EFFECT OF IRRIGATION AND VARIETY ON GROWTH AND YIELD OF LENTIL

By

A. H. M. RAYHAN
Reg. No. 04-01366

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Approved by:

(Assoc. Prof. Dr. Md. Shahidul Islam)
Supervisor

(Prof. Dr. Md. Hazrat Ali)
Co-Supervisor

(Prof. Dr. Md. Fazlul Karim)
Chairman
Examination Committee

Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

Ref: *Dated:*

CERTIFICATE

This is to certify that the thesis entitled, **"Effect of Irrigation and Variety on Growth and Yield of Lentil"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) IN AGRONOMY,** embodies the result of a piece of *bona fide* research work carried out by **A. H. M. RAYHAN,** Registration No. **04-01366** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: 11.05.2011

Dhaka, Bangladesh

(Dr. Md. Shahidul Islam)
Associate Professor
Department of Agronomy
Sher-e-Bangla Agricultural University
Supervisor

Dedicated to

My

Beloved Parents

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ABSTRACT

A field experiment was conducted at Sher-e-Bangla Agricultural University farm, Dhaka during the period from November 2008 to February 2009 to study the effect of irrigation and variety on growth and yield of lentil. The experiment was consisted of two treatment factors; factor A: four irrigation levels (I_0= no irrigation, I_1= irrigation at 25 DAS, I_2= irrigation at 50 DAS and I_3= Irrigation at both 25 and 50 DAS) and factor B: four lentil varieties (V_1= BARI Masur-3, V_2= BARI Masur-4, V_3= BARI Masur-5 and V_4= BARI Masur-6). The experiment was laid-out in split plot design with three replications assigning irrigation level in the main-plot and variety in the sub-plot. Results showed that irrigation level, variety and their interaction exerted significant influence on plant height and plant dry matter at different days after sowing (DAS), on pods plant^{-1}, seeds per pod^{-1}, 1000-seed weight, seed yield, stover yield, biological yield and harvest index of lentil. Increasing irrigation level increased seed yield. BARI Masur-6 gave the highest seed yield followed by BARI Masur-5, BARI Masur-4 and BARI Masur-3. Irrigation at both 25 and 50 DAS in BARI Masur-6 showed the highest seed yield. In all the cases, increasing seed yield were obtained by increasing the values of the said parameters.

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ACRONYMS AND ABBREBIATIONS

%	Percentage
°C	Degree Centigrade
AEZ	Agro- Ecological Zone
ANOVA	Analysis of variance
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
BINA	Bangladesh Institute of Nuclear Agriculture
BRRI	Bangladesh Rice Research Institute
cm	Centimeter
CV %	Percent Coefficient of Variance
cv.	Cultivar (s)
DAT	Days After Transplanting
DMRT	Duncan's Multiple Range Test
e.g.	Example given
et al.	et alia (and others)
FAO	Food and Agriculture Organization
Fig.	Figure
g	Gram (s)
HI	Harvest Index
hr	Hour(s)
i.e.	That is
IFDC	International Fertilizer Development Centre
IRRI	International Rice Research Institute
K_2O	Potassium Oxide
kg	Kilogram (s)
lb	Pound
LSD	Least Significant Difference
m^2	Square meter
m^{-2}	Per square meter
mm	Millimeter
MP	Muriate of Potash
N	Nitrogen
No.	Number
NS	Non Significant
P_2O_5	Phosphorus Penta Oxide
PU	Prilled Urea
S	Sulphur
SAU	Sher-e-Bangla Agricultural University
S_x	Standard error of means
t ha^{-1}	Ton per hectare
var.	Variety
Viz.	Namely
wt.	Weight

Chapter 1

Introduction

CHAPTER I

INTRODUCTION

Various types of pulse crops can be grown in Bangladesh of which lentil, grass pea, mungbean, blackgram, chickpea, pegionpea, field pea and cowpea are important. These are important food crops because they provide a cheap source of easily digestible dietary protein. Pulse protein is rich in amino acids like isoleucine, leucine, lysine, valine etc. According to FAO (2008), a minimum intake of pulse should be 80 g per head per day, whereas, it is only 14.19 g in Bangladesh (BBS, 2009). This is because of the fact that national production of the pulses is not adequate to meet the national demand.

Among the pulse crops, lentil *(Lens culinaris)* is one of the important pulse crop grown in Bangladesh. In Bangladesh, lentil ranks second in acreage and production but ranks first in market price (BBS, 2008). Lentil grain contains 59.8% carbohydrate, 25.8% protein, 10% moisture, 4% mineral and 3% vitamins (Khan, 1981). The green plants can also be used as animal feed and its residues have manural value.

Lentil grains contain high protein, good flavor and easily digestible component. It may play an important role to supplement protein in the cereal-based low-protein diet of the people of Bangladesh. But the acreage and production of lentil are steadily declining (BBS, 2009).

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

The average yield of lentil in Bangladesh is very poor in comparison to other lentil growing countries of the world (BBS, 2008). There are many reasons of lower yield of lentil. The management of irrigation water is important one that greatly affects the growth, development and yield of this crop. We know that pulses, mostly lentil, need less amount of water. Water is required for it's production and maintenance (Sadasivam *et al.,* 1988). If we supply sufficient amount of water at critical growth stages, then growth and production will be increased (Michael, 1985). Critical stages of lentil production for water is vegetative stage, pre-flowering stage and pod setting stage. If at these stages, water supply can be ensure, production will be increased. Quah and Jafar (1994) reported the significant increase of the yield attributes of lentil applying irrigation water, though most of the farmers of Bangladesh do not use irrigation water in pulse crops.

Variety is an important factor in lentil production. Bangladesh Agricultural Research Institute developed some new lentil varieties. These varieties are higher yielder than previous ones. All the high yielding varieties of crops require high inputs, one of which is water. Therefore, these high yielding varieties of lentil may require more water.

Lentil is a rain fed crop in most countries, grown either during the wet season or on the residual soil moisture in the post-rainy season. Hence, in most circumstances, irrigation water is not applied. It is considered as a drought resistant crop, capable of drawing water from deeper layers of soil through extensive roots but most varieties respond favorably to added water resulting in higher yields, especially when irrigation is given at the time of water stresses or during short drought periods or at the critical growth stages (Majumdar, 1992).

Hence, it is necessary to maximize the seed yield of lentil combining optimum level and stage of irrigation with the best variety of lentil.

Considering the above facts, the present work was conducted with the following objectives:

- to find out the optimum level and time of irrigation.
- to find out the best variety of lentil studied.
- to investigate the combined effect of variety and irrigation for maximum yield of lentil.

Chapter 2
Review of literature

CHAPTER II

REVIEW OF LITERATURES

Irrigation and variety are the important factors for lentil production. These two factors play a significant role on the yield and yield contributing attributes of lentil. Relevant research information regarding the cultivar of lentil with irrigation, which are pertinent to the present experiment, have been reviewed and presented in this chapter.

2.1. Effect of irrigation

Irrigation may have variable effects on growth, yield components and yield of lentil. Dastan and Aslam (1986) found that in sandy loam soil of Delhi, lentil responded positively up to 2 irrigation each at 15 and 30 days after sowing.

Giriappa (1987) studied that in lateritic sandy loam soils, two irrigations of 6 cm depth, each at flowering and pod development stages, were the best for growth, dry matter production, grain yield and grain protein content of lentil.

Pannu and Singh (1988) demonstrated that the total dry matter as well as grain yields of mungbean were affected by moisture deficit in lentil.

Petersen (1989) reported that water deficit reduced pods per plant and mean seed yield in *Phaseolus vulgaris*; whereas, pods per plant and seeds per pod in *Lens culinaris.*

Yadav *et al.* (1992) found that lentil needs relatively better moisture regime than gram. In north east plains (Faizabad) one irrigation at flower initiation (50 DAS) was found most promising; whereas, in Central India (Jabalpur), 2 irrigation, each at branching and flowering were found optimum.

Siowit and Kramer (1977) observed in soybean that, the maximum reduction in yield due to moisture deficit occurred during grain filling stage. Drastic yield reduction was also reported in mungbean due to water deficit (Sadasivam *et al.*, 1988; Hamid and Rahih, 1990). The yield loss was primarily caused by the reduction of canopy development, inhibition of photosynthetic rate and lower dry matter production

Michael (1985) found that the plant height, branches per plant, pods per plant and 1000-grain weight increased significantly with one irrigation; whereas, three irrigations reduced the grain yield, 1000-grain weight, grain protein content and nodulation in lentil.

Pandey *et al.* (1984) reported that mungbean is more susceptible to water deficits compared to other grain legumes. Water deficit affects canopy development and overall growth process but there are varietals differences in tolerance to water deficit.

Talukder (1987) reported that wheat seed yield and harvest index were the most susceptible parameters to water deficit at flowering and pod development stages.

Sadasivam *et al.* (1988) reported that water deficit during vegetative phase reduces grain yield through reducing plant size, limiting root growth and number of pods and harvest index in mungbean. Decreased grain yield due to water deficit was also reported in chickpea (Provakar and Suraf, 1991), soybean (Rajput *et al.,* 1991), green gram and black gram (Tripurari and Yadav, 1990) and fababean (Khade and Varma, 1990).

Lopes *et al.* (1988) reported that moisture deficiency resulted in lower number of leaves, pods per plant, reduced plant height-root length ratio in *Phaseolus vulgaris.* Pannu and Singh (1988) demonstrated that the total dry matter as well as grain yields were affected by moisture deficit in lentil.

Hamid and Haque (2003) reported a drastic yield reduction in mungbean due to water deficit. They also explained that the yield loss was primarily caused by the reduction of canopy development, inhibition of photosynthesis and lowering of dry matter production.

Venkateswarlu and Ahlawat (1993) observed significant yield increase due to irrigation; the higher yield was obtained under wet moisture regime (0.6 IW/CPE) as compared to dry moisture regime (0.35 IW/CPE) under Delhi conditions on sandy loam soils.

Rathi *et al.* (1995) found that most critical growth stage for moisture deficit in lentil is pod formation followed by the initiation of flowering. In case of failure of winter rains, 1 to 2 irrigations were required for enhanced productivity of the crop. The importance of irrigation was increased under late planting of the crop due to poor root developments as well as higher depletion of soil moisture.

Majumdar and Roy (1992) reported that the higher grain yield and positive effect on yield components due to irrigation application in summer sesame. Similar result was found in soybean (Rajput *et al.,* 1991), in edible pea (Rahman, 2001), in greengram (Pal and Jana, 1991).

Denmead *et al.* (1990) in their studies with corn stated that plant growth, grain yield and dry matter production were reduced by water deficit at all the growth stages. They further reported that when the deficit was removed the growth rate did not immediately return to normal but required several days to recover.

Salter and Goode (1967) stated that the extent of yield reduction from water deficits depends not only on the magnitude of the deficit but also on the stage of growth of bush bean. Yield and dry matter production were reduced at all the growth stages by water deficit. They further reported that when the deficit was removed the growth rate did not immediately return to normal but required several days to recover.

Dubtez and Mahalle (1998) found that water deficit reduced yield of bush bean by 53%, 71% and 35% when the deficit prevailed during pre-flowering, flowering and pod formation stages, respectively.

Vitkov (1972) found that soil wetting up to 60 cm depth by sprinkler irrigation increased seed yield up to 950 kg per hectare in French bean. It was also reported that field pea were most sensitive to water deficit during flowering and early pod filling stage (Lewis *et al*, 1994).

Lewis *et al.* (1994) reported that sorghum grain yield was reduced to 17.34% and 10% over control when water deficit occurred at late vegetative and booting stage, respectively.

Turk *et al.* (1980) studied the response of cowpea to water deficit at different growth stages and reported that yield was not reduced by water deficit imposed at vegetative stage; while at flowering stage, yield reduction was substantial. Variation in yields resulted from difference in number of pods per m^2 and seed size.

Cselotel (1984) reported that a regular water supply particularly during flowering and pod formation is necessary for high yield and good quality of snap beans. Higher number of dry pods per plant, increased seed weight and seed yield per hectare was found when irrigation water was supplied weekly. Haque (1998) and Sankar (1992) reported similar results in peas and green gram, respectively.

Lawlor *et al.* (1981) observed that yields, total dry matter production and harvest index of barley were decreased by water deficit. The grain growth in un-irrigated crop was decreased. They explained the results as probability of insufficient supply of current assimilates towards the grain due to poor photosynthates under water deficit condition.

