) showed the lowest values of yield parameters. Combined of V_2N_2 (Basal application of 40 Kg N ha^{-1} with BARI Masur 5) showed the highest grain yield (2164 kg ha^{-1}), stover yield (3335 kg ha^{-1}) and biological yield (5499 kg ha^{-1}). The lowest grain yield (903 kg ha^{-1}), stover yield (3288 kg ha^{-1}) and biological yield (2385 kg ha^{-1}) were obtained by combination of V_1N_0 (BARI Masur 4 and 0 kg N ha^{-1}).

It may be concluded that V_2 (BARI Masur 5) showed its yield potentiality when it was given 40 kg N ha^{-1} as basal application.

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

CHAPTER VI

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CHAPTER VII

Appendices

Appendix I. Monthly average air temperature, relative humidity and total rainfall of the experimental site during the period from October 2010 to March 2011

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

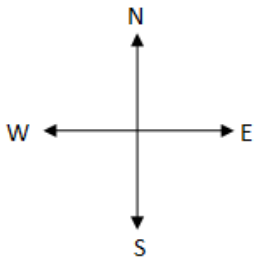
Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

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

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

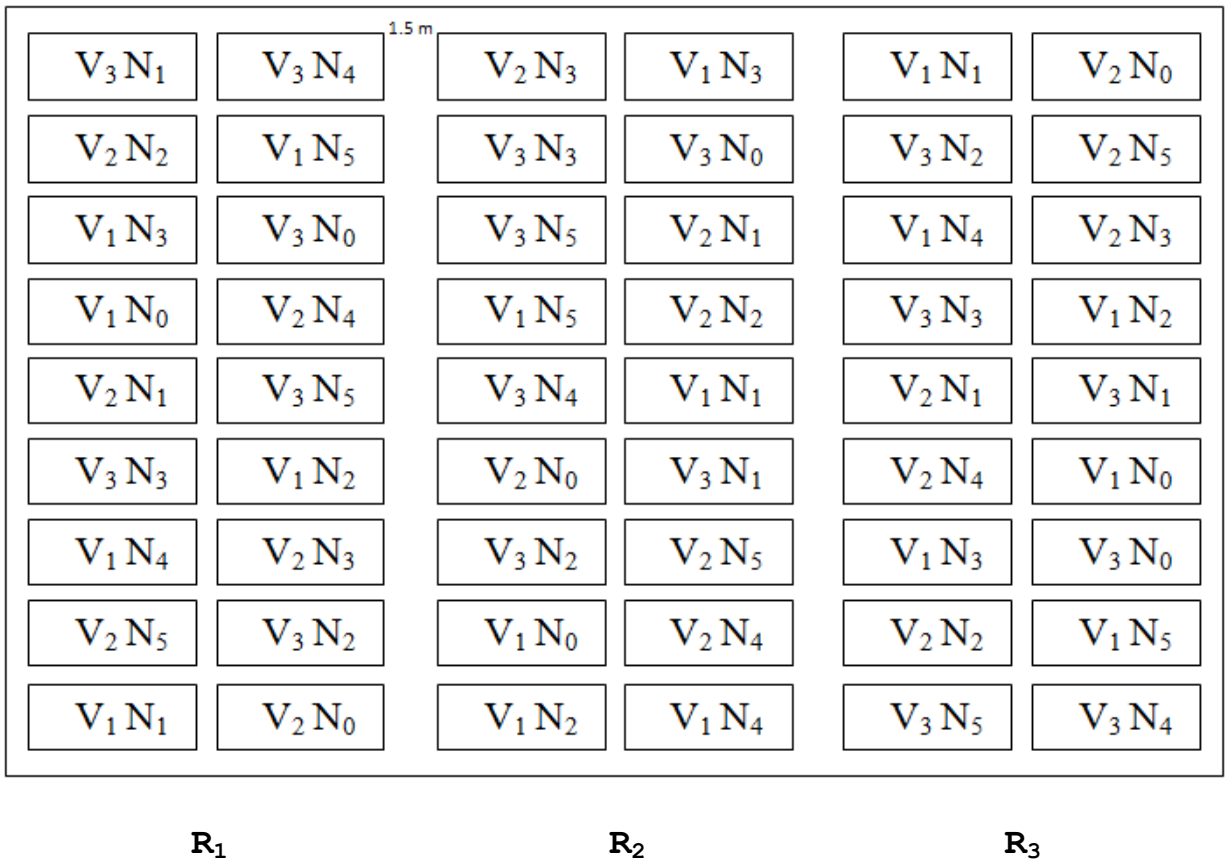
Source: Soil Resource Development Institute, Khamarbari, Dhaka.

