EFFECT OF PLANTING GEOMETRY FOR YIELD AND YIELD COMPONENTS OF LENTIL

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EFFECT OF PLANTING GEOMETRY FOR YIELD AND YIELD COMPONENTS OF LENTIL

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Dedicated

To

My Beloved Parents and Elder Brothers

DEPARTMENT OF AGRONOMY

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CERTIFICATE

This is to certify that the thesis entitled **“EFFECT OF PLANTING GEOMETRY FOR YIELD AND YIELD COMPONENTS OF LENTIL”** submitted to the Faculty of Agriculture**,** Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (MS)** in **AGRONOMY,** embodies the results of a piece of bonafide research work carried out by **Mst. Fahmida Akter,** Registration no. **10-03834** under my supervision and guidance. No part of this thesis has been submitted for any other degree ordiploma.

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

Dated:

Dhaka, Bangladesh

(Prof. Dr. Md. Fazlul Karim)

Supervisor

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EFFECT OF PLANTING GEOMETRY FOR YIELD AND YIELD COMPONENTS OF LENTIL

ABSTRACT

A field research was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh during November, 2015 to March, 2016 in rabiseason to study the influence of variety and spacing in lentil cultivation. The experiment was laid out in split plot design assigning three varieties *i.e*. BARI Masur-5, BARI Masur-6 and BARI Masur-7 in the main plot and five different spacing namely S_1 (30 cm × 10 cm), S_2 (20 cm × 20 cm), S_3 (30 cm × 30 cm), S_4 (40 cm × 40 cm) and S_5 (50 cm × 50 cm) in the sub plot with three replications. Recommended fertilizers @ 40 kg Urea, 80 kg TSP and 40 kg MOP per hectare, respectively were applied in the experimental field. Results revealed that BARI Masur-5 gave the highest no. of branches/plant (1.02, 5.00, 18.06, 29.93 and 30.90) at 20, 40, 60, 80 DAS and harvest, respectively, no. of leaflets/plant (217.4) at 80 DAS, pods/plant (124.7), seed yield (1.04 t ha^{-1}), stover yield (1.00 t ha^{-1}) and biological yield (2.04 t ha^{-1}). On the other hand, among different spacing S_4 (40 cm × 40 cm) gave the highest no. of branches/plant (1.24, 5.43, 18.37, 32.06 and 33.13) at 20, 40, 60, 80 DAS and harvest, respectively, no. of leaflets/plant (226.2) at 80 DAS and pods/plant (151.2). But narrower spacing: S_1 (30 cm × 10 cm) scored the highest seed yield (1.67 t ha^{-1}) which was 74.25%, 61.07%, 52.69% and 35.32% higher than wider spacing: S_5 (50 cm × 50 cm), S_4 (40cm × 40 cm), S_3 (30 cm × 30 cm) and S_2 (20 cm × 20 cm), respectively, stover yield (1.22 t ha^{-1}) and biological yield (2.89 t ha^{-1}) due to more number of plants per unit area. Treatment BARI Masur-5 in combination with S_1 (30 cm × 10 cm) produced the highest seed yield (1.82 t ha^{-1}) which was 28.00% and 8.79% higher than the treatment combination BARI Masur-7 and BARI Masur-6 along with S_1 (30 cm × 10 cm).

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LIST OF ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
et al.	=	And others
TSP	=	Triple Super Phosphate
MOP	=	Muriate of Potash
NPK	=	Nitrogen, Phosphorus and Potassium
DAP	=	Diammonium phosphate
DAE	=	Days after emergence
DAS	=	Days after sowing
Ha^{-1}	=	Per hectare
g	=	gram
kg	=	kilogram
mg	=	milligram
mm	=	millimeter
cm	=	centimeter
t	=	ton
q	=	quintal
no.	=	number
max.	=	maximum
min.	=	minimum
%	=	Per cent
wt.	=	weight

cv.	=	cultivar
CV%	=	Percentage of coefficient of variance
LSD	=	Least Significant Difference
Vs.	=	versus
Viz.	=	Videlicet (namely)
V	=	Variety
S	=	Spacing
^0C	=	Degree Celsius
NS	=	Non significant
HI	=	Harvest index
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
Fig.	=	Figure
DM	=	Dry matter
m^2	=	Square meter
@	=	At the rate of
Min	=	Minute
SRI	=	System of Rice Intensification
SCI	=	System of Crop Intensification
i.e.	=	That is

CHAPTER I

INTRODUCTION

Now-a-days food security is a major concern in the countries all over the world.The global population will be expected to top 9 billion in 2050 and given the demands to increase 60 per cent for more protein-rich diets by populations with increasing incomes of farmers around the world. Economic and political improvement in poor countries will constantly be frustrated if populations are unable to feed themselves (UN, 2014).

Agriculture is the single biggest source in the world, presenting livelihoods for 40 per cent of worldwide population. It is the most important source of earnings for poor rural families. Population growth in Bangladesh is increasing at a alarming rate. Outstanding measures need to be carried in the field of agriculture to deliver meals for fast growing populationof Bangladesh. Agriculture sector contributes about 17 percent to the country's Gross Domestic Product (GDP) and employs more than 45 percent of total labour pressure. Boro is the most vital and single largest crop in Bangladesh in appreciate of volume of production (BBS, 2014).

Despite being an important issue of agriculture in Bangladesh, acreage production of pulses has been in a declining rate over the recent years (BBS, 2012). Pulse crops play a significant role in Bangladesh agriculture contributing closer to food and dietary safety, nitrogen economy, crop intensification, diversification and sustainable farming system. The cultivation of legumes gains primary significance in Bangladesh. Pulses are regardred as "the poor man's meat" due to the fact nonetheless pulses are the cheapest source of protein. In Bangladesh, there may be an increase of approximately 25% in consistent with capita availability of pulses in 2013 (56 g/capita/day) as compared to 1992 level (45 g/capita/day) (http://www.researchgate.net/publication/305955113).

Lentil (*Lens culinaris*) belonging to the family Fabaceae is a major pulse crop in Bangladesh. Among the pulses grown in Bangladesh, lentil holds the second position in both of areage& production but first in market price (Afzal*et al.*, 1999). Lentil was grown approximately 124617 hactares producing 157000 tons of seed with a mean yield of 1.25 t/ha (FAOSTAT, 2014). Bangladesh occupies 6th position amongst top 10th lentil producing countries in the world and has 3.3% of global's proportion (FAOSTAT, 2014). Lentil is the major legume crop that is a major source of nutritional protein, fiber, complicated carbohydrates, and minerals (Jood e*t al.*, 1998; Xu, B. and Chang, S. K. C., 2009; Dellavalle*et al.*, 2013). Lentil seed containing high protein (25%) and digestibility (70-90%) is seemed as alternative of animal protein (Gowda and Kaul, 1982). Proteins contain the essential amino acids isoleucine and lysine and lentil is a vital source of inexpensive protein in many elements of the sector, particularly in West Asia and the Indian subcontinent that have large vegetarian populations (http://www.glisonline.com). Lentils are poor in essential amino acids as methionine and cysteine (North Dakota State University, 2009). However, sprouted lentils include sufficient levels of all essential amino acids, inclusive of methionine and cysteine (http://www.bitterpoison.com).

In Bangladesh, the yield of lentil is low because of using low yielding cultivars, lack of production inputs, improper management and conventional cultural practices. The variety of the crop is important in producing a tremendous yield. Recent releases of advanced lentil varieties in India have produced yields which were 54% to 91% higher than local varieties (Maalouf*et al.*, 2011). In Bangladesh, BARI Masur-4, BARI Masur-5 and BARI Masur-6 are rich in iron and zinc and provide yields 90% higher than the country wide average. Besides those, spatial arrangement of lentil still requires exploration for further improvement of its yield. The goal of that is to discover the proper plant population to get maximum yield.

Improper spacing can reduce the yield by as much as 40% (AVRDC, 1976) and cause competition for light, space, water and nutrition. On the other hand, optimum spacing allows the plants to flourish in both their above-ground and underground portions through efficient use of natural resources, hence increasing the production. Reduction of plant spacing by increasing seed rate would ensure a more even distribution of plant over the land occupied by the crop. As a result, the plant has the chance to use maximum solar radiation through the canopy and also provide shade which suppress weed. Wider spacing generally provides less competition for each individual plant; however it also means fewer plants per unit area, so the number of pods is lesser.

For ensuring efficient use of space and maximized yield, the precept of wider spacing and square geometry which is applied in System of Rice Intensification (SRI) was put to use. SRI is a technology that reduces the seed price by using 80-90% and water savings up to 25%-50%. The System of Rice Intensification (SRI) was developed in the 1980s to improve the situations of poor, rice-growing households in Magascar (Laulanie, 1993). Using SRI methods, smallholding farmers in many countries are starting to get higher yields and greater productivity from their crops due to hazards of climate change (Thakur *et al.*, 2009 and Zhao *et al.*, 2009). Recommended SRI control practices consist of widely spaced flowers to inspire extra root and canopy growth. The seeds are placed in a rectangular pattern, consisting of 25 cm × 25 cm or wider in desirable fine soil. The plant geometry and spatial association set the initial vigor of the genotypes. Effect of the spatial association is utilized in SRI is useful in different crops as nicely (Abraham *et al.*, 2014). In recent years, the adaptation of SRI experience and principles to other crops is referred to as the System of Crop Intensification (SCI) like wheat, sugarcane, maize, vegetables, mustard, lentil, mungbean and many others. SRI technique is good for other crops as well as rice (Uphoff*et al*., 2012). With SCI practices, the people's Science Institute in Dehradun reported that small farmers in Uttarkhand state of India found 65% increase of lentil from 850 kg/ha to 1.4 t/ha. But the System of Crop Intensification is completely new in our country. The aim of the study was to increase lentil production by practicing SRI principles. Considering the above facts the experiment was designed to achieve the following objectives-

- To evaluate the performance of lentil varieties
- To determine the effect of spacing on the yield and yield attributes of lentil and
- To study the combined effect of variety and spacing on the growth & yield of lentil.

CHAPTER II

REVIEW OF LITERATURE

Variety and management practices both have considerable effects on the growth and development of any crop. Among these, plant geometry is an undoubtedly important. A number of studies have been done to evaluate the influence of variety and spatial arrangement on lentil. Among the above factors some of the recent past information on variety and spacing on lentil have been reviewed under the following headings:

2.1 Influence of varieties on plant characters of lentil :

2.1.1 Plant height

Hossain*et al.* (2016) carried out an on-farm trial with BARI released lentil varieties at the MLT site, Ulipur, Kurigram in rabi season of 2013-14 and 2014-15 following Lentil-Sesame-Fallow cropping pattern in the charland. Four varieties viz., BARI Masur-4, BARI Masur-5, BARI Masur-6 and BARI Masur-7 with local cultivar had been in comparison for this purpose. The tallest plant was determined in BARI Masur-7 (30.82 cm and 31.85 cm) and the shortest one was found in local cultivar (25.68 cm and 26.22 cm) in 2013-14 and 2014-15, respectively.

Awal*et al.* (2015) conducted an experiment on effect of weeding on the growth and yield of three varieties of lentil (*Lens culinaris*L.) and found the variation in plant height which was significant due to the interaction between 3 varieties of lentil and 2 weeding regimes. Three varieties were BINA masur-1, BINA masur-2 and BINA masur-3. The tallest plant was observed in BINA masur-3 followed by BINA masur-2.

Islam *et al.* (2015) conducted an experiment at the Regional Agricultural Research Station, BARI, Ishurdi, Pabna, Bangladesh during the rabi season of 2007-08 and 2008-09. They used three lentil varieties viz. BARI Masur-2, BARI Masur-3 and BARI Masur-

4 and found a significant variation of the different varieties on plant height. Maximum plant height (30.93 cm) was found from BARI Masur-4 followed by BARI Masur-3 (30.23 cm).

A study was undertaken by Hakim *et al.* (2006) in Mansehra, Pakistan, during rabi season, 2004-05. Thirteen cultivars of lentil were used. They were PL-339319, FLIP-97-28L, FLIP-99-IL, FLIP-2002-IL, FLIP-2002-16L, FLIP-2003-10L, FLIP-2003-13L, 81-S-15-28, FLIP-2004-5L, FLIP-2004-30L, Shenaz-96, Masoor-93 and Masoor-local. The tallest plant (48.0 cm) was found in FLIP-2004-30L, at the same time as the shortest plant was produced by 81-S-15-28 (31.30 cm).

2.1.2 Branches plant $^{-1}$ (no.)

Awal*et al.* (2015) conducted an experiment on effect of weeding on the growth and yield of three varieties of lentil (*Lens culinaris*L.). Three varieties were BINA masur-1, BINA masur-2 and BINA masur-3. The highest number of branches plant^{-1} was produced in BINA masur-3, closely followed by BINA masur-2 while the BINA masur-1 variety produced the lowest.

An experiment was conducted by Rahman*et al.* (2013) to evaluate the effect of nitrogen utility on distinct agro-physiological tendencies of three lentil cultivars on the Agronomic Research Area, Department of Agronomy, University of Agriculture, Faisalabad, Pakistan. The 3 lentil cultivars were Punjab Masoor (PM)-2009, NIAB Masoor (NM)-2006 and NIAB Masoor (NM)-2002. They observed that the no. of branches per plant differed statistically of the cultivars. NIAB Masoor (NM)-2006 produced the maximum no. of branches per plant (11.32) followed by NM -2002 and PM-2009 as 10.28 and 8.62, respectively.

2.1.3 Above ground dry matter plant^{-1}

Awal *et al.* (2015) conducted an experiment on effect of weeding on the growth and yield of three varieties of lentil (*Lens culinaris*L.). Three varieties were BINA masur-1, BINA masur-2 and BINA masur-3. The highest total plant dry matter at harvest was recorded in BINA masur-3 with weeding treatment and the lowest total dry matter was recorded in BINA masur-1 with no weeding treatment.

2.1.4. Nodule dry weight plant^{-1}

Senaratne and Ratnasinghe (1993) said that N_2 fixation in legumes is maximum among flowering and early pod filling and all legumes derived approximately 90% in their N from the ecosystem by means of 80 days after emergence (DAE).

2.1.5 Pods plant $^{-1}$

The on-farm trial of BARI released lentil varieties was conducted by Hossain*et al.* (2016) at the MLT site, Ulipur, Kurigram during rabi season of 2013-14 and 2014-15 folloeing Lentil-Sesame-Fallow cropping pattern in the charland.Four variety viz., BARI Masur-4, BARI Masur-5, BARI Masur-6 and BARI Masur-7 with local cultivar were compared for this purpose. The highest number of pods per plant (68.13 & 66.36) was recorded from the variety BARI Masur-7 which was similar with BARI Masur-6 (66.30) and BARI Masur-5 (64.10) during 2013-14 followed by BARI Masur-6 (64.47), BARI Masur-5 (63.93) and BARI Masur-4 (61.52) during 2014-15 and the lowest number of pods per plant was found in local variety (43.56 and 45.24), respectively.

A field study was undertaken by Rahman*et al*. (2013) to observe the effect of nitrogen application on different agro-physiological traits of three lentil cultivars at the Agronomic Research Area, Department of Agronomy, University of Agriculture, Faisalabad, Pakistan. The three lentil cultivars were Punjab Masoor (PM)-2009, NIAB Masoor (NM)-2006 and NIAB Masoor (NM)-2002. Different cultivars of lentil produced significantly different number of pods plant^{-1}. The highest number of pods plant^{-1} (48.29) was found by cultivar NIAB Masoor-2006 while the lowest number of pods plant^{-1} (41.27) from Punjab Masoor-2009.

Mahmood*et al*. (2010) worked out a experiment on three lentil cultivars (Masoor-93, NIAB Masoor-2002 and NIAB Masoor-2006) to various NPK fertilizer combinations (25-0-0, 25-25-25, 25-50-50 and 25-75-75 kg/ha) was studied during the year 2007-08 and 2008-09. The experiment was replicated three times at Agronomic Research Area, PirMehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan. Lentil cultivars produced significantly different number of pods per plant. Masoor-2006 produced the highest number of pods per plant (39.98) followed by Masoor-2002 (37.57). Lowest number of pods per plant was recorded for Masoor-93 (35.07).

A study was done by Hakim *et al*. (2006) in Mansehra, Pakistan, during rabi 2004-05 using 13 diverse genotypes of lentil: PL-339319, FLIP-97-28L, FLIP-99-IL, FLIP-2002-IL, FLIP-2002-16L, FLIP-2003-10L, FLIP-2003-13L, 81-S-15-28, FLIP-2004-5L, FLIP-2004-30L, Shenaz-96, Masoor-93 and Masoor-local. Genetic variances, heritability and correlations among unique traits (days to flowering and maturity, plant height, pods/plant, seeds/pod, one thousand-seed weight and yield) were studied. Differences for all the developments were discovered statistically substantial. Pods/plant varies significantly from 29 (FLIP-2004-5L) to 52 (Masoor-93).

2.1.6 Seeds pod $^{-1}$

A field study was carried out by Rahman*et al*. (2013) to evaluate the effect of nitrogen application on different agro-physiological traits of three lentil cultivars at the Agronomic Research Area, Department of Agronomy, University of Agriculture, Faisalabad, Pakistan. The three lentil cultivars were Punjab Masoor (PM)-2009, NIAB Masoor (NM)-2006 and NIAB Masoor (NM)-2002. Among cultivars Punjab Masoor-2009 produced the maximum number of seeds pod^{-1} (1.82) as compared with NIAB Masoor-2006 and NIAB Masoor-2002 which produced 1.65 and 1.68 number of seeds pod^{-1}, respectively.

2.1.7 1000 seed weight

The on-farm trial of BARI released lentil varieties was conducted by Hossain*et al.* (2016) at the MLT site, Ulipur, Kurigram during rabi season of 2013-14 and 2014-15 following Lentil-Sesame-Fallow cropping pattern in the Charland.Four variety viz., BARI Masur-4, BARI Masur-5, BARI Masur-6 and BARI Masur-7 with local cultivar were compared for this purpose. Variety had a significant influence on 1000-seed weight. The maximum 1000-seed weight (21.07 g & 20.86 g) was scored from the variety BARI Masur-7 followed (20.15 g & 19.77) by BARI Masur-6, respectively. The lowest 1000-seed weight (16.74 g & 16.38 g) was achieved in local variety.

Islam *et al.* (2015) were conducted an experiment at the Regional Agricultural Research Station, BARI, Ishurdi, Pabna, Bangladesh during the rabi season of 2007-08 and 2008-09 on performance of lentil varieties under relay and minimum tillage conditions in T. Aman rice. They used 3 lentil varieties viz. BARI Masur-2, BARI Masur-3 and BARI Masur-4 and they found a good sized have an effect on the different sorts on plant 1000-seed weight. The maximum 1000-seed weight received from BARI Masur-3 (21.24 g) while BARI Masur-2 gave the lowest (16.10 g). Weight of 1000-seeds of BARI Masur-3 was 31.92% higher than BARI Masur-2 and 8.42% higher than BARI Masur-4.

A field study was conducted by Rahman*et al.* (2013) to evaluate the effect of nitrogen application on different agro-physiological traits of three lentil cultivars at the Agronomic Research Area, Department of Agronomy, University of Agriculture, Faisalabad, Pakistan. The three lentil cultivars were Punjab Masoor (PM)-2009, NIAB Masoor (NM)-2006 and NIAB Masoor (NM)-2002). The maximum thousand seed weight (20.37 g) was produced by cultivar Punjab Masoor-2009 as compared with NIAB Masoor-2006 and NIAB Masoor-2002 which produced 19.30 g and 18.84 g 1000-seed weight, respectively.

A study was laid out by Hakim *et al*. (2006) in Mansehra, Pakistan, during rabi 2004-05 using 13 diverse genotypes of lentil: PL-339319, FLIP-97-28L, FLIP-99-IL, FLIP-2002-IL, FLIP-2002-16L, FLIP-2003-10L, FLIP-2003-13L, 81-S-15-28, FLIP-2004-5L, FLIP-2004-30L, Shenaz-96, Masoor-93 and Masoor-local. Genetic variances, heritability and correlations among different genotypes (days to flowering and maturity, plant height, pods per plant, seeds per pod, 1000-seed weight and yield) were studied. 1000-seed weight ranged from 22 g (FLIP-97-28L) to 40 g (FLIP-2003-13L).

2.1.8 Seed yield

The on-farm trial of BARI released lentil varieties was conducted by Hossain*et al.* (2016) at the MLT site, Ulipur, Kurigram during rabi season of 2013-14 and 2014-15 following Lentil-Sesame-Fallow cropping pattern in the Charland.Four variety viz., BARI Masur-4, BARI Masur-5, BARI Masur-6 and BARI Masur-7 with local cultivar were compared for this purpose. The maximum seed yield was recorded in BARI Masur-7 (1428 kg/ha). Local lentil variety produced the lowest seed yield (860 kg/ha). Next year highest seed yield was recorded in BARI Masur-7 (1400 kg/ha) which was statistically similar with BARI Masur-6 (1380 kg/ha) and local gave the lowest seed yield (834 kg/ha).