Irrigation increased pigeonpea yield by 97%, while water deficit during the reproductive phase was the major yield-limiting factor (Masood and Meena, 1986). Duque and Pessanha (1990) found that the deleterious effects of drought deficit imposed at flowering reduced numbers of filled spikelets per panicle and reduced photosynthetic leaf area that affected directly the grain yield of chickpea. Petersen (1989) reported that water deficit reduced pods per plant and mean seed weight in

Phaseolus vulgaris and pods per plant and seeds per pod in *Phaseolus acutifolius*. Similar results were reported by Lopes *et al,* (1988).

Khade and Varma (1990) found highest number of pods (8.28) plant^{-1}, seeds (16.43) pod^{-1} and seed yield (1.03 t ha^{-1}) with 3 irrigations in *Vicia sp.*

Viera and Banik (1991) reported a yield reduction of 35 to 40% when drought deficit was imposed during seed filling but found no effect on germination or vigour in soybean seeds.

Karim and Banik (1993) stated that soil and atmospheric water deficit controls plant growth directly of soybean.

Sharma *et al.* (1998) reported that grain yield and net returns were higher with 3 irtigations than with 1 and 2 irrigations in french bean (Provakar and Suraf, 1991) and blackgram (Tripurari and Yadav, 1990).

Biswas (2001) reported that irrigation frequency exerted a remarkable impact on yield of field bean. Application of 3 irrigations increased vegetable pod and 1000 seed weight.

2. 2. Effect of Variety

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

BARI (1982) reported that strain 7706 gave significantly higher yield than 7704. BINA (1998) reported that MC-18 (BINA moog 5) produced higher seed yield over BINA mung 2. Field duration of BINA mung 5 was about 78 days and 82 days for BINA mung 2.

Farrag (1995) reported from a field trial with 23 mungbean accessions that the seed yield, number of pods plant-1, number of seeds pod-1and 1000-seed weight varied among the tested accessions. He also observed that some cultivars like VC 2711 A, KPSI and UTT performed well under late sown condition. Varital differences in yield do exist under similar field condition. This indicates that all varieties do not perform equally under similar condition.

Among the 32 accessions of mungbean under three sowing dates, Farghali and Hossain (1995) concluded that V6017 had the highest seed yield. They also recorded that the accessions V6017 and UTI had significantly higher plant height, number of seeds pod^{-1}, pod length and number of pods plant^{-1} than that of other accessions.

Haque et al. (2002) reported that there was significant positive correlation between the number of pods per plant and yield per plant.

Cultivars played a key role in increasing yield since the response to management practices was mainly decided by the genetic potential. The yields of mungbean cultivars Mubarik, Kanti and Binamoog 1 ranged from 0.8 to 1.0. 1.0 to 1.2 and 0.8 to 1.0 t ha^{-1}, respectively (Farghali and Hussein, 1995).

In an experiment under Bangladesh condition with four varieties of mungbean Duqueand Pessanha (1990) reported the highest number of branches plants^{-1} given by the variety

Faridpur-1 followed by Mubarik, BM-7715 and BM-7704. The maximum number of pod/plant was produced by Mubarik followed by BM-7704, BM-7715 and Faridpur 1. He identified that pods per plant were a useful agronomic character contributing to higher yield in mungbean.

Jain and Kanderar (1988) reported from an experiment with four mungbean varieties that 'ML 131' produced the highest seed yield as compared with other varieties. In another study Kalita and Shah (1998) studied 19 cultivars of *Vigna radiata* and found that 1000 seed weight was the highest in Gajaral 2 (39 g) and the lowest in ML 131 (24 g). Seed yield was the highest in PIMS-1 (0.89 t/ha) and the lowest in 11/99 (0.52 t ha^{-1}). Yield variation due to different mungbean varieties were also reported by Masood and Meena (1986) and Pahlwan and Hossain (1983).

Patil and Salimath (2003) studied genetic diversity among 36 genotypes of mungbean, consisting of both released varieties and advance lines are selected for tolerance to different deficit conditions. The genotypes were grown in three distinct environments with recommended dose of fertilizer + plant protection measures, only recommended dose of fertilizers, and fertilizer- and pesticide- free conditions in Dharwad, Karnataka, India. Observations were recorded for plant height, branches $plant^{-1}$, cluster $plant^{-1}$, pods $plant^{-1}$, seeds pod^{-1}, 100- seed weight, biological yield, harvest index, days of first flowering, days to 50% flowering, days to initiation of pod maturity, days to 75% pod maturity, powdery mildew at 45 days, and mungbean yellow mosaic virus. The simultaneous test for significance for pooled effect of all the characters in all the test environments showed significant differences among the genotypes, indicating the presence of considerable genetic variability for different characters. Among the genotypes, K 851, LM 608 and LM 5-12 were the most genetically diverse in all the 3 environments.

Pookpakdi and Pinja (1980) working with five cultivars of mungbean viz. CES 87, CES 14, Pagasa, Hong 1 and local Thai variety with 32 plants per m-2 reported that the highest yield of CES 14 was due to highest number of seeds pod^{-1} and the low yield of local variety resulted from the lowest number of pods $plant^{-1}$. Among the varieties, Pagasa produced the lowest amount of total dry weight because the variety gave the lowest shoot dry weight.

Rajat and Gowda (1978) found that the highest grain yield was produced by 'PS 7' followed by 'PS 16' and 'PS 10'. The higher yield was due to the results of higher number of pods $plants^{-1}$ and 1000- grain weight.

Singh and Singh (1988) observed that four mungbean cultivars sown at a density of 40, 50 or 60 plants m^{-2} gave similar seed yields of 1.3-1.15 t ha^{-1}. The cultivars UPM 79-1-12 and ML 26/10/3 gave the yield of 1.21 and 1.18 t ha^{-1} respectively, compared to 1.06-1.21 t ha^{-1} that of the two other cultivars.

The experimental evidence presented above revealed that asynchronous type of lentil and other legume crops continued flowering over a period of several weeks, plants contains mature pods, green pods and flower at the same time and the yield of lentil was also influenced by variety. Any delayed in harvesting of mature pods from the optimum stage of maturity leads to shattering of seeds. Moreover, excessive rainfall at maturity period also reduced the seed quality. Therefore, it was necessary to pick up the pods at a suitable time for obtaining better yield and quality of seed with minimum cost. It was thus important to examine the effect of different harvesting time on the yield and yield attributes as well as on seed quality attributes of lentil.

Chapter 3

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at Agronomy farm, Sher-e-Bangla Agricultural University, Dhaka during November 2008 to February 2009. This chapter deals with a brief description on experimental site, climate, soil, land preparation, layout, experimental design, intercultural operations, data recordings and their analyses.

3. 1. Site description

The experiment was conducted at the research field of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka under the Agro-ecological zone of Madhupur Tract, (AEZ-28). The land was situated at 23°41'N latitude and 90°22'E longitude at an altitude of 8.6 meter above sea level. The experimental site has been shown in the AEZ map of Bangladesh in Appendix I.

3. 2. Climate

The experimental area was under the sub-tropical region that is characterized by moderate temperature and low rainfall with occasional gusty winds in rabi season (October-February). The weather data during the study period of the experimental site has shown in Appendix II.

3. 3. Soil

The soil of the experimental field belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. The experimental area was flat having available irrigation and drainage system. The land was above flood level and sufficient sunshine was available during the experimental period. Soil samples from 0-15 cm depths were collected from experimental field. The analyses were done from Soil Resources Development

Institute (SRDI), Dhaka. The physicochemical propertey of the soil has presented in Appendix III.

3. 4. Planting materials

Four high yielding varieties of lentil viz., BARI Mosur 3, BARI Mosur 4, BARI Mosur 5, BARI Mosur 6, developed by Bangladesh Agricultural Research Institute (BARI), Gazipur were used as a planting material. The seeds of these varieties were collected from the Pulse Research Centre, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3. 5. Experimental treatments

The experimental treatments consisted of two factors i.e. irrigation and variety.

Factor A: Irrigation level - 4

Irrigation level	**Symbol used**
No irrigation	I_0
Irrigation at 25 DAS	I_1
Irrigation at 50 DAS	I_2
Irrigation at both 25 and 50 DAS	I_3

Factor B: Variety -4

Variety	**Symbol used**
BARI Mosur-3	V_1
BARI Mosur-4	V_2
BARI Mosur-5	V_3
BARI Mosur-6	V_4

3. 6. Design and layout of the experiment

The experiment was laid out in a Split-plot design comprising three replications, assigning irrigation in the main plot and variety in the sub-plot. The size of each unit plot was 3.5 × 2.5 m. The inter-block and inter-plot distances were 1.0 m and 0.75 m, respectively.

3. 7. Land preparation

The land was first opened with the tractor drawn disc plough. The ploughed soil was then brought into desirable fine tilth by 6 ploughing operations followed by laddering. The stubbles and weeds were removed. Experimental land was divided into unit plots following the design of experiment. The pots were spaded one day before sowing and all the fertilizers were incorporated well in soil before sowing.

3. 8. Fertilizer application

Cowdung was applied at the rate of 10 t ha^{-1} during the land preparation. Other nutrients were applied at the rate of 21, 30, 25, 5, 0.34 and 1.8 kg ha^{-1} N, P, K, S, B and Zn, respectively.

3. 9. Seed sowing

Seeds were sown at 16th November, 2008. Seeds were sown in line. Line to line distance was 20 cm and plant to plant distance was 10 cm.

3. 10. Intercultural operations

The following intercultural operations were done for ensuring normal growth of the crop:

3. 10. 1. Weeding

During plant growth period two hand weeding were done using nirani. First weeding was done at 20 days after sowing followed by second weeding at 30 days after first sowing.

3. 10. 2. Thinning

Thinning was done in all the unit plots with care so as to maintain a uniform plant population in each experimental plot. The job was done in twice at 20 and 30 days after sowing of lentil seeds.

3. 10. 3. Irrigation and drainage

Irrigation water was applied as per treatment with watering can as substitute of sprinkler system. Water application was continued till soil saturation.

3. 10. 4. Plant protection measures

During the growth period lentil plants protection measures was taken as per recommendation.

3. 11. General observation of the experimental field

The research field looked nice with normal green plants. Field was observed time to time to detect visual difference among the treatments and any kind of infestation by weeds, insects and diseases so that considerable losses by pest was minimized taking necessary control measures.

3. 12. Harvesting and threshing

The crop was harvested at different dates of February 12 to 19, 2009. The crop was harvested plot wise when about 80% of the pods attained maturity. From each plot 1 m^2 area was selected from the middle portion of the plot. Plant of these 1 m^2 was collected. Harvested plants were tied into bundles and carried to the threshing floor. The bundles were dried in the open sunshine for three consecutive days. The seeds were separated from the pods by beating with the bamboo sticks and then cleaned, dried and weight. The yield of dry stover was also taken.

3. 13. Collection of experimental data

The data on different parameters of lentil were collected. Ten plant samples were selected plot wise keeping the central 1 m^2 area undisturbed, which was kept for yield. The sample plants were uprooted carefully from the soil with khurpi so that no seeds were dropped into the soil and then cleaned, dried and the data on the following crop characters were collected from those sample plants-

1. Plant height (cm)
2. Dry weight of plant (g)
3. Pods plant^{-1} (no.)
4. Seeds pod^{-1} (no.)
5. Pod weight (g)
6. 1000-seed weight (g)
7. Seed yield (kg ha^{-1})
8. Stover yield (kg ha^{-1})
9. Biological yield (kg ha^{-1})
10. Harvest index (%)

A brief outline of the data recording on the above mentioned parameters is given below:

3. 13. 1. Plant height

The height of each plant at 20, 40, 60, 80 and 100 DAS was measured from the base to the tip of the plant and the mean height of 10 sample plants was expressed in centimeter.

3. 13. 2. Plant dry matter

The plant dry mater was taken by oven dry method. Ten plant samples randomly collected from unit plots at 20, 40, 60, 80 and 100 DAS were gently washed to remove sand and dust particles adhere to the plants. Then the water adhere to the plants were soaked with paper towel; afterwards the samples were kept in an oven at 70°C for 72 hours to attain constant weight. When the plant samples were attained at constant weight, the dry weights were recorded.