Appendix.III:



V_1= BARI Masur 4
V_2= BARI Masur 5
V_3= BARI Masur 6

N_0 = Control (0 kg N ha^{-1})
N_1 = 20 kg N ha^{-1} as basal application
N_2 = 40 kg N ha^{-1} as basal application
N_3 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at branch initiation
N_4 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at flower initiation
N_5 = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} at pod initiation



R_1 **R_2** **R_3**

Fig.: Layout of the field

Appendix.IV(a): ANOVA table for plant height of lentil at 20 DAS

A N A L Y S I S O F V A R I A N C E T A B L E

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Replication	2	0.303	0.152	0.2883
Factor A	2	0.056	0.028	0.0533
Factor B	5	0.682	0.136	0.2593
AB	10	4.967	0.497	0.9447
Error	34	17.878	0.526	
Total	53	23.886		

Appendix.IV(b): ANOVA table for plant height of lentil at 40 DAS

A N A L Y S I S O F V A R I A N C E T A B L E

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Replication	2	0.364	0.182	0.1535
Factor A	2	9.498	4.749	4.0040
Factor B	5	3.437	0.687	0.5796
AB	10	30.099	3.010	2.5377
Error	34	40.326	1.186	
Total	53	83.724		

Appendix.IV(c): ANOVA table for plant height of lentil at 60 DAS

A N A L Y S I S O F V A R I A N C E T A B L E

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	
Replication	2	2.710	1.355	0.4823	
Factor A	2	15.162	7.581	2.6983	0.08
Factor B	5	29.287	5.857	2.0848	0.091
AB	10	26.341	2.634	0.9376	
Error	34	95.524	2.810		
Total	53	169.024			

Appendix.IV(d): ANOVA table for plant height of lentil at 80 DAS

A N A L Y S I S O F V A R I A N C E T A B L E

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Replication	2	6.733	3.367	0.5476
Factor A	2	56.398	28.199	4.5867
Factor B	5	20.223	4.045	0.6579
AB	10	50.230	5.023	0.8170
Error	34	209.032	6.148	
Total	53	342.615		

Appendix.IV(e): ANOVA table for plant height of lentil at 100 DAS

A N A L Y S I S O F V A R I A N C E T A B L E

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Replication	2	12.740	6.370	0.6676
Factor A	2	82.662	41.331	4.3314
Factor B	5	50.440	10.088	1.0572
AB	10	31.170	3.117	0.3267
Error	34	324.434	9.542	
Total	53	501.447		

Appendix.IV(f): ANOVA table for plant height of lentil at harvest

A N A L Y S I S O F V A R I A N C E T A B L E

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Replication	2	0.125	0.062	0.0047
Factor A	2	72.371	36.186	2.7180
Factor B	5	68.047	13.609	1.0222
AB	10	29.423	2.942	0.2210
Error	34	452.647	13.313	
Total	53	622.613		

Appendix.V(a): ANOVA table for branches plant^{-1} of lentil at 40 DAS

A N A L Y S I S O F V A R I A N C E T A B L E

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Replication	2	1.360	0.680	0.4429
Factor A	2	8.675	4.337	2.8258
Factor B	5	56.646	11.329	7.3809
AB	10	14.237	1.424	0.9275
Error	34	52.188	1.535	
Total	53	133.106		

Appendix.V(b): ANOVA table for branches plant^{-1} of lentil at 60 DAS

A N A L Y S I S O F V A R I A N C E T A B L E

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Replication	2	14.574	7.287	1.6104
Factor A	2	14.167	7.083	1.5653
Factor B	5	297.647	59.529	13.1550
AB	10	37.758	3.776	0.8344
Error	34	153.858	4.525	
Total	53	518.003		

Appendix.V(c): ANOVA table for branches plant^{-1} of lentil at 80 DAS

A N A L Y S I S O F V A R I A N C E T A B L E

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Replication	2	23.249	11.624	1.4356
Factor A	2	28.274	14.137	1.7459
Factor B	5	379.710	75.942	9.3787
AB	10	38.257	3.826	0.4725
Error	34	275.308	8.097	
Total	53	744.798		