Awal*et al.* (2015) conducted an experiment on effect of weeding on the growth and yield of three varieties of lentil (*Lens culinaris*L.). Three varieties were BINA masur-1, BINA masur-2 and BINA masur-3. BINA masur-3 was found as a higher yielder than the other two varieties.

Islam *et al.* (2015) carried out an experiment at the Regional Agricultural Research Station, BARI, Ishurdi, Pabna, Bangladesh during the rabi season of 2007-08 and 2008-09 on performance of lentil varieties under relay and minimum tillage conditions in T. Aman rice. They used three lentil varieties viz. BARI Masur-2, BARI Masur-3 and BARI Masur-4 and they found a significant influence of the different varieties on seed yield. The maximum seed yield was obtained from BARI Masur-4 (1.59 t/ha) due to higher pods/plant and seeds/pod while lowest yield attributes resulted lower seed yield in BARI Masur-2 (1.39 t/ha).

A field study was conducted by Rahman*et al.* (2013) to evaluate the effect of nitrogen application on different agro-physiological traits of three lentil cultivars at the Agronomic

Research Area, Department of Agronomy, University of Agriculture, Faisalabad, Pakistan. The three lentil cultivars were Punjab Masoor (PM)-2009, NIAB Masoor (NM)-2006 and NIAB Masoor (NM)-2002). Punjab Masoor-2009 produced the highest seed yield (971.86 kg ha^{-l}) as compared with NIAB Masoor-2006 and NIAB Masoor-2002, those produced 780.93 kg and 745.30 kg grain yield ha^{-1}, respectively.

A study was conducted by Hakim *et al*. (2006) in Mansehra, Pakistan, during rabi 2004-05 using 13 diverse genotypes of lentil: PL-339319, FLIP-97-28L, FLIP-99-IL, FLIP-2002-IL, FLIP-2002-16L, FLIP-2003-10L, FLIP-2003-13L, 81-S-15-28, FLIP-2004-5L, FLIP-2004-30L, Shenaz-96, Masoor-93 and Masoor-local. The highest seed yield of 1713 kg/ha was attained from the plots of Masoor-93, followed by FLIP-99-IL with 1622 kg/ha.

Recent releases of improved lentil varieties in India have produced yields which were 54% to 91% higher than local varieties. BARI Masur-4, BARI Masur-5 and BARI Masur-6 are rich in iron and zinc and give yields 90% higher than the national average (ICARDA).

2.1.9 Biological yield:

A field study was conducted by Rahman *et al.* (2013) to evaluate the effect of nitrogen application on different agro-physiological traits of three lentil cultivars at the Agronomic Research Area, Department of Agronomy, University of Agriculture, Faisalabad, Pakistan. The three lentil cultivars were Punjab Masoor (PM)-2009, NIAB Masoor (NM)-2006 and NIAB Masoor (NM)-2002. Lentil cultivar NIAB Masoor-2006 produced the highest biological yield (3889.3 kg ha^{-1}) as against the lowest biological yield (3740 kg ha^{-1}) produced by cultivar Punjab Masoor-2009.

2.1.10 Harvest index

Awal*et al.* (2015) conducted an experiment on effect of weeding on the growth and yield of three varieties of lentil (*Lens culinarisL.).*The highest harvest index (42.1%) was scored in BINA masur-3 variety along with weeding treatment and minimum (31.5%) inBINA masur-2 along with no weeding condition. Highest harvest index was recorded in BINA masur-3 and minimum in BINA masur-2 while the variety BINA masur-1 ranked intermediate.

A field study was conducted by Rahman*et al.* (2013) to evaluate the effect of nitrogen application on different agro-physiological traits of three lentil cultivars at the Agronomic Research Area, Department of Agronomy, University of Agriculture, Faisalabad, Pakistan. The three lentil cultivars were Punjab Masoor (PM)-2009, NIAB Masoor (NM)-2006 and NIAB Masoor (NM)-2002). Cultivar Punjab Masoor-2009 gave the highest value (26.98%) of harvest index as compared with NIAB Masoor-2006 and NIAB Masoor-2002 with harvest index values of 22.22% and 19.54%, respectively.

Mahmood*et al.* (2010) worked out an experiment on three lentil cultivars (Masoor-93, NIAB Masoor-2002 and NIAB Masoor-2006) to various NPK fertilizer combinations (25-0-0, 25-25-25, 25-50-50 and 25-75-75 kg/ha) was studied during the year 2007-08 and 2008-09. The experiment was replicated three times at Agronomic Research Area, PirMehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan. Regarding cultivars, NIAB Masoor-2002 gave higher harvest index (42.38%) against the lowest for Masoor-93 (38.38%). Non-significant differences were observed between harvest index of NIAB Masoor-2002 and NIAB Masoor-2006.

Dey (2002) and Rahman (2006) also observed the large variation of harvest index in the different genotypes of lentil.

Harvest index is an important physiological character that reflects dry matter partitioning of a given genotype to the economic part. Higher harvest index results higher crop yield probably due to more partitioning of dry matter to reproductive stage (Plainiappan, 1985).

2.2 Influence of planting arranement on plant characters of Lentil

2.2.1 Plant height

Ouji*et al.* (2016) laid out a study in kef (Northwest Semi-Arid region of Tunisia) in order to determine the impact of row spacing and seeding rate on yield and yield components of lentil. 'Siliana' lentil cultivar was sown at 17 cm and 34 cm row spacing. The average plant height was 24.9 cm and 27.1 cm for 17 cm and 34 cm, respectively. Indeed the average plant height became reduced 8.5% as the row spacing became increased from 17 cm to 34 cm.

The increase in plant height could be justified on the bases of increase in the number of plants per unit area coupled with high plant competition for light, resulting in taller plants as reported by Mekkei*et al.* (2014).

Shahram*et al.* (2012) reported that when plant density is too high, it encourages interplant competition for resources. Then, plant height will be affected by less light penetration in the crop canopy as well as increase in the competition for available nutrient which will affect plant branches. The plants which received less light enlarged the height of the main stem to compensate for this deficiency and to get more radiation.

Ganjali and Majidi (2000) also reported that plant height is increased under too high plant density due to competition for light interception. In this study, plant height was taller in higher plant population treatments due to more competition for light.

Jasinska and Kotecki (1995); Felton *et al.* (1996); Khan *et al.* (2001) and Sharar*et al.* (2001) reported that plant height increased with high densities of plants.

2.2.2 Total dry matter/plant

The effect of population density on dry matter (DM) accumulation over time, grain yield and its components of four grain legumes was examined in a field experiment at Lincoln

University Canterbury, New Zealand, in the 1998-99 season by Ayaz*et al*. (1999). The four legumes were sown at four different populations viz. lentils cv. Rajah (15, 150, 300 and 600 plants/m^2), desi chickpeas (5, 50, 100 and 200 plants/m^2), peas cv. Beacon and lupins (*Lupinusangustifolius*) cv. Fest (10, 100, 200 and 400 plants/m^2). The experiment was a split plot design with three replications. The trial was sown on 30 October 1998 and the species were harvested on different dates depending on their physiological maturity. Lupins produced the most DM (878 g/m^2) and DM was less affected by population than the other species. Lentil DM was highly dependent upon population and ranged from 186 to 513 g/m^2 at the lowest and highest population. Chickpeas and pea DM were also affected by population. Chickpeas produced from 430-869 g/m^2 dry matter as population increased and peas from 292-670 g/m^2 dry matter.

2.2.3 Pods plant $^{-1}$

Ouji*et al.* (2016) conducted a study in Kef (Northwest Semi-Arid region of Tunisia) with a view to determine the impact of row spacing and seeding rate on yield and yield components of lentil. Number of pods/plants, an important primary yield component, is the more unsteady attribute among yield components of legumes. Pod number per plant increased with the row spacing, so that the increasing of row spacing from 17 cm to 34 cm increased pod number per plant by 35.5%. On the other hand, number of pods and seeds/plant were tending to increase with increasing plant density up to a density threshold away from which the number of pods/plants decreases. Indeed, results revealed that the increase in plant density led to the loss of pod number per plant, so that with the increase in population from 80 and 120 seeds/m^2, pod number per plant increased by 48.6%. However, at plant density higher than optimal (160 seeds/m^2) pod number per plant decrease.

A field experiment was undertaken by Singh *et al.* (2009) on sandy loam soil of Allahabad during the winter season of 2008-09 on effect of row spacing and dates of sowing on growth and yield of lentil (*Lens culinaris*). Row spacings of 30 cm resulted in significantly more number of pods and seed yield as compared to row spacing of 20 cm and 40 cm. The enhance in seed yield in case of 30 cm row spacing was 3.6% and 1% over 20 cm and 40 cm row spacing, respectively.

2.2.4 Seeds pod^{-1}

Ouji*et al.* (2016) worked out a study in Kef (Northwest Semi-Arid region of Tunisia) in order to determine the impact of row spacing and seeding rate on yield and yield components of lentil. Seed number per plant increased by 31% when row spacing amplified from 17 cm to 34 cm.

2.2.5 1000 seed weight

Ouji*et al.* (2016) undertaken a study in Kef (Northwest Semi-Arid region of Tunisia) to determine the impact of row spacing and seeding rate on yield and yield components of lentil. Maximum 100- seed weight (6.7 g) was scored in 34 cm row spacing.

2.2.6 Seed yield/plant

Ouji*et al.* (2016) worked out a study in Kef (Northwest Semi-Arid region of Tunisia) to determine the impact of row spacing and seeding rate on yield and yield components of lentil. Increasing row spacing led to significantly higher seed yields per hectare. The close row spacing of 34 cm gave the maximum seed yield of 881 kg/ha. Thus, 34 cm row spacing produced about 38.4 % higher seed yield than 17 cm row spacing.

A field study was conducted by Singh *et al.* (2009) on sandy loam soil of Allahabad during the winter season of 2008-09. There was a significant reduction in seed yield with delay in sowing from 20th October to 10th November by a margin of 10.4%, row spacings of 30 cm (16.83 q/ha) resulted in 3.6% and 1% added seed yield than closer (20 cm) and wider (40 cm) row spacings, respectively.

Lal*et al.* (2006) undertook a field trial on different row spacings (15, 20, 25, 30 and 35 cm) and dates of sowing (15 and 25 October, and 5, 15 and 25 November) during the

2000/01 and 2001/02 rabi seasons in Bihar, India, with lentil cultivars Sehore 74-3 and SLC-5 to determine yield of lentil. Highest seed yield (860.5 kg/ha) was recorded in 25 cm spacing in Sehore 74-3.

A field experiment was conducted by Inderjit*et al.* (2005) on sandy-loam soil of Gurdaspur, Punjab, India, during the 1998-2000 winter season (rabi) to study the effect of different sowing dates, row spacings and seed rates on the productivity of lentil cv. LG 308.Row spacing of 20 cm (12.3 q/ha) resulted in 4.2 and 9.5% more seed yield than closer (17.5 cm) and wider (22.5 cm) row spacings, respectively.

Lentil cultivars Pant L 209, Pant L 639, Pant L 406 and T 36 were evaluated by Tomar*et al*. (2000) for yield, protein yield and nutrient uptake under 2 sowing methods (20 cm row spacing with 60 kg seed rate and 30 cm row spacing with 45 kg seed rate), in a field in Uttar Pradesh, India, during the winter seasons of 1994-95 and 1995-96. The effect of 4 diammonium phosphate (DAP) levels (0, 50, 100 and 150 kg/ha) on the performance of the genotypes was also investigated. Narrow row spacing (20 cm) with high (60 kg) seed rate produced higher yield than wider row spacing (30 cm) with normal seed rate (45 kg).

Dutta*et al*. (1998) carried out a field trial in 1994/95 in Mymensingh, Bangladesh, lentil. L-5 were grown at row spacings of 20, 25 or 30 cm and intra-row spacings of 3, 4, 6 or 8 cm. Higher densities gave higher seed yields despite the favourable effect of lower densities on branches/plant, pods/plant and seed yield/plant.

In a field experiment in Mymensingh, Bangladesh, 10 lentil genotypes were cultivated by Chowdhury*et al*. (1998) at 15 cm row spacing and seed inoculated with Rhizobium or given N or P fertilizer were grown at 30 cm row spacing with Rhizobium + N + P. The cultivar Bm 513 gave a significantly higher yield than any of the other genotypes. Yield was highest with Rhizobium, nodule number and nodule weight were highest with Rhizobium alone or with N + P, while plant height and pods per plant were highest with Rhizobium + N + P.

Singh and Verma (1996) conducted a field experiment during the winter season of 1988/89 at Gorakhpur, Uttar Pradesh, 7 lentil cultivars were grown in rows 20, 25 or 30 cm apart. Seed yields were highest at the row spacings 25 (1.56 t/ha) and 30 cm (1.55 t/ha). The highest yielding cultivar was Pant L 209 (1.84 t/ha).

Singh *et al*. (1994) examined a field trials in 1987-89 on clay loam soil at Shalimar, Jammu and Kashmir, lentil sown in rows 20, 25 and 30 cm apart gave seed yields of 1.15, 1.38 and 1.34 t/ha, respectively. Sowing at rates of 30, 35, 40 and 45 kg/ha gave seed yields of 1.07, 1.25, 1.44 and 1.40 t/ha, respectively.

The effect of population density on dry matter (DM) accumulation over time, grain yield and its components of four grain legumes was examined in a field experiment at Lincoln University Canterbury, New Zealand, in the 1998-99 season by Ayaz*et al*. (1999). The four legumes were sown at four different populations viz. lentils cv. Rajah (15, 150, 300 and 600 plants/m^2), desi chickpeas (5, 50, 100 and 200 plants/m^2), peas cv. Beacon and lupins (*Lupinusangustifolius*) cv. Fest (10, 100, 200 and 400 plants/m^2). The experiment was a split plot design with three replications. The trial was sown on 30 October 1998 and the species were harvested on different dates depending on their physiological maturity. Lupins grain yield was least affected by population, being 323 and 434 g/m^2 at the lowest and highest populations. Lentil seed yield had a higher dependency on population than the other species and it was 91 and 304 g/m^2 at the low and the highest populations. The species by population interaction showed that in all four species, the mean seed weight, pods per plant and seeds per pod were inversely related to plant density.

2.2.7 Biological yield:

Ouji*et al.* (2016) conducted an experiment in Kef (Northwest Semi-Arid region of Tunisia) to study the impact of row spacing and seeding rate on yield and yield components of lentil. Biological yield is sum total of all dry matter produced through physiological and biochemical processes going on in the plant system. Maximum biological yield (1769.9 kg/ha) was recorded in 34 cm row spacing. While the lowest biological yield (1235.4 kg/ha) was found in 17 cm row spacing. Indeed, plants are able to fill available space by initiating lateral branches thus, can compensate for height row spacing.

Application of low distances for planting rows or high plant densities raise speed of canopy closure and amount of solar radiation interception and therefore improves growth speed was reported by Neda and Mehrdad (2015).

2.3 Influence of SCI on plant characters

In the past 6 years, farmers in Asian and African countries have begun adapting and extrapolating what they have known from the system of rice intensification (SRI) to other crops such as finger millet, wheat, sugarcane, tef, oilseeds like as mustard, legumes known as soya and kidney beans, and various vegetables - in what is being named the system of crop intensification (SCI). The system of crop intensification (SCI) with four principles are able to raise significantly the production and yield of more 'intensively' managed crops increased production methods that are grouped and extended under the rubric of SCI are being scaled up in a significant way as found in India and Ethiopia.

The World Bank showed higher yield and production for food-insecure households under one of its projects in Bihar state. In June, 2012, it informed 348,759 farmers were using SCI methods on over 50,000 ha. It concised their yield increases as 86% for rice, 72% for wheat, 56% for pulses, 50% for oilseeds, and 20% for vegetables. The profitability increases for these different crops were calculated, respectively, as averaging 250%, 86%, 67%, 93%, and 47% (Behra*et al.*, 2013).

Farmers in Haveri district in the southern state of Karnataka, India over several decades used their own practice methods for growing finger millet that were remarkably close to SRI management. Conventional crop management which started with broadcasting finger millet seed on a tilled field, gave yields between 1.25 to 2 t/ha. With proper irrigation and fertilizer applications, millet yields in the district was 3.75 t/ha. With their GuliVidhana methodology, farmers made a square grid of shallow furrows on their fields using a simple ox-drawn plow. The grooves in the soil, made in parallel and perpendicular directions were widely spaced (45 cm × 45 cm). At each intersection of the grid, two young and 12-days-old seedlings were transplanted with a handful of compost or manure around the roots to give the young plants a good growing environment. This active soil aeration along with organic matter supplementation enabled the millet plants to have 40 to 80 tillers and to give yields of 3.75 to 5 t/ha, even up to 6.25 t/ha, which was more 2 to 3 times than the usual yield in the district (Green Foundation, 2006).

SCI management have been popular in Tigray province, Ethiopia. The first farmer who transplanted finger millet seedlings obtained a yield alike to 7.8 t/ha in 2003, compared to usual millet yields of 1.4 t/ha with broadcasting method or 2.8 t/ha with the use of compost (Araya *et al.*, 2013). Farmers in Ethiopia named this methodology 'planting with space' and applied it also to other crops.

System of Wheat Intensification (SWI) was first experienced in northern India in 2006 by farmers working with the People's Science Institute (PSI). First-year trials near Dehradun, using several varieties, showed average increases of 18% to 67% in grain yield and 9% to 27% higher straw yields (important for subsistence farmers as fodder) compared with the yields that farmers usually attained with conventional broadcast methods for crop establishment. Revealed with these results, PSI began promoting SWI in the states of Uttarakhand and Himachal Pradesh (Prasad, 2008).

The Aga Khan Rural Support Programme in India (AKRSP-I) introduced SWI in Bihar state, with different but still favorable results. Its SWI yield increases was 32% with farmers averaging 3.48 t/ha instead of 2.63 t/ha (Raol, 2012).

In 2011-12, farmer placed a field experiment in Sindhuli district with similarly modified SWI practices also showed better yield and economic returns. Pre-germinated seed of Bhirkuti variety sown at 20 cm x 20 cm spacing gave 54% more yield than the available 'best practices' used under similar conditions of irrigation and fertilization: 6.5 t/ha from SWI, compared to 3.7 t/ha with conventional broadcasting and 5 t/ha with row sowing (Adhikari, 2012).

In Mali, SRI was not very successful. The mortality of transplanted seedlings was 9% to 22% and 25 cm × 25 cm spacing was too large for plants to utilize all the arable area.

Transplanted SWI produced 29% less grain than the control plots (1.4 t/ha vs. 1.97 t/ha). Direct-seeded SWI, on the other hand, with generally spaced individual plants showed a 13% yield increase, producing 2.22 t/ha. Farmers were pleased with their 94% reduction in seed requirements with this method of SWI (10 kg/ha vs. 170 kg/ha). They also found their labor investment condensed by 40% and their need for irrigation water was 30% less (Styger*et al.*, 2008). Thus, farmer's curiosity in this innovation was aroused.

The SCI experience was undertaken on some crops such as with sugarcane, mustard (*Brassica rapa*) (*PRADAN, 2012*), maize (*Zea mays*), various legumes such as pigeon pea (*Cajanuscajan*, also known as red gram), mung bean (*Vignaradiata*, or green gram), lentils (*Lens culinaris*), broad bean (*Viciafaba*), soya bean (*Glysine max*), kidney beans (*Phaseolus vulgaris*), faba bean (Mahmoud, 2014) and peas (*Pisumsativum*) as well as a number of vegetables including tomatoes, chilies, eggplant (aubergine or brinjal), and even a root crop, turmeric (*Baskaran, 2012)* and castor bean in the spurge family (Daisy, 2013).

In 2009-10, 7 women farmers in Gaya district who cooperated with PRADAN (Professional Assistance for Development Action) and the Government's Agricultural Technology Management Agency (ATMA) underwayed adapting SRI practices to their mustard crop (SMI). Usual grain yields using broadcasting methods were 1 t/ha. But with different management, their yield was tripled to 3 t/ha. The following year, 283 women farmers using SMI methods averaged 3.25 t/ha. Then in 2011-12, 1,636 farmers, mostly women, got average mustard yields of 3.5 t/ha. PSI had conducted on-farm trials of maize cropping in Uttarakhand to consider different spacings and plant densities. Best results was obtained from hills spaced 40 cm x 40 cm, each with just 1-2 seeds. Their yield was 6.5 t/ha compared to 2.3 t/ha from control plots using the usual practices. In another set of trials where plant number was evaluated, 1 seed/hill gave an average yield of 6.1 t/ha compared with 5.3 t/ha from 2-seed hills and 2.8 t/ha from farmers' practice.