3. 13. 3. Pods plant^{-1}

The pods from all the branches of the pre-selected ten plants were counted and the number of pods plant^{-1} was calculated from their mean values.

3. 13. 4. Seeds pod^{-1}

The number of seeds of ten randomly selected pods collected from ten pre-selected plants was counted. The seeds pod^{-1} was calculated from their mean values.

3. 13. 5. Pod weight

The weight of a single pod was measured from all the pods of the pre-selected ten plants and mean values were taken, and expressed in gram per pod.

3. 13. 6. 1000-seed weight

The weight of thousand seeds were measured by counting 1000 seeds randomly from each plot and finally expressed in gram by air dry weight basis.

3. 13. 7. Seed yield

The seed weight was taken by threshing and separating grain from the central 1m^2 areas of unit plot and then seed yield was expressed in kg ha^{-1}.

3. 13. 8. Stover yield

The stover weight was taken from the remaining plant parts after threshing and separating grain from the plants collected from the central 1m^2 area of unit plot by threshing and then stover yield was expressed in kg ha^{-1}.

3. 13. 9. Biological yield

The summation of economic yield (grain yield) and biomass yield (stover yield) was considered as biological yield. Biological yield was calculated by using the following formula:

Biological yield = Grain yield + stover yield (dry weight basis)

3.13.10. Harvest index

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

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

3.14. Statistical analysis of the data

All the data collected on different parameters were statistically analyzed following the analysis of variance (ANOVA) technique and mean differences were adjudged by Least Significant Difference (LSD) test using the MSTAT computer package program.

Chapter 4

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The present findings showed that variety and irrigation levels exerted significant influences on most of the parameters of lentil.

4. 1. Plant height

4. 1. 1. Effect of irrigation

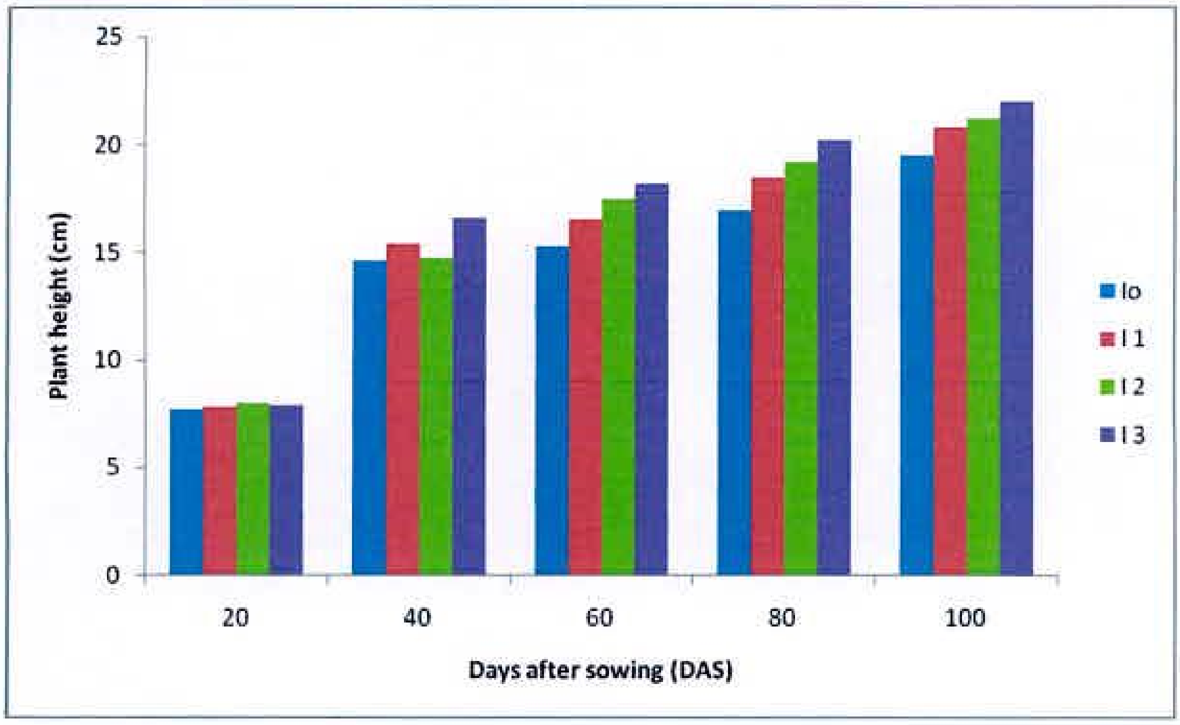
Plant height was significantly influenced by irrigation levels (Figure 1). At 20 DAS there was no significant variation. At 40 DAS, the treatment I_1 (Irrigation at 25 DAS) and I_3 (Irrigation at both 25 and 50 DAS) showed higher plant height. At 60 DAS I_3 (Irrigation at both 25 and 50 DAS) show highest plant height and I_0 (No Irrigation) showed the lowest. At 80 DAS and 100 DAS, I_3 (Irrigation at both 25 and 50 DAS) showed higher plant height comparatively to the other treatments. It was observed that plant height increases with the increases of irrigation levels. Similar result was reported by Giriappa (1998) and Yadav *et al.* (1992).

4. 1. 2. Effect of variety

Plant height was significantly influenced by variety (Table 1). At 20 DAS, a very little variation in plant height was found due to their similar growth rate. BARI Masur-6 showed the highest and the BARI Masur-3 showed the lowest plant height at all the growth stages studied. BARI Masur-5 showed higher plant height compared to BARI Masur-4 at all the growth stages except 40 and 100 DAS. Variations in plant height due to variety was also reported by Agarawal (1998) in mungbean.

4. 1. 3. Interaction effect of irrigation level and variety

The interaction effect of irrigation level and variety on plant height was found significant (Table 2). Significant difference was found among the interaction effects at different growth stages. Maximum plant height was found in the interaction of I_3V_4 (Irrigation at both 25 and 50 DAS in BARI Mosur-6) at 100 DAS. Whereas, the lowest plant height was found in the interaction of I_0V_1 (No Irrigation in BARI Mosur-3). Maximum plant growth was showed at middle stage of life (at 40 and 60 DAS). Increased rate of plant height reduced after 80 DAS. At harvest maximum plant height was found in I_3V_4 (Irrigation at both 25 and 50DAS in BARI Mosur-6).



I_0 = No irrigation

I_1 = Irrigation at 25 DAS

I_2 = Irrigation at 50 DAS

I_3 = Irrigation at both 25 and 50 DAS

Fig. 1. Effect of irrigation level on plant height (cm) at different DAS of lentil.
($LSD_{0.05}$ = NS, 0.96, 1.268, 1.364, 1.957 at 20,40,60,80 and 100 DAS,respectively)

Table 1. Effect of variety on plant height of lentil at different days after sowing (DAS)

Variety	Plant height at different DAS (cm)				
	20	40	60	80	100
V_1	7.66	14.98	15.97	17.66	19.82
V_2	7.74	15.49	16.71	18.18	20.44
V_3	7.87	15.08	17.02	18.54	20.18
V_4	8.12	16.15	17.92	18.54	21.27
LSD (0.05)	0.37	0.97	1.268	1.37	1.96
CV(%)	5.64	7.91	8.93	8.88	6.38

V_1 = BARI Mosur-3

V_2 = BARI Mosur-4

V_3 = BARI Mosur-5

V_4 = BARI Mosur-6

Table 2. Interaction effect of irrigation level and variety on plant height of lentil at different days after sowing (DAS)

Irrigation × Variety	Plant height at different DAS (cm)				
	20	40	60	80	100
$I_0 \times V_1$	7.92	15.62	17.53	16.91	19.73
$I_0 \times V_2$	8.14	15.96	17.10	17.26	18.63
$I_0 \times V_3$	7.67	14.53	16.31	17.08	19.80
$I_0 \times V_4$	7.72	15.44	17.24	17.65	19.87
$I_1 \times V_1$	8.75	16.23	18.15	18.10	21.57
$I_1 \times V_2$	7.46	16.04	16.42	19.37	19.66
$I_1 \times V_3$	7.35	15.23	15.94	19.08	19.87
$I_1 \times V_4$	7.61	16.18	16.28	18.95	20.74
$I_2 \times V_1$	7.67	14.44	17.52	18.40	23.11
$I_2 \times V_2$	7.62	15.08	17.36	18.06	19.86
$I_2 \times V_3$	7.81	14.25	17.31	17.93	20.15
$I_2 \times V_4$	7.72	14.77	16.89	18.59	19.39
$I_3 \times V_1$	8.13	16.02	18.43	19.73	20.67
$I_3 \times V_2$	8.22	17.49	17.15	18.91	21.12
$I_3 \times V_3$	7.77	16.88	17.30	18.61	21.33
$I_3 \times V_4$	7.89	16.46	17.48	18.95	21.67
$LSD_{(0.05)}$	0.75	2.10	2.53	2.73	3.91
CV (%)	7.60	8.10	6.90	7.65	8.10

I_0 = No irrigation
I_1 = Irrigation at 25 DAS
I_2 = Irrigation at 50 DAS
I_3 = Irrigation at both 25 and 50 DAS

V_1 = BARI Mosur-3
V_2 = BARI Mosur-4
V_3 = BARI Mosur-5
V_4 = BARI Mosur-6

4. 2. Plant dry weight

4. 2. 1. Effect of irrigation

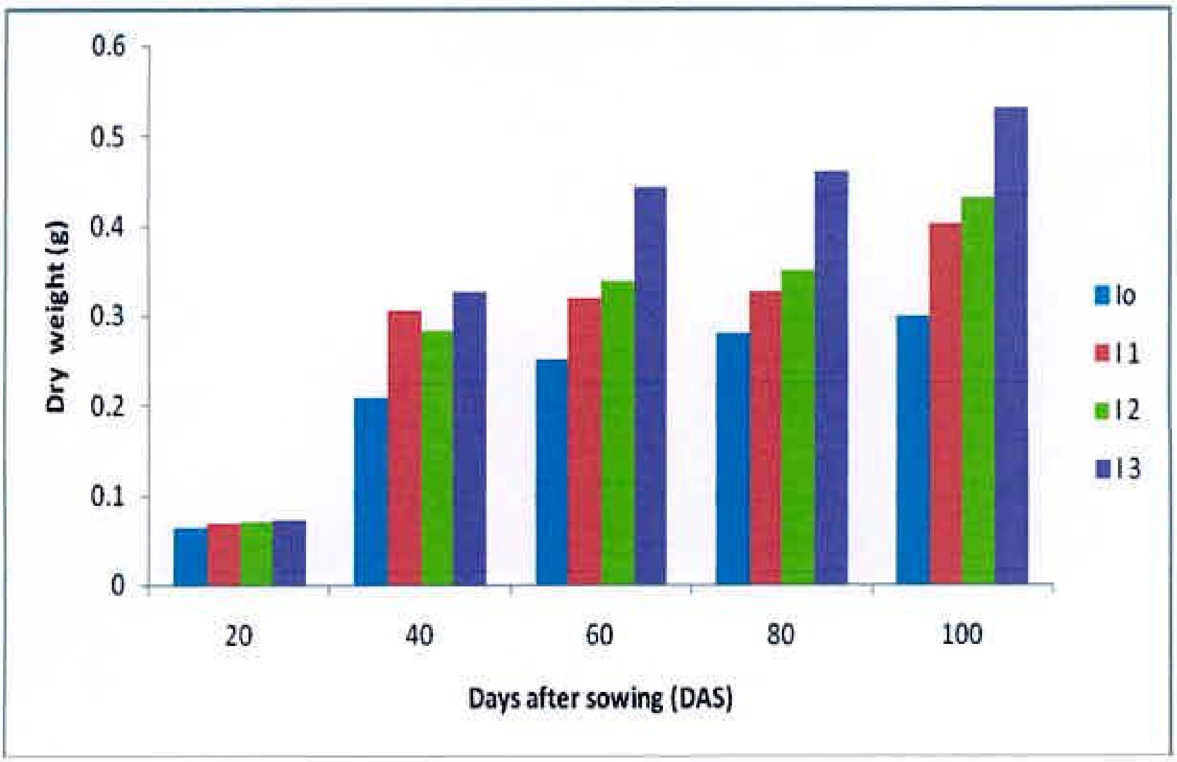
The present finding showed that plant dry matter was significantly influenced by irrigation level (Figure 2). At 20 DAS, no significant variation was found among the treatment effects on plant dry weight. At 40 DAS, the treatment I_1 (Irrigation at 25 DAS) and I_3 (Irrigation at both 25 and 50 DAS) produced higher plant dry matter compared to that of the others. After 40 DAS, the highest plant dry matter was produced by the treatment I_3 (Irrigation at both 25 and 50 DAS) followed by I_2 (Irrigation 50 DAS) and I_1 (Irrigation at 25 DAS) at all the growth stages studied. The lowest plant dry matter was produced by the treatment I_0 (with no Irrigation). In I_2 and I_3 treatments, the plants at flowering stage received irrigation water when irrigated at 50 DAS and thereby delayed maturity by partitioning dry matter towards the vegetative parts. Therefore, plant dry matter in I_2 and I_3 treatment was increased at 60 DAS and 100 DAS compared to that of the other treatments. This explanation may also be supported by the findings of Giriappa (1998).

