EFFECT OF VARIETY AND POTASSIUM ON WATER RELATIONS AND YIELD OF LENTIL UNDER RESIDUAL SOIL MOISTURE CONDITION

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CERTIFICATE

This is to certify that the thesis entitled **"EFFECT OF VARIETY AND POTASSIUM ON WATER RELATIONS AND YIELD OF LENTIL UNDER RESIDUAL SOIL MOISTURE CONDITION"** submitted to the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS)** in **AGRONOMY**, embodies the result of a piece of *bona fide* research work carried out by**ShabnoorNaher Topy**, Registration No. **10-03994** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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ABSTRACT

The experiment was conducted in the Agronomy Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2015 to March 2016 to find out the effect of variety and potassium on the yield of lentil under residual soil moisture condition. The experiment consisted of two factors: Factor A: Three varieties of lentil (V_1: BARI masur-5, V_2: BARI masur-6, V_3: BARI masur-7). Factor B: 4 doses of Potassium fertilizer (P_1 : 25 kg K_2O ha^{-1}, P_2 : 30 kg K_2O ha^{-1}, P_3 : 35 kg K_2O ha^{-1}, P_4 : 40 kg K_2O ha^{-1}). There were 12 treatment combinations. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Variety, potassium level and their interactions had significant influence on water relations, yield contributing characters and yield of lentil. The maximum relative water content, exudation rate, grain yield (1.05 t ha^{-1}) and biological yield (2.38 t ha^{-1}) were found in BARI Masur-7 whereas the minimum in BARI Masur-5. The maximum relative water content, exudation rate, grain yield (0.99 t ha^{-1}) and biological yield (2.20 t ha^{-1}) were also found from 40 kg K_2O ha^{-1} whereas the minimum were obtained from 25 kg K_2O ha^{-1}. The maximum relative water content, exudation rate, grain yield (1.12 t ha^{-1}), biological yield (2.57 t ha^{-1}) were found from BARI Masur-7 with 40 kg K_2O ha^{-1} while the minimum from BARI Masur-5 with 25 kg K_2O ha^{-1}.

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LIST OF ACRONYMS

ABBREVIATIONS	ELABORATIONS
AEZ	Agro-Ecological Zone
Anon.	Anonymous
ANOVA	Analysis of Variance
@	at the rate of
a.i	Active ingredient
Adv.	Advanced
Agron .	Agronomy
Agric.	Agriculture Agricultural
Agril.	Agricultural
BRRI	Bangladesh Rice Research Institute
BARI	Bangladesh Agricultural Research Institute
SAU	Sher-e-Bangla Agricultural University
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
RCBD	Randomized Complete Block Design
CV	Coefficient of Variation
cv.	Cultivar
EC	Emulsifiable Concentrate
cm	Centimeter
df	Degrees of Freedom
DAS	Days After Sowing
LSD	Least significance difference
et al.	and others
etc.	etcetera
FAO	Food and Agricultural Organization
Fig	Figure
ns	Non Significant

ABBREVIATIONS	ELABORATIONS
J.	Journal
PP.	Pages
g	Gram
ha^{-1}	Per hectare
t	Ton
%	Percent
m^2	Square meter
pod^{-1}	Per pod
J.	Journal
kg	Kilogram
No.	Number
NS	Non Significant
NOS	Number of species
^0C	Degree Celsius
Res.	Research
RH	Relative humidity
WCE	Weed control efficiency
SRDI	Soil Resource Development Institute
Sci.	Science 's
HI	Harvest Index
Vol.	Volume

CHAPTER I

INTRODUCTION

Lentil (*Lens culinaris* L. Medik) is one of the most important pulse crops grown in Bangladesh and it belongs to the sub family Papilionaceae under the family Fabaceae.In South Asia as well as in Bangladesh, it is popularly known as Masurand one of the most ancient annual food crops that have been grown as an important food source for over 8,000 years (Dhuppar*et al*., 2012). Various types of pulse crops can be grown in Bangladesh of which grasspea, lentil, mungbean, blackgram, cheakpea, fieldpea and cowpea are important. These are important food crop because they provide a cheap source of easily digestible protein.Pulse supplies about four times as much protein and eight times as riboflavin and the caloric value of it is equal to rice (Anonymous, 1966). Moreover, pulse is known as poor man's meat. It is a versatile source of nutrients for man, animal and soil (Miah, 1976). According to FAO (1999) a minimum intake of pulse by a human should be 80 g per head per day, whereas it is only 18 g in Bangladesh (BBS, 2015). This is because of the fact that the national production of the pulse is not adequate to meet the national demand. Among the pulse crops lentil is one of the important crop grown in Bangladesh.Greater Faridpur, Jessore, Khustia, Pabna, and Rajshahi are the major lentil growing area in the country. In Bangladesh, lentil ranks second in acreage and production but ranks first in market price.

Nutritionally, lentil is very rich and complementary to any cereal crops including rice. Lentil grain contains 59.8% CHO, 25.8% protein, 10% moisture, 4% mineral and 3% vitamins (Khan, 1981; Kaul, 1982).Sufficient amount of vitamins *viz*., vitamin-A 16I U; thiamine 0.23 mg and vitamin C 2.5 mg are available from a gram of lentil (Anonymous, 1966) and it forms a balanced diet when supplemented with cereals (Abu-Shakra and Tannous, 1981). It occupies a unique position in the world of agriculture by virtue of its high protein content and capacity of fixing atmospheric nitrogenin soil through biological N_2 fixation, which may reduce the extra input, cost of nitrogenous fertilizer for the crop plants. It is also used as cover crop to check the soil erosion. The stover of the plants together with husk popularly known as bhushi is highly protein rich concentrated feed to cattle, horse, pig and sheep (Tomar*et al*., 2000).The green plants can also be used as animal feed and its residues have manural value.Lentil grains contain high protein, good flavor and easily digestible component. It may play an important role to supplement protein in the cereal-based low protein diet of the people of Bangladesh but the acreage (359367 acres in 2014-15) and production (167261 metric tons in 2014-15) of lentil are steadily declining (BBS, 2015).Cultivation of high yielding varieties of wheat and boro rice has occupied considerable land suitable for lentil cultivation. Besides these, low yield potentiality of this crop is responsible for declining the area andproduction of lentil. At present the area under pulse crops is 0.76 million hectares with a production of 0.55 million tons where lentil is cultivated in the area of 0.22 million hectares with production of 0.19 million tons (BBS, 2015).The average yield of lentil in Bangladesh is 0.83 ton/ha (BBS, 2016) which is very poor in comparison to lentil growing countries of the world as it has been cultivated on the increasing land.

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

An improved variety is the first and foremost requirement for initiation and accelerated production program of any crop. Furthermore, variety plays an important role in producing high yield of lentil because different varieties responded differently for their genotypic characters; BARI has developed some varieties of lentil. Although varieties of a crop may exist somewhere else, but unavailability and high prices of inputs, old traditional methods of sowing, low plant population in the field, climate, soil, unawareness of the farmers about site specific production technology, marketing system and other agronomic factors may also affect lentil yield potential locally. Therefore, varieties may have to be tested for special local growing conditions (Hussain, 2002).

There is also a wrong notion with farmers that this crop being a legume does not need any nutrition. Farmers usually grow lentil without any fertilizer. Whereas, potassium is a key element involved in various functions in growth and metabolism of pulses. It is classified as a major nutrient, meaning that it is frequently deficient for crop production and is required by crops in relatively large amounts. Pulse crops showed yield benefits from potassium application. Improved potassium supply also enhances biological nitrogen fixation and protein content of pulse grains (Srinivasarao*et al*., 2003). Soil fertility was improved significantly with farmyard manure used either alone or in combination with NPK over that of initial soil status (Singh *et al*., 2001). The supply of phosphorus and potassium to leguminous crops is necessary especially at the flowering and pod setting stages (Zahran*et al*., 1998). It is grown either on residual soil water or on current rainfall and in both cases it is frequently subjected to terminal drought that results in low and variable seed yields. Besides, under residual soil moisture condition, the lentil plants face gradual shortage of soil moisture. Therefore, water relations specially relative water content, exudation rate, leaf water potential may adversely affected of which ultimate effect is reduction in photosynthesis, dry matter production as well as yield (Arjenaki*et al*., 2012). Potassium has a positive role on maintaining turgidity, water relation traits asenhances water use efficiency helps plant to adjust low water potential under drought stress of which ultimate effects are maintaining photosynthetic rate as well as yield (Arjenaki*et.al*., 2012; Mengel and Kirkby,2001).Therefore, potassium might has positive effect on improvinggrowth development and yield of lentil under residual soil moisture condition.