The management practices change an efficient difference in crop performance, which farmers appreciate. This work is just getting started, but it indicates how different practices can boost crop productivity. The extra labor invested in intensified management, to raise yields and pick up plant health and resilience is well rewarded (Bhatt, 2014).

Gembichu farmers have also experimented with SCI control for this legume, their next most vital business crop after durum wheat. In a ordinary wet season, an improved sort of lentil yields approximately 1.8 t/ha. Even so, 7 farmers who experimented with wider spacing and row planting were given a mean yield of 1.27 t/ha in that 12 months in spite of the drought, with the great farmer obtaining 2.12 t/ha. All the farmers using the brand new methods observed that their lentil plant life had accelerated numbers of branches in line with plant and set greater pods from the bottom as much as the top of every branch.

In eastern India, the Bihar rural livelihood support program reported a tripling of yields from mungbean when using SCI methods. Typical yields was about 625 kg/ha, whereas with SCI management, the average was 1.87 t/ha on farmer's fields. In northern India, People's Science Institute (PSI) reported that with adaptations of SRI practices to the cultivation of various legumes, small farmers in Uttarakhand and Himachal Pradesh states obtained higher yields by 65% in lentil & black gram, 67% in kidney beans, 50% in soybean and 42% in pea (Abraham *et al.* 2014).

No transplanting is concerned with these legume crops, just sowing only 1-2 seeds per hill as much wider spacing than in conventional practice. The result of SCI crops were found to be more high, more resistant to pest and disease damage and less affected by adverse climatic conditions.

A World Bank evaluation of SCI in Bihar, India reported that an average increase in oilseed production of 50% using SCI methods with the profitability of oilseed almost doubled raised by 93% and an average yield increases for pulses by 56%, and productivity increases by 67% (Behera*et al.* 2013).

From the above presented past research work it is revealed that optimum plant spacing using SCI technique ensures judicious use of natural resources and makes the intercultural operations easier. It increases the no. of leaves, branches and healthy foliage as well as maximum yield.

CHAPTER III

MATERIALS AND METHODS

A field experiment was undertaken at the research field of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from November 29, 2015 to March 3, 2016. This chapter contents with a concise description on experimental site, climate, soil and land preparation, layout of the experimental design, intercultural operations, data recording and their analyses.

3.1 Geographical location of the experimental site

The present piece of research work was placed in the field of Agronomy Department, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The location of the site is 23°74'N latitude and 90°35'E longitude with an elevation of 8.2 meter from sea level (Anon., 2004).

3.2 Agro-Ecological Region of the experimental site

The experimental field belongs to the agro-ecological zone of "The Modhupur Tract", AEZ-28 (Anon., 1988a). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as "islands" surrounded by floodplain (Anon., 1988b). The experimental site has been shown in the Map of AEZ of Bangladesh in Appendix I.

3.3 Weather condition of the experimental site

The climate of the experimental site is subtropical, characterized by three distinct seasons, the monsoon from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris*et al.*, 1979).

3.4 Characteristics of Soil

The soil of the experimental area was loamy belonging to the Madhupur Tract under AEZ 28. The soil of the experimental plots were clay loam, land was medium high with medium fertility level (Appendix II).The organic matter and nitrogen status of the soil was poor. The pH varied from 6.00-6.63.Morphological characteristics of the soil of experimental field was given in (Appendix III).

3.5 Planting Material

The seeds of BARI Mashur-5, BARI Masur-6, BARI Masur-7 were collected from Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh. The seeds were healthy, vigorous, well matured and free from other crop seeds and inert materials.

3.6 Description of the variety

3.6.1 BARI Masur-5: This variety was introduced from ICARDA, Syria in 2006 with medium plant stature. The plant height is 38-40 cm which is resistant to stemphylium blight and rust and is tolerant to foot rot and modrerately resistant to aphid. It contains 26% protein and 59.80% carbohydrate. It takes 12 minutes for cooking. 1000-seed weight is 19 g. The average seed yield is 1.5- 2.2 t/ha. The crop duration is 98-110 days.

3.6.2 BARI Masur-6: This variety was introduced from ICARDA, Syria in 2006. Plant height is 40-45 cm and resistant to stemphylium blight and rust. Protein% and CHO% are 26 and 58.9 respectively. Cooking time is 12 minutes for this variety. 1000-seed weight is 19.8 g. Seed yield is 1.6-2.5 t/ha. The duration is 110-115 days.

3.6.3 BARI Masur-7: This variety was introduced from ICARDA, Syria in 2011. Plant height is 32-38 cm that tolerant to stemphylium blight and rust. Protein: 26%, CHO: 58.9%. Cooking Time is 12 min. 1000-seed weight is 23-25 g. Seed yield is 1.8-2.3 t/ha. Duration is 115-120 days.

3.7 Land preparation

The land of the experimental site was first opened in November with power tiller. Later on, the land was ploughed and cross-ploughed three times followed by laddering to obtain the desired tilth. The corners of the land were spaded and larger clods were broken into smaller pieces after ploughing and laddering all the stubbles and uprooted weeds were removed and the land was ready.

3.8 Design and layout of the experiment

The two factors experiment was laid out in split plot design with three replications. An area of 25 m × 15.5 m was divided into three blocks. Three lentil varieties were placed in the main plot and five spacing treatments were in sub-plot. There were 15 treatment combinations. The total number of plots were 45. The treatments were placed to the main plots and sub plots randomly. The size of each unit plot was 2.5 m × 2 m. The space between two adjacent replications was 1.5 m. The space between two adjacent plots was 0.5 m. The layout was done at 28^{th} November, 2015. The layout of the experimental plot is shown in Appendix iv.

3.9 Treatments of the experiment

The experiment comprised of two factors

Factor A: Variety (3)

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

Factor B: Spacing (5)

S_1 = 30 cm × 10 cm
S_2 = 20 cm × 20 cm
S_3 = 30 cm × 30 cm
S_4 = 40 cm × 40 cm
S_5 = 50 cm × 50 cm

Total 15 (5x3) treatment combinations were used in the study such as- V_1S_1, V_1S_2, V_1S_3, V_1S_4, V_1S_5, V_2S_1, V_2S_2, V_2S_3, V_2S_4, V_2S_5, V_3S_1, V_3S_2, V_3S_3, V_3S_4 and V_3S_5.

3.10 Fertilizer application

Urea, Triple super phosphate (TSP), Muriate of potash (MOP) were used as a source of nitrogen, phosphorus, potassium and sulphur, respectively. Urea, TSP and MOP were applied at the rate of 40, 80 and 40 kg per hectare, respectively following the Bangladesh Agricultural Research Institute (BARI) recommendation during final land preparation. All the fertilizers were applied as basal dose during final land preparation.

3.11 Lentil seed sowing

The lentil seeds were sown at November 29 in 2015. The seeds were sown in solid rows in the furrows having a depth of 2-3 cm. Line to line distance was maintained as treatment combination.

3.12 Intercultural operations

3.12.1 Thinning

Seeds were germinated four days after sowing (DAS). Thinning was done two times; first thinning was done at 10 DAS and second was done at 20 DAS maintained spacing of plants as per treatments of the experiment to obtain proper plant population in each plot.

3.12.2 Irrigation and drainage

Irrigation was done at 20, 30 and 50 DAS. The crop field was weeded three times; first weeding was done at 15 DAS and second at 30 DAS and last one was done at 45 DAS.

3.12.3 Weeding and Mulching

The crop field was weeded three times; first weeding was done at 15 DAS and second at 32 DAS and last one was done at 45 DAS. Mulching was done after every irrigation to breakdown upper crusts.

3.12.4 Protection against pests

At early stage of lentil foot and root rot attacked the young plants ,Bavistin 250EC was applied for three times with recommended rate with 7 days intervals and at latter stage, aphid attacked the plant. Ropcord 50EC was sprayed at the rate of 1 litre ha^{-1} for two times with 7 days intervals.

3.13 Crop Sampling and data collection

Five plants from each treatment were randomly collected for data collection. Plant height, number of leaves, number of branches and dry matter content in plant were recorded from randomly collected plants at an interval of 20 days after sowing upto harvest.

3.14 Harvest and post harvest operations

The crop harvest was completed at 95 DAS. The crop was harvested plot wise after about 80% of the pods became mature. The harvested pods were sorted into individual bags for each plot. They were taken to the threshing floor and sun dried for three days. Afterwards the seeds and stover were separately weighed.

3.15 Collection of data

A. Growth parameters

- Plant height (cm) (starting from 20 DAS to harvest at 20 days interval)
- Branches per plant (no.) (starting from 20 DAS to harvest at 20 days interval)
- Leaflets per plant (no.) (starting from 20 DAS to harvest at 20 days interval)
- Above ground dry weight per plant (g) (20,40,60,80 DAS and at harvest)
- Nodules wt. Per plant (at 75 DAS)

B. Yield contributing characters

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

- Seeds pod^{-1} (no.)
- Weight of 1000 seeds (g)

C. Yield and harvest Index

- Seed yield (t ha$^{-1)}$
- Stover yield (t ha^{-1})
- Biological yield (t ha^{-1})
- Harvest index (%)

3.16 Procedure of data collection

3.16.1 Plant height (cm)

Plant height of 5 randomly collected plants was measured with a meter scale from the ground level to the tip of the plants and the mean height was expressed in cm. Data were recorded from the inner rows of each plot starting from 20 DAS at 20 days interval up to harvest.

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

Branches were counted from collected plants starting from 20 DAS at 20 days interval up to harvest. The total branches of 5 plants were averaged to have number of branches plant^{-1}.

3.16.3 Leaflets/plant (no.)

Leaflets were counted from collected plants starting from 20 DAS at 20 days interval up to harvest.The total branches of 5 plants were averaged to have number of leaflets plant^{-1}.

3.16.4 Above ground dry matter plant^{-1} (g)

Five sample plants from each plot were collected and gently root were removed. The sample was oven dried at 70^{0}C for 72 hours. Then oven-dried samples were transferred into a desiccator and allowed to cool down to room temperature, thereafter dry weight of plants was taken and expressed in gram. Above ground dry matter plant^{-1} was recorded at 20, 40, 60, 80 DAS and harvest.

3.16.5 Nodule dry weight/plant (mg)

At 75 DAS, when maximum flowers were bloomed and pod initiation was seen, 3 plants from inner rows were collected for nodules. The sample was oven dried at 70^0C for 72 hours. Then oven-dried samples were transferred into a desiccator and allowed to cool down to room temperature, thereafter dry weight of nodules was taken and expressed in milligram (mg).

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

Total pods of collected plants from each plot were counted and the mean numbers were expressed as pods plant^{-1}. Data were recorded as the average of 10 plants collected at random from the inner rows of each plot.

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

Seeds pod^{-1} was recorded randomly from 20 pods at the time of harvest.

3.16.8 Weight of 1000 seeds (g)

One thousand cleaned, dried seeds were counted from each harvested sample and weighed by using a digital electric balance and weight was expressed in gram (g).

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

The seeds collected from 2 m^2 square meter area of each plot were sun dried properly. The weight of seeds was taken and converted the yield in t ha^{-1}.

3.16.10 Stover yield (t ha^{-1})

The stover collected from 2 m^2 area of each plot was sun dried properly. The weight of stover was taken and converted the yield in t ha^{-1}.

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

Seed yield and stover yield together were regarded as biological yield. The biological yield was calculated with the following formula:

Biological yield = Seed yield + Stover yield.

3.16.12 Harvest index(%)

Harvest index was calculated from the seed yield and Stover yield of lentil for each plot and expressed in percentage.

Harvest Index was calculated with the help of following formula-

Harvest index (HI%) = (Seed yield/Biological yield) ×100.

Here, Biological yield = (Seed yield + Stover yield)

3.17 Statistical analysis

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

CHAPTER IV

RESULT AND DISCUSSION

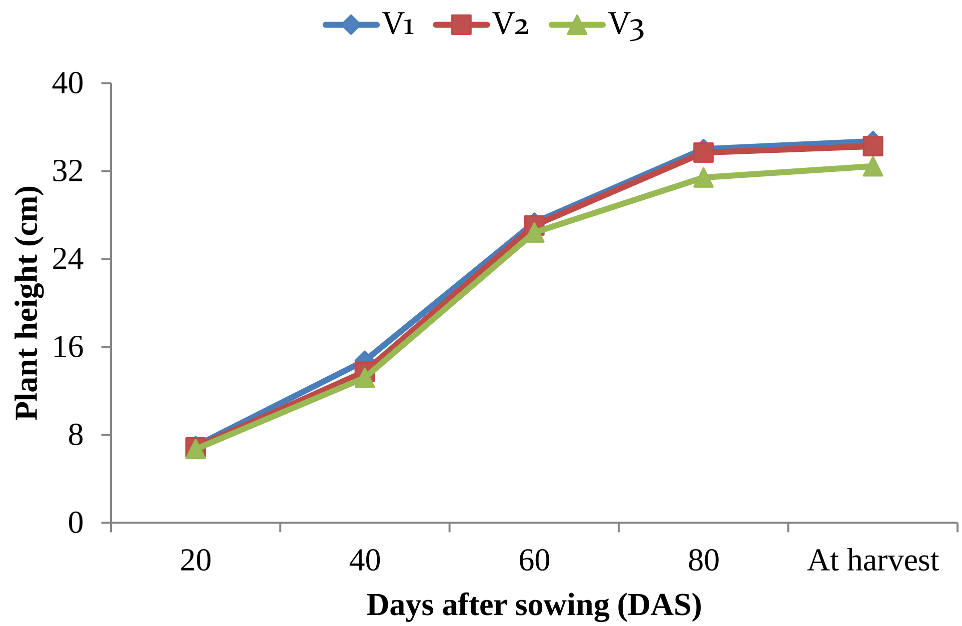
This chapter included presentation and discussion of the results obtained from the study of the growth and yields of lentil as affected by variety and spacing, under agro climatic condition of Sher-e-Bangla Agricultural University (SAU), Dhaka. The analysis of variance (ANOVA) of the data on different yield contributing characters and yield of lentil are presented in Appendix. The results which are influenced by different treatment have been presented and discussed in different tables and graphs and possible interpretations given under the following headings:

4.1 Parameters of crop growth

4.1.1 Plant height (cm)

4.1.1.1 Variety effect

There was no significant variation for plant height of lentil varieties at 20, 40 and 60 DAS. On the other hand, significant variation was found for plant height of lentil for different factors at 80 DAS and harvest (Fig. 1). At 80 DAS, the tallest plant was found in V_1 (34 cm) which was similar to V_2 (33.68 cm).The shortest plant at 80 DAS was found in V_3 (31.42 cm). At harvest, the tallest plant was found in V_1 (34.72 cm) which was statistically similar to V_2 (34.26 cm) and the shortest one was in V_3 (32.44 cm). Hossain*et al.* (2016) showed the statistically similar plant height of lentil for different varieties.

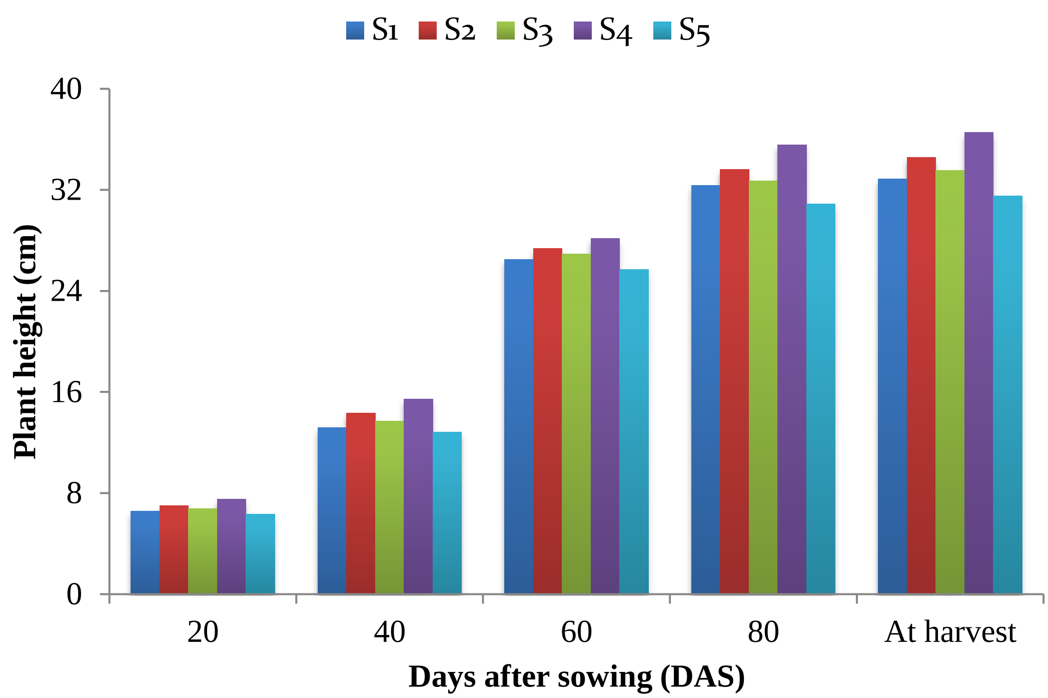


V_1 =BARI Masur-5, V_2 =BARI Masur-6 and V_3= BARI Masur-7

Figure 1. Variety effect on the plant height of lentil at different days after sowing ($LSD_{(0.05)}$ = NS, NS, NS, 3.24 and 2.63 at 20, 40, 60, 80 DAS and harvest, respectively)

4.1.1.2 Influence of different spacing

Significant variation was found for different spacing of lentilat 20, 40, 60, 80 DAS and at harvest for plant height (Fig. 2). Here the tallest plant was found in S_4(7.52 cm) at 20 DAS. The shortest plant at 20 DAS was found in S_5 (6.32 cm) which was statistically similar with S_1 (6.58 cm). At 40 DAS, the tallest plant was found in S_4(15.44 cm).The shortest plant at 40 DAS was found in S_5 (12.82 cm) which was statistically similar with S_1 (13.18 cm) and S_3 (13.69 cm). At 60 DAS, the tallest plant was shown in S_4 (28.14 cm) which was statistically similar with S_2 and S_3 was 27.35 cm and 26.94 cm, respectively. The shortest plant at 60 DAS was found in S_5 (25.70 cm) that was statistically similar with S_1 (26.48 cm) and S_3 (26.94 cm). At 80 DAS, the tallest plant was found in S_4(35.56 cm).The shortest plant at 80 DAS was found in S_5 (30.89 cm) which was statistically similar to S_1 (32.37 cm). At harvest, the tallest plant was found in S_4 (36.55 cm) statistically similar with S_2 (34.56 cm) and the shortest one was in S_5 (31.52 cm) statistically similar with S_1 (32.88 cm) and S_3 (33.53 cm), respectively. But Habbasha*et al.* (1996); Muehlbauer*et al.* (1985) and Singh *et al.* (2003) reported that increasing plant density increased plant height of lentil.



S_1: 30 cm × 10 cm, S_2: 20 cm × 20 cm, S_3: 30 cm × 30 cm, S_4: 40 cm × 40 cm, S_5: 50 cm × 50 cm

Figure 2. Influence of spacing on the plant height of lentil at different days after sowing (LSD (0.05) = 0.41, 0.99, 1.57, 1.75 and 2.25 at 20, 40, 60, 80 DAS and harvest, respectively)

4.1.1.3 Combined effect of variety and spacing

Statistically significant differences were recorded for the combined effect of variety and spacing for plant height at 20, 40, 60, 80 DAS and at harvest (Table 1). The highest plant height (7.90 cm) was recorded for V_1S_4 combination which showed statistical similarity with V_2S_4 (7.53 cm). the shortest plant (6.27 cm) was recorded from V_3S_5 combination which was statistically similar with V_1S_5 (6.33cm), V_2S_5 (6.37 cm), V_3S_1 (6.37cm), V_2S_1 (6.53cm), V_2S_3 (6.77cm), V_3S_3 (6.77 cm), V_1S_3 (6.83 cm), V_1S_1 (6.87 cm), V_1S_2 (6.97 cm) and V_3S_2 (6.97 cm).