4. 2. 2. Effect of variety

Plant dry matter was significantly influenced by variety at 40 and 80 days after sowing (DAS) (Table 3). BARI Mosur-6 showed the highest plant dry matter followed by BARI Mosur-5 and BARI Mosur-4 at all the growth stages studied. BARI Mosur-3 produced the lowest plant dry matter at that stage. Variation of plant dry matter due to varieties was also reported by Farghali and Hossain (1995) in mungbean.

4. 2. 3. Interaction effect of irrigation level and variety

The interaction effect of irrigation level and variety on plant dry matter was significant at all the growth stages studied except 20 days after sowing (DAS) (Table 4). Maximum plant dry matter was found in the interaction of I_3V_4 (Irrigation at both 25 and 50 DAS in BARI Mosur-6) except at 60 DAS, at which maximum value was found in the interaction I_2V_4 (Irrigation 50 DAS in BARI Mosur-6). The lowest plant dry matter was found in the interaction I_0V_1 (No irrigation in BARI Mosur-3) at 20 and 40 DAS, and that in I_0V_2 (No Irrigation in BARI Mosur-4) at 60, 80 and 100 DAS. Plant growth rate was higher from 20 to 40 DAS, afterwards it was declined. The highest plant dry matter was observed at 100 DAS in all the interactions since reproductive dry matter were also included in this stage.



I_0 = No irrigation
I_1 = Irrigation at 25 DAS
I_2 = Irrigation at 50 DAS
I_3 = Irrigation at both 25 and 50 DAS

Fig. 2. Effect of irrigation level on dry weight (g) at different DAS of Lentil. ($LSD_{0.05}$ = NS, 0.092, 0.1099, 0.059, and 0.113 at 20, 40, 60, 80 and 100 DAS, respectively).

Table 3. Effect of variety on plant dry weight of lentil at different days after sowing (DAS)

Variety	Dry weight at different DAS (g)				
	20	40	60	80	100
V_1	0.64	2.07	2.87	3.25	3.41
V_2	0.68	2.82	3.16	3.85	4.12
V_3	0.72	3.06	3.54	4.03	4.26
V_4	0.74	3.25	3.77	4.12	4.39
LSD (0.05)	NS	0.92	1.09	0.59	1.13
CV(%)	8.24	6.25	7.15	5.32	8.12

V1 = BARI Mosur-3
V2 = BARI Mosur-4
V3 = BARI Mosur-5
V4 = BARI Mosur-6

Table 4. Interaction effect of irrigation level and variety on plant dry weight of lentil at different days after sowing (DAS)

Irrigation × Variety	Plant dry weight at different DAS (g)				
	20	40	60	80	100
$I_0 \times V_1$	0.60	1.70	1.67	1.72	1.92
$I_0 \times V_2$	0.63	2.20	1.47	1.54	1.62
$I_0 \times V_3$	0.67	2.17	1.83	1.90	1.98
$I_0 \times V_4$	0.67	2.20	2.10	2.23	2.31
$I_1 \times V_1$	0.63	4.07	3.07	3.13	3.21
$I_1 \times V_2$	0.63	3.33	2.80	3.37	3.51
$I_1 \times V_3$	0.70	2.83	2.97	3.23	3.50
$I_1 \times V_4$	0.77	2.00	3.93	4.17	4.25
$I_2 \times V_1$	0.67	2.23	2.70	2.80	3.41
$I_2 \times V_2$	0.70	2.47	3.93	2.61	2.82
$I_2 \times V_3$	0.77	2.93	2.33	3.37	3.51
$I_2 \times V_4$	0.73	3.63	4.57	2.67	2.75
$I_3 \times V_1$	0.70	2.63	3.23	3.57	3.68
$I_3 \times V_2$	0.70	2.57	2.93	3.47	3.64
$I_3 \times V_3$	0.70	3.63	3.63	2.78	3.21
$I_3 \times V_4$	0.87	4.17	4.47	4.53	4.61
$LSD_{(0.05)}$	NS	1.84	2.19	1.19	2.26
CV (%)	7.10	6.24	5.92	8.64	9.22

I_0 = No irrigation
I_1 = Irrigation at 25 DAS
I_2 = Irrigation at 50 DAS
I_3 = Irrigation at both 25 and 50 DAS

V_1 = BARI Mosur-3
V_2 = BARI Mosur-4
V_3 = BARI Mosur-5
V_4 = BARI Mosur-6

4. 3. Pods plant^{-1}

4. 3. 1. Effect of irrigation

The different levels of irrigation had a significant effect on total pods plant^{-1} of lentil (Table 5). The maximum number of pods plant^{-1} (62.90) were recorded from the highest level of irrigation I_3 (Irrigation at both 25 and 50 DAS) followed by I_1 (Irrigation at 25 DAS) and I_2 (Irrigation at 50 DAS) where I_1 and I_2 showed similar results. The lowest pods plant^{-1} was produced by the treatment I_0 (No irrigation). From this study, it was found that optimum amount of water reduced pod shattering there by increased pods plant^{-1}. Similar result was found by Bhan (1977).

4. 3. 2. Effect of variety

The variety had a significant effect on total pods plant^{-1} of lentil (Table 6). The highest number of pods plant^{-1} (53.50) was recorded from the variety BARI Mosur-6, followed by BARI Mosur-5 (49.20) and BARI Mosur-4 (44.50). BARI Mosur-3 produced the lowest pods plant^{-1} (40.00). Variations in pods plant^{-1} due to variety were also reported by Farghali and Hossain (1995), and Islam *et al.* (2010) in mungbean.

4. 3. 3. Interaction effect of irrigation level and variety

The interaction effect of irrigation level and variety on total number of pods plant^{-1} of lentil was significant (Table 7). The highest number of pods plant^{-1} (74.57) was recorded from the interaction of I_1V_4 (Irrigation at 25 DAS in BARI Mosur-6). The interaction of I_1V_3 (Irrigation at 25 DAS in BARI Mosur-5) ranked the second position regarding number of pod plant^{-1} (66.03), which was statistically similar to that of I_3V_3 (Irrigation at both 25 and 50 DAS in BARI Mosur-5). The lowest number of total pods plant^{-1} (14.40) was recorded from the interaction of I_0V_1 (No irrigation in BARI Mosur-3).

4. 4. Seeds pod^{-1}

4. 4. 1. Effect of irrigation level

Irrigation level exerted a significant influence on seeds pod^{-1} of lentil (Table 5). The highest number of seeds pod^{-1} (1.75) was recorded in the treatment I_2 (Irrigation at 50), followed by I_3 (Irrigation at both 25 and 50 DAS). The lowest number of seeds pod^{-1} (1.19) was obtained from the control treatment I_0 (No irrigation). It was noted that increasing the irrigation increased the seeds pod^{-1}. It may be explained that lack of irrigation water at pre-flowering to harvest in I_0 and I_1 treatment reduced dry matter partitioning towards the pod and thereby reduced pod length and seed number. Reduction in seed number per pod might be due to poor fertilization under lack of irrigation water at reproductive stage. This finding was also similar to the findings of Islam *et al.* (2010) and Kumar *et al.* (2005).

4. 4. 2. Effect of variety

The number of seeds pod^{-1} of lentil was not significantly influenced by variety (Table 6). The highest (1.55) seeds pod^{-1} was recorded from the variety BARI Mosur-3 followed by both BARI Mosur-6 and BARI Mosur-5 (1.52). The lowest (1.48) seeds pod^{-1} was recorded from the variety BARI Mosur-4.

4. 4. 3. Interaction effect of irrigation level and variety

The Interaction effect of irrigation level and variety on seeds pod^{-1} showed significant variation (Table 7). The highest number of seeds pod^{-1} (1.89) was recorded from both the interaction of I_1V_4 (Irrigation at 25 DAS in BARI Mosur-6) and I_1V_3 (Irrigation at 25 DAS in BARI Mosur-5). The lowest number of total seeds pod^{-1} (1.00) was recorded from the interaction of I_0V_1 (No Irrigation in BARI Mosur-3).

Table 5. Effect of irrigation on yield contributing characters of lentil

Irrigation level	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	Pod weight (g pod^{-1})	1000-seed weight (g)
I_0	19.80	1.19	0.08	9.22
I_1	52.90	1.58	0.11	15.23
I_2	51.70	1.75	0.13	16.54
I_3	62.90	1.61	0.14	17.33
LSD $_{(0.05)}$	2.70	0.23	0.03	1.04
CV (%)	5.02	7.25	5.21	8.32

I_0 = No irrigation
I_1 = Irrigation at 25 DAS
I_2 = Irrigation at 50 DAS
I_3 = Irrigation at both 25 and 50 DAS

Table 6. Effect of variety on yield contributing characters of lentil

Irrigation level	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	Pod weight (g pod^{-1})	1000-seed weight (g)
V_1	40.00	1.55	0.08	14.65
V_2	44.50	1.50	0.13	14.83
V_3	49.20	1.52	0.13	15.28
V_4	53.50	1.53	0.14	15.40
LSD $_{(0.05)}$	2.70	NS	0.03	NS
CV (%)	5.02	7.15	5.31	8.33

V_1 = BARI Mosur-3
V_2 = BARI Mosur-4
V_3 = BARI Mosur-5
V_4 = BARI Mosur-6

4. 5. Weight of pod

4. 5. 1. Effect of irrigation

The weight of pod was significantly influenced by irrigation level (Table 5). The highest pod weight (0.13 g) was recorded from the treatment I_3 (Irrigation at both 25 and 50 DAS) followed by the treatment I_2 (Irrigation at 50 DAS). The lowest pod weight (0.08 g) was recorded from the control treatment I_0 (No irrigation). From this study it was shown that irrigation increased the pod weight. The similar result was also found by Turk *et al.* (1980).

4. 5. 2. Effect of variety

The variety showed significant influence on weight of pod (Table 6). The highest pod weight (0.14 g) was recorded from the variety BARI Mosur-6 followed by BARI Mosur-4 (0.13 g). The lowest pod weight (0.08g) was recorded from the variety BARI Mosur-3.

4. 5. 3. Interaction effect of irrigation level and variety

The Interaction of irrigation level and variety on pod weight showed significant variation in pod weight of lentil (Table 7). The highest pod weight (0.14g) was recorded from the treatment I_3V_3 (Irrigation at both 25 and 50 DAS + BARI Mosur-5). The interactions I_3V_4 (Irrigation at both 25 and 50 DAS in BARI Mosur-6) along with I_2V_4 (Irrigation at 50 DAS in BARI Mosur-6) ranked the second position in pod weight (1.40 g). The lowest weight of pod (0.06 g) was recorded from the interaction of I_0V_1 (No irrigation in BARI Mosur-3).

4. 6. Thousand seeds weight

4. 6. 1. Effect of irrigation

The effect of irrigation on 1000 seeds weight of lentil was found significant (Table 5). The highest 1000 seeds weight (17.33 g) was recorded from the treatment I_3 (Irrigation at both 25 and 50 DAS) followed by the treatment I_2 (Irrigation at 50 DAS) The lowest value (9.22 g) was recorded from the control treatment I_0 (No irrigation). The result showed that increasing the irrigation levels increased the 1000 seeds weight. Similar result was also found from the study of Michael (1985).