Considering the above facts, the present investigation was undertaken with the following objectives:

- To find out the effect of variety on water relation, yield components and yield of lentil under residual soil moisture condition.
- To find out the effect of potassium on water relation, yield components and yield of lentil under residual soil moisture condition.
- To find out the interaction effect of variety and potassium on water relation, yield components and yield of lentil under residual soil moisture condition.

CHAPTER II

REVIEW OF LITERATURE

Variety and fertilizer doses are the most important factors on their relation to maximum the growth, yield and yield contributing attributes of any crops as well as lentil variety. Relevant research information regarding the cultivar of lentil with fertilizer treatment, which are pertinent to the present experiment, have been reviewed and presented in this chapter.

2.1. Effect of variety

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

Hasan*et al*. (2015) conducted an experiment and reported that the highest plant height (45.83 cm), the highest (1.62 g) dry weight plant^{-1}, highest seeds pod^{-1}(98), the highest (22.02g) 1000 seed weight were found from BARI Masur 5 and the lowest plant height (34.67 cm), the lowest dry weight plant^{-1} (1.22g),thelowest seeds pod^{-1} (49.00) and the lowest 1000 seed weight (20.08) from BARI Masur 7.

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

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

Datta (2013) carried out an experiment to study the effect of variety and level of phosphorus fertilizer on the yield and yield components of lentil at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during October 2009 to March 2010. Three lentil varieties viz. BINA Masur 2, BINA Masur 3 and

BARI Masur- 4 and four levels of phosphorus viz. 0 kg P ha^{-1} (P0), 15 kg P ha^{-1} (P15), 30 kg P ha^{-1} (P30) and 45 kg P ha^{-1} (P45) were used in this experiment. He obsereved that tallest plant was obtained from BINA Masur-2 (38.18 cm). He also reported that BARI Masur-4 produced maximum number of pods $plant^{-1}$ (128.5) and BARI Masur-2 produced lowest pods $plant^{-1}$ (111.7). He also reported that the highest seed yield (1317 kg ha^{-1}) was obtained BARI Masur-4 when sown with 45 kg P ha^{-1} and the lowest seed yield (830 kg ha^{-1}) was observed in BARI Masur-3 with control treatment combination. He also reported that BINA Masur-2 and BARI Masur-4 were superior to BINA Masur- 3 in respect of yield with 30 kg P ha^{-1}. They reported that BARI Masur-4 gave the highest harvest index (26.74%) and the lowest (25.62%) was found in BINA Masur-2.

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

Mian*et al*. (2011) conducted experiments in the selected charland of Koikunda under Ishurdiupazilla of Pabna district with five lentil varieties namely BARI Masur-3, BARI Masur-4, BARI Masur-5, BARI Masur- 6 and one local variety for two consecutive years of 2009-2010 and 2010-2011. They reported that BARI Masur-3 (1033-1065 kg ha^{-1}) and BARI Masur-6 (1305-1358 kg ha^{-1}) showed better yield performance as compared to others in 2009-2010 and 2010-2011.Four promising lentil genotypes (X95S-167(4), X95S-167(5), ILL-5134 and X95S-136), 3 local cultivars (Kushtia, Rajshahi and Rajbari local) and released varieties (BINA Masur-3, BARI Masur-3 and BARI Masur-4) were tested by Ali *et al*. (2011). They found that BARI Masur-4 performed better regarding yield (1708- 1750 kg ha^{-1}).

Haque*et al*. (2009) conducted an experiment at the research farm of Bangladesh Agricultural University, Mymensingh during rabi seasons of 2009 -2010 to study the effect of *Rhizobium* inoculum on nodulation and dry matter production of lentil. They used BINA L4, TAL 640 and mixed culture of both as Rhizobium inoculants and BARI Masur-1, BARI Masur- 2 and BARI Masur-3 as planting material. They reported that irrespective of *Rhizobium* strain BARI Masur-3 performed better than other two lentil varieties in respect of nodule number.

An experiment was conducted by Zahan*et al*. (2009) at the Agronomy Field, University of Rajshahi to study the effects of potassium levels on the growth, yield and yield contributing characters of lentil. The experiment comprised of three varieties (BARI Masur-4, BARI Masur-5, BARI Masur-6 and BARI Masur-7) and five potassium levels (0, 15, 25, 35 and 45 kg K ha^{-1}). They found that the tallest plant (36.19 cm) was obtained from BARI Masur7 and the shortest plant (33.78 cm) from BARI Masur- 4 at 85 DAS. Numerically the highest number of branches was recorded in BARI Masur- 4 at 45 and 65 DAS but 65 DAS BARI masur5 produced the highest number of branches $plant^{-1}$. At 45 and 85 DAS, the lowest number of branches was found in BARI Masur-7 and BARI Masur-5 produced the lowest number of branches $plant^{-1}$ at 65 DAS. They also found that the highest number of effective pods $plant^{-1}$ was produced by BARI Masur-7 (176.77) and the lowest (158.49) from BARI Masur-4. They reported that the highest 1000-seed weight (21.54 g) was produced by BARI Masur-7 and the lowest 1000-seed weight (20.75 g) was produced by BARI Masur-4. BARI Masur-7 produced the highest seed yield (2.24 t ha^{-1}) and BARI Masur- 4 produced the lowest seed yield (1.79 t ha^{-1}).

Barman *et al.* (2009) carried out a field experiment at Bangladesh Agricultural University, Mymensigh, during the Rabi season of 2007 to 2008 with a view to studying the effects of variety and compost from different sources on the yield and yield components of lentil. The varieties BINA Masur-2, BARI Masur-3 and BARI Masur-4 as well as compost of *Mimosa invisa*, *Sesbaniarostrata*, and *Sesbaniaaculeata* were included in the study. They reported that the tallest plant (42.55 cm), the highest 1000-seed weight (25.15 g) and the maximum number of pods $plant^{-1}$ (97.14) were obtained from BARI Masur-4.

Khan *et al*. (2007) conducted a field experiment at the experimental farm of the Bangladesh Agriculture Research Institute, Gazipur during rabi season of 2006-07 to identify the most suitable varieties of lentil under rainfed condition with four lentil varieties (BARI Masur-1, BARI Masur-2, BARI Masur-3 and BARI Masur-4). They reported that BARI Masur-4 gave the highest 1000-seed weight, the highest grain yield (1177 kg ha^{-1}) followed by BARI Masur-1 (1095 kg ha^{-1}). The lowest grain yield was obtained from BARI Masur- 2 (958 kg ha^{-1}) under rainfed condition.

Rahman*et al.* (2013) conducted a field trial with four varieties of lentil at the Hill Agricultural Research Station, Kagrachari during the period from November 2006 to March 2007. They noted that BARI Masur-5 showed better growth and development with maximum branching. They found that hilly environment significantly affects the growth, development and yield of lentil varieties. BARI Masur-5 showed better growth and development having highest total dry matter, maximum branching and finally contributed highest grain yield under hilly environment.

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

BARC (2015) conducted an experiment at six agro-ecological distinct field locations in Bangladesh and reported that the uptake of macro-nutrients (K, P, Ca and Mg) as well as micro-nutrients (Fe, Mn, Zn, Cu, B and Mo) by BARI Masur7 was significantly higher, compared to BARI Masur-6. BARI Masur-7 gave significantly higher (10-20%) grain yield than BARI Masur-5.

Patil*et al*. (2003) studied genetic diversity among 36 genotypes of lentil, 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 fertilizer, and fertilizer and pesticide free conditions in Dharwad, Karnataka, India. 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 512 were the most genetically diverse in all the 3 environments.

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

Sharar*et al*. (2003) also stated that all cultivars of lentil differed significantly from one another regarding harvest index. The Masur-93 produced significantly highest harvest index value than other cultivars.Masur-93 had significant effect on 1000-seed weight of lentil. Masur-93 owing to more number of pods $plant^{-1}$ also found that among the cultivars, Masur-93 owing to more number of seed pod^{-1}.Similar results also have been reported by Hussain*et al*. (2002).