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

Treatment combination	Plant height (cm) at different days after sowing (DAS)				
	20	40	60	80	At harvest
V_1S_1	6.87 b-d	14.13 b-d	26.74 a-c	33.17 c-e	33.53 b-e
V_1S_2	6.97 b-d	15.19 ab	27.78 ab	35.17 a-c	36.27 a-c
V_1S_3	6.83 b-d	14.19 b-d	26.90 a-c	34.00 a-d	34.34 a-d
V_1S_4	7.90 a	16.49 a	28.85 a	37.00 a	38.00 a
V_1S_5	6.33 d	13.67 b-e	26.21 a-c	30.67 ef	31.48 de
V_2S_1	6.53 cd	13.16 c-e	26.40 a-c	32.98 c-e	33.45 b-e
V_2S_2	7.10 bc	14.16 b-d	27.53 a-c	33.58 b-e	34.18 a-e
V_2S_3	6.77 cd	13.54 b-e	27.21 a-c	33.08 c-e	33.87 b-e
V_2S_4	7.53 ab	15.07 ab	28.13 ab	36.42 ab	37.12 ab
V_2S_5	6.37 d	12.77 de	25.96 bc	32.35 c-f	32.66 c-e
V_3S_1	6.37 d	12.26 e	26.30 a-c	30.95 ef	31.65 de
V_3S_2	6.97 b-d	13.65 b-e	26.75 a-c	32.12 d-f	33.22 c-e
V_3S_3	6.77 cd	13.33 c-e	26.70 a-c	31.10 d-f	32.38 c-e
V_3S_4	7.13 bc	14.75 bc	27.44 a-c	33.25 c-e	34.53 a-d
V_3S_5	6.27 d	12.04 e	24.92 c	29.67 f	30.41 e
$LSD_{(0.05)}$	0.71	1.71	2.72	3.04	3.89
CV (%)	6.16	7.30	6.00	5.45	6.83

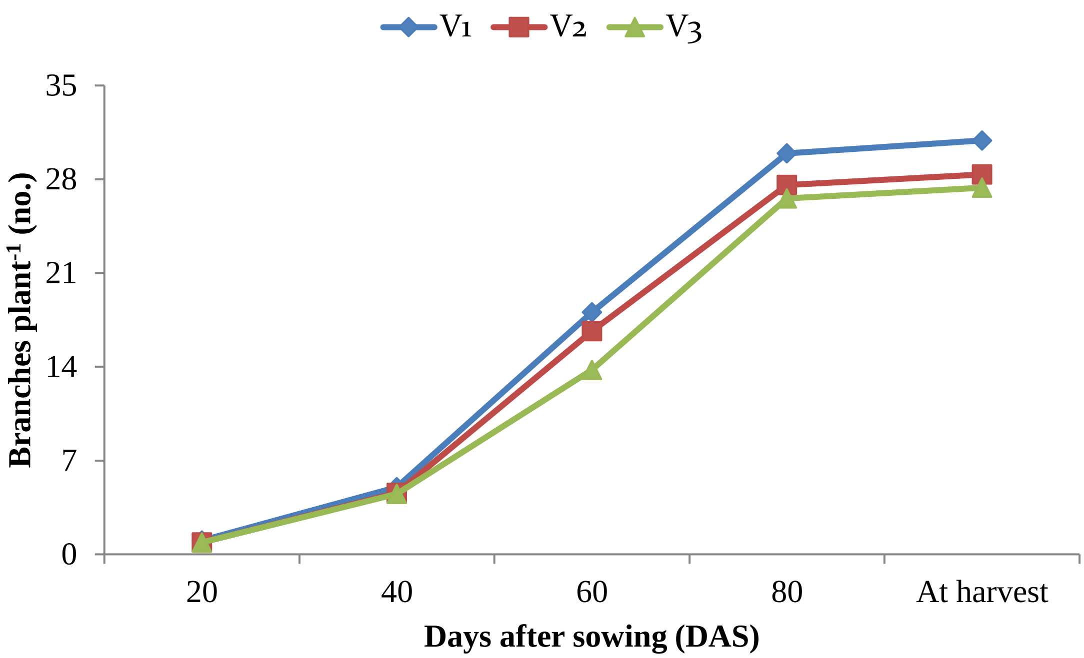
V_1 = BARI Masur-5, V_2 = BARI Masur-6 and V_3= BARI Masur-7

S_1=30 cm × 10 cm, S_2=20 cm × 20 cm, S_3=30 cm × 30 cm, S_4=40 cm × 40 cm, S_5=50 cm × 50 cm

4.1.2 Branches per plant (no.)

4.1.2.1 Influence of variety

Number of branches per lentil plant varied significantly due to variety at 20, 40, 60, 80 DAS and at harvest (Fig. 3). The highest number of branches per plant (1.02)was obtained from V_1 (BARI Masur-5) while the lowest number of branches per plant (0.88) was found in V_3 (BARI Masur-7) and V_2 (BARI Masur-6) at 20 DAS. At 40 DAS, the highest branches/plant (5.00) was recorded from V_1 (BARI Masur-5), the lowest no. of branches/plant (4.50) was found in V_3 (BARI Masur-7) which was statistically similar (4.58) with V_2 (BARI Masur-6).

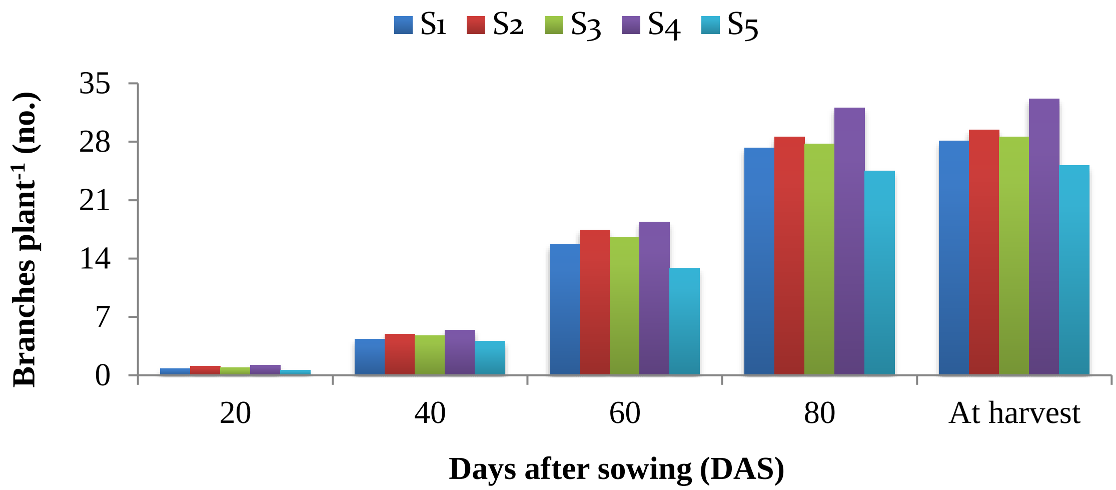


V_1 =BARI Masur-5, V_2 =BARI Masur-6 and V_3 =BARI Masur-7

Figure 3. Influence of variety on the branches plant^{-1} of lentil at different days after sowing (LSD $_{(0.05)}$ = 0.03, 0.33, 1.50, 2.69 and 3.35 at 20, 40, 60, 80 DAS and harvest, respectively

4.1.2.2 Spacing effect

Statistically significant variation was recorded for number of branches per plant of lentil at 20, 40, 60, 80 DAS and at harvest due to different spacings (Fig. 4). At 20 DAS the highest number of branches per plant (1.24) was found in S_4 and the lowest number of branches per plant (0.62) was obtained from S_5. The highest number of branches/plant (5.43) was found from S_4 and the lowest number of branches/plant (4.07) was in S_5 which was statistically similar with S_1 (4.32) at 40 DAS. The highest number of branches/plant (18.37) was found from S_4 which was statistically similar with S_2 (17.41) and the lowest number of branches/plant (12.85) was in S_5 at 60 DAS. The highest number of branches/plant (32.06) was found from S_4 and the lowest number of branches/plant was in S_5 (24.50) at 80 DAS. Finally, at harvest, the highest number of branches/plant (33.13) was found from S_4 and the lowest number of branches/plant was in S_5 (25.15). Seyyed*et al.* (2014) showed the similar result. In general, number of branches per plant increased in optimum plant density and it was probably due to availability of suitable space, nutrition and environment viz. air, moisture, humidity, water, light intensity etc.



S_1: 30 cm × 10 cm, S_2: 20 cm × 20 cm, S_3: 30 cm × 30 cm, S_4: 40 cm × 40 cm, S_5: 50 cm × 50 cm

Figure 4. Spacing effect on the branches plant^{-1} of lentil at different days after sowing (LSD $_{(0.05)}$ = 0.05, 0.28, 1.32, 2.09 and 1.84 at 20, 40, 60, 80 DAS and harvest, respectively)

4.1.2.3 Combined effect of variety and spacing

Statistically significant differences were detected for the combined effect of variety and spacing for number of branches at 20, 40, 60, 80 DAS and at harvest (Table 2). The highest number of branches/plant was shown in the treatment combination V_1S_4 (1.43) whereas the lowest number of branches/plant was observed in the combination V_3S_5 (0.57) wchich was statistically similar with V_1S_5 (0.57) at 20 DAS. The highest number of branches/plant was recorded in the treatment combination V_1S_4 (5.77) that was statistically similar with V_3S_4 (5.40) whereas the lowest number of branches/plant was observed in the combination V_3S_5 (3.87) which was statistically identical with V_2S_5 (4.07), V_3S_1 (4.23), V_2S_1 (4.23) and V_1S_5 (4.30) at 40 DAS. The most number of branches/plant was shown in the treatment combination V_1S_4 (21.11) that was statistically similar with V_1S_2 (19.66) whereas the lowest number of branches/plant was observed in the combination V_3S_5 (10.78) at 60 DAS. The highest number of branches/plant was recorded in the treatment combination V_1S_4 (34.50) that was statistically similar with V_2S_4 (31.33) whereas the lowest number of branches/plant was observed in the combination V_3S_5 (22.33) which was statistically identical with V_2S_5 (24.00) at 80 DAS. The highest number of branches/plant was recorded in the treatment combination V_1S_4 (36.00) and the lowest number of branches/plant was observed in the combination V_3S_5 (23.00) which was statistically identical with V_2S_5 (24.44) at harvest.

Table 2. Combined effect of variety and spacing on the leaflets plant $^{-1}$of lentil at different days after sowing

Treatment combination	Leaflets plant^{-1} at different days after sowing (DAS)				
	20	40	60	80	At harvest
V_1S_1	7.53 d-g	34.63 b	81.73 cd	200.9 de	176.1 cd
V_1S_2	9.27 ab	36.63 a	90.44 ab	229.5 b	199.9 b
V_1S_3	8.10 cde	35.37 ab	85.13 bc	211.6 cd	191.9 b
V_1S_4	9.33 a	33.73 bc	95.40 a	254.5 a	222.4 a
V_1S_5	7.33 f-h	31.43 de	80.04 c-e	190.7 ef	170.2 cd
V_2S_1	7.37 e-h	28.93 f-h	72.22 f-i	176.0 gh	145.9 f
V_2S_2	8.43 c	30.70 d-f	76.97 d-f	197.3 ef	176.7 c
V_2S_3	8.23 cd	29.90 e-g	75.16 e-h	184.6 fg	166.0 c-e
V_2S_4	8.57 bc	32.23 cd	85.79 bc	222.3 bc	201.7 b
V_2S_5	7.00 gh	26.17 ij	69.17 hi	171.4 gh	164.8 de
V_3S_1	7.07 gh	27.10 hi	70.30 g-i	176.0 gh	155.1 ef
V_3S_2	7.97 c-f	29.27 fg	76.01 d-g	184.6 fg	171.4 cd
V_3S_3	7.57 d-g	28.17 gh	72.22 f-i	171.4 gh	158.2 e
V_3S_4	8.20 cd	31.25 de	80.97 c-e	201.8 de	190.7 b
V_3S_5	6.70 h	25.16 j	67.23 i	164.8 h	145.0 f
LSD $_{(0.05)}$	0.75	1.84	6.32	14.14	11.84
CV (%)	5.61	3.55	4.77	4.29	4.00

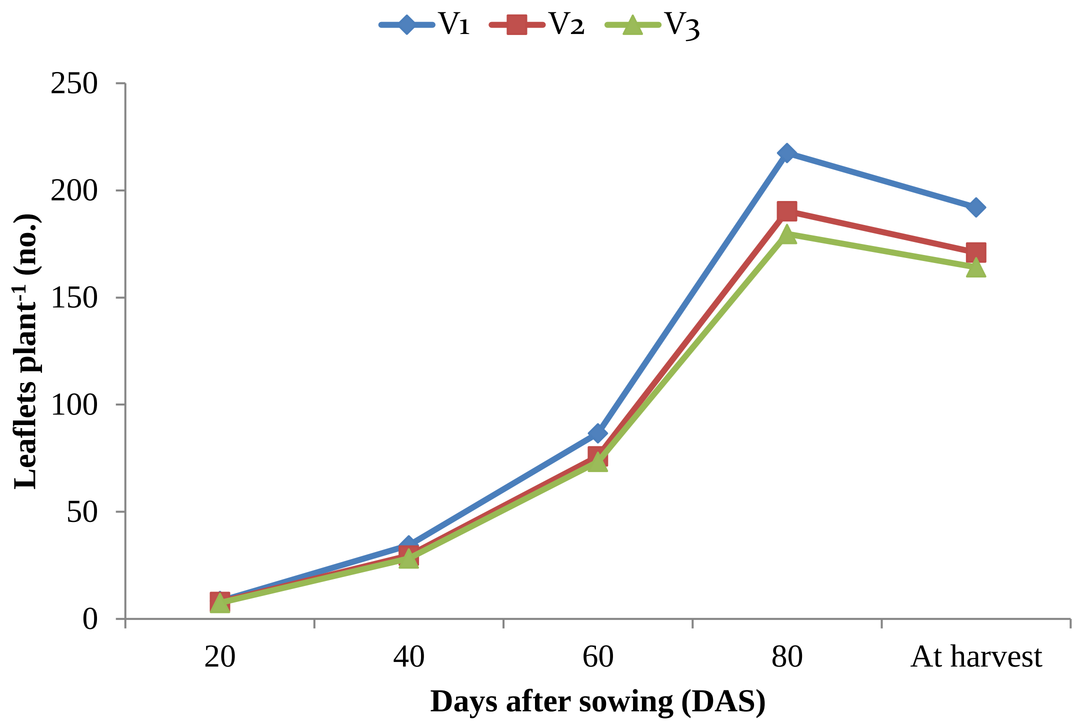
V_1 = BARI Masur-5, V_2 = BARI Masur-6 and V_3 = BARI Masur-7

S_1: 30 cm × 10 cm, S_2: 20 cm × 20 cm, S_3: 30 cm × 30 cm, S_4: 40 cm × 40 cm, S_5: 50 cm × 50 cm

4.1.3 Leaflets per plant (no.)

4.1.3.1 Variety influence

Number of leaflets per lentil plant varied significantly due to variety at 20, 40, 60, 80 DAS and harvest (Fig. 5). The highest number of leaflets (8.31) per plant was obtained from V_1 (BARI Masur-5) at 20 DAS while the lowest number of leaflets per plant (7.50) was found in V_3 (BARI Masur-7). At 40 DAS the most no. of leaflets/plant (34.36) was recorded from BARI Masur-5(V_1) and the lowest number of leaflets per plant (28.19) was found in V_3 (BARI Masur-7) which was statistically identical (29.59) to V_2 (BARI Masur-6). At 60 DAS the most leaflets/plant (86.55) was recorded from BARI Masur-5 (V_1) and the lowest number of leaflets per plant (73.35) was found in V_3 (BARI Masur-7) which was statistically identical (75.86) to V_2 (BARI Masur-6). The highest number of leaflets (217.4) per plant was obtained from V_1 (BARI Masur-5) at 80 DAS while the lowest number of leaflets per plant (179.7) was found in V_3 (BARI Masur-7). The most leaflets/plant (192.1) was recorded from BARI Masur-5(V_1) and the lowest number of leaflets per plant (164.1) was found in V_3 (BARI Masur-7) which was statistically identical (171.0) to V_2 (BARI Masur-6) at harvest.

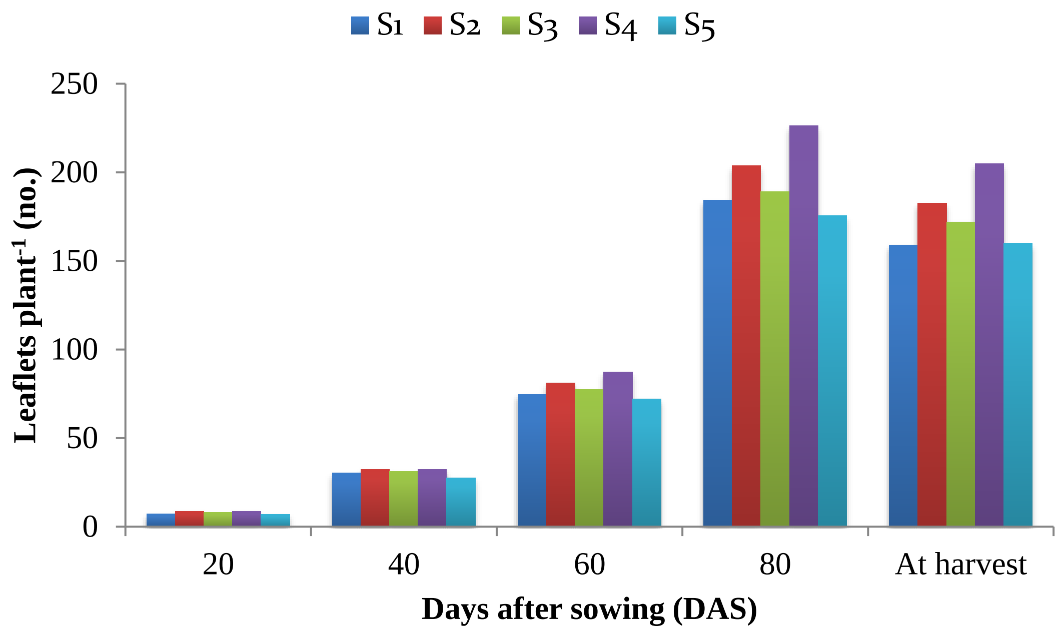


V_1 = BARI Masur-5, V_2 = BARI Masur-6 and V_3= BARI Masur-7

Figure 5. Variety influence on the leaflets plant^{-1} of lentil at different days after sowing (LSD $_{(0.05)}$ = 0.27, 2.35, 6.20, 5.59 and 7.87 at 20, 40, 60, 80 DAS and harvest, respectively)

4.1.3.2 Influence of spacing

Statistically significant variation was recorded for number of leaflets per plant of lentil at 20, 40, 60, 80 DAS and at harvest due to different spacings (Fig. 6). At 20 DAS the highest number of leaflets per plant was found in S_4 (8.7) which was statistically identical to S_2 (8.56) and the lowest number of leaflets per plant was obtained from S_5 (7.01) was statistically similar with S_1 (7.32). At 40 DAS the highest number of leaflets per plant was found in S_4 (32.40) which was statistically identical to S_2 (32.20) and the lowest number of leaflets per plant was obtained from S_5 (27.59). At 60 DAS the highest number of leaflets per plant was found in S_4 (87.39) and the lowest number of leaflets per plant was obtained from S_5 (72.15) was statistically similar with S_1 (74.75). The highest number of leaflets per plant was found in S_4 (226.2) and the lowest number of leaflets per plant was obtained from S_5 (175.6) at 80 DAS. The highest number of leaflets per plant was found in S_4 (204.9) and the lowest number of leaflets per plant was obtained from S_5 (160) was statistically similar with S_1 (159) at harvest. In general, number of leaflets per plant increased in optimum plant density and it was probably due to availability of suitable space, nutrition and environment viz. air, moisture, humidity, water, light intensity etc.



S_1: 30 cm × 10 cm, S_2: 20 cm × 20 cm, S_3: 30 cm × 30 cm, S_4: 40 cm × 40 cm, S_5: 50 cm × 50 cm

Figure 6. Influence of spacing on the leaflets plant^{-1} of lentil at different days after sowing (LSD $_{(0.05)}$ = 0.43, 1.06, 3.65, 8.17 and 6.83 at 20, 40, 60, 80 DAS and harvest, respectively)

4.1.3.3 Combined effect of variety and spacing

Statistically significant differences were detected for the combined effect of variety and spacing for number of leaflets at 20, 40, 60, 80 DAS and at harvest (Table 3). The most number of leaflets/plant was shown in the treatment combination V_1S_4 (9.33) that was statistically identical with V_1S_2 (9.27) whereas the lowest number of leaflets/plant was observed in the combination V_3S_5 (6.70) wchich was statistically identical with V_2S_5 (7.00), V_3S_1 (7.07) , V_1S_5 (7.33) and V_2S_1 (7.37) at 20 DAS. The highest number of leafles/tplant was recorded in the treatment combination V_1S_2 (36.63) that was statistically similar with V_1S_3 (35.37) whereas the lowest number of leaflets/plant was observed in the combination V_3S_5 (25.16) which was statistically identical with V_2S_5 (26.17) at 40 DAS. The most number of leaflets/plant was shown in the treatment combination V_1S_4 (95.40) that was statistically similar with V_1S_2 (90.44) whereas the lowest number of leaflets/plant was observed in the combination V_3S_5 (67.23) that was statistically similar with V_2S_5 (69.17), V_3S_1 (70.30), V_3S_3 (72.22) and V_2S_1 (72.22) at 60 DAS. The highest number of leaflets/plant was recorded in the treatment combination V_1S_4 (254.5) and the lowest number of leaflets/plant was observed in the combination V_3S_5 (164.8) which was statistically identical with V_2S_5 (171.4), V_3S_3 (171.4), V_3S_1 (176) andV_2S_1 (176) at 80 DAS. The highest number of leaflets/plant was recorded in the treatment combination V_1S_4 (222.4) and the lowest number of leaflets/plant was observed in the combination V_3S_5 (145) which was statistically identical with V_2S_1 (145.9) and V_3S_1 (155.1) at harvest.