4. 6. 2. Effect of variety

The variety showed little influence on 1000 seeds weight of lentil. The effect of variety on 1000 seeds weight of lentil was statistically insignificant (Table 6). The highest 1000 seeds weight (15.40 g) was recorded from the variety BARI Mosur-6 followed by the variety BARI Mosur-5 (15.28 g). The lowest value (14.65 g) was recorded from the variety BARI Mosur-3. Variation in 1000 seed weight was also reported by Rajat and Gowda (1998) in mungbean.

4. 6. 3. Interaction effect of irrigation level and variety

The interaction effect of irrigation level and variety had a significant influence on 1000 seeds weight of lentil (Table 7). The highest 1000 seeds weight (20.62 g) was found in the interaction of I_3V_4 (Irrigation at both 25 DAS and 50 DAS in BARI Mosur-6) followed by the interaction of I_3V_3 (Irrigation at 25 DAS and 50 DAS in BARI Mosur-5). The lowest value (6.60g) was recorded from the interaction of I_0V_1 (No irrigation in BARI Mosur-3). It was observed that shortage of water decreased the seed size and weight. Water application increased the seed size thereby increased 1000 seed weight. The similar result was found by Siowit and Kramer (1997).

Table 7. Interaction effect of irrigation levels and variety on yield contributing characters of lentil

Irrigation × Variety	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	Pod weight (g pod^{-1})	1000-seed weight (g)
$I_0 \times V_1$	14.40	1.00	0.057	6.60
$I_0 \times V_2$	19.97	1.11	0.083	10.06
$I_0 \times V_3$	24.80	1.22	0.090	10.35
$I_0 \times V_4$	20.03	1.44	0.097	10.27
$I_1 \times V_1$	45.53	1.66	0.120	15.35
$I_1 \times V_2$	44.36	1.55	0.130	16.00
$I_1 \times V_3$	66.03	1.89	0.133	15.33
$I_1 \times V_4$	74.57	1.89	0.120	16.67
$I_2 \times V_1$	47.80	1.44	0.133	15.36
$I_2 \times V_2$	59.97	1.55	0.130	16.25
$I_2 \times V_3$	57.72	1.77	0.133	16.69
$I_2 \times V_4$	60.32	1.66	0.140	17.15
$I_3 \times V_1$	57.77	1.55	0.130	16.57
$I_3 \times V_2$	53.62	1.55	0.133	16.86
$I_3 \times V_3$	62.30	1.44	0.143	19.36
$I_3 \times V_4$	59.80	1.77	0.140	20.62
LSD $_{(0.05)}$	3.66	0.46	0.163	2.09
CV (%)	5.02	5.58	7.04	5.78

I_0 = No irigation — V_1 = BARI Mosur-3
I_1 = Irrigation at 25 DAS — V_2 = BARI Mosur-4
I_2 = Irrigation at 50 DAS — V_3 = BARI Mosur-5
I_3 = Irrigation at both 25 and 50 DAS — V_4 = BARI Mosur-6

4. 7. Seed yield

4. 7. 1. Effect of irrigation

Irrigation level exerted a significant effect on lentil seed yield (Figure 3). The maximum seed yield (1643.0 kg ha^{-1}) of lentil was obtained from the treatment I_3 (Irrigation at both 25 and 50 DAS) followed by the treatment I_2 (Irrigation at 50 DAS) (1463.0 kg ha^{-1}). The lowest seed yield (603.6 kg ha^{-1}) was recorded from the control treatment I_0 (No irrigation). From the results it was observed that seed yield increased gradually with the increases of irrigation level. Shortage of irrigation water greatly reduced the yield. The similar results were also found by Michael (1985) and, Pannu and Singh (1988).

4. 7. 2. Effect of variety

The variety had also a significant influence on seed yield of lentil (Figure 4). The highest seed yield (1362.0 kg ha^{-1}) was recorded from the variety BARI Mosur-6 followed by BARI Mosur-5(1210.3 kg ha^{-1}). The lowest seed yield (1107.1 kg ha^{-1}) was recorded from the variety BARI Mosur-3.

4. 7. 3. Interaction effect of irrigation level and variety

The interaction of irrigation level and variety had a significant influence on seed yield (Table 8). The highest seed yield (2269.0 kg ha^{-1}) was found in the interaction I_3V_4 (Irrigation at both 25 DAS and 50 DAS in BARI Mosur-6) followed by the interaction I_3V_3 (Irrigation at both 25 DAS and 50 DAS in BARI Mosur-5), which was statistically similar to that of I_3V_2 (Irrigation at both 25 DAS and 50 DAS in BARI Mosur-4) and I_3V_1 (Irrigation at both 25 DAS and 50 DAS in BARI Mosur-3). The lowest seed yield (565.7 kg ha^{-1}) was recorded from I_0V_1 (No irrigation in BARI Mosur-3). It was recorded that shortage of water decreased the seed size and weight, whereas, water application increased the seed size and weight, thereby increased seed yield. The similar result was found by Vitkov (1972).

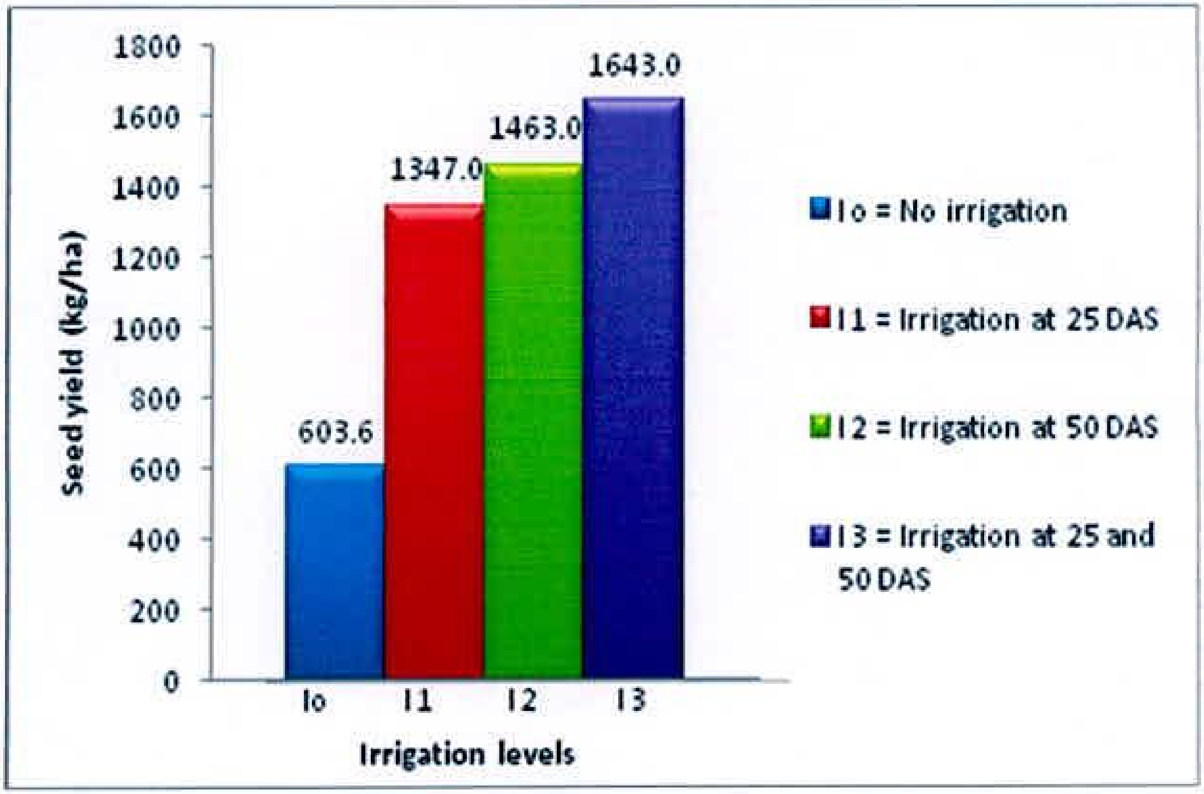


Fig. 3. Effect of irrigation level on seed yield of lentil ($LSD_{0.05}$ = 120.1).

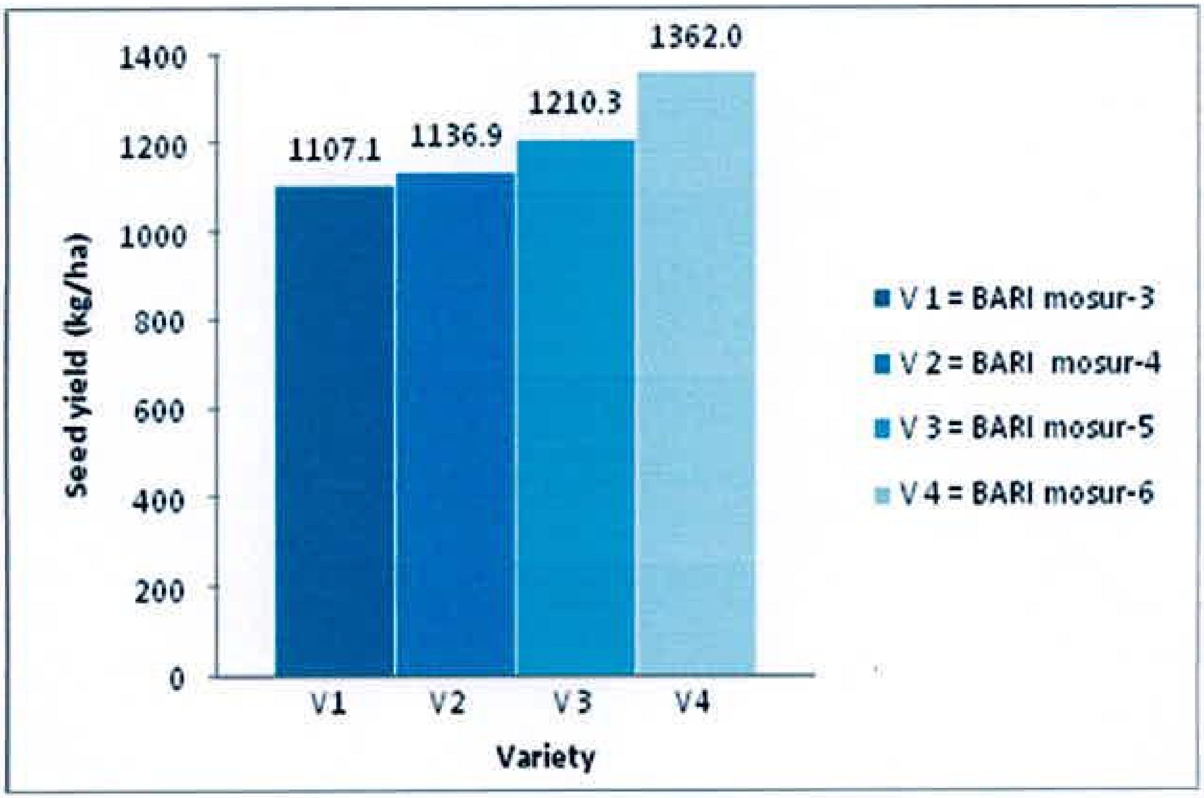


Fig. 4. Effect of variety on seed yield of lentil ($LSD_{0.05}$ = 120.1).

4. 8. Stover yield

4. 8. 1. Effect of irrigation level

Application of irrigation at different levels increased stover yield significantly (Figure 5). The maximum stover yield (2172.0 kg ha^{-1}) was recorded from the treatment I_3 (Irrigation at both 25 DAS and 50 DAS) followed by (2033.0 kg ha^{-1}) from the treatment I_2 (Irrigation at 50 DAS) and the minimum yield (971.2 kg ha^{-1}) was recorded from the control treatment I_0 (No irrigation). It is interesting that increasing irrigation level increased plant height, branch and leaf number per plant. For that stover yield was increased. The results showed that stover yield directly proportional to the application of irrigation water. It might be due to luxuriant vegetative growth of plants in presence of optimum water, which enhanced dry matter accumulation and finally increased stover yield. Similar result was reported by Pandey *et al.* (1984).

4. 8. 2. Effect of variety

Stover yield was significantly influenced by variety (Figure 6). The highest stover yield (1952.1 kg ha^{-1}) was recorded from the variety BARI Mosur-6 followed by the variety BARI Mosur-3(1824.0 kg ha^{-1}). The lowest stover yield (1778.6 kg ha^{-1}) was recorded from the variety BARI Mosur-4. Variety BARI Mosur-6 and BARI Mosur-3 are tall and highly branched. For that these varieties produced higher stover yield compare to that of other varieties.