Hussain*et al*. (2002) reported that varieties vary greatly in number of seed pod^{-1} and 1000 seed weight of lentil plants.

Farrag (1995) reported from a field trial with 23 lentil accessions that seed yield, number of pods $plant^{-1}$, number of seeds pod^{-1} and 1000-seed weight varied among the tested accessions. He also observed that some cultivars like VC2711 A, KPSI and UTT performed well under late sown condition. Varietal differences in yield do exist under similar field condition. This indicates that all varieties do not perform equally under similar condition

Farghali and Hussain, (1995) reported that cultivars played a key role in increasing yield since the response to management practices was mainly decided by the genetic potential. The yields of lentil 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. Among the 32 accessions of lentilunder three sowing dates,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.

Kalita and Shah (1998) studied 19 cultivars of *Lens culinaris* and found that 1000 seed weight was the highest in Gajaral 2 (29 g) and the lowest in ML 131 (24 g). Seed yield was the highest in PIMS^{-1} (0.89 t ha^{-1}) and the lowest in 11/99 (0.2 t ha^{-1}).

Singh and Singh (1988) observed that four lentil cultivars sown at a density of 40, 50 or 60 plants m^{-2} gave similar seed yields of 1.3 – 1.5 t ha^{-1}. The cultivars UPM 792 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.

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

Rajat and Gowda (1984) conducted an experiment on lentil varieties in India and reported that the highest number of pods plant^{-1}of lentil was produced by PS 7 followed by PS 16 and PS 10.

2.2. Effect of potassium

Ganga,*et al.* (2014) conducted an experiment during rabi of 2006-07 on a sandy clay loam soil to study the effect of potassium levels and foliar application of nutrients on growth and yield of late sown lentil. It was observed that application of 40 kg K_2O ha^{-1} at sowing and combined foliar spraying of 2% urea and 0.25% multiplex at pre-flowering stage of lentil resulted in maximum grain yield and ancillary characters

Kumar *et al*. (2014) conducted an experiment to study the effect of different potassium levels on lentil under custard apple based agri-horti system at Agricultural Research Farm of Rajiv Gandhi South Campus, Barkachha, Mirzapur. The experiment was conducted in a complete randomized block design with seven treatments which were replicated thrice. Potassium application is directly related to growth, plant biomass and yield in crops. Results showed that application of different potassium levels gave varying yield. Lowest yield (700 kg ha^{-1}) was obtained with the application of 0 kg/ha and highest yield (1096 kg ha^{-1}) was obtained with the application of 120 kg/ha potassium. It is concluded that the application of 80 kg/ha potassium gave highest Benefit/Cost ratio of lentil and looks more remunerative in *Vindhyan*region.

Hamayun*et al.*(2011**)** conducted to evaluate the effect of foliar and soil application of nitrogen, phosphorus and potassium (NPK) on yield component of lentil (*Lens culinaris*Medic). Optimal concentration of NPK for the various yield parameters was found to be 0.17% N, 0.21% P and 0.33% K for foliar and 0.35% N, 0.32% P and 0.50% K for soil application at pH 7.0. Multiple application of both soil and foliar application of NPK gave better results as compared to single application of NPK. Soil application produce slightly improved results compared to foliar application when applied unaided. The foliar application of nitrogen alone was more effective than NPK in producing higher number of seeds per pod.

Hussain*et al*. (2010) carried out an experiment in the Department of Agronomy, University of Agriculture, Faisalabad during summer 2007. The objective was to find out the best level of potash fertilizer on growth and yield response of two lentil (*Lens culinaris* L.) cultivars (Niab lentil-93 and ChakwalLentil-08) to different levels of potassium. Treatments were comprised of five levels of potash fertilizer (0, 30, 60, 90,120 kg ha^{-1}). Different potassium levels significantly affected the seed yield and yield contributing parameters except number of plants per plot. Maximum seed yield (753 kg ha^{-1}) was obtained with the application of 90 kg potash per hectare. Genotype Lentil-08 produced higher seed yield than that of NL-93. The interactive effect of Lentil varieties and potassium level was found significant in respect of protein contents (%).It is concluded that the application of Potash fertilizer gave higher yield of lentil cultivars.

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

Mahboob and Asghar (2002) studied the effect of seed inoculation at different NPK level on the yield and yield components of lentil at the agronomic research station, Farooqabad in Pakistan during the year of 2000 and 2001. They reported that various yield components like 1000 grain weight were affected significantly with 50-50-50 NPK kg ha^{-1} application. They reported that seed inoculation along with 40-80-30 NPK kg ha^{-1} exhibit superior performance in respect of seed yield (1670 kg ha^{-1}).

Tariq *et al*. (2001) reported that the number of pod bearing branches per plant wassignificantly increased by potassium application in lentil. Different varieties, however, differed significantly from each other. The variety Chakwal Mung-06 produced more branches than NM-92. These results are in contrast to those of earlier studies (Khan*et al*., 1999).Ali *et al.* (1996) reported that plant height, number of pods $plant^{-1}$, seeds pod^{-1} and seed yield were increased significantly with increasing potassium application and maximum seed yield was obtained with 90 kg potash per hectare.

Hussain (1994) also concluded that the maximum 1000 seeds weight (48.74 g) was obtained when the lentil crop was fertilized at the rate of 50- 90-90 NPK kg ha^{-1}.

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

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

Khokar and Warsi (1987) reported that addition of potash from 20 to 60 kg K_2O ha^{-1} raised the grain production. This finding is in close conformity with earlier findings made by Rathi and Singh (1976), Chowdhury*et al*. (1971) and Manjhi and Chowdhury (1971).

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted during the period from November 2015 to March 2016 to study the effect of variety and potassium fertilizer on water relations and yield of lentil (*Lens culinaris*) under residual soil moisture condition. This chapter includes materials and methods that were used in conducting the experiment and presented below under the following headings:

3.1. Experimental site

The experiment was conducted at the Research field of Agronomy Department of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the rabi season (November 2015 to March 2016). The location of the experimental site is $23^0 77'$N latitude and $90^0 35'$E longitude and at an elevation of 8.2 m from sea level.

3.2. Climate of the experimental site

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

3.3. Characteristics of soil

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

3.4. Plant materials

Three high yielding variety of lentil viz., BARI Masur-5, BARI Masur-6, and BARI Masur-7 developed by Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur were used in the experiment as test plant materials.

3.4.1. BARI Masur-5

BARI Masur-5 is a recommended cross variety of lentil. It grows in rabi season and was released in 2006. It is resistant to diseases, insects and other pests. This variety is also resistant to *Cercospora*leaf spot and yellow mosaic virus. It contains tendril at the tip of the leaf. The flower color is light violet. Bushy type plant and maximum height 38 cm. Maximum seed yield is 2.1-2.2 t ha^{-1}. Seeds contain 26.93 % protein and 59.90 % carbohydrate. Life cycle of the crop is 110-115 days (Anon, 2015).

3.4.2. BARI Masur-6

BARI Masur-6 is a recommended cross variety of lentil. It grows in rabi season and was released in 2006. The variety is resistant to diseases, insects and other pests. It is also resistant to *Cercospora*leaf spot and yellow mosaic virus. There is no tendril at the tip of the leaf. Plant height remains 35-40 cm and bushy type plant. Seed color deep brown. Flower color is white. Maximum seed yield is 2.2-2.3 t ha^{-1}. Seeds contain 27.12 % protein and 59.40 % carbohydrate. Life cycle of the crop is 100-105 days (Anon, 2015).

3.4.3. BARI Masur-7

BARI Masur-7 is a recommended cross variety of lentil. It grows in rabi season and was released in 2008. The variety is resistant to *stemphylium* blight diseases, insects and other pests. It is also resistant to *Cercospora*leaf spot and yellow mosaic virus. It is counted as the late variety also. It can be sown up to last week of November and harvested in mid February to mid March. Seed round shape gray color with black spot. 100 seed weight 1.90-2.20 g. Maximum seed yield is 2.2-2.3 t ha^{-1}. Seeds contain 26.17 % protein and 56.50 % carbohydrate. Life cycle of the crop is 110-115 days (Anon, 2015).

3.5. Experimental treatments

Variety and potassium were used as treatment factors. Three lentil varieties and four levels of potassium were used for the combination of twelve (12) treatments of the present experiment.