Appendix.V(d): ANOVA table for branches plant^{-1} of lentil at 100 DAS

A N A L Y S I S O F V A R I A N C E T A B L E

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Replication	2	35.157	17.578	1.7155
Factor A	2	27.331	13.666	1.3336
Factor B	5	346.996	69.399	6.7727
AB	10	67.857	6.786	0.6622
Error	34	348.395	10.247	
Total	53	825.735		

Appendix.V(e): ANOVA table for branches plant^{-1} of lentil at 100 DAS

A N A L Y S I S O F V A R I A N C E T A B L E

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Replication	2	51.248	25.624	2.0854
Factor A	2	47.037	23.518	1.9140
Factor B	5	393.351	78.670	6.4025
AB	10	72.989	7.299	0.5940
Error	34	417.771	12.287	
Total	53	982.396		

Appendix.V(f): ANOVA table for branches plant^{-1} of lentil at harvest

A N A L Y S I S O F V A R I A N C E T A B L E

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	
Replication	2	0.700	0.350	1.1137	0.3400
Factor A	2	3.997	1.999	6.3557	0.0045
Factor B	5	59.969	11.994	38.1389	0.0000
AB	10	2.777	0.278	0.8830	
Error	34	10.692	0.314		
Total	53	78.136			

Appendix.VI(a): ANOVA table for above ground dry weight plant^{-1} of lentil at 20 DAS

A N A L Y S I S O F V A R I A N C E T A B L E

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Replication	2	0.006	0.003	2.5460
Factor A	2	0.132	0.066	52.6310
Factor B	5	5.330	1.066	848.0788
AB	10	0.056	0.006	4.4476
Error	34	0.043	0.001	
Total	53	5.567		

Appendix.VI(b): ANOVA table for above ground dry weight plant^{-1} of lentil at 40 DAS

A N A L Y S I S O F V A R I A N C E T A B L E

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Replication	2	0.006	0.003	2.5460
Factor A	2	0.132	0.066	52.6311
Factor B	5	5.330	1.066	848.0805
AB	10	0.056	0.006	4.4476
Error	34	0.043	0.001	
Total	53	5.567		

Appendix.VI(c): ANOVA table for above ground dry weight plant^{-1} of lentil at 60 DAS

A N A L Y S I S O F V A R I A N C E T A B L E

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Replication	2	0.749	0.375	7.5156
Factor A	2	1.838	0.919	18.4286
Factor B	5	28.533	5.707	114.4588
AB	10	0.377	0.038	0.7566
Error	34	1.695	0.050	
Total	53	33.192		

Appendix.VI(d): ANOVA table for above ground dry weight plant^{-1} of lentil at 80 DAS

A N A L Y S I S O F V A R I A N C E T A B L E

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Replication	2	2.929	1.464	8.8034
Factor A	2	6.348	3.174	19.0821
Factor B	5	120.958	24.192	145.4318
AB	10	3.439	0.344	2.0673
Error	34	5.656	0.166	
Total	53	139.330		

Appendix.VI(e): ANOVA table for above ground dry weight plant^{-1} of lentil at 100 DAS

A N A L Y S I S O F V A R I A N C E T A B L E

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	
Replication	2	2.501	1.251	7.2347	0.0024
Factor A	2	6.604	3.302	19.1036	0.0000
Factor B	5	123.355	24.671	142.7239	0.0000
AB	10	3.199	0.320	1.8505	0.0886
Error	34	5.877	0.173		
Total	53	141.536			

Appendix.VI(f): ANOVA table for above ground dry weight plant^{-1} of lentil at harvest

A N A L Y S I S O F V A R I A N C E T A B L E

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Replication	2	0.757	0.379	1.8634
Factor A	2	8.923	4.462	21.9515
Factor B	5	154.537	30.907	152.0636
AB	10	5.563	0.556	2.7368
Error	34	6.911	0.203	
Total	53	176.691		

Appendix.VII(a): ANOVA table for nodules plant^{-1} of lentil at 40 DAS

A N A L Y S I S O F V A R I A N C E T A B L E

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Replication	2	0.007	0.003	2.3825
Factor A	2	0.141	0.070	50.2671
Factor B	5	5.431	1.086	775.8516
AB	10	0.056	0.006	3.9985
Error	34	0.048	0.001	
Total	53	5.682		