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

Treatment combination	Branches plant^{-1} at different days after sowing (DAS)				
	20	40	60	80	At harvest
V_1S_1	0.77 gh	4.50 d	17.22 c-e	28.83 b-e	29.83 b-e
V_1S_2	1.33 b	5.23 b	19.66 ab	30.00 b-d	30.76 b-d
V_1S_3	1.03 d	5.20 b	18.44 bc	29.17 b-e	29.90 b-e
V_1S_4	1.43 a	5.77 a	21.11 a	34.50 a	36.00 a
V_1S_5	0.57 i	4.30 de	13.89 gh	27.17 c-f	28.00 de
V_2S_1	0.80 gh	4.23 de	16.11 d-g	26.67 d-f	27.46 ef
V_2S_2	0.97 de	5.00 bc	17.78 b-d	28.50 b-e	29.45 b-e
V_2S_3	0.77 gh	4.50 d	16.89 c-f	27.33 c-f	28.33 c-e
V_2S_4	1.17 c	5.13 b	18.66 bc	31.33 ab	32.10 b
V_2S_5	0.73 h	4.07 de	13.89 gh	24.00 fg	24.44 fg
V_3S_1	0.83 fg	4.23 de	13.77 h	26.23 ef	27.03 ef
V_3S_2	1.00 d	4.53 cd	14.78 f-h	27.16 c-f	28.07 de
V_3S_3	0.90 ef	4.50 d	14.22 gh	26.75 c-f	27.47 ef
V_3S_4	1.13 c	5.40 ab	15.33 e-h	30.33 bc	31.28 bc
V_3S_5	0.57 i	3.87 e	10.78 i	22.33 g	23.00 g
LSD $_{(0.05)}$	0.09	0.49	2.28	3.61	3.19
CV (%)	6.26	6.15	8.37	7.65	6.55

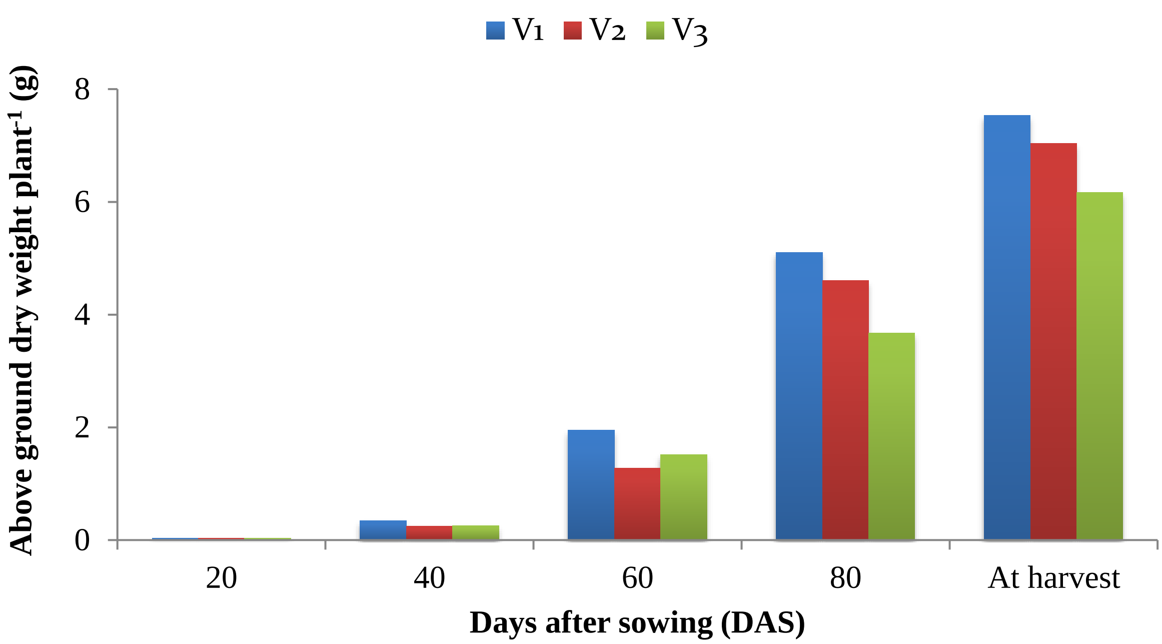
V_1 =BARI Masur-5, V_2 =BARI Masur-6 and V_3=BARI Masur-7

S_1= 30 cm × 10 cm, S_2= 20 cm × 20 cm, S_3= 30 cm × 30 cm, S_4= 40 cm × 40 cm, S_5= 50 cm × 50 cm

4.1.4. Above ground dry matter per plant (g)

4.1.4.1 Influence of variety

Above ground dry matter per plant of lentil varied significantly due to cultivar at 20, 40, 60, 80 DAS and harvest (Fig. 7). There was no significant differences of above ground dry matter per plant found among V_1 (BARI Masur-5), V_2 (BARI Masur-6) and V_3 (BARI Masur-7) at 20 DAS. At 40 DAS, the most above ground dry matter per plant (0.34 g) was recorded from BARI Masur-5 (V_1) and the lowest above ground dry matter per plant (0.24 g) was found both in V_2 (BARI Masur-6). At 60 DAS, the highest above ground dry matter/plant (1.94 g) was recorded from BARI Masur-5 (V_1) and the lowest number of leaflets per plant (1.27 g) was found in V_2 (BARI Masur-6). The highest above ground dry matter per plant (5.10 g) was obtained from V_1 (BARI Masur-5) at 80 DAS while the lowest above ground dry matter per plant (3.67 g)) was found in V_3 (BARI Masur-7). The highest above ground dry matter/plant (7.53 g) was recorded from BARI Masur-5 (V_1) and the lowest above ground dry matter per plant (6.16 g) was found in V_3 (BARI Masur-7) at harvest.

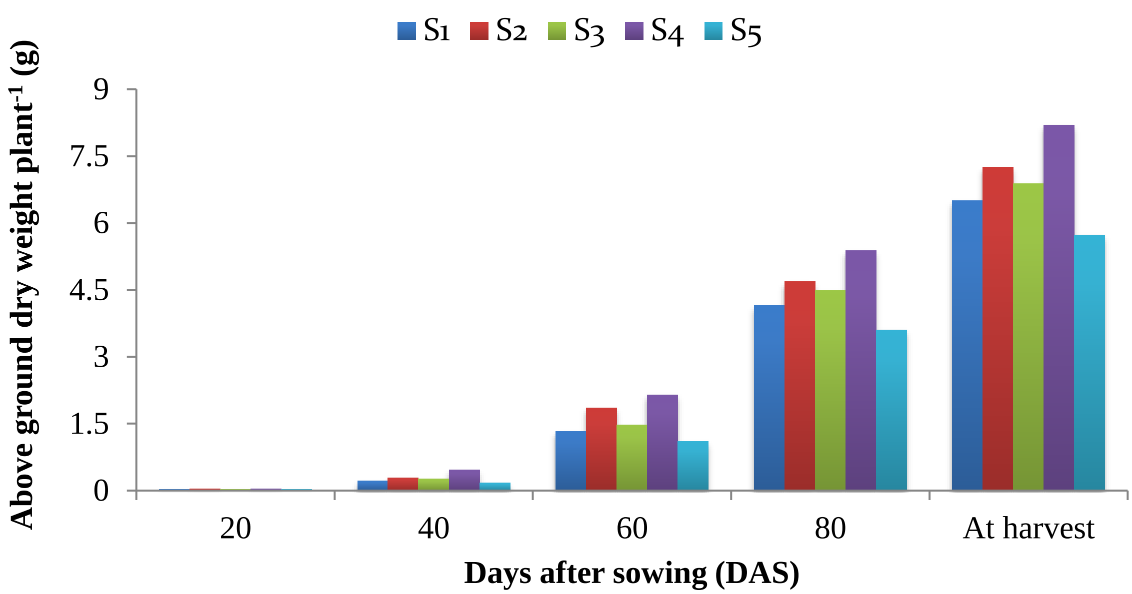


V_1 = BARI Masur-5, V_2 = BARI Masur-6 and V_3 = BARI Masur-7

Figure 7. Influence of variety on the above ground dry weight plant^{-1} of lentil at different days after sowing (LSD $_{(0.05)}$ = 0.01, 0.01, 0.08, 0.38 and 0.24 at 20, 40, 60, 80 DAS and harvest, respectively)

4.1.4.2 Influence of spacing

Above ground dry matter per lentil plant varied significantly due to spacing at 20, 40, 60, 80 DAS and harvest (Fig. 8). The maximum above ground dry matter was recorded from S_4 (0.04 g) which was statistically similar with S_2 (0.04 g) , S_3 (0.03 g) at 20 DAS. The minimum above ground dry matter/plant (0.02 g) was obtained from S_5 which statistically identical with S_1 (0.03 g) and S_3 (0.03 g) at 20 DAS. The maximum above ground dry matter was recorded from S_4 (0.47 g) while the minimum above ground dry matter/plant (0.18 g) was obtained from S_5 at 40 DAS. The maximum above ground dry matter was recorded from S_4 (2.15 g) while the minimum above ground dry matter/plant (1.10 g) was obtained from S_5 at 60 DAS. The maximum above ground dry matter was recorded from S_4 (5.38 g) while the minimum above ground dry matter/plant (3.60 g) was obtained from S_5 at 80 DAS. The maximum above ground dry matter was recorded from S_4 (8.20 g) while the minimum above ground dry matter/plant (5.73 g) was obtained from S_5 at harvest.



S_1=30 cm × 10 cm, S_2=20 cm × 20 cm, S_3=30 cm × 30 cm, S_4=40 cm × 40 cm, S_5=50 cm × 50 cm

Figure 8. Influence of spacing on the above ground dry weight plant^{-1} of lentil at different days after sowing (LSD $_{(0.05)}$ = 0.01, 0.03, 0.13, 0.36 and 0.46 at 20, 40, 60, 80 DAS and harvest, respectively)

4.1.4.3 Combined effect of variety and spacing

Statistically significant differences were detected for the combined effect of cultivar and spacing for above ground dry matter at 20, 40, 60, 80 DAS and harvest (Table 4). The highest above ground dry matter was observed in the treatment combination V_1S_4 (0.05 g) which was statistically identical with V_1S_2, V_2S_2, V_2S_4, V_3S_2, V_3S_4, V_1S_3, V_2S_1 and V_2S_3 treatment combination whereas the lowest above ground dry matter was observed in the combination V_3S_5 (0.02 g) which was statistically identical with V_1S_5, V_2S_5, V_1S_1, V_3S_1, V_3S_3, V_1S_3, V_2S_1, V_2S_3, V_2S_2, V_2S_4, V_3S_2 and V_3S_4 treatment combination at 20 DAS. The highest above ground dry matter was observed in the treatment combination V_1S_4 (0.63 g) while the lowest above ground dry matter was observed in the combination V_2S_5 (0.14 g) which was statistically identical with V_3S_5 (0.16 g) and V_2S_1 (0.16 g) treatment combination at 40 DAS. The highest above ground dry matter was observed in the treatment combination V_1S_4 (2.57 g) while the lowest above ground dry matter was observed in the combination V_2S_5 (0.94 g) which was statistically identical with V_3S_5 (0.97 g), V_2S_1 (1.07 g) and V_2S_3 (1.09 g) treatment combination at 60 DAS. The highest above ground dry matter was observed in the treatment combination V_1S_4 (6.30 g) which was statistical identical with V_1S_2 (5.68 g) while the lowest above ground dry matter was observed in the combination V_3S_5 (2.83 g) which was statistically identical with V_3S_1 (3.87 g) treatment combination at 80 DAS. Finally, at harvest, the highest above ground dry matter was observed in the treatment combination V_1S_4 (8.87 g) which was statistical identical with V_2S_4 (8.15 g) while the lowest above ground dry matter was observed in the combination V_3S_5 (5.24 g) which was statistically identical with V_3S_1 (5.67 g), V_1S_5 (5.92 g), V_3S_3 (5.93 g) and V_2S_5 (6.03 g) treatment combination.

Table 4. Combined effect of variety and spacing on the above ground dry weight plant $^{-1}$of lentil at different days after sowing

Treatment combination	Branches plant^{-1} at different days after sowing (DAS)				
	20	40	60	80	At harvest
V_1S_1	0.030 bc	0.25 de	1.57 d	4.45 ef	7.14 c-f
V_1S_2	0.047 ab	0.33 c	2.30 b	5.68 ab	7.99 b
V_1S_3	0.033 a-c	0.28 cd	1.91 c	5.29 bc	7.75 bc
V_1S_4	0.050 a	0.64 a	2.57 a	6.30 a	8.87 a
V_1S_5	0.027 c	0.22 e	1.39 de	3.81 gh	5.92 g-i
V_2S_1	0.033 a-c	0.16 f	1.08 f	4.60 de	6.68 e-g
V_2S_2	0.037 a-c	0.25 de	1.39 de	4.52 de	7.37 b-e
V_2S_3	0.033 a-c	0.23 e	1.10 f	4.64 de	6.95 d-f
V_2S_4	0.037 a-c	0.43 b	1.89 c	5.08 b-d	8.15 ab
V_2S_5	0.027 c	0.14 f	0.94 f	4.17 e-g	6.03 g-i
V_3S_1	0.030 bc	0.22 e	1.33 e	3.39 hi	5.68 hi
V_3S_2	0.037 a-c	0.29 cd	1.86 c	3.85 f-h	6.38 f-h
V_3S_3	0.030 bc	0.27 de	1.41 de	3.52 h	5.94 g-i
V_3S_4	0.037 a-c	0.33 c	1.98 c	4.76 c-e	7.58 b-d
V_3S_5	0.023 c	0.16 f	0.97 f	2.83 i	5.25 i
LSD $_{(0.05)}$	0.02	0.05	0.23	0.63	0.79
CV (%)	14.38	9.26	8.43	8.36	6.77

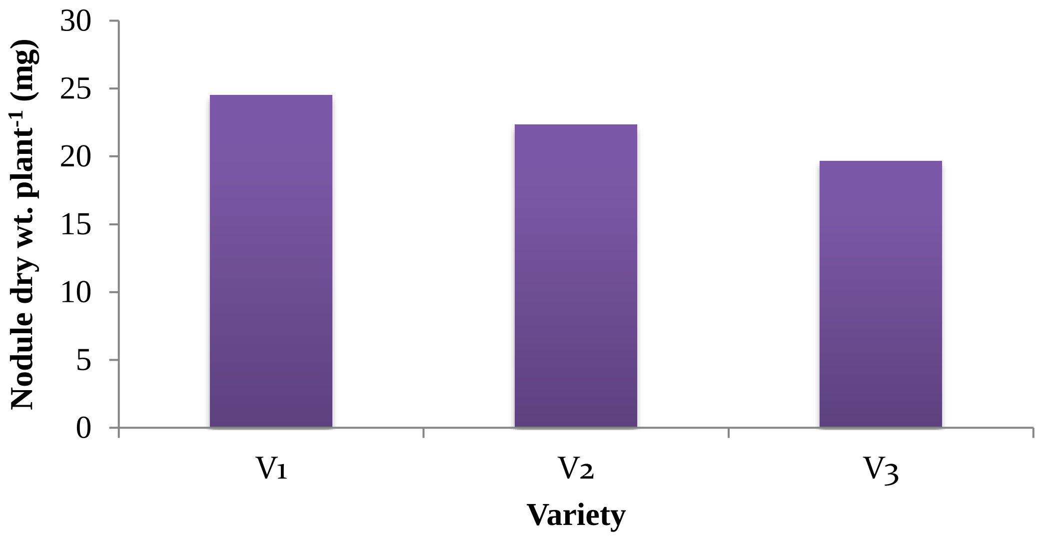
V_1 = BARI Masur-5, V_2 = BARI Masur-6 and V_3= BARI Masur-7

S_1: 30 cm × 10 cm, S_2: 20 cm × 20 cm, S_3: 30 cm × 30 cm, S_4: 40 cm × 40 cm, S_5: 50 cm × 50 cm

4.1.5 Nodule dry weight per plant (mg)

4.1.5.1 Effect of variety

Nodules dry weight/plant varied significantly of lentil due to cultivar at 75 DAS (Fig. 9). The maximum nodules dry wt. per plant (24.53 mg) was obtained from V_1(BARI Masur-5) while the lowest nodules dry wt. per plant (19.67 mg) was found in V_3 (BARI Masur-7).

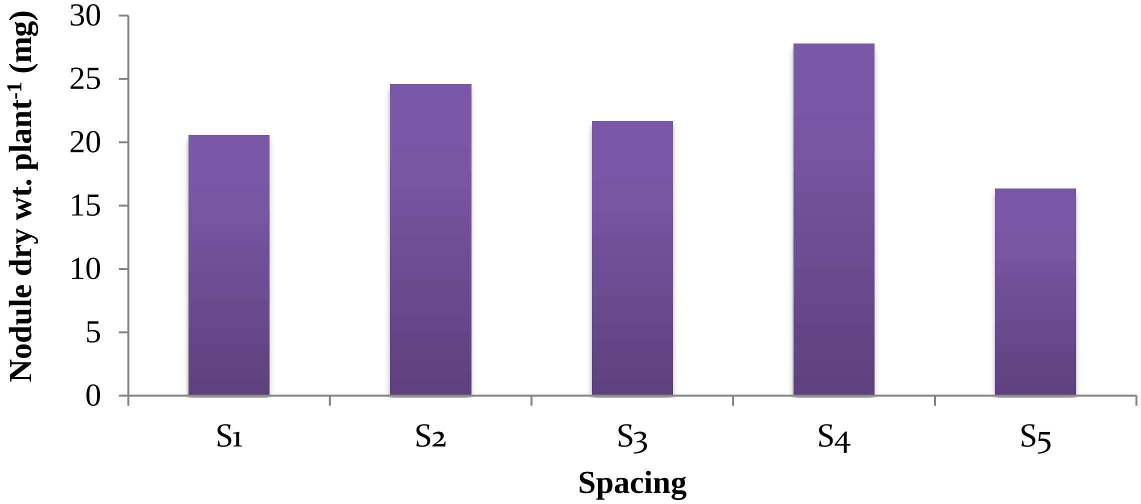


V_1 =BARI Masur-5, V_2 =BARI Masur-6 and V_3 =BARI Masur-7

Figure 9. Effect of cultivar on the nodule dry wt. plant^{-1} of lentil (LSD $_{(0.05)}$ = 2.18)

4.1.5.2 Influence of spacing

Statistically significant variation was recorded for nodules dry wt. per plant of lentil at 75 DAS due to different spacings (Fig. 10). At the maximum nodules dry wt.per plant was found in S_4 (27.78 mg) and the minimum nodules dry matter per plant was obtained from S_5 (16.33 mg) at 75 DAS.



S_1=30 cm × 10 cm, S_2=20 cm × 20 cm, S_3=30 cm × 30 cm, S_4=40 cm × 40 cm, S_5=50 cm × 50 cm

Figure 10. Influence of spacing on the nodule dry wt. plant^{-1} of lentil (LSD $_{(0.05)}$ = 0.97)

4.1.5.3 Combined effect of variety and spacing

Statistically significant differences were detected for the combined performance of cultivar and spacing for nodules dry wt. per plant at 75 DAS (Table 5). The highest nodules dry wt. per plant was observed in the treatment combination V_1S_4 (30.33 mg) whereas the lowest nodules dry wt. per plant was observed in the combination V_3S_5 (14.33 mg).