The experiment was consisted of two treatment factors as follows:

Factor A: 3 Varieties of lentil

V_1: BARI masur-5

V_2: BARI masur-6

V_3: BARI masur-7

Factor B: 4 doses of Potassium

P_1 : 25 kg K_2O ha^{-1}

P_2 : 30 kg K_2O ha^{-1}

P_3 : 35 kg K_2O ha^{-1}

P_4 : 40 kg K_2O ha^{-1}

3.5.1. Experimental design and layout

The experiment was laid out in a Randomized Complete Block Design (factorial) (RCBD) with three replications. The size of unit plot was 2 × 2.4 m where block to block and plot to plot distances were 40 cm and 40 cm, respectively. Row to row and plant to plant distances were also 30 cm and 10 cm, respectively, in each plot.

3.6. Land preparation

Power tiller was used for the preparation of the experimental field. Then it was exposed to the sunshine for 5/6 days prior to the next ploughing. Thereafter, the land was ploughed and cross-ploughed and deep ploughing was due to obtained good tilth, which was necessary to get better yield of this crop. Laddering was done in order to break the soil clods into small pieces followed by each ploughing. All the weeds and stubbles were removed from the experimental field. The plots were spaded one day before planting and the whole amount of fertilizers were incorporated thoroughly before planting according to fertilizer recommendation guide (BARC, 1997). The soil was treated with insecticides at the time of final ploughing. Insecticides Furadan 5G was used @ 8 kg ha^{-1} to protect young plants from the attack of mole cricket, ants, and cutworms.

3.7. Fertilizer application

In this experiment potassium was applied as per treatment as Muriate of Potash (MOP).Nitrogen and phosphorus were applied at the rate of 45 and 85 kg per hectare, respectively, BARC (1997) recommention . Whole amount of urea, TSP and MoP were applied as basal dose (during final land preparation). The applied manures were mixed properly with the soil in the plot using a spade.

3.8. Seed sowing

Seeds of BARI masur varieties were sown in the experimental plot on 28 November 2015. The row to row and plant to plant distances were 30 and 10 cm, respectively. Seeds were placed at about 3 cm depth from the soil surface. Seeds were treated with Bavistin before sowing to control the seed borne diseases.

3.9. Intercultural operations

3.9.1. Thinning

The optimum plant population was maintained by thinning excess plants. Seeds were germinated 6 days after sowing (DAS). Over crowded seedlings were thinned out two times. First thinning was done after 15 days of sowing which is done to remove unhealthy and lineless seedlings. The second thinning was done 10 days after first thinning.

3.9.2. Weeding

First weeding was done at 20 DAS and then once in a week to keep the plots free from weeds and to keep the soil loose and aerated.

3.9.3. Irrigation

The light irrigation water was applied with watercan until seedling establishment (15 DAS) to protect the seedlings from permanent wilting. Thereafter the crop plants were dependent on residual soil moisture throughout the total growing period.

3.9.4. Disease and pest management

The research field looked nice with normal green plants. The field was observed time to time to detect visual difference among the treatments and any kind of infestation. The experimental crop was infected with foot and root rot disease and Bavistin was used to control the disease. Hairy caterpillars attacked the young plants and accumulated on the lower surface of leaves and also removed the green surface of the leaves. Borers also attacked the pods. To control these pests, the infected leaves were removed from the stem and destroyed together with insects by hand picking. Beside, spraying pyriphos controlled these insects. The insecticide was sprayed three times at seven days interval starting from 45 DAS.

3.9.5. Harvesting and threshing

Harvesting of the crop was done after 95 days of sowing on 05 March 2016 for data collection when about 80% of the pods attained maturity. The crop sampling was done at harvest stage to record morphological, growth and yield attributes. Data were recorded on 1m^{2}area of the middle portion of each plot for obtaining yield. The harvested plants of each treatment were brought to the cleaned threshing floor and separated pods from plants by hand and allowed them for drying well under bright sunlight. Thereafter the seeds were separated from the pods.

3.10. Crop sampling and data collection

The data of the different parameters of lentil were collected from randomly selected ten plant samples which collected from the middle portion of the plot (1m^2). The harvested plants were 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 on floor and separated pods from plants by hand and allowed them for drying well under bright sunlight. Finally,seed weights were taken on individual plot basis at moisture content of 12% and converted into kg ha^{-1}. The yield of dry stover was also taken. The data on growth and yield parameters were recorded at harvest stage. At final harvest, data on some morpho-physiological, yield components and yield were also collected. A brief outline of the data recording on morpho-physiological and yield contributing characters are given below.

3.10.1. Plant height (cm)

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

3.10.2. Days to emergence

Days to seedling emergence were recorded by counting the number of days required after sowing to emergence seedlings in each plot.

3.10.3. Days to flowering

Days to flowering was counted from the date of sowing to the date of 80% of plants flowered in each plot.

3.10.4. Days to pod maturity

Days to 80% pod maturity were measured by counting the number of days required after sowing to attain maturity of 80% pods. Maturity was measured on the basis of brown colour of leaves including stem and dark grey colour of pods.

3.10.5. Relative water content (%)

Relative water content (RWC) was measured from first fully expanded leaf of lentil plants in different treatments. The leaf samples were cut with a sharp knife with petiole and were put in a polythene bag treatment wise. The bags were kept on a tray and wrapped with a moist towel to avoid light and desiccation. Then the samples were brought in the laboratory and their fresh weights were recorded immediately.

The leaf samples were then dipped in water for 24 hours and their turgid weights were recorded after soaking the leaf surface water gently by tissue paper. The samples were then oven dried to constant weight. The relative water content (RWC) was measured using the following formula:

$$\text{RWC} = \frac{(\text{Fresh weight} - \text{Dry weight})}{(\text{Turgid weight} - \text{Dry weight})} \times 100\%$$

3.10.6. Exudation rate (mg hr^{-1})

Exudation rate (ER) was measured from the stem at about 5 cm above from the ground. At first, dry cotton including celophane paper piece was weighed. A slanting cut on the stem was made with a sharp knife. Then the weighed cotton was placed on the cut surface and was covered with the celophane paper piece. The exudation of the sap was collected from the stem for 30 minutes at normal temperature. The final weight of the cotton with sap including celophane paper was taken. The exudation rate was calculated by deducting cotton weight including celophane paper from the sap containing cotton weight including celophane paper and was expressed as miligram per hour basis as follows:

ER (mg hr^{-1}) =

$$\frac{(\text{Weight of cotton with celophane paper} + \text{sap}) - (\text{Weight of cotton with celophane paper})}{\text{Time (minute)}} \times 60$$

3.10.7. Pod length (cm)

Pod length was measured from randomly selected ten pods and the mean length was expressed as per pod basis.

3.10.8. Number of pods plant^{-1}

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

3.10.9. Number of seeds pod^{-1}

Number of seeds per pod was recorded after harvesting of the crop from the ten randomly selected pods from ten pre-selected plants was counted. The seed per pod was calculated from their mean values.

3.10.10. Thousand seed weight (g)

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

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

The seed yield per plot was measured by threshing and separating grain from the central $1m^2$ areas of unit plot and then seed yield was calculated and expressed in t ha^{-1}.

3.10.12. Stover yield (t ha^{-1})

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

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

The summation of economic yield (seed yield) and biomass yield (stover yield) was considered as biological yield.

Biological yield was calculated by using the following formula:

Biological yield= Seed yield + stover yield

3.10.14. Harvest index (%)

It is the ratio of economic yield (seed yield) to biological yield and express in percentage. It was calculated with the following formula:

$$\text{Harvest index (\%)} = \frac{\text{Seed Yield}}{\text{Biological Yield}} \times 100\%$$

3.11. Statistical analysis

The data obtained from experiment on various parameters were statistically analyzed in MSTAT-C computer program. The mean values for all the parameters were calculate and the analysis of variance for the characters was accomplished by Least Significant Differences (LSD) test at 5 % levels of probability (Gomez and Gomez, 1984).