Appendix.VII(b): ANOVA table for nodules plant^{-1} of lentil at 60 DAS

A N A L Y S I S O F V A R I A N C E T A B L E

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Replication	2	0.755	0.377	7.3819
Factor A	2	1.883	0.942	18.4178
Factor B	5	29.146	5.829	114.0308
AB	10	0.387	0.039	0.7573
Error	34	1.738	0.051	
Total	53	33.909		

Appendix.VII(c): ANOVA table for nodules plant^{-1} of lentil at 80 DAS

A N A L Y S I S O F V A R I A N C E T A B L E

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Replication	2	0.007	0.003	2.3825
Factor A	2	0.141	0.070	50.2672
Factor B	5	5.431	1.086	775.8525
AB	10	0.056	0.006	3.9985
Error	34	0.048	0.001	
Total	53	5.682		

Appendix.VII(d): ANOVA table for nodules plant^{-1} of lentil at 80 DAS

A N A L Y S I S O F V A R I A N C E T A B L E

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Replication	2	0.007	0.003	2.3825
Factor A	2	0.141	0.070	50.2671
Factor B	5	5.431	1.086	775.8518
AB	10	0.056	0.006	3.9985
Error	34	0.048	0.001	
Total	53	5.682		

Appendix.VIII: ANOVA table for pods plant^{-1} of lentil at harvest

A N A L Y S I S O F V A R I A N C E T A B L E

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Replication	2	85.053	42.526	0.2887
Factor A	2	845.654	422.827	12.8146
Factor B	5	8143.441	1628.688	49.3605
AB	10	124.434	12.443	0.3771
Error	34	1121.857	32.996	
Total	53	10320.438		

Appendix.XI: ANOVA table for seeds pod^{-1} of lentil at harvest

A N A L Y S I S O F V A R I A N C E T A B L E

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	
Replication	2	0.010	0.005	1.0837	0.3497
Factor A	2	0.075	0.038	8.5322	0.0010
Factor B	5	0.749	0.150	34.0184	0.0000
AB	10	0.026	0.003	0.5871	
Error	34	0.150	0.004		
Total	53	1.009			

Appendix.X: ANOVA table for 1000 grain weight of lentil at harvest

A N A L Y S I S O F V A R I A N C E T A B L E

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	
Replication	2	3.999	2.000	0.6280	
Factor A	2	15.998	7.999	2.5123	0.0960
Factor B	5	85.432	17.086	5.3664	0.0010
AB	10	44.438	4.444	1.3957	0.2240
Error	34	108.254	3.184		
Total	53	258.121			

Appendix.XI: ANOVA table for seed yield plant^{-1} of lentil at harvest

A N A L Y S I S O F V A R I A N C E T A B L E

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Replication	2	24676.874	12338.437	0.6440
Factor A	2	289628.084	144814.042	7.5588
Factor B	5	5361529.018	1072305.804	55.9709
AB	10	220588.301	22058.830	1.1514
Error	34	651381.545	19158.281	
Total	53	6547803.823		

Appendix.XII: ANOVA table for stover yield plant^{-1} of lentil at harvest

A N A L Y S I S O F V A R I A N C E T A B L E

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Replication	2	62711.749	31355.875	2.0390
Factor A	2	280779.889	140389.944	9.1292
Factor B	5	3454283.852	690856.770	44.9249
AB	10	131730.159	13173.016	0.8566
Error	34	522853.784	15378.052	
Total	53	4452359.433		

Appendix.XIII: ANOVA table for biological yield plant^{-1} of lentil at harvest

A N A L Y S I S O F V A R I A N C E T A B L E

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Replication	2	81854.031	40927.016	1.8501
Factor A	2	971283.887	485641.943	21.9529
Factor B	5	16809794.190	3361958.838	151.9734
AB	10	606611.029	60661.103	2.7421
Error	34	752148.669	22122.020	
Total	53	19221691.806		

Appendix.XIV: ANOVA table for harvest index of lentil at harvest

A N A L Y S I S O F V A R I A N C E T A B L E

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Replication	2	6.920	3.460	0.7079
Factor A	2	30.916	15.458	3.1626
Factor B	5	534.102	106.820	21.8550
AB	10	34.698	3.470	0.7099
Error	34	166.181	4.888	
Total	53	772.818		