Table 5. Combined effect of variety and spacing on nodule dry weight plant^{-1} at 75 days after sowing

Treatment combination	Nodule dry weight plant^{-1} (mg)
V_1S_1	22.33 d
V_1S_2	27.33 b
V_1S_3	24.67 c
V_1S_4	30.33 a
V_1S_5	18.00 ef
V_2S_1	21.00 d
V_2S_2	24.33 c
V_2S_3	21.67 d
V_2S_4	28.00 b
V_2S_5	16.67 f
V_3S_1	18.33 ef
V_3S_2	22.00 d
V_3S_3	18.67 e
V_3S_4	25.00 c
V_3S_5	14.33 g
$LSD_{(0.05)}$	1.68
CV (%)	4.50

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

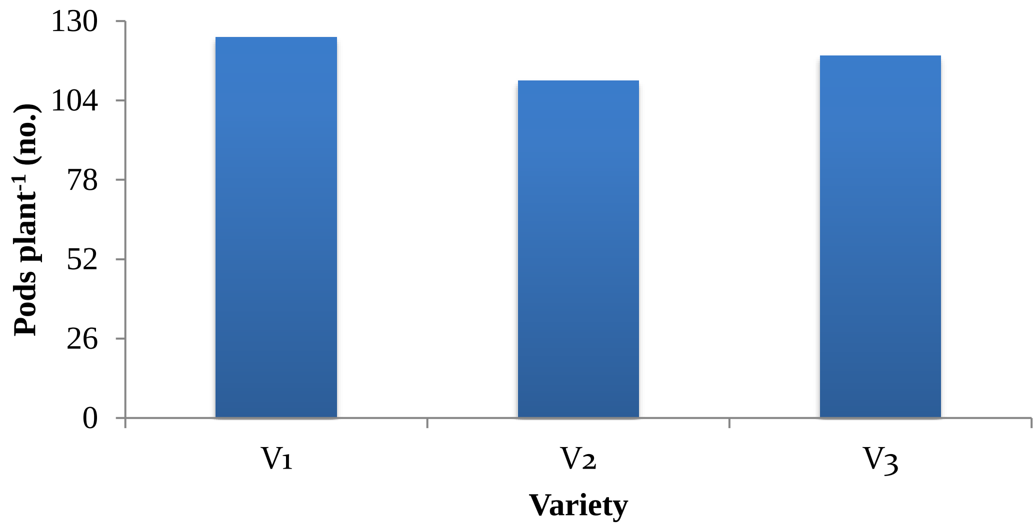
S_1=30 cm × 10 cm, S_2=20 cm × 20 cm, S_3=30 cm × 30 cm, S_4=40 cm × 40 cm, S_5=50 cm × 50 cm

4.2 Yield and yield contributing characters of lentil

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

4.2.1.1 Influence of variety

A statistically significant variation was recorded for number of pods plant^{-1}of lentil due to different cultivar (Fig. 11). The highest number of pods per plant (124.7) was found in V_1 (BARI Masur-5) while the lowest number of pods per plant was found in V_2 (110.4) as BARI Masur-6.



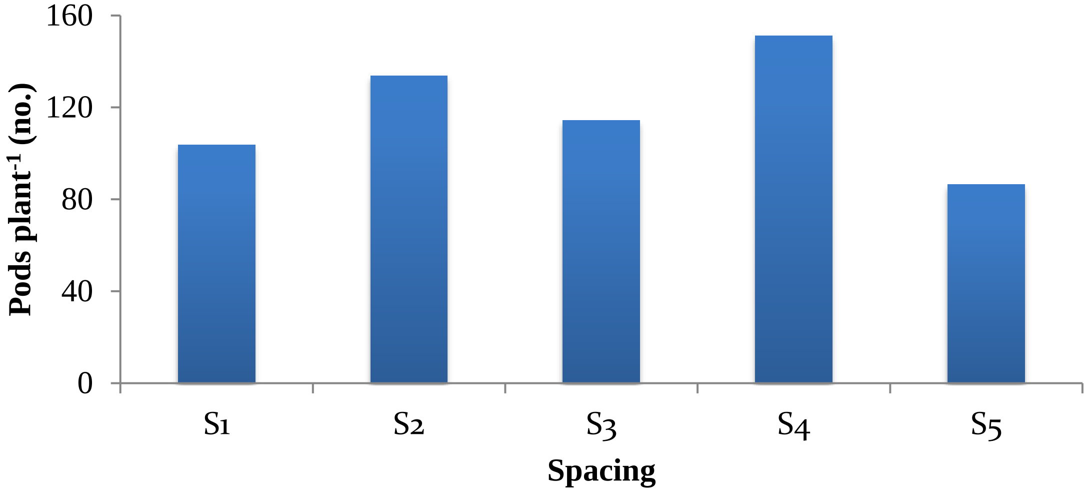
V_1 = BARI Masur-5, V_2 = BARI Masur-6 and V_3 = BARI Masur-7

Figure 11. Variety influence on the pods plant^{-1} of lentil (LSD $_{(0.05)}$ = 4.64)

4.2.1.2 Influence of spacing

Number of pods per plant of lentil varied significantly due to spacing (Fig. 12). The highest number of pods per plant was found in S_4 (151.2). The lowest number of pods per plant was observed in S_5 (86.47). The optimization of plants per unit area enabled the plants to utilize nutrient and light and might have caused the consequent result in number of pods per plant. It was corroborate with the finding of Singh and Varma (1999).

Thus, optimum row spacing have optimally utilized the growth resources, particularly solar radiation as compared to narrow row spacing where plants might have suffered due to mutual shading in case of bordering rows and more plants within case of wider spacing.



S_1=30 cm × 10 cm, S_2=20 cm × 20 cm, S_3=30 cm × 30 cm, S_4=40 cm × 40 cm, S_5=50 cm × 50 cm

Figure 12. Influence of spacing on the pods plant^{-1} of lentil (LSD $_{(0.05)}$ = 7.93)

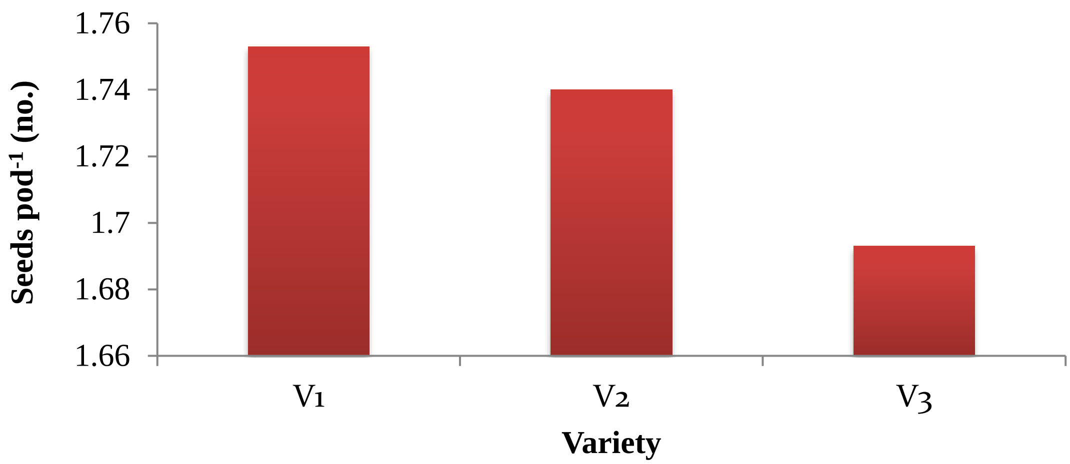
4.2.1.3 Combined effect of variety and spacing

Combined effect of cultivar and spacing showed statistically significant differences for number of pods per plant (Table 6). The highest number of pods per plant was recorded from V_1S_4 (161.5) which was statistically similar with V_2S_4 (148.8) and the lowest was found in V_3S_5 (75.13) while statistically identical data was recorded from V_2S_5 (76.26) and V_2S_1 (83.80) respectively.

4.2.2 Number of seeds pod^{-1}

4.2.2.1 Influence of variety

A statistically significant differences was observed for number of seeds pod^{-1}of lentil due to different cultivar (Fig. 13). The highest number of seeds pod^{-1}was found in V_1 (1.753) known as BARI Masur-5 which was statistically similar to V_2 known as BARI Masur-6 (1.74). The lowest number of seeds pod^{-1}was found in V_3 known as BARI Masur-7 (1.69).It means that the number of seeds pod-1 is a genetically controlled character and the difference among genotypes was due to their different genetic ability for this parameter. Similar results also laid out by Jan and Nawabzada (2004).

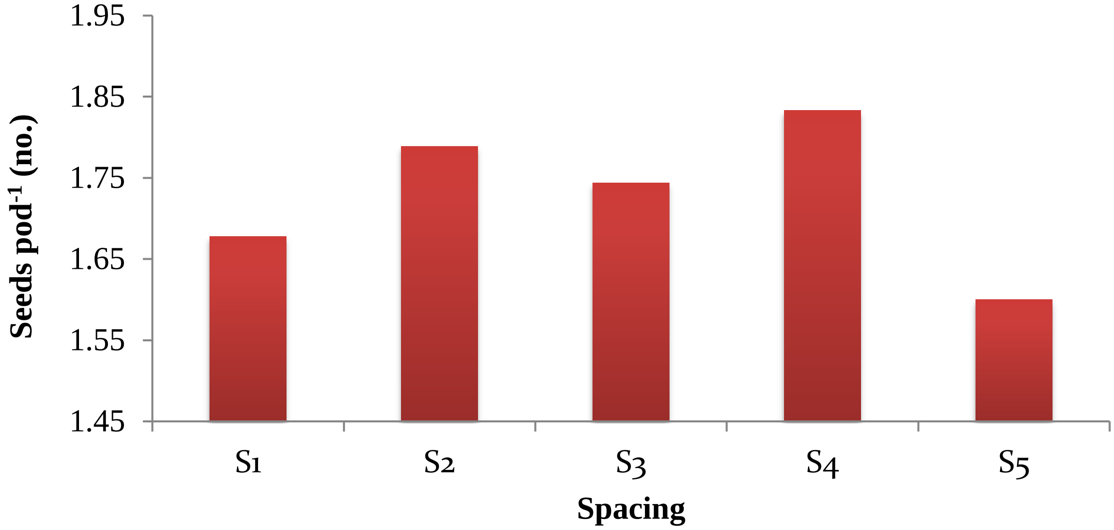


V_1 = BARI Masur-5, V_2 = BARI Masur-6 and V_3= BARI Masur-7

Figure 13. Influence of variety on the seeds pod^{-1} of lentil (LSD $_{(0.05)}$ = 0.06)

4.2.2.2 Influence of spacing

Number of seeds per pod of lentil varied significantly due to spacing (Fig. 14). The highest number of seeds per pod was found in S_4 (1.83) whereas S_3 and S_4 were statistically identical 1.74 and 1.78 with S_4, respectively. The lowest number of seeds per pod was found in S_5 (1.60) which was similar to S_1 (1.67) statistically.



S_1=30 cm × 10 cm, S_2=20 cm × 20 cm, S_3=30 cm × 30 cm, S_4=40 cm × 40 cm, S_5=50 cm × 50 cm

Figure 14. Influence of spacing on the seeds pod^{-1} of lentil (LSD $_{(0.05)}$ = 0.10)

4.2.2.3 Combined effect of variety and spacing

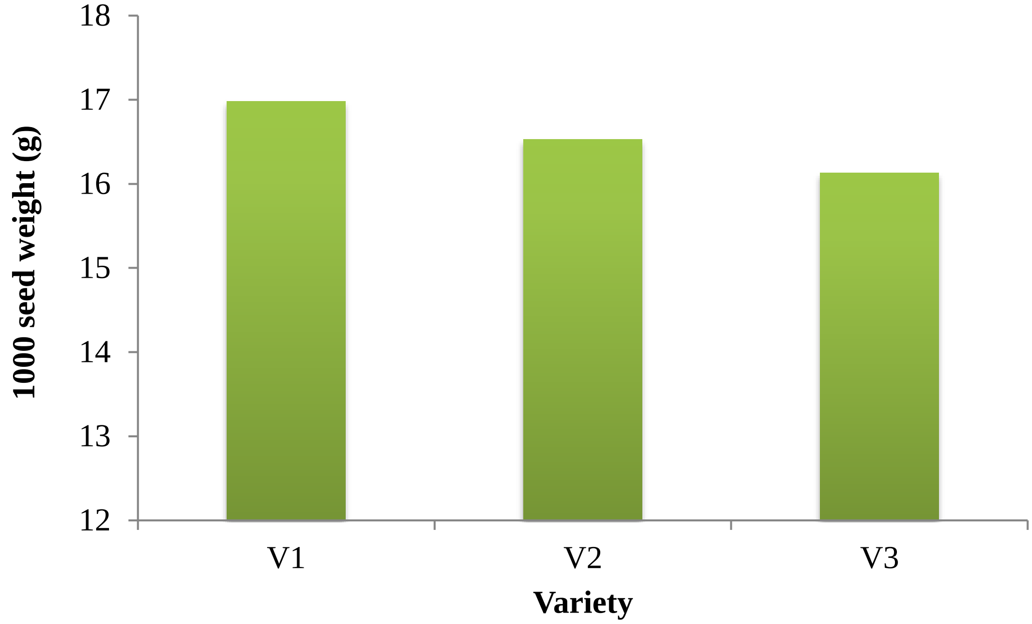
Combined effect of cultivar and spacing showed statistically significant differences for number of seeds per pod (Table 6). The highest number of seeds per pod was recorded from V_1S_4 (1.87) treatment combination which was statistically similar with V_2S_4, V_1S_2, V_2S_2, V_3S_4, V_1S_3, V_2S_3, V_3S_2, V_1S_1, V_2S_1 and V_3S_3 treatment combination. On the otherhand, the lowest seeds/pod was found in V_3S_4 (1.57) treatment combination which was statistically similar with V_2S_5, V_1S_5, V_3S_1, V_1S_1, V_3S_3 treatment combination.

4.2.3 1000 seed weight

4.2.3.1 Variety effect

A statistically non-significant variation was recorded for 1000 seed weight of lentil due to different variety (Fig. 15). The 1000-seed weight (16.98 g) was found in V_1 (BARI

Masur-5), V_2 known as BARI Masur-6 (16.53 g) and V_3 known as BARI Masur-7 (16.13 g).

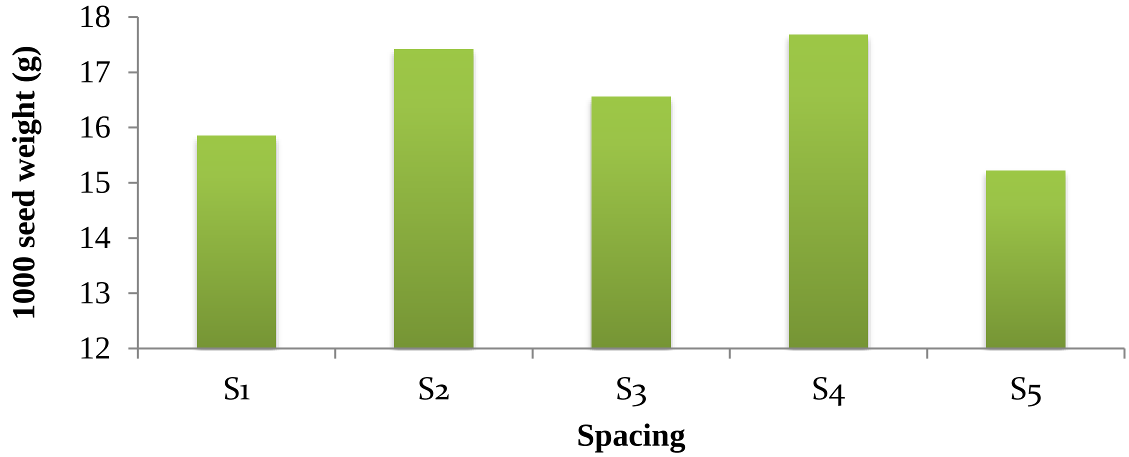


V_1 = BARI Masur-5, V_2 = BARI Masur-6 and V_3= BARI Masur-7

Figure 15. Variety effect on the 1000 seed weight of lentil ($LSD_{(0.05)}$ = NS)

4.2.3.2 Influence of spacing

1000 seed weight of lentil varied significantly due to spacing (Fig. 16). The highest 1000 seed weight was found in S_4 (17.68 g) which was statistically similar with S_2 (17.42 g) and S_3 (16.56 g) while the lowest 1000 seed weight was found in S_5 (15.22 g) which was statistically similar with S_1 (15.85 g).



S_1=30 cm × 10 cm, S_2=20 cm × 20 cm, S_3=30 cm × 30 cm, S_4= 40 cm × 40 cm,S_5=50 cm × 50 cm

Figure 16. Influence of spacing on the 1000 seed weight of lentil (LSD $_{(0.05)}$ = 1.20)

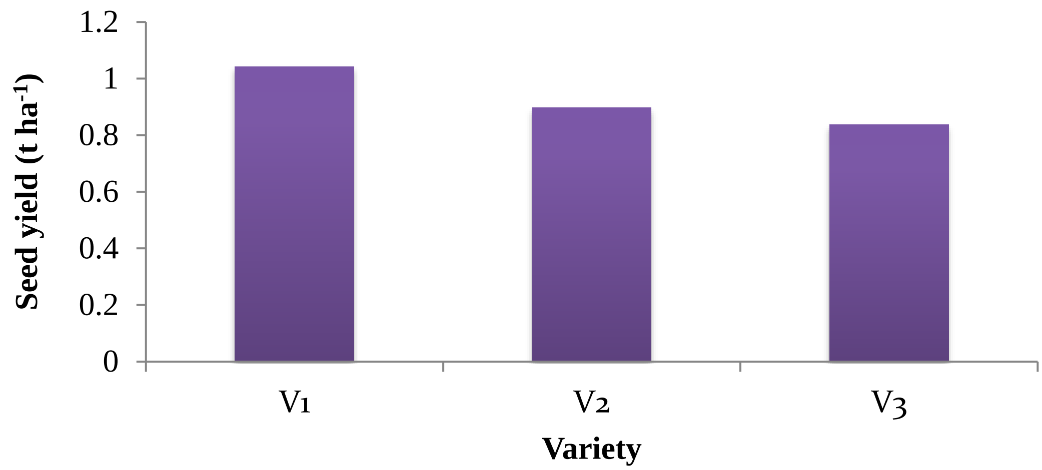
4.2.3.3 Combined influence of cultivar and spacing

Combined influence of cultivar and spacing showed statistically significant differences for 1000 seed weight (Table 6). The highest 1000 seed weight was recorded from V_1S_4 (18.73 g) treatment combination which showed statistical similarity with V_1S_2, V_2S_4, V_2S_2, V_3S_4 treatment combination while the lowest was found in V_3S_5 (14.93 g) treatment combination which was similar to V_1S_5, V_2S_5, V_1S_1, V_3S_1, V_2S_1, V_3S_3, V_1S_3 and V_3S_4 treatment combination.

4.2.4 Seed yield (t/ha)

4.2.4.1 Influence of variety

A statistically significant variation was recorded for grain yieldof lentil due to different cultivar (Fig. 17). The highest grain yield (1.04 t ha^{-1}) was found in V_1 (BARI Masur-5). On the other hand, the lowest grain yield (0.83 t ha^{-1}) was found in V_3 (BARI Masur-7) which was closely to V_2 (.83 t ha^{-1}) known as (BARI Masur-6).

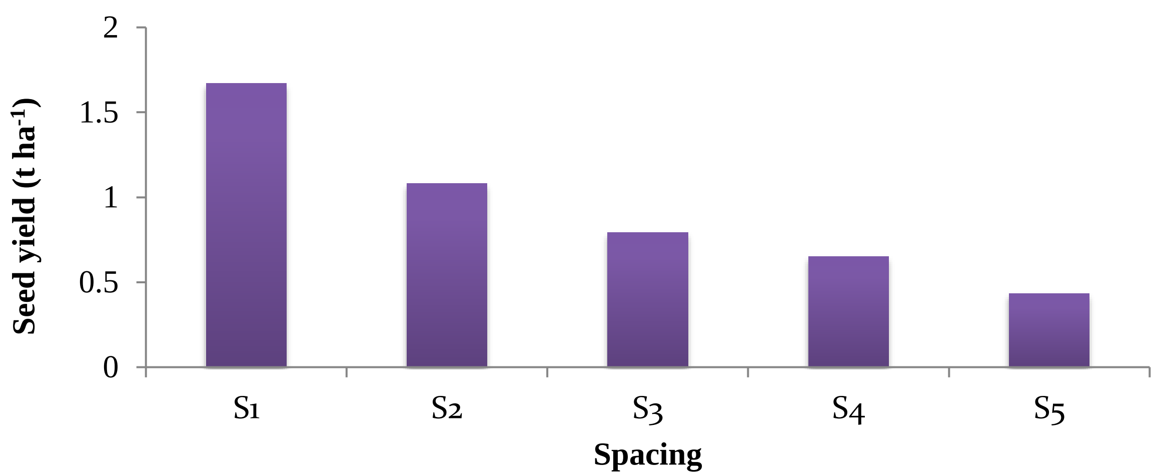


V_1 =BARI Masur-5, V_2 =BARI Masur-6 and V_3 =BARI Masur-7

Figure 17. Influence of variety on the seed yield of lentil (LSD $_{(0.05)}$ = 0.08)

4.2.4.2 Influence of spacing

Seed yield of lentil varied significantly due to spacing (Table 6). The highest grain yield was found in S_1 (1.67 t ha^{-1}) while the lowest grain yield was found in S_5 (0.43 t ha^{-1}). It was corroborate with the finding of Singh and Varma (1999).