CHAPTER IV
RESULTS AND DISCUSSION

The present study was conducted to study the water relation and yield of lentil as influenced by different varieties and potassium levels. Data on different water relation and yield contributing characters were recorded. The analysis of variance (ANOVA) of the data on different water relation and yield parameters are given in Appendix II-VI. The results have been presented and discussed with the help of tables and graphs and possible interpretations were given under the following headings:

4.1. Plant height

Significant differences were observed due to planting of different varieties at 30, 45, 60, 75 DAS and at harvest (Appendix II).At 30, 45, 60, 75 DAS and at harvest, the highest plant height (16.22 cm, 20.34 cm, 23.66 cm, 28.68 cm and 31.21 cm respectively) were recorded from V_3 (BARI Masur-7) and on the other hand the shortest plants (12.32 cm, 16.44 cm, 19.76 cm, 24.78 cm and 27.31 cm respectively) were found from V_1 (BARI Masur-5) variety (Fig. 1). BARI Masur-7 is the latest variety and it takes slightly more nutrient from soil. It has found in the different experiment that the growth of BARI Masur-7 plant is always higher than other varieties (Razzak*et al*., 2015). Zahan*et al.* (2009) found the similar results.

Due to potassium application, significant differences were observed at 30, 45, 60, 75 DAS and at harvest (Appendix II).At 30, 45, 60, 75 DAS and at harvest the highest plant height (15.63 cm, 19.75 cm, 23.07 cm, 28.09 cm and 30.62 cm, respectively) were obtained from P_4 (40 kg K_2O ha^{-1}) treatment and on the other hand the shortest plant (13.19 cm, 16.35 cm, 19.10 cm, 24.10 cm and 28.18 cm, respectively) were found from P_1 (25 kg K_2O ha^{-1}) treatment (Fig. 2). Potassium is the most important macro element for the plant. If the potassium is available in appropriate levels then all the nutrients can act and divide accurately in plant body. Potassium can control the functions of all elements. So that higher amount of potassium application can give the maximum growth of the plant (Rahman, 2013).

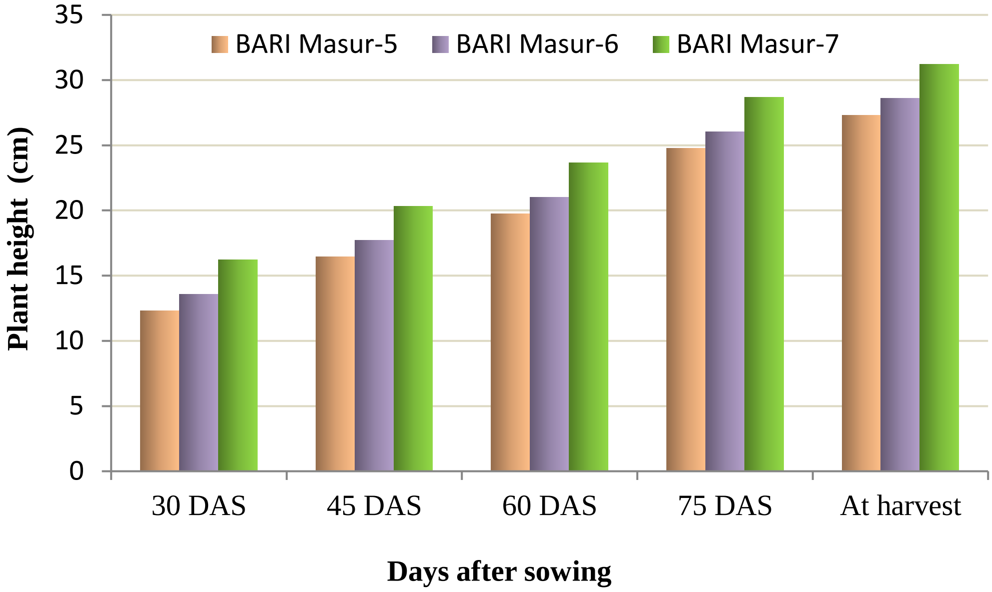

Fig 1. Effect of variety on plant height of lentil at different days after sowing ($LSD_{0.05}$ =0.88, 0.68, 0.74, 0.65 and 0.88 for 30, 45, 60, 75 DAS and at harvest, respectively)

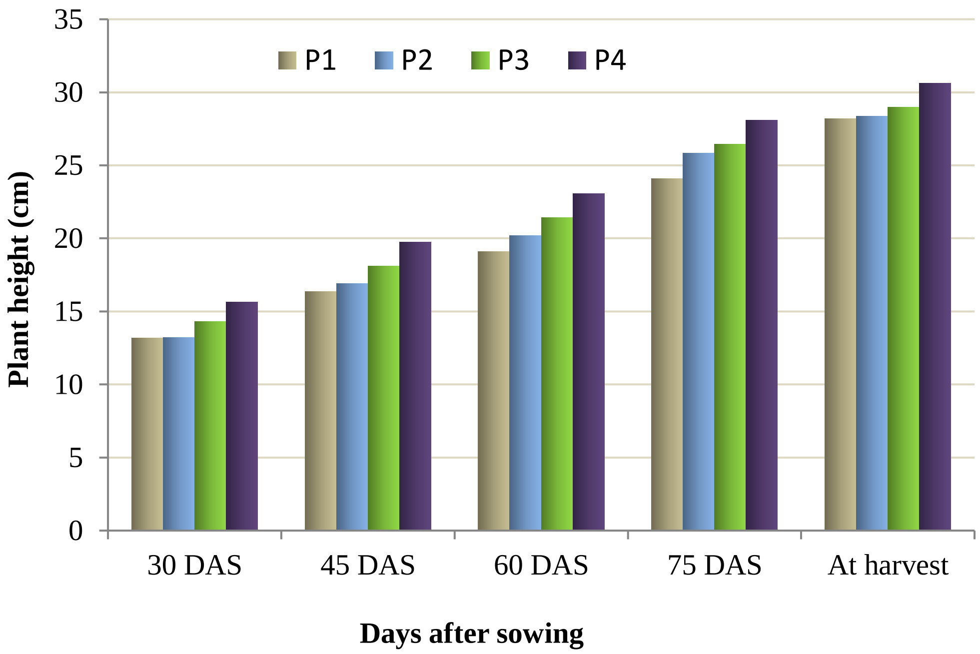

Fig 2. Effect of potassium on plant height of lentil at different days after sowing ($LSD_{0.05}$ =1.01, 1.21, 1.15, 1.47 and 1.01 for 30, 45, 60, 75 DAS and at harvest, respectively)

Interaction effects of variety and potassium showed significant differences on plant height at all observations like 30, 45, 60, 75 DAS and at harvest (Appendix II).At 30, 45, 60, 75 DAS and at harvest the longest plant (19.72 cm, 23.84 cm, 27.16 cm, 32.18 cm and 34.71 cm respectively) were recorded from V_3P_4 (BARI Masur-7 with 40 kg K_2O ha^{-1}) treatment combination. On the other hand the shortest plant (12.01 cm, 16.13 cm, 19.45 cm, 24.47 cm and 27.00 cm respectively) were recorded from V_1P_1 (BARI Masur-5 with 25 kg K_2O ha^{-1}) treatment combination which is statistically identical to that of V_1P_2, V_1P_3 and V_1P_4 treatment combinations (Table 1). Zahan*et al.* (2009) found the similar results in relation to the variety and potassium fertilizers.

Table 1.Interaction effects of variety and potassium on plant height of lentil at different days after sowing

Treatment	30 DAS	45 DAS	60 DAS	75 DAS	At harvest
V_1P_1	12.01 d	16.13 d	19.45 d	24.47 d	27.00 d
V_IP_2	12.03 d	16.15 d	19.47 d	24.49 d	27.02 d
V_1P_3	12.56 d	16.68 d	20.00 d	25.02 d	27.55 d
V_1P_4	12.70d	16.82 d	20.14 d	25.16 d	27.69 d
V_2P_1	13.01 cd	17.13 cd	20.45 cd	25.47 cd	28.00 cd
V_2P_2	13.36 cd	17.48 cd	20.80 cd	25.82 cd	28.35 cd
V_2P_3	13.54 cd	17.66 cd	20.98 cd	26.00 cd	28.53 cd
V_2P_4	14.47 bc	18.59 bc	21.91 bc	26.93 bc	29.46 bc
V_3P_1	14.55 bc	18.67 bc	21.99 bc	27.01 bc	29.54 bc
V_3P_2	14.74 bc	18.86 bc	22.18 bc	27.20 bc	29.73 bc
V_3P_3	15.89 b	20.01 b	23.33 b	28.35 b	30.88 b
V_3P_4	19.72 a	23.84 a	27.16 a	32.18 a	34.71 a
LSD (0.05)	**1.76**	**1.75**	**1.76**	**1.77**	**1.75**
CV %	**7.40**	**5.72**	**4.84**	**3.92**	**5.26**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance

V_1: BARI Masur-5, V_2: BARI Masur-6, V_3: BARI Masur-7, P_1: 25 kg K_2O ha^{-1}, P_2: 30 kg K_2O ha^{-1}, P_3: 35 kg K_2O ha^{-1}, P_4: 40 kg K_2O ha^{-1}

4.2. Days to emergence

Emergence of the plant under the favorable condition is a varietal characteristic. Significant variation was observed due to the variety on days to emergence (Appendix III). The maximum days to emergence (8.02 days) was recorded from V_1 variety that is BARI Masur-5 variety and minimum days to emergence (6.34 days) was found in V_3 variety that is BARI Masur-7 (Table 2). It is the most important characteristics for good variety.