4. 8. 3. Interaction effect of irrigation level and variety

The interaction of irrigation level and variety had a significant role on stover yield of lentil (Table 8). The highest stover yield of lentil (2876.3 kg ha^{-1}) was recorded from the treatment I_3V_4 (Irrigation at both 25 DAS and 50 DAS in BARI Mosur-6) followed by the treatment I_3V_2 (Irrigation at both 25 DAS and 50 DAS in BARI Mosur-4) was (2712.1 kg ha^{-1}). The lowest stover yield (786.3 kg ha^{-1}) was recorded from the treatment I_0V_1 (No irrigation in BARI Mosur-3).

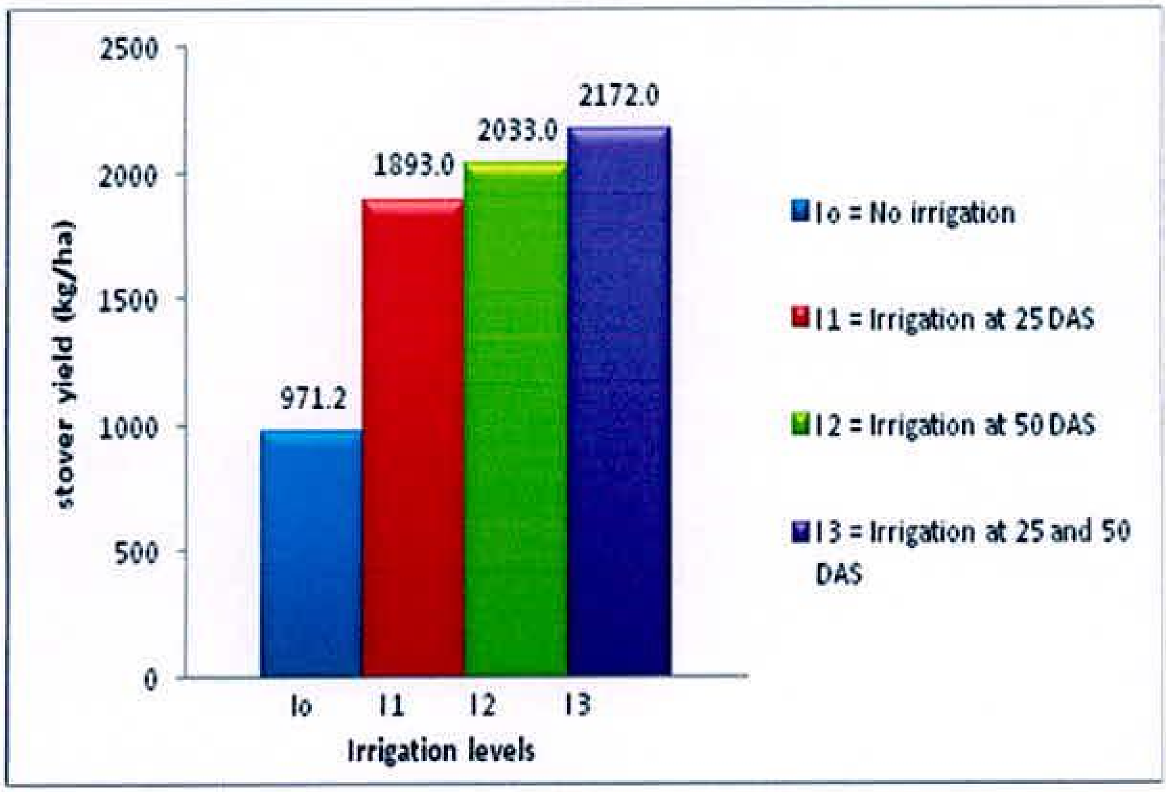


Fig. 5. Effect of irrigation level on stover yield of lentil ($LSD_{0.05}$ = 132.3).

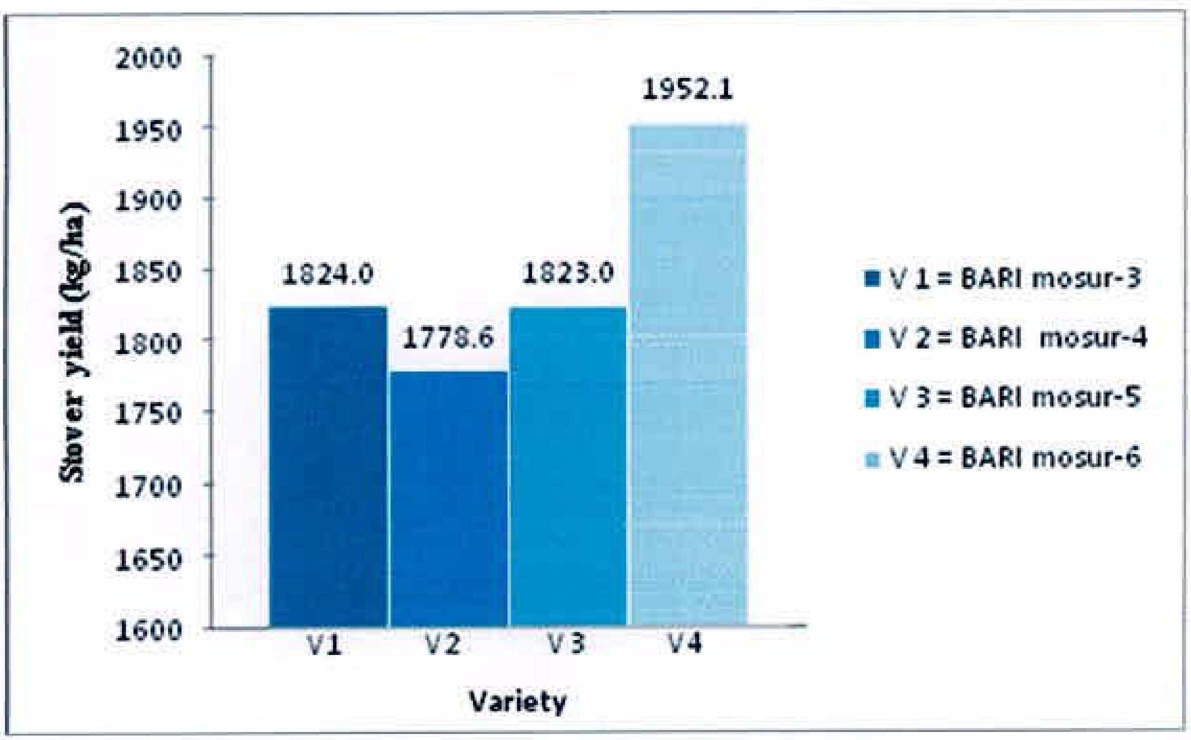


Fig. 6. Effect of variety on stover yield of lentil ($LSD_{0.05}$ = 132.3).

4. 9. Biological yield

4. 9. 1. Effect of irrigation

The irrigation level exerted a significant effect on biological yield (Figure 7). The highest biological yield (3815.0 kg ha^{-1}) was recorded from the treatment I_3 (Irrigation at both 25 DAS and 50 DAS) followed by the treatment I_2 (Irrigation at 50 DAS). The lowest biological yield (1574.8 kg ha^{-1}) was recorded from the control treatment I_0 (No irrigation). From the result it appeared that biological yield increased with the increase of irrigation level.

4. 9. 2. Effect of variety

Variety had a significant influence on biological yield (Figure 8). The highest biological (yield 3314.2 kg ha^{-1}) was recorded from the variety BARI Mosur-6 followed by the variety BARI Mosur-5. The lowest biological yield (2911.5 kg ha^{-1}) was obtained from the variety BARI Mosur-4. Variety BARI Mosur-6 and BARI Mosur-5 were tall, highly branched and grain size is heavier compare to the others. Therefore, these varieties produced higher biological yield compare to others. Variations in biological yield due to variety were also reported by Patil and Salimath (2003).

4. 9. 3. Interaction effect of irrigation level and variety

The interaction effect of irrigation level and variety had a significant role on biological yield of lentil (Table 8). The highest biological yield (5145.3 kg ha^{-1}) was obtained from the interaction of I_3V_4 (Irrigation at both 25 DAS and 50 DAS in BARI Mosur-6) followed by the interaction of I_3V_3 (Irrigation at 25 DAS and 50 DAS in BARI Mosur-5). The lowest biological yield (1352.0 kg ha^{-1}) was obtained from the interaction of I_0V_1 (No Irrigation in BARI Mosur-3). Similar result was also reported by Kumar *et al.* (2005).

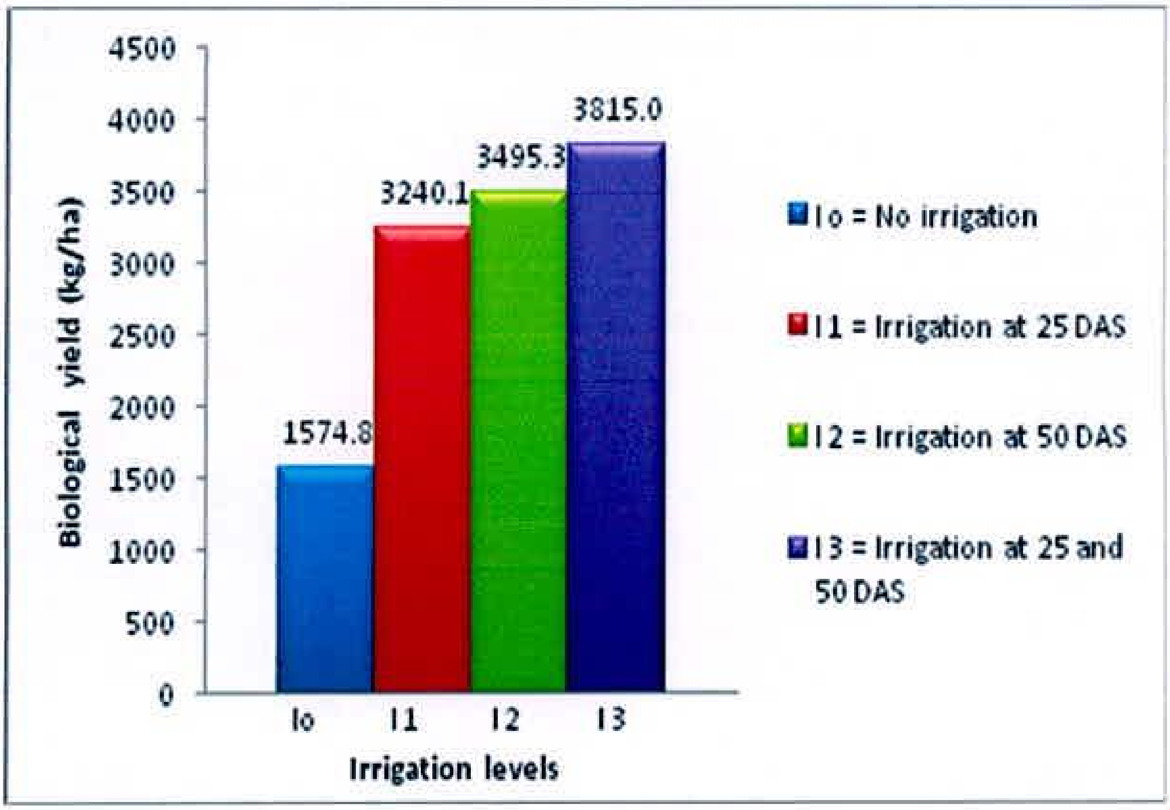


Fig. 7. Effect of irrigation level on biological yield of lentil ($LSD_{0.05}$ = 209.3).