S_1=30 cm × 10 cm, S_2=20 cm × 20 cm, S_3=30 cm × 30 cm, S_4=40 cm × 40 cm, S_5=50 cm × 50 cm

Figure 18. Influence of spacing on the seed yield of lentil (LSD $_{(0.05)}$ = 0.06)

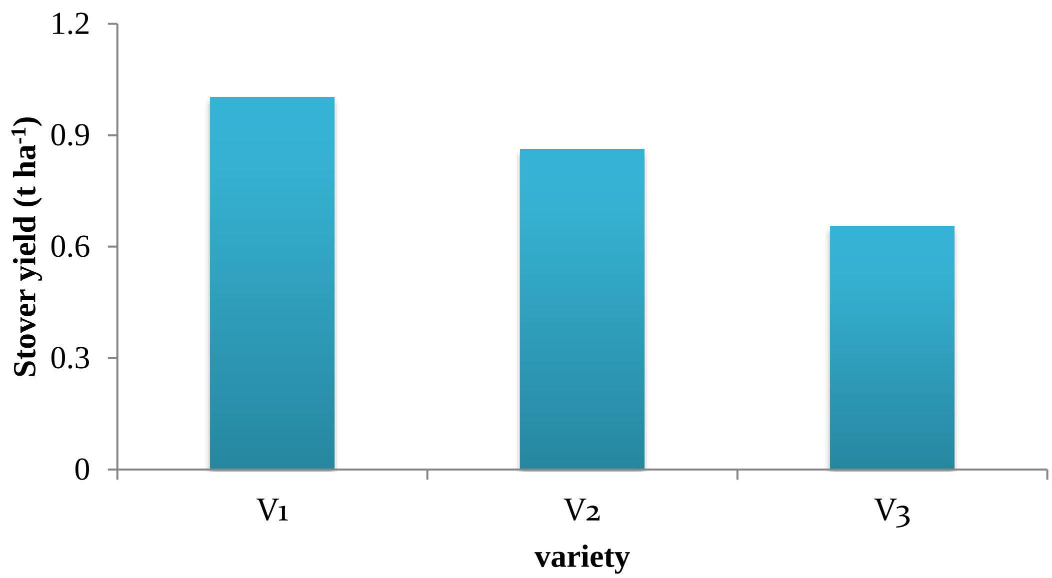
4.2.4.3 Combined effect of variety and spacing

Combined performance of cultivar and spacing showed statistically significant differences for grain yield in lentil (Table 6). The highest grain yield was got from V_1S_1 (1.82 t ha^{-1}) treatment combination and the lowest was found in the treatment combination of V_3S_5 (0.36 t ha^{-1}) .

4.2.5 Stover Yield

4.2.5.1 Variety influence

Statistically significant variation was seen for stover yield of lentil due to different cultivar (Fig. 19). The highest stover yield (1.00 t ha^{-1}) was found in V_1 (BARI Masur-5) whereas the lowest stover yield was found in V_3 (0.65 t ha^{-1}) named (BARI Masur-7).

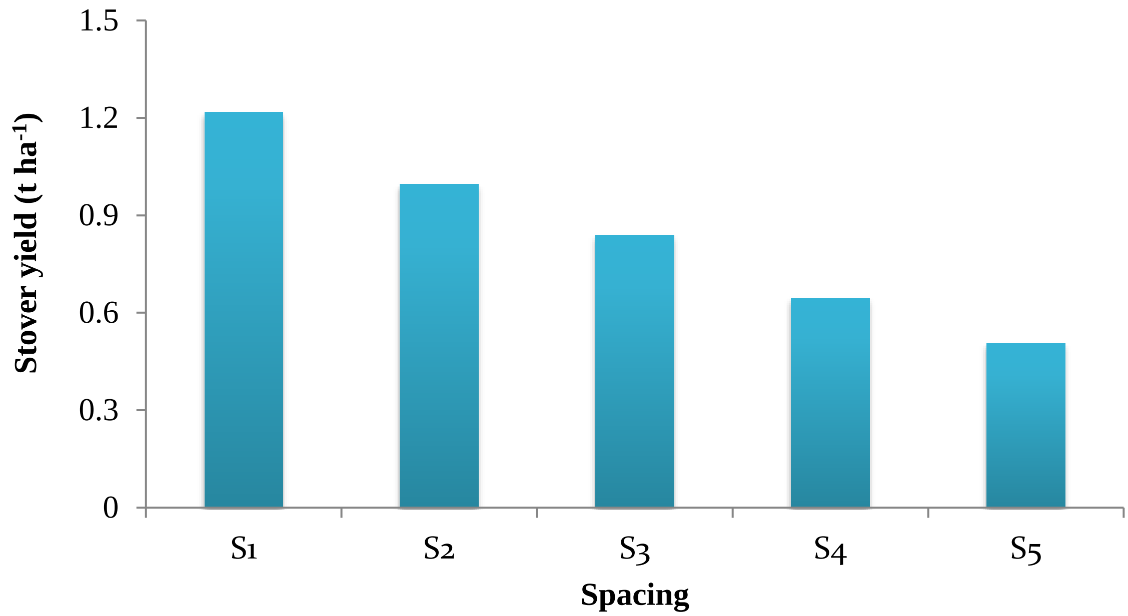


V_1 = BARI Masur-5, V_2 = BARI Masur-6 and V_3= BARI Masur-7

Figure 19. Variety influence on the stover yield of lentil (LSD $_{(0.05)}$ = 0.06)

4.2.5.2 Influence of spacing

Stover yield of lentil varied significantly due to spacing (Fig. 20). The maximum stover yield was found in S_1 (1.22 t ha^{-1}). The lowest stover yield was found in S_5 (0.51 t ha^{-1}).



S_1=30 cm × 10 cm, S_2=20 cm × 20 cm, S_3= 30 cm × 30 cm, S_4=40 cm × 40 cm,S_5= 50 cm × 50 cm

Figure 20. Influence of spacing on the stover yield of lentil (LSD $_{(0.05)}$ = 0.06)

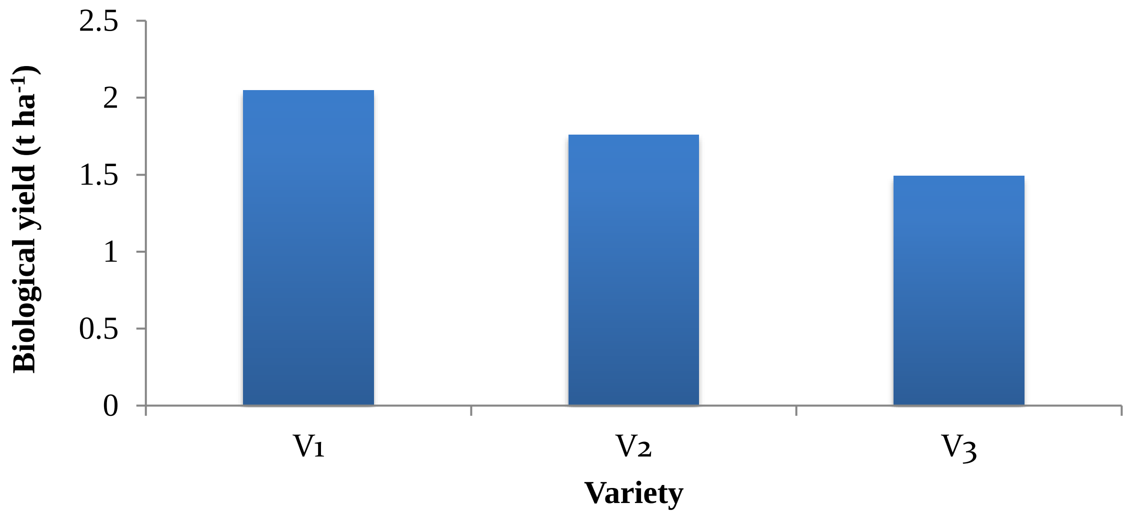
4.2.5.3 Combined effect of variety and spacing

Combined effect of variety and spacing showed statistically significant differences for stover yield in lentil(Table. 6). The highest number of stover yield was recorded from V_1S_1 (1.46 t ha^{-1}) and the lowest was found in V_3S_5 (0.36 t ha^{-1}) treatment combination.

4.2.6 Biological Yield

4.2.6.1 Influence of variety

Statistically significant variation was observed for Biological yield of lentil due to different variety (Fig. 21). The highest biological yield (2.04 t ha^{-1}) was found in V_1 (BARI Masur-5) whereas the lowest biological yield was obtained in V_3 (1.49 t ha^{-1}) named (BARI Masur-7).

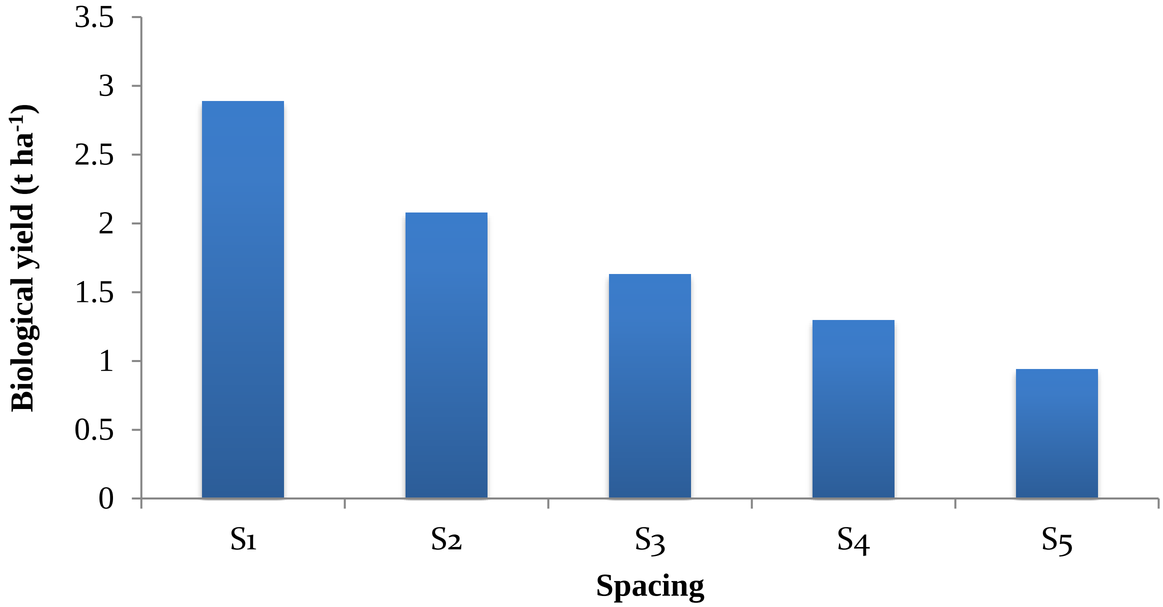


V_1 = BARI Masur-5, V_2 = BARI Masur-6 and V_3= BARI Masur-7

Figure 21. Influence of variety on the biological yield of lentil (LSD $_{(0.05)}$ = 0.10)

4.2.6.2 Influence of spacing

Biological yield of lentil varied significantly due to spacing (Fig. 22). The maximum biological yield was found in S_1 (2.89 t ha^{-1}). The lowest biological yield was obtained in S_5 (0.94 t ha^{-1}).



S_1=30 cm × 10 cm, S_2=20 cm × 20 cm, S_3=30 cm × 30 cm, S_4=40 cm × 40 cm, S_5=50 cm × 50 cm

Figure 22. Influence of spacing on the biological yield of lentil (LSD $_{(0.05)}$ = 0.10)

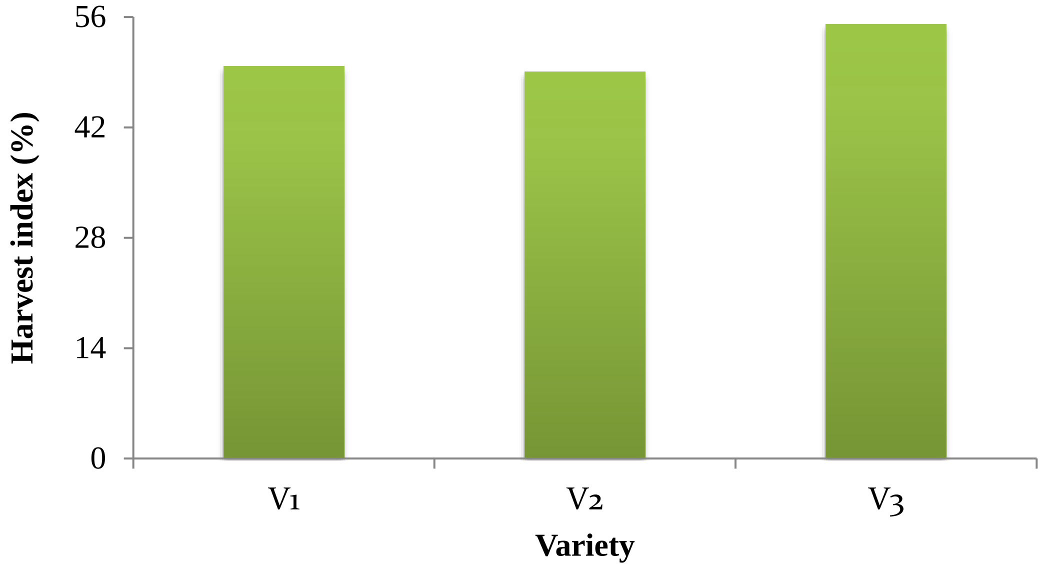
4.2.6.3 Combined Effect of variety and spacing

Combined performance of cultivar and spacing was statistically significant differences for biological yield in lentil (Table 6). The maximum biological yield was obtained from V_1S_1 (1.46 t ha^{-1}) and the lowest was found in V_3S_5 (0.36 t ha^{-1}) treatment combination.

4.2.7 Harvest Index (%)

4.2.7.1 Variety effect

Harvest index of lentil showed significant differences due to different cultivar (Fig. 23). The highest harvest index (55.06%) was attained from V_3 (BARI Masur-7) and the lowest HI(49.04%), was observed from V_2 (BARI Masur-6) closely (49.77%) followed by V_1(BARI Masur-5).Plainiappan (1985) showed similar result.

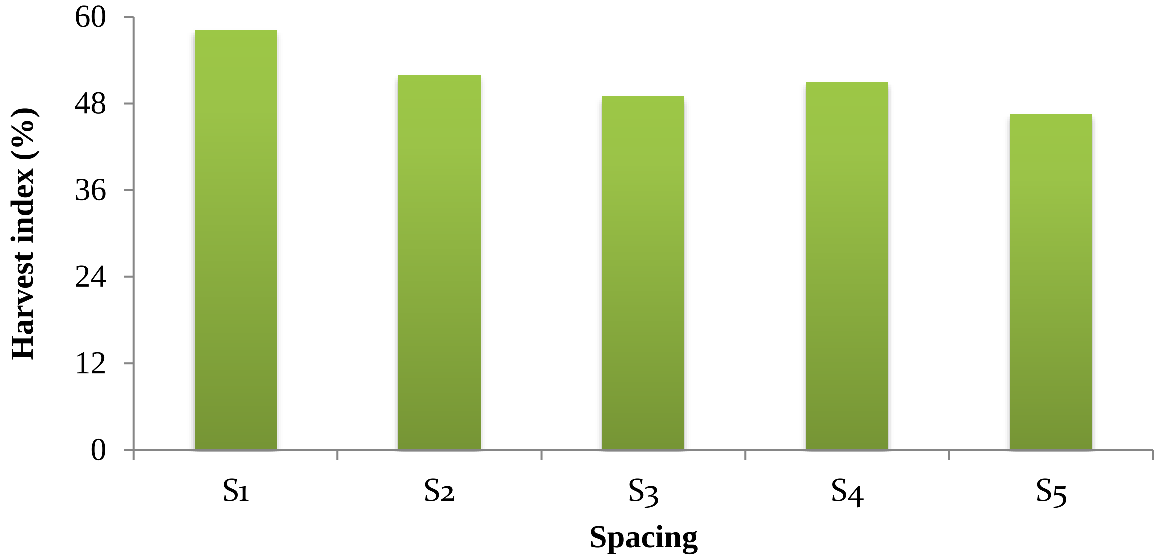


V_1 = BARI Masur-5, V_2 = BARI Masur-6 and V_3 = BARI Masur-7

Figure 23. Variety effect on the harvest index of lentil (LSD $_{(0.05)}$ = 3.57)

4.2.7.2 Influence of Spacing

Differences in spacing showed significant variations in terms of harvest index of lentil (Fig. 24). The higest harvest index was found from S_1 (58.13%) whereas the lowest value was recorded from S_5 (46.47%).



S_1=30 cm × 10 cm, S_2=20 cm × 20 cm, S_3=30 cm × 30 cm, S_4=40 cm × 40 cm, S_5=50 cm × 50 cm

Figure 24. Influence of spacing on the harvest index of lentil (LSD $_{(0.05)}$ = 2.30)

4.2.7.3 Combined Effect of Variety and Spacing

Significant variation was found in combined performance of different cultivars and spacing in terms of harvest index of lentil (Table 6). The highest havest index was found from V_3S_1(60.64%) and the lowest was obtained from V_2S_5(41.68%) treatment combination.

Table 6. Combined effect of variety and spacing on the yield and yield contributing character of lentil

Treatment combination	Pods plant^{-1} (No.)	Seeds pod^{-1} (No.)	1000 seed weight (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
V_1S_1	104.0 f	1.70 a-d	15.55 c-e	1.82 a	1.46 a	3.28 a	55.42 bc
V_1S_2	138.9 bc	1.80 ab	18.55 ab	1.30 d	1.15 b	2.45 c	53.10 cd
V_1S_3	110.9 ef	1.77 a-c	16.72 a-e	0.83 fg	0.99 c	1.82 e	45.77 f
V_1S_4	161.5 a	1.87 a	18.73 a	0.74 g	0.84 d	1.57 f	46.78 ef
V_1S_5	108.0 f	1.63 b-d	15.36 de	0.53 h	0.58 e	1.11 hi	47.75 ef
V_2S_1	83.80 g	1.70 a-d	16.31 c-e	1.66 b	1.19 b	2.84 b	58.32 ab
V_2S_2	136.6 b-d	1.80 ab	17.09 a-d	1.04 e	1.01 c	2.05 d	50.60 de
V_2S_3	106.7 f	1.77 a-c	16.42 c-e	0.80 g	0.88 d	1.68 ef	47.44 ef
V_2S_4	148.8 ab	1.83 a	17.46 a-c	0.59 h	0.66 e	1.25 gh	47.13 ef
V_2S_5	76.27 g	1.60 cd	15.37 de	0.41 i	0.57 e	0.98 i	41.68 g
V_3S_1	123.7 de	1.63 b-d	15.68 c-e	1.54 c	1.00 c	2.54 c	60.64 a
V_3S_2	125.9 cd	1.77 a-c	16.63 b-e	0.91 f	0.83 d	1.74 ef	52.16 cd
V_3S_3	125.7 cd	1.70 a-d	16.55 b-e	0.75 g	0.64 e	1.39 g	53.74 cd
V_3S_4	143.2 b	1.80 ab	16.86 a-e	0.63 h	0.44 f	1.07 i	58.80 ab
V_3S_5	75.13 g	1.57 d	14.93 e	0.36 i	0.36 f	0.73 j	49.98 de
LSD $_{(0.05)}$	13.74	0.18	2.08	0.11	0.11	0.17	3.98
CV (%)	6.91	6.05	7.46	6.70	7.10	5.56	4.60

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

S_1=30 cm × 10 cm, S_2=20 cm × 20 cm, S_3=30 cm × 30 cm, S_4=40 cm × 40 cm, S_5=50 cm × 50 cm

CHAPTER V

SUMMARY AND CONCLUSION

The field experiment was carried out during the rabi season from November, 2015 to March 2016 at the Agronomic farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh to look through the effect of variety and spacing on lentil. Three varieties (V_1= BARI Masur-5, V_2= BARI Masur-6 and V_3= BARI Masur-7) and five spacing (S_1 = 30 cm × 10 cm, S_2 = 20 cm × 20 cm, S_3 = 30 cm × 30 cm, S_4 = 40cm × 40 cm, S_5 = 50 cm × 50 cm) were applied. There were fifteen treatment combinations under the study. The two factor experiment was placed in Split plot design with three replications. The size of the individual plot was 2.5 m x 2 m and total numbers of plots were 45. Three lentil cultivars seeds were sown in 29th November, 2015 followed by the treatments. Harvesting was done in 3rd March, 2016. Data on different growth, yield contributing characters and yield was filed and observed significant variation for different treatments.