Due to potassium application, significant difference was found on days to emergence (Appendix III).The maximum days to emergence (7.49 days) was recorded from P_1 (25 kg K_2O ha^{-1}) treatment and the minimum days to emergence (6.89 days) was found from P_4 (40 kg K_2O ha^{-1}) treatment (Table 3). Higher amount of potassium application can give the maximum growth of the plant and break the dormancy (Haque*et al.,* 2013).

Interaction effects of variety and potassium showed significant differences on days to emergence (Appendix III).At reproductive stage the maximum days to emergence (8.42 days) was recorded from V_1P_1 (BARI Masur-5 with 25 kg K_2O ha^{-1}) treatment combination. On the other hand the minimum days to emergence (5.85 days) was recorded from V_3P_4 (BARI Masur-7 with 40 kg K_2O ha^{-1}) treatment (Table 4).

4.3. Days to flowering

When 80 % plants of the plot flowered, the days to flowering data was recorded. Significant variation was observed due to the variety on days to flowering (Appendix III). The maximum days to flowering (52.47) was recorded from V_3 variety that is BARI Masur-7 variety and minimum days to flowering (50.16) was found inV_1 variety that is BARI Masur-5 (Table 2). The vegetative growth of BARI Masur-7 is higher so that the reproductive stage or flowering stage comes slightly late, which contributed to produce biological yield as well as higher grain yield. Hasan*et al.* (2015) observed the similar results.

Due to potassium application, significant differences were found for days to flowering (Appendix III).The maximum days to flowering (51.81) was recorded from P_4 (40 kg K_2O ha^{-1}) treatment followed by P_3 (51.33) which is statistically identical (51.11) to P_2 treatment and the minimum days to flowering (50.59) was found from P_1 (25 kg K_2O ha^{-1}) treatment (Table 3). Potassium is the most important macro element for the plant. Higher amount of potassium application can give the maximum growth of the plant. Potassium can control the functions of all nutrient elements. Due to the good vegetative growth the reproductive stage that means flowering stage starts slightly late (Haque*et al.,* 2013).

Interaction effects of variety and potassium showed significant differences on days to flowering (Appendix III).At reproductive stage the maximum days to flowering (53.66 days) was recorded from V_3P_4 (BARI Masur-7 with 40 kg K_2O ha^{-1}) treatment combination. On the other hand the minimum days to flowering (50.00 days) was recorded from V_1P_1 (BARI Masur-5 with 25 kg K_2O ha^{-1}) treatment combination which is statistically identical to V_1P_2, V_1P_3 and statistically similar to that of V_1P_4 and V_2P_1 treatment combinations (Table 4).

4.4. Days to pod maturity

When 80 % pods of the plant became mature then the data were recorded by maintaining the maturity index. Significant variation was observed due to the variety on pod maturity (Appendix III). The maximum days to pod maturity (91.08) was recorded from V_3 variety (BARI Masur-7) and minimum (89.41) was found from V_1 (BARI Masur-5) variety (Table 2). The reproductive stage or flowering stage comes slightly late in V_3 variety compared to the other varieties. Zahan*et al.* (2009) were agreed with the similar results.

Table 2. Effect of variety on days to emergence, days to flowering and days to maturity of lentil

Variety	Days to emergence	Days to flowering	Days to maturity
V_1	8.02 a	50.16 c	89.41 c
V_2	7.16 b	50.99 b	89.91 b
V_3	6.34 c	52.47 a	91.08 a
LSD $_{(0.05)}$	**0.19**	**0.26**	**0.14**
CV %	**3.24**	**3.26**	**5.42**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance

V_1: BARI Masur-5, V_2: BARI Masur-6, V_3: BARI Masur-7

Table 3.Effect of potassium on days to emergence, days to flowering and days to maturity of lentil

Potassium	Days to emergence	Days to flowering	Days to maturity
P_1	7.49 a	50.59 c	89.66 c
P_2	7.25 b	51.11 b	89.96 bc
P_3	7.06 bc	51.33 b	90.15 b
P_4	6.89 c	51.81 a	90.77 a
LSD $_{(0.05)}$	**0.22**	**0.30**	**0.35**
CV %	**3.24**	**3.26**	**5.42**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance

P_1: 25 kg K_2O ha^{-1}, P_2: 30 kg K_2O ha^{-1}, P_3: 35 kg K_2O ha^{-1}, P_4: 40 kg K_2O ha^{-1}

Table 4.Interaction effects of variety and potassium on days to emergence, days to flowering and days to maturity of lentil

Treatment	Days to emergence	Days to flowering	Days to maturity
V_1P_1	8.42 a	50.00 f	89.00 f
V_IP_2	8.14 ab	50.00 f	89.33 ef
V_1P_3	7.88 bc	50.22 f	89.67 de
V_1P_4	7.62 cd	50.44 ef	89.67 de
V_2P_1	7.40 de	50.44 ef	89.67 de
V_2P_2	7.20 ef	51.33 d	90.00 cd
V_2P_3	7.07 ef	50.88 de	90.00 cd
V_2P_4	6.99 fg	51.33 d	90.00 cd
V_3P_1	6.66 gh	51.33 d	90.33 bc
V_3P_2	6.54 h	52.00 c	90.55 bc
V_3P_3	6.31 h	52.89 b	90.78 b
V_3P_4	5.85 i	53.66 a	92.66 a
LSD $_{(0.05)}$	**0.39**	**0.53**	**0.61**
CV %	**3.24**	**3.26**	**5.42**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance

V_1: BARI Masur-5, V_2: BARI Masur-6, V_3: BARI Masur-7, P_1: 25 kg K_2O/ha, P_2: 30 kg K_2O/ha, P_3: 35 kg K_2O/ha, P_4: 40 kg K_2O/ha

Due to potassium application, significant differences were found on days to flowering (Appendix III).At reproductive stage the maximum days to pod maturity (90.77) was recorded from P_4 (40 kg K_2O ha^{-1}) treatment followed by P_3 (90.15) which is statistically similar (89.96) to that of P_2 (30 kg K_2O ha^{-1}) treatment and the minimum days to pod maturity (89.66) was found from P_1 (25 kg K_2O ha^{-1}) treatment (Table 3). Increasing potassium dose decreased the potassium deficiency stress thereby increased the duration of vegetative as well as reproductive phases. Hence, increased the number of days to pod maturity.(Haque*et al.*, 2013).

Interaction effects of variety and potassium showed significant differences on days to pod maturity (Appendix III).At reproductive stage the maximum days to pod maturity (92.66 days) was recorded from V_3P_4 (BARI Masur-7 with 40 kg K_2O ha^{-1}) treatment combination. On the other hand the minimum days to pod maturity (89.00 days) was recorded from V_1P_1 (BARI Masur-5 with 25 kg K_2O ha^{-1}) treatment combination which was similar to that of V_1P_2 treatment combinations (Table 4).

4.5. Relative water content (%)

Variety influenced significantly the relative water content (Appendix IV). The maximum relative water content (77.20 %) was recorded from V_3 (BARI Masur-7) variety and minimum relative water content (71.44 %) was found from V_1 (BARI Masur-5) variety (Table 5). Mian *et al*. (2011) observed the similar results.