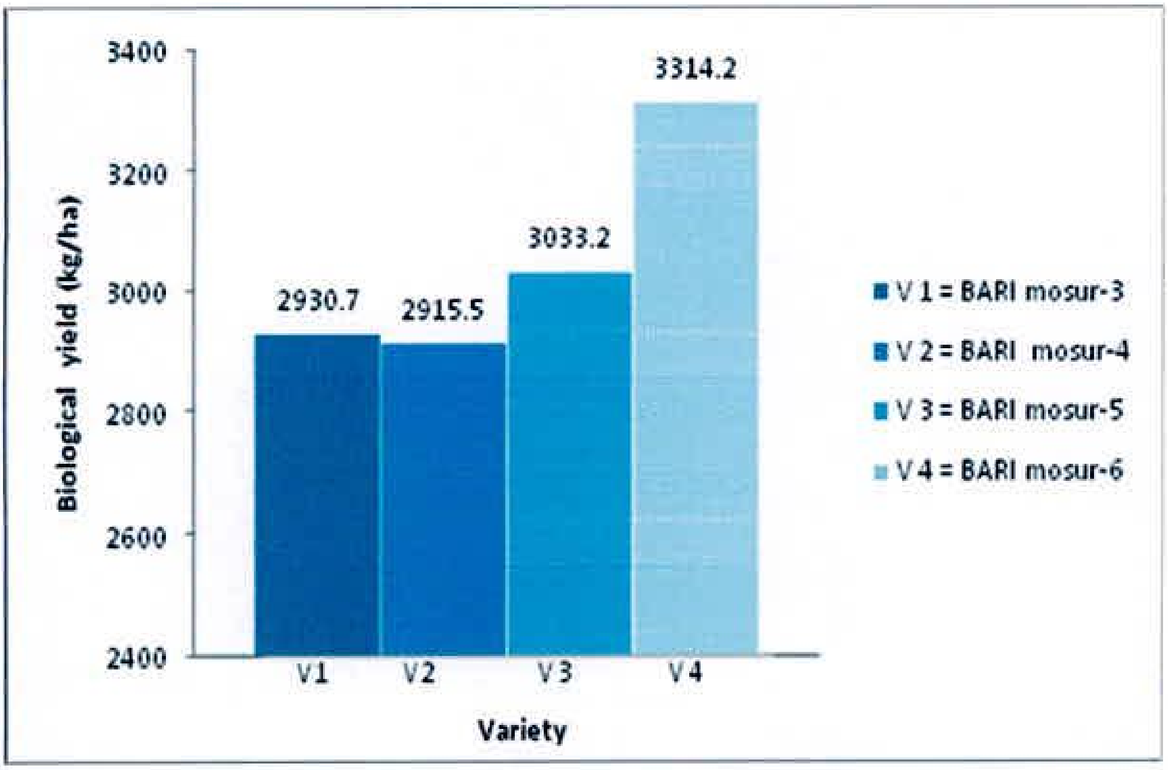


Fig. 8. Effect of variety on biological yield of lentil ($LSD_{0.05}$ = 209.3).

4. 10. Harvest index

4. 10. 1. Effect of irrigation

The harvest index was greatly influenced by irrigation levels (Figure 9). The highest harvest index (43.08%) was recorded from the treatment I_3 (Irrigation at both 25 DAS and 50 DAS) followed by the treatment I_2 (Irrigation at 50 DAS). The lowest harvest index (38.33%) was obtained from the control treatment I_0 (No irrigation). From the result it was appeared that harvest index increased with the increased rate of water application up to a certain limit. Harvest index increased (5%) in the treatment consisting two irrigations over that of the treatment having no irrigation. The similar finding was also reported by Nandan (1998).

4. 10. 2. Effect of variety

The present study showed that the harvest index was influenced by variety (Figure 10). The highest harvest index (41.10%) was recorded from the variety BARI Mosur-6 followed by the variety BARI Mosur-5 (39.90%). The lowest harvest index (37.78%) was recorded from the variety BARI Mosur-3. Harvest index was 3.06% higher in the variety BARI Mosur-6 over that of the variety BARI Mosur-3.

4. 10. 3. Interaction effect of irrigation level and variety

The interaction effect of irrigation level and variety exerted a significant influence on harvest index of lentil (Table 8). The highest harvest index (44.10%) was recorded from the interaction I_3V_4 (Irrigation at both 25 DAS and 50 DAS in BARI Mosur-6) followed by the interaction I_1V_2 (Irrigation at 25 DAS in BARI Mosur-4). The lowest harvest index (38.82%) was recorded from the treatment I_0V_2 (No Irrigation in BARI Mosur-4). Harvest index was increased 5.28% in the interaction by treatment I_3V_4 (Irrigation at both 25 DAS and 50 DAS in BARI Mosur-6) over that of the interaction I_0V_2 (No irrigation in BARI Mosur-4).

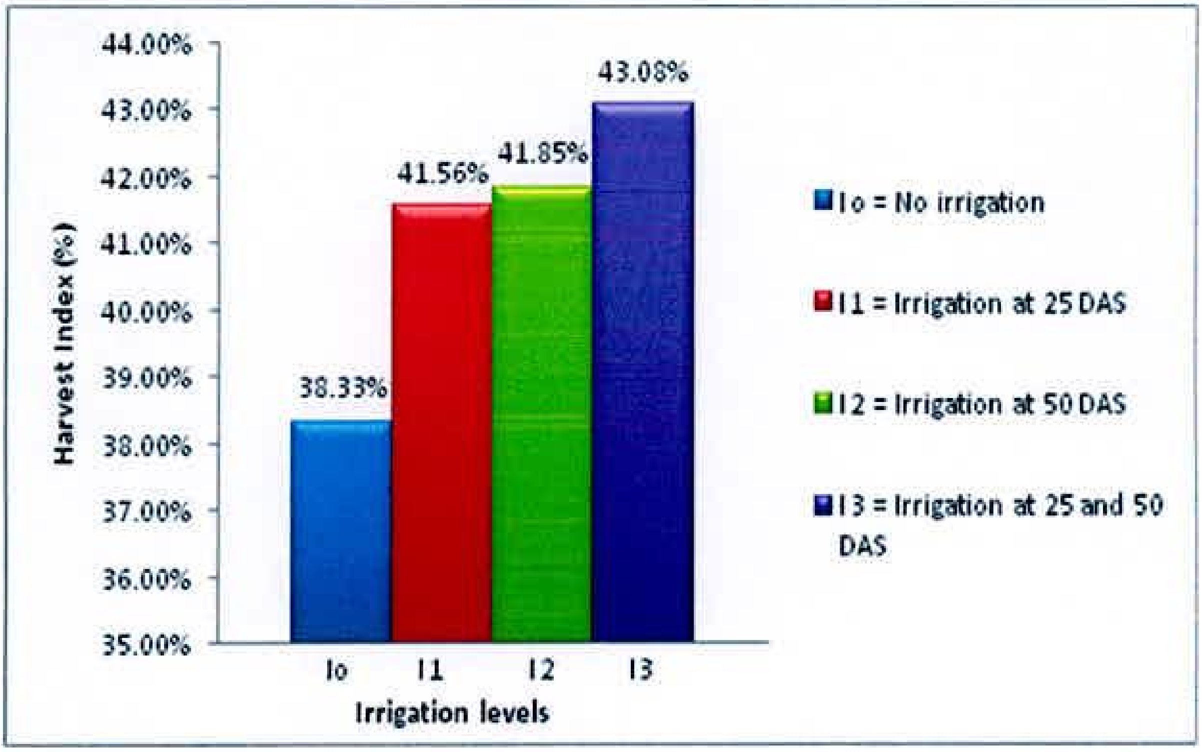


Fig. 9. Effect of irrigation level on harvest index of lentil ($LSD_{0.05}$ = 1.00).

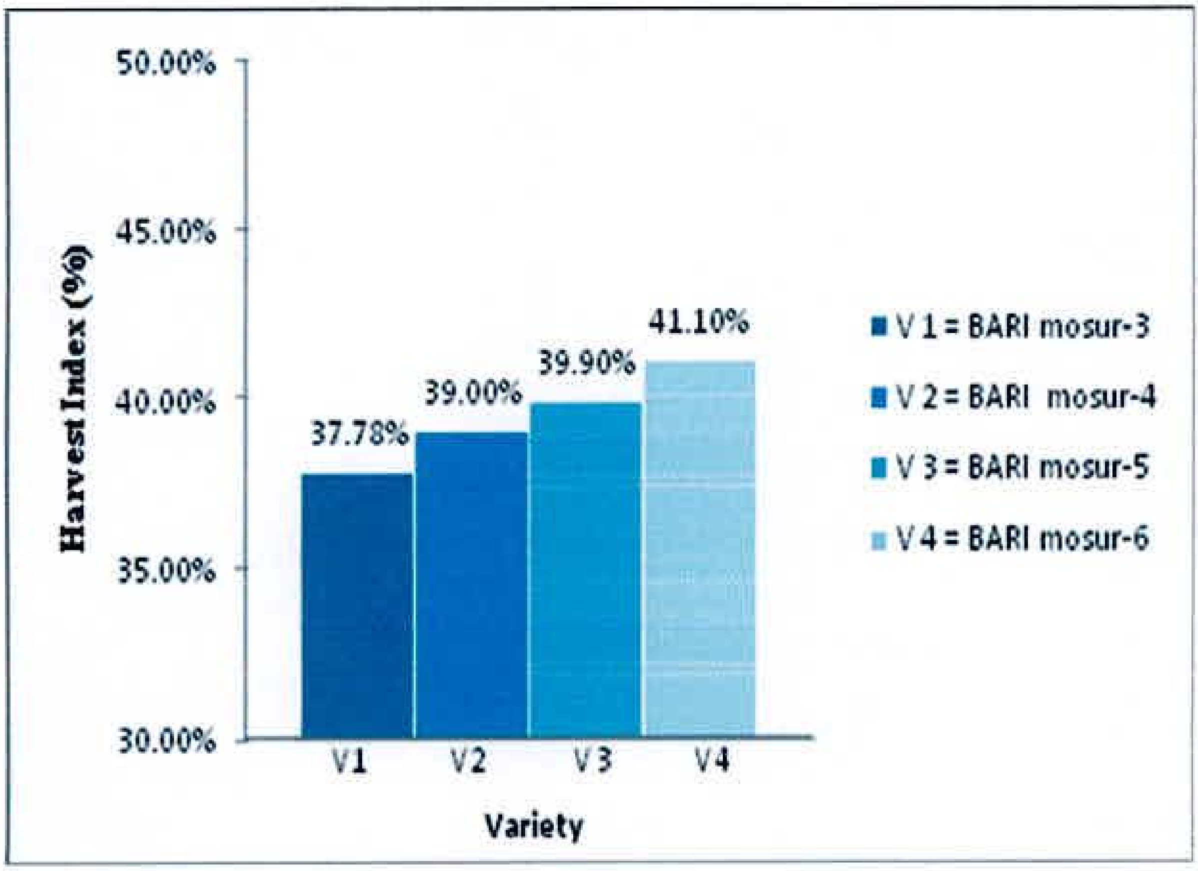


Fig. 10. Effect of variety on harvest index of lentil ($LSD_{0.05}$ = 1.00).

Table. 8. Interaction effect of irrigation level and variety on seed yield, stover yield, biological yield and harvest index of lentil

Interaction Irrigation × Variety	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest Index (%)
$I_0 \times V_1$	565.7	786.3	1352.0	41.84
$I_0 \times V_2$	566.0	892.0	1458.0	38.82
$I_0 \times V_3$	605.7	925.3	1531.0	39.56
$I_0 \times V_4$	674.7	969.7	1644.4	41.03
$I_1 \times V_1$	1013.9	1365.4	2379.3	42.61
$I_1 \times V_2$	1095.1	1408.3	2503.4	43.74
$I_1 \times V_3$	1156.4	1493.4	2649.8	43.64
$I_1 \times V_4$	1285.7	1678.7	2964.4	43.37
$I_2 \times V_1$	1356.7	1855.7	3212.4	42.23
$I_2 \times V_2$	1432.7	2060.3	3493.0	41.02
$I_2 \times V_3$	1540.7	2294.0	3834.7	40.18
$I_2 \times V_4$	1589.0	2362.4	3951.4	40.21
$I_3 \times V_1$	1844.3	2605.1	4449.4	41.45
$I_3 \times V_2$	1906.7	2712.1	4618.8	41.28
$I_3 \times V_3$	1973.4	2704.7	4678.1	42.18
$I_3 \times V_4$	2269.0	2876.3	5145.3	44.10
$LSD_{(0.05)}$	240.2	264.6	418.5	2.06
CV (%)	6.81	5.46	6.75	7.69

I_0 = No irrigation
I_1 = Irrigation at 25 DAS
I_2 = Irrigation at 50 DAS
I_3 = Irrigation at both 25 and 50 DAS

V_1 = BARI Mosur-3
V_2 = BARI Mosur-4
V_3 = BARI Mosur-5
V_4 = BARI Mosur-6

Chapter 5
Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

An experiment was conducted to study the effect of irrigation and variety on growth and yield of lentil during rabi season (November-February), 2008-2009 at Agronomy farm of Sher-e-Bangla Agricultural University, Dhaka. The trial was consisted of two factors of treatments. There are four levels of irrigation. [I_0 : control (no irrigation), I_1 : Irrigation at 25 DAS, I_2 : Irrigation at 50 DAS and I_3 : Irrigation at both 25 and 50 DAS]. Four latest varieties of lentil were used, which were released by Bangladesh Agricultural Research Institute [V_1 : BARI Mosur-3, V_2 : BARI Mosur-4, V_3 : BARI Mosur-5 and V_4 : BARI Mosur-6].