The data on growth parameters viz. plant height (cm), branches plant^{-1} (no.), leaflets plant^{-1} (no.), above ground dry matter weight plant^{-1} (g) were recorded during the period from 20 DAS to harvest at 20 days interval, nodule dry weight plant^{-1} (mg) at 75 DAS. Pods plant^{-1} (no.), seeds pod^{-1} (no.), 1000 seeds weight (g), seed yield (t ha^{-1}), stover yield (t ha^{-1}), biological yield (t ha^{-1}), harvest index (%) were recorded at harvest.

The tallest plants were found in V_1 (6.98 cm, 14.73 cm, 27.30 cm, 34 cm and 34.72 cm) at 20, 40, 60, 80 DAS and harvest at all the stages observed. The shortest plant was obtained from V_3 (6.70 cm, 13.21 cm , 26.42 cm, 31.42 cm and 32.44 cm). The highest number of branches per plant were gained from V_1 (1.02, 5.00, 18.06, 29.93 and 30.90) while the lowest number of branches per plant was observed in V_3 (0.88, 4.50, 13.78, 26.56 and 27.37). The maximum leaflets (no.) per plant were achieved from V_1 (8.31, 34.36, 86.55, 217.4 and 192.1) while the lowest leaflets (no.) per plant was scored in V_3 (7.50, 28.19, 73.35, 179.7 and 164.1). The most above ground dry matter per plant was recieved from V_1 (0.03 g, 0.34 g, 1.94 g, 5.10 g and 7.53 g) whereas the lowest dry matter was found in V_3 (0.03 g, 0.25 g, 1.51 g, 3.67 g and 6.16 g). The highest nodule dry weight per plant was gotten from V_1(24.53 mg) while the lowest nodule dry weight per plant was found in V_3 (19.67 mg) at flowering and pod initiation stage. V_1 scored the highest number of pods per plant (124.7) as V_2 gave the lowest no. of pods per plant(110.4). The highest number of seeds per pod was found in V_1 (1.75) and the lowest number of seeds per pod was gained in V_3 (1.69) both were statistically identical with V_2 (1.74). Three lentil varieties showed a non-significant variation with a view to 1000 seed weight (g). V_1 (1.04 t/ha) gave the most seed yield where V_3 (0.83 t/ha) which was similar to V_2 (0.89 t/ha). The highest stover yield was found in V_1 (1.00 t/ha) and the lowest stover yield was found in V_3 (0.65 t/ha). The highest biological yield was gained from V_1 (2.04 t/ha) and the lowest biological yield was found in V_3 (1.49 t/ha). The highest harvest index was attained from V_3(55.06%) and the lowest was gotten from V_2 (49.04%), closely followed by V_1 (49.77%).

On the other hand, the tallest plant was found in S_4 (7.52 cm, 15.44 cm, 28.14 cm, 35.56 cm and 36.55 cm) spacing at 20 DAS, 40 DAS, 60 DAS, 80 DAS and harvest, whereas the shortest plant was seen in S_5 (6.32 cm, 12.82 cm, 25.70 cm, 30.89 cm and 31.52 cm) spacing.At 20, 40, 60 and 80 DAS & harvest, the highest number of branches per plant was found in S_4 (1.24, 5.43, 18.37, 32.06 and 33.13) and the lowest number of branches per plant was gained from S_5 (0.62, 4.07, 12.85, 24.50 and 25.15). At 20 DAS, 40 DAS, 60 DAS, 80 DAS and at harvest, the most leaflets per plant was obtained from S_4 (8.70, 32.40, 87.39, 226.2 and 204.9) and the lowest one was seen in S_5 (7.01, 27.59, 72.15, 175.6 and 160). At 20, 40, 60 & 80 DAS and harvest, the highest above ground dry matter per plant was found in S_4 (0.40 g, 0.47 g, 2.15 g, 5.38 g and 8.20 g) and the lowest dry matter per plant was achieved from S_5 (0.25 g, 0.17 g, 1.10 g, 3.60 g and 5.73 g). At 75 DAS, S_4 (27.78 mg) showed the maximum nodule dry weight per plant as S_5 (16.33 mg) gave the lowest nodule dry weight per plant. The highest number of pods/plant was found in S_4 (151.2) and the lowest no. of pods/plant was found in S_5 (86.47).The highest number of seeds per pod was found in S_4 (1.83) as the lowest number of seeds per pod was achieved in S_5 (1.60).The highest 1000 seed weight was received in S_4 (17.68 g) closely followed by S_2 (17.42 g). The lowest 1000 seed weight was found in S_5 (15.22 g).

The highest seed yield was found in S_1 (1.67 t/ha) and the lowest seed yield was attained in S_5 (0.43 t/ha).The highest stover yield was found in S_1 (1.22 t/ha) as the minimum stover yield was observed from S_5 (0.94 t/ha). The higest harvest index was scored in S_1 (58.13%) whereas the lowest value was recorded from S_5 (46.47) treatment.

Combined effect of variety and spacing showed a significant variation on different growth parameters and yield contributing characters. The tallest plant was recorded for V_1S_4 (7.90 cm, 16.94 cm, 28.85 cm, 37 cm and 38 cm) and the shortest plant was recorded from the treatment combination V_1S_5 (6.27 cm, 12.04 cm, 24.92 cm, 29.67 cm and 30.41 cm) at different stages studied. The most number of branches/plant was scored in the treatment combination V_1S_4 (1.43, 5.77, 21.11, 34.50 and 36.00) whereas the lowest number of branches was found in the combination V_3S_5 (0.57, 3.87, 10.78, 22.33 and 23.00). The most number of leaflets/plant was scored in the treatment combination V_1S_4 (9.33, 33.73, 95.40, 254.5 and 222.4) as the lowest was found in the combination V_3S_5 (6.70, 25.16, 67.23, 164.8 and 145). The highest dry matter was observed in the treatment combination V_1S_4 (0.05 g, 0.64 g, 2.57 g, 6.30 g and 8.87 g), while the lowest dry matter was recorded in the combination V_3S_5 (0.02 g, 0.16 g, 0.97 g, 2.83 g and 5.24 g). The highest nodule dry wt. per plant was observed in the treatment combination V_1S_4 (30.33 mg) whereas the lowest nodule dry wt. per plant was gained in the combination V_3S_5 (14.33 mg) at 75 DAS.

The highest number of pods/plant was recorded from V_1S_4 (161.5) treatment combination and the lowest was scored in V_3S_5 (75.13) closely followed by V_2S_5 (76.27) and V_2S_1

(83.80) treatment combination.The maximum number of seeds per pod was recorded from V_1S_4 (1.87) closely followed by V_2S_4 (1.83) treatment combination whereas the lowest was attained in treatment combination of V_3S_5 (1.57).The highest 1000 seed weight was scored from V_1S_4 (18.73 g) and the lowest was found in V_3S_5 (14.93 g) treatment combination.

The highest seed yield was recorded from V_1S_1 (1.82 t/ha) and the lowest was found in V_3S_5 (0.36 t/ha).The maximum stover yield was scored from treatment combination V_1S_1 (1.46 t/ha) and the lowest was found in V_3S_5 (0.36 t/ha). The maximum biological yield was scored from treatment combination V_1S_1 (3.28 t/ha) and the lowest was found in V_3S_5 (0.73 t/ha). The highest havest index (60.64%) was shown from treatment combination V_3S_1 while the lowest (41.68%) was observed from V_2S_5 treatment combination.

It may be concluded that wider spacing had greater influence on individual plant to produce maximum yield contributing parameters but failed to maximize seed yield due to lower number of plants per unit area. Thus, the optimum spacing was identified as 30 cm × 10 cm.

Recommendations:

These treatment variable could be further tested around the lentil growing areas in Bangladesh to study whether growing areas would response to planting geometry system.

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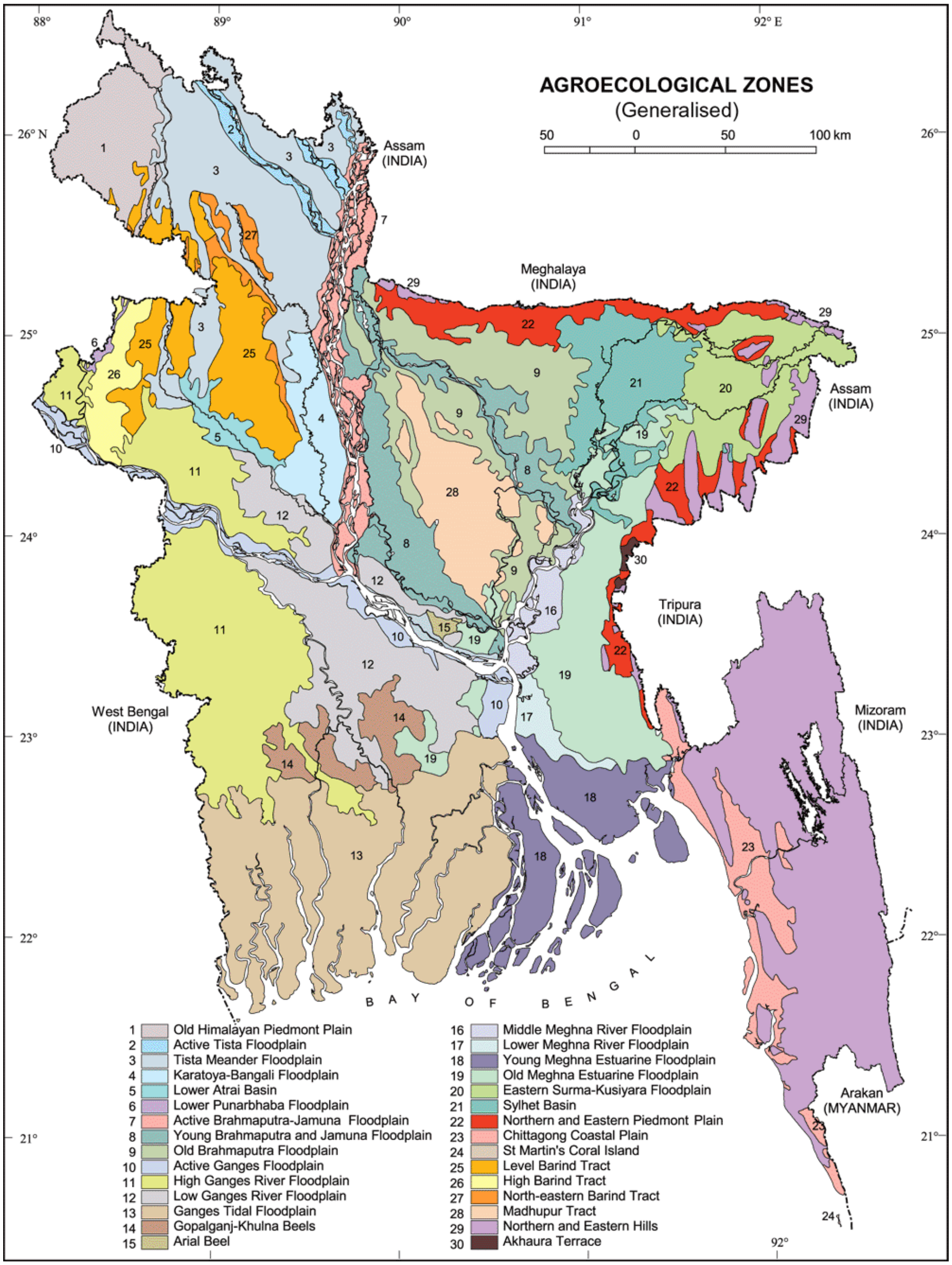
APPENDICES

Appendix I. Map showing the experimental site under the study



Appendix II. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
%Silt	43
%Clay	30
Textural class	Silty-clay
pH	6.1
Organic matter (%)	1.13
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100g soil)	0.10
Available S (ppm)	23

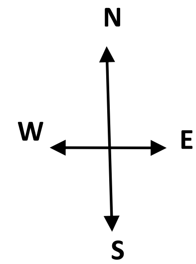
Source: Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

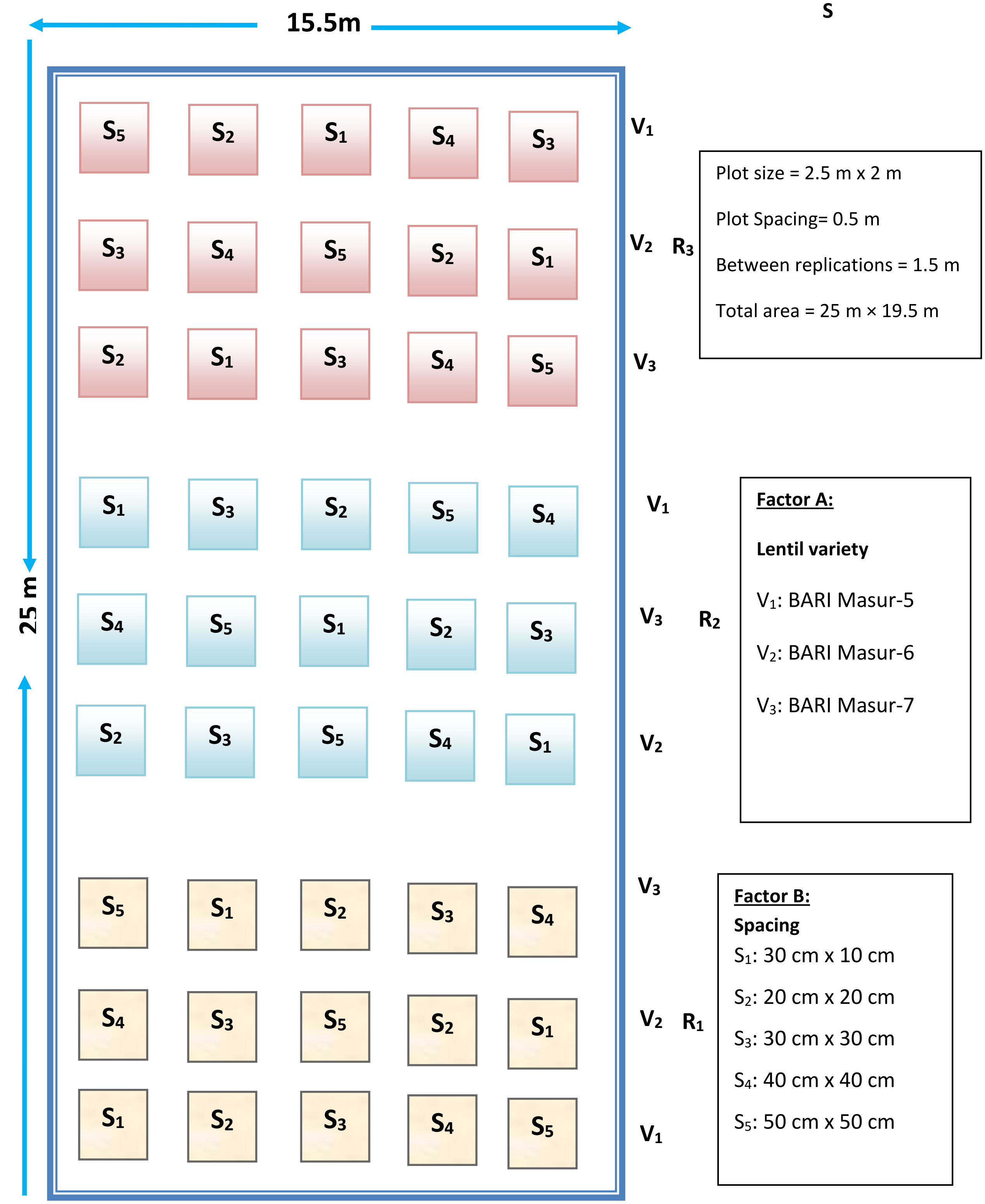
Appendix III. Morphological characteristics of the soil of experimental field

Morphological features	Characteristics
Location	Experimental Field, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

Source: Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

Appendix IV. Layout of the experimental fie





Appendix V. Analysis of variance of the data on plantheightof lentil as affected by combined effect of variety and plant spacing

Source of variation	df	Mean square of plant height at different days after sowing (DAS)				
		20	40	60	80	At harvest
Replication	2	0.37	0.72	0.45	3.93	4.85
Variety (A)	2	0.30^{NS}	9.02^{NS}	3.05^{NS}	29.78^{NS}	21.85^{NS}
Error	4	0.29	2.68	5.60	10.19	6.75
Plant spacing (B)	4	1.86*	9.61*	7.56*	26.60*	32.10*
Variety(A) × Plant spacing (B)	8	0.09*	0.16*	0.27*	1.52*	1.38*
Error	24	0.18	1.03	2.61	3.25	5.34

*Significant at 5% level of significance

^{NS} Non significant

Appendix VI. Analysis of variance of the data on branches plant^{-1} of lentil as affected by combined effect of variety and plant spacing

Source of variation	df	Mean square of branches plant^{-1} at different days after sowing (DAS)				
		20	40	60	80	At harvest
Replication	2	0.03	0.60	0.27	5.99	14.46
Variety (A)	2	0.10*	1.05*	71.77*	44.94*	49.77*
Error	4	0.001	0.10	2.20	7.03	10.92
Plant spacing (B)	4	0.54*	2.52*	39.87*	66.68*	74.17*
Variety(A) × Plant spacing (B)	8	0.05*	0.08*	1.09*	1.00*	1.51*
Error	24	0.003	0.08	1.83	4.59	3.57

*Significant at 5% level of significance

^{NS} Non significant

Appendix VII. Analysis of variance of the data on leaflets plant^{-1} of lentil as affected by combined effect of variety and plant spacing

Source of variation	df	Mean square of leaflets plant^{-1} at different days after sowing (DAS)				
		20	40	60	80	At harvest
Replication	2	3.30	41.86	120.73	1069.42	1545.36
Variety (A)	2	2.48*	157.06*	737.25*	5668.85*	3192.24*
Error	4	0.07	5.38	37.39	30.41	60.43
Plant spacing (B)	4	4.94*	34.35*	317.95*	3531.57*	3237.28*
Variety(A) × Plant spacing (B)	8	0.17*	4.03*	3.23*	117.50*	112.69*
Error	24	0.20	1.19	14.08	70.45	49.33

*Significant at 5% level of significance

^{NS} Non significant

Appendix VIII. Analysis of variance of the data on above ground dry weight plant^{-1} of lentil as affected by combined effect of variety and plant spacing

Source of variation	df	Mean square of above ground dry weight plant^{-1} at different days after sowing (DAS)				
		20	40	60	80	At harvest
Replication	2	0.00	0.00	0.11	0.35	1.97
Variety (A)	2	0.00^{NS}	0.05*	1.72*	7.98*	7.23*
Error	4	0.00	0.00	0.01	0.14	0.06
Plant spacing (B)	4	0.00*	0.11*	1.58*	3.91*	7.49*
Variety(A) × Plant spacing (B)	8	0.00*	0.01*	0.04*	0.44*	0.18*
Error	24	0.00	0.001	0.02	0.14	0.22

*Significant at 5% level of significance

^{NS} Non significant

Appendix IX. Analysis of variance of the data on nodule dry weight plant^{-1}, yield contributing characters of lentil as affected by combined effect of variety and plant spacing

Source of variation	df	Mean square value of			
		nodule dry weight plant^{-1}	Pods plant^{-1}	Seeds pod^{-1}	1000 seed weight
Replication	2	14.16	27.74	0.02	0.10
Variety (A)	2	89.09*	767.79*	0.02*	2.71^{NS}
Error	4	4.62	20.91	0.003	2.68
Plant spacing (B)	4	166.64*	5751.29*	0.08*	9.68*
Variety(A) × Plant spacing (B)	8	0.89*	545.34*	0.001*	0.94*
Error	24	0.99	66.48	0.01	1.52

*Significant at 5% level of significance

^{NS} Non significant

Appendix X. Analysis of variance of the data on yield characters of lentil as affected by combined effect of variety and plant spacing

Source of variation	df	Mean square value of			
		Seed yield	Stover yield	Biological yield	Harvest index
Replication	2	0.01	0.03	0.06	11.04
Variety (A)	2	0.17*	0.46*	1.15*	162.37*
Error	4	0.01	0.004	0.01	12.43
Plant spacing (B)	4	2.05*	0.71*	5.12*	170.76*
Variety(A) × Plant spacing (B)	8	0.01*	0.01*	0.03*	27.89*
Error	24	0.004	0.004	0.01	5.57

*Significant at 5% level of significance

^{NS} Non significant