Due to potassium application, significant variation was found on relative water content (Appendix IV).The maximum relative water content (75.54 %) was recorded from P_4 (40 kg K_2O ha^{-1}) treatment which is statistically similar (74.24 %) to P_3 treatment and the minimum relative water content (73.05 %) was found from P_1 (25 kg K_2O ha^{-1}) treatment which was statistically identical (73.38 %) to P_2 treatment (Table 6). Higher amount of potassium application can retain the maximum relative water content to the plant (Faraghali*et al.,* 1995).

Interaction effects of variety and potassium showed significant differences on relative water content (Appendix IV).At first flowering stage the maximum relative water content (79.26 %) was recorded from V_3P_4 (BARI Masur-7 with 40 kg K_2O ha^{-1}) treatment combination. On the other hand the minimum relative water content (71.61 %) was recorded from V_1P_1 (BARI Masur-5 with 25 kg K_2O ha^{-1}) treatment combination which is statistically identical to V_1P_2 and statistically similar to V_1P_3, V_1P_4 and V_2P_1 treatment combination (Table 7).

4.6. Exudation rate (mg $hour^{-1}$)

Due to different variety significant variation was observed on exudation rate of plant (Appendix IV). The maximum exudation rate (14.83 mg $hour^{-1}$) was recorded from V_3 that is BARI Masur-7 variety and minimum exudation rate (4.41 mg $hour^{-1}$) was found from V_1 variety (Table 5). Mian *et al*. (2011) observed the similar results.

Due to potassium application, significant variation was found in exudation rate of plant (Appendix IV).The maximum exudation rate (10.66 mg $hour^{-1}$) was recorded from P_4 (40 kg K_2O ha^{-1}) treatment followed by P_3 treatment which is statistically identical to P_2 treatment and the minimum exudation rate of plant (7.66 mg $hour^{-1}$) was found in P_1 (25 kg K_2O ha^{-1}) treatment (Table 6). Higher amount of potassium application can retain the maximum relative water content in plant and also increase the exudation rate of the plant (Faraghali*et al.*, 1995).

Interaction effects of variety and potassium showed significant differences on exudation rate (Appendix IV).At reproductive stage the maximum exudation rate (17.33 mg $hour^{-1}$) was recorded from V_3P_4 (BARI Masur-7 with 40 kg K_2O ha^{-1}) treatment combination. On the other hand the minimum exudation rate (4.00 mg $hour^{-1}$) was recorded from V_1P_3 (BARI Masur-5 with 35 kg K_2O ha^{-1}) treatment combination which is statistically identical to V_1P_2 and statistically similar to V_1P_1 and V_1P_4treatment combination (Table 7).

Table 5. Effect of variety on relative water content and exudation rate of lentil

Variety	Relative water content (%)	Exudation rate (mg $hour^{-1}$)
V_1	71.44 c	4.41 c
V_2	73.52 b	8.08 b
V_3	77.20 a	14.83 a
LSD $_{(0.05)}$	**1.39**	**0.48**
CV %	**2.23**	**6.31**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance

V_1: BARI Masur-5, V_2: BARI Masur-6, V_3: BARI Masur-7

Table 6.Effect of potassium on relative water content and exudation rate of lentil

Potassium	Relative water content (%)	Exudation rate (mg $hour^{-1}$)
P_1	73.05 b	7.66 c
P_2	73.38 b	8.77 b
P_3	74.24 ab	9.33 b
P_4	75.54 a	10.66 a
LSD $_{(0.05)}$	**1.61**	**0.56**
CV %	**2.23**	**6.31**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance

P_1: 25 kg K_2O ha^{-1}, P_2: 30 kg K_2O ha^{-1}, P_3: 35 kg K_2O ha^{-1}, P_4: 40 kg K_2O ha^{-1}

Table 7.Interaction effects of variety and potassium on relative water content and exudation rate of lentil

Treatment	Relative water content (%)	Exudation rate (mg hour^{-1})
V_1P_1	71.61 de	4.66 hi
V_IP_2	70.20 e	4.33 i
V_1P_3	72.29 de	4.00 i
V_1P_4	71.67 de	4.66 hi
V_2P_1	71.65 de	5.33 h
V_2P_2	73.14 cd	8.00 g
V_2P_3	73.60 cd	9.00 f
V_2P_4	75.70 bc	10.00 e
V_3P_1	75.90 bc	13.00 d
V_3P_2	76.80 ab	14.01 c
V_3P_3	76.83 ab	15.02 b
V_3P_4	79.26 a	17.33 a
LSD $_{(0.05)}$	**2.79**	**0.97**
CV %	**2.23**	**6.31**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance

V_1: BARI Masur-5, V_2: BARI Masur-6, V_3: BARI Masur-7, P_1: 25 kg K_2O ha^{-1}, P_2: 30 kg K_2O ha^{-1}, P_3: 35 kg K_2O ha^{-1}, P_4: 40 kg K_2O ha^{-1}

4.7. Pod Length (cm)

Due to different variety significant variation was observed on pod length (Appendix V). The highest pod length (1.04 cm) was recorded from V_3 (BARI Masur-7) variety and lowest (0.93 cm) was found from V_1 (BARI Masur-5) variety (Table 8). BARI Masur-7 can bear homogenous pods than others (Razzak*et al.,* 2015).

Due to potassium application, significant variation was found on pod length (Appendix V).The highest pod length (1.01 cm) was recorded from P_4 (40 kg K_2O ha^{-1}) treatment which is statistically identical to P_3 treatment and the lowest pod length (0.94 cm) was found from P_1 (25 kg K_2O ha^{-1}) treatment which is statistically identical to P_2 treatment (Table 9). Higher amount of potassium application can increase the pod length of the plant (Faraghali*et al.*, 1995).

Interaction effects of variety and potassium showed significant differences on pod length (Appendix V).At reproductive stage the highest pod length (1.10 cm) was recorded from V_3P_4 (BARI Masur-7 with 40 kg K_2O ha^{-1}) treatment combination which is statistically identical to V_3P_4 treatment combination. On the other hand the lowest pod length (37.13) was recorded from V_1P_1 (BARI Masur-5 with 25 kg K_2O ha^{-1}) treatment combination which is statistically similar to V_1P_2 and V_1P_3treatment combination (Table 10).

4.8. Number of pods plant^{-1}

Due to different variety significant variation was observed on number of pods plant^{-1} (Appendix V). The maximum number of pods plant^{-1} (56.89) was recorded from V_3 (BARI Masur-7) variety and minimum number of pods plant^{-1} (38.12) was found from V_1 (BARI Masur-5) variety (Table 8). Pod bearing is the most important characteristics of lentil plant and it mostly depends on variety. BARI Masur-7 can bear more pods than others (Razzaque*et al.*, 2014).

Due to potassium application, significant variation was found on number of pods plant^{-1} (Appendix V).The maximum number of pods plant^{-1} (50.27) was recorded from P_4 (40 kg K_2O ha^{-1}) treatment followed by P_3 treatment which is statistically identical to P_2 treatment and the minimum number of pods plant^{-1} (44.69) was found from P_1 (25 kg K_2O ha^{-1}) treatment (Table 9). Higher amount of potassium application can increase the number of pods plant^{-1} of the plant (Faraghali*et al.*, 1995).