The experiment was laied-out in split plot design with three replications assigning irrigation level in the main plot and variety in the sub plot. The plot was fertilized with N, P, K, S, B and Zn, respectively at the rate of 21, 30, 25, 5, 0.34 and 1.8 kg ha^{-1} along with cowdung at the rate of 10 t ha^{-1} during the final land preparation.

Lentil seeds were sown on 16th November, 2008 and harvested on 12th to 19th February, 2009. Data on growth, yield attributes and yield were recorded and analyzed statistically following LSD test at 5% level of significance.

A progressive increase of plant height at each successive growth stage was found in I_3, which was significantly different from other treatments, while minimum was found in I_0. The interaction of two irrigation and BARI Mosur-6 gave higher plant height. Plant height at 20 DAS showed no significant difference for their similar growth.

Dry weight was greatly influenced by irrigation. The control treatment (no irrigation) produced lower dry weight at all the DAS studied. Two irrigation produced the highest dry weight. Among the varieties BARI Mosur-6 gave the highest dry weight. The interaction of two irrigation at 25 and 50 DAS and BARI Mosur-6 gave the highest dry weight.

One irrigation at vegetative growth stage (25 DAS) gave higher number of pods per plant compared to that of the treatment consisting one irrigation at pre-flowering stage (50 DAS). Irrigation showed great influence on number of pods per plant. Initiation of pod occurred at early stage. For that the treatment I_3 (Irrigation at both 25 and 50 DAS) showed higher number of pods (62.90). Among the varieties BARI Mosur-6 gave the highest number of pod per plant (53.50). The interaction of the treatment I_1 (Irrigation at 25 DAS) and BARI Mosur-6 gave the highest number of pods per plant.

Irrigation showed significant influence on seeds per pod. The control treatment (no irrigation) produced lowest number of seeds per pod (0.08). One irrigation at flowering stage produced the highest number of seeds per pod (1.75). The interaction of one irrigation at flowering stage and BARI Mosur-6 and also irrigation at flowering stage in BARI Mosur-5 gave the highest number of seeds per pod (1.89).

Irrigation showed significant influence on weight of pod. The control treatment (no irrigation) produced the lowest weight of pod (0.08 g). Two irrigations produced the highest weight of pod (0.14 g). Among the varieties BARI Mosur-6 gave the highest weight of pod. The interaction of two irrigation and BARI Mosur-6 gave the highest weight of pod (0.14 g).

Irrigation showed significant influence on weight of 1000 seeds. The control treatment (no irrigation) scored the lowest weight of 1000 seeds (9.22 g). Two irrigations scored the highest weight of 1000 seeds (17.33 gm). Among the varieties BARI Mosur-6 gave the highest weight of 1000 seeds. The interaction of two irrigation and BARI Mosur-6 gave the highest weight of 1000 seeds (20.62 g).

Irrigation showed significant influence on seed yield. Lack of water produced small sized seed. The control treatment (no irrigation) showed lower seed yield. Two irrigation showed the highest seed yield (1643.0 kg ha^{-1}). Among the varieties BARI Mosur-6 gave the highest seed yield (1362.0 kg ha^{-1}). The interaction of two irrigation and BARI Mosur-6 gave the highest seed yield (2269.0 kg ha^{-1}).

Irrigation showed significant influence on stover yield. Lack of water produced little branch per plant. For that stover yield was reduced. The control treatment (no irrigation) showed the lowest stover yield (971.2 kg ha^{-1}). Two irrigation showed the highest stover yield (2172.0 kg ha^{-1}). Among the varieties BARI Mosur-6 gave the highest stover yield. The interaction of two irrigation and BARI Mosur-6 gave higher stover yield (2876.0 kg ha^{-1}).

Irrigation had a great influence on biological yield. For water application both economic yield and stover yield were increased. It was found that shortage of water application reduced the biological yield. The control treatment (no irrigation) showed the lowest biological yield (1574.8 kg ha^{-1}). Two irrigation showed the highest biological yield (3815.0 kg ha^{-1}). Among the varieties BARI Mosur-6 gave the highest biological yield (3314.2 kg ha^{-1}). The interaction of two irrigation and BARI Mosur-6 gave the highest biological yield (5145.3 kg ha^{-1}).

Among the four treatments of irrigation the treatment I_3 (Irrigation at 25 and 50 DAS) showed the highest harvest index (43.08%). Control treatment (No irrigation) showed the lowest harvest index (38.33%). Among the varieties BARI Mosur-6 gave the highest harvest index (41.10%). The interaction of two irrigation and BARI Mosur-6 gave the highest harvest index (44.10%).

From the present study, it may be concluded that irrigation level influenced the growth, yield and yield components of lentil varieties. Among the irrigation levels two irrigation (Irrigation at both 25 and 50 DAS) followed by one irrigation at 25 DAS and among the varieties BARI Mosur-6 followed by BARI Mosur-5 and the interaction between two irrigations and BARI Mosur-6 were found to be most promising.

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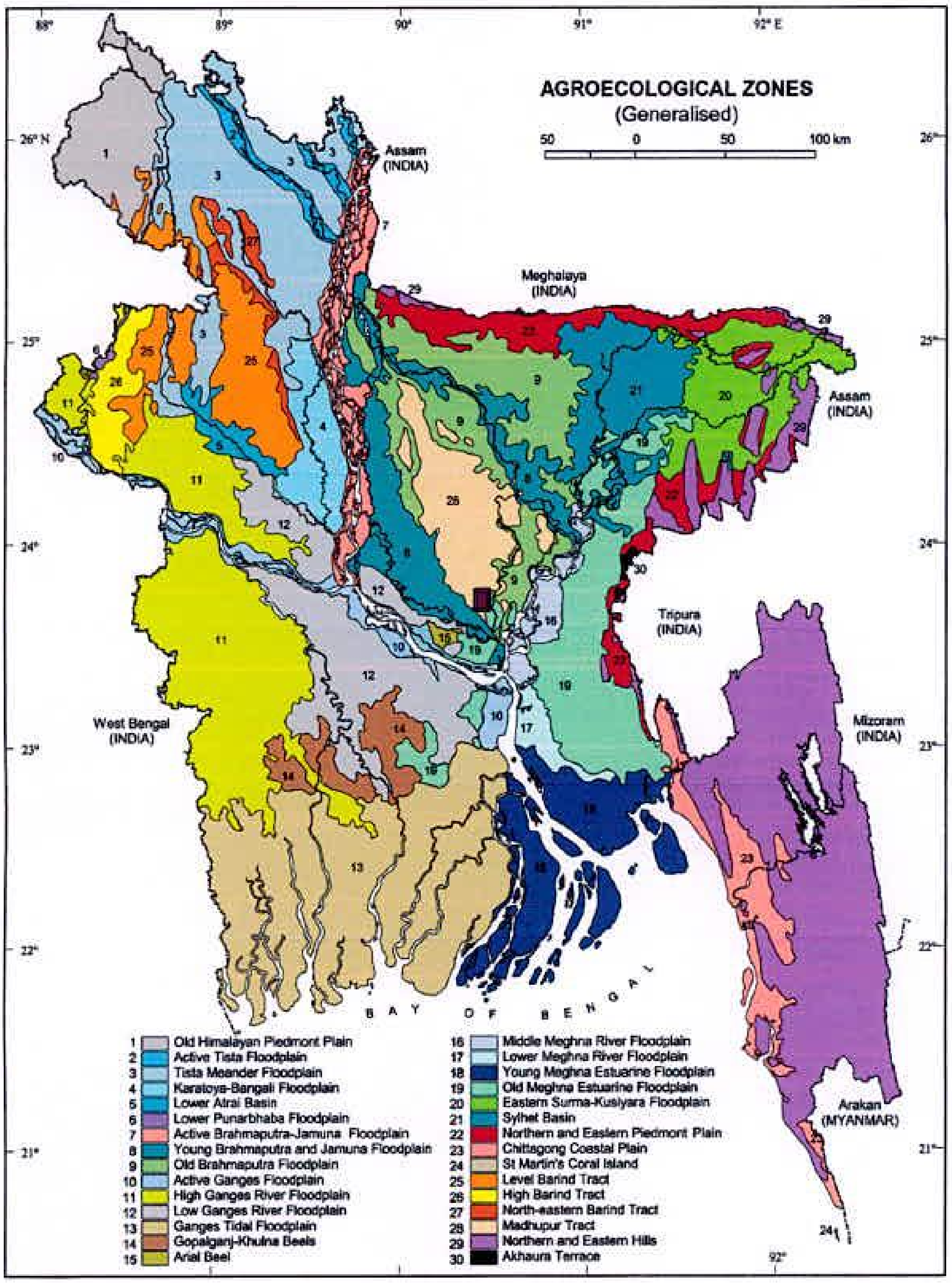
Appendices

APPENDICES

Appendix I. Map showing the experimental sites under study



■ **The experimental site under study**

Appendix II. Meteorological data during the study period from November to February, 2008-2009.

Month	Temperature (^0C)		Rainfall (cm)	Relative humidity (%)
	Maximum	Minimum		
November	32.8	22.3	12	71
December	32.3	18.4	5	70
January	30.0	16.5	4	65
February	31.6	17.8	8	75

Source: National Meteorological Research Centre, Dhaka.

Appendix III. Physiochemical characteristics of the initial soil

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

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

Appendix III. Summary of analysis of variance on plant height at different DAS of lentil

Source of variance	Mean square					
	Degrees of freedom	20 DAS	40 DAS	60 DAS	80 DAS	100 DAS
Replication	2	0.007	1.031	8.352	4.424	5.426
Irrigation	3	0.190	4.954**	2.750**	13.397**	5.945**
Variety	3	0.493	3.376**	8.154**	2.091**	4.332**
Irrigation × Variety	9	0.345	0.628**	1.339**	2.736**	2.66**
Error	30	0.196	3.309	2.264	2.621	5.394
Total	47					
CV (%)		0.07	0.96	1.268	1.364	1.957

Appendix IV. Summary of analysis of variance on Dry matter production at different DAS of lentil

Source of variance	Mean square					
	Degrees of freedom	20 DAS	40 DAS	60 DAS	80 DAS	100 DAS
Replication	2	0.007	0.018	0.089	0.002	0.006
Irrigation	3	0.021	0.032**	0.143**	0.046**	0.211**
Variety	3	0.001	0.005**	0.036**	0.012**	0.00**
Irrigation × Variety	9	0.009	0.016**	0.037**	0.003**	0.032**
Error	30	0.004	0.012	0.017	0.122	0.018
Total	47					
CV (%)		0.10	0.092	0.1099	0.059	0.11

Appendix V. Summary of analysis of variance on yield attributes of lentil

Source of variance	Mean square									
	Degrees of freedom	Pod plant^{-1}	Seeds pod^{-1}	Pod weight	1000 seeds weight (g)	Seed yield (kg/ha^{-1})	Stover yield (kg/ha^{-1})	Biological yield	Harvest index (%)
Replication	2	9.350	0.046	0.02	23.906	13.852	16.35	17.62	0.158
Irrigation	3	41.975**	0.676**	0.07**	182.726**	251.10**	284.35**	295.68**	3.848**
Variety	3	4.093**	0.008**	0.05 ^{NS}	4.801**	45.004**	62.34**	71.64**	3.700**
Irrigation × Variety	9	7.149**	0.101**	0.04**	16.980 **	11.226*	14.91**	16.34**	0.459**
Error	30	5.061	0.036	0.03	7.864	2.393	3.34	4.01	0.284
Total	47								
CV (%)		6.39	7.25	5.21	8.32	8.98	6.41	6.75	7.69