Table 8:Effect of variety on pod length, number of pods plant^{-1}, number of seeds pod^{-1} and 1000-seed weight of lentil

Variety	Pod length (cm)	No. of pods plant^{-1}	No. of seeds pod^{-1}	1000-seed weight (g)
V_1	0.93 c	38.12 c	1.42 c	18.35 c
V_2	0.96 b	45.28 b	1.57 b	19.46 b
V_3	1.04 a	56.89 a	1.64 a	20.61 a
LSD $_{(0.05)}$	**0.02**	**1.30**	**0.06**	**0.14**
CV %	**2.61**	**3.29**	**5.03**	**5.31**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

V_1: BARI Masur-5, V_2: BARI Masur-6, V_3: BARI Masur-7

Table 9. Effect of potassium on pod length, number of pods plant^{-1}, number of seeds pod^{-1} and 1000-seed weight of lentil

Potassium	Pod length (cm)	No. of pods plant^{-1}	No. of seeds pod^{-1}	1000-seed weight (g)
P_1	0.94 b	44.69 b	1.47 b	19.09 d
P_2	0.96 b	45.92 b	1.56 a	19.30 c
P_3	1.00 a	46.17 b	1.55 ab	19.59 b
P_4	1.01 a	50.27 a	1.60 a	19.91 a
LSD $_{(0.05)}$	**0.02**	**1.50**	**0.07**	**0.16**
CV %	**2.61**	**3.29**	**5.03**	**5.31**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance

P_1: 25 kg K_2O ha^{-1}, P_2: 30 kg K_2O ha^{-1}, P_3: 35 kg K_2O ha^{-1}, P_4: 40 kg K_2O ha^{-1}

Interaction effects of variety and potassium showed significant differences on number of pods plant^{-1} (Appendix V).At reproductive stage the maximum number of pods plant^{-1} (58.90) was recorded from V_3P_4 (BARI Masur-7 with 40 kg K_2O ha^{-1})

treatment combination. On the other hand the minimum number of pods plant^{-1} (37.13) was recorded from V_1P_3 (BARI Masur-5 with 35 kg K_2O ha^{-1}) treatment combination which is statistically identical to V_1P_1 and statistically similar to V_1P_2 and V_1P_4treatment combination (Table 10).

Table 10. Interaction effects of variety and potassium on pod length, number of pods plant^{-1}, number of seeds pod^{-1} and 1000-seed weight of lentil

Treatment	Pod length (cm)	No. of pods plant^{-1}	No. of seeds pod^{-1}	1000-seed weight (g)
V_1P_1	0.90 d	37.31 f	1.31 e	17.79 j
V_IP_2	0.94 cd	38.13 ef	1.50 cd	18.09 i
V_1P_3	0.94 bcd	37.80 f	1.40 de	18.49 h
V_1P_4	0.95 bc	39.26 ef	1.50 cd	18.94 g
V_2P_1	0.96 bc	40.55 e	1.52 bd	19.15 fg
V_2P_2	0.96 bc	43.90 d	1.57 ac	19.37 ef
V_2P_3	0.96 bc	44.00 d	1.60 ac	19.56 de
V_2P_4	0.98 bc	52.67 c	1.60 ac	19.75 d
V_3P_1	0.98 bc	55.73 b	1.60 ac	20.23 c
V_3P_2	0.99 b	55.73 b	1.63 ac	20.46 bc
V_3P_3	1.09 a	57.20 ab	1.65 ab	20.72 b
V_3P_4	1.10 a	58.90 a	1.70 a	21.05 a
LSD $_{(0.05)}$	**0.04**	**2.60**	**0.13**	**0.29**
CV %	**2.61**	**3.29**	**5.03**	**5.31**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance

V_1: BARI Masur-5, V_2: BARI Masur-6, V_3: BARI Masur-7, P_1: 25 kg K_2O ha^{-1}, P_2: 30 kg K_2O ha^{-1}, P_3: 35 kg K_2O ha^{-1}, P_4: 40 kg K_2O ha^{-1}

4.9. Number of seeds pods^{-1}

Due to different varieties significant variation was observed on number of seeds pod^{-1} of (Appendix V). The highest number of seeds pod^{-1} (1.64) was recorded from V_3 that is BARI Masur-7 variety and lowest number of seeds pod^{-1} (1.42) was found from V_1 variety (Table 8). BARI Masur-7 pods contain 1 or 2 seed(s) (Razzak*et al.*, 2015).

Due to potassium application, significant variation was found on number of seeds pod^{-1} (Appendix V).The highest number of seeds pod^{-1} (1.60) was recorded from P_4 (40 kg K_2O ha^{-1}) treatment which is statistically identical to P_2 and statistically similar to P_3 treatment and the lowest (1.47) from P_1 (25 kg K_2O ha^{-1}) treatment (Table 9). Higher amount of potassium application can increase the number of seeds pod^{-1} (Faraghali*et al.*, 1995).

Interaction effects of variety and potassium showed significant differences on number of seeds pod^{-1} (Appendix V).At reproductive stage the highest number of seeds pod^{-1} (1.70) was recorded from V_3P_4 (BARI Masur-7 with 40 kg K_2O ha^{-1}) treatment combination. On the other hand the lowest (1.31) was recorded from V_1P_1 (BARI Masur-5 with 25 kg K_2O ha^{-1}) treatment combination which is statistically similar to V_1P_3treatment combination (Table 10).

4.10. Thousand- seed weight

Significant variation was observed due to the different variety on 1000-seed weight (Appendix V). The maximum 1000-seed weight (20.61 g) was recorded from V_3 (BARI Masur-7) variety and minimum (18.65 g) was found in V_1 (BARI Masur-5) variety (Table 8). This data can prove that the seeds BARI Masur-7 are slightly bolder than other varieties. Zahan*et al.* (2009) found the similar results.

Due to potassium application, significant differences were found among 1000-seed weight (Appendix V).The maximum 1000-seed weight (19.91 g) was recorded from

P_4 (40 kg K_2O ha^{-1}) treatment followed by P_3 (19.59 g) and the minimum 1000-seed weight (19.09 g) was found from P_1 (25 kg K_2O ha^{-1}) treatment (Table 9). Higher amount of potassium application can accumulate the maximum dry matter to the plant and seed (Zahan*et al.,* 2009).

Interaction effects of variety and potassium on 1000-seed weight was found significant (Appendix V).The maximum 1000-seed weight (21.05 g) was recorded from V_3P_4 (BARI Masur-7 with 40 kg K_2O ha^{-1}) treatment combination. On the other hand the minimum 1000-seed weight (17.79 g) was recorded from V_1P_1 (BARI Masur-5 with 25 kg K_2O ha^{-1}) treatment combination (Table 10).

4.11. Seed yield

Due to different variety significant variation was observed on seed yield (Appendix VI). The maximum seed yield (1.05 t ha^{-1}) was recorded from V_3 (BARI Masur-7) variety and minimum (0.81 t ha^{-1}) was found from V_1 (BARI Masur-5) variety (Table 11). Zahan*et al. (*2009) and Hasan*et al.* (2015) found the similar results.

Due to potassium application, significant variation was found on seed yield (Appendix VI).The maximum seed yield (0.99 t ha^{-1}) was recorded from P_4 (40 kg K_2O ha^{-1}) treatment and the minimum seed yield (0.82 t ha^{-1}) was found from P_1 (25 kg K_2O ha^{-1}) treatment (Table 12). Higher amount of potassium application can increase the seed yield of the plant (Crook *et al.* 1999).

Interaction effects of variety and potassium showed significant differences on seed yield (Appendix VI).At reproductive stage the maximum seed yield (1.12 t ha^{-1}) was recorded from V_3P_4 (BARI Masur-7 with 40 kg K_2O ha^{-1}) treatment combination. On the other hand the minimum seed yield (0.72 t ha^{-1}) was recorded from V_1P_1 (BARI Masur-5 with 25 kg K_2O ha^{-1}) treatment combination (Table 13). Zahan*et al. (*2009) found the similar results.

4.12. Stover yield

Due to different variety significant variation was observed on stover yield (Appendix VI). The maximum stover yield (1.35 t ha^{-1}) was recorded from V_3 (BARI Masur-7) variety and minimum (0.92 t ha^{-1}) from V_1 (BARI Masur-5) variety (Table 11). Zahan*et al. (*2009) and Datta*et al.* (2013) found the similar results.

Due to potassium application, significant variation was found on stover yield (Appendix VI).The maximum stover yield (1.20 t ha^{-1}) was recorded from P_4 (40 kg K_2O ha^{-1}) treatment and the minimum (0.99 t ha^{-1}) was found from P_1 (25 kg K_2O ha^{-1}) treatment (Table 12). Higher amount of potassium application can increase the stover yield of the plant (Crook *et al.*, 1999).Zahan*et al. (*2009) found the similar results.

Interaction effects of variety and potassium showed significant differences on stover yield (Appendix VI).At reproductive stage the maximum stover yield (1.45 t ha^{-1}) was recorded from V_3P_4 (BARI Masur-7 with 40 kg K_2O ha^{-1}) treatment combination which is statistically similar to V_3P_3 treatment combination. On the other hand the minimum stover yield (0.84 t ha^{-1}) was recorded from V_1P_1 (BARI Masur-5 with 25 kg K_2O ha^{-1}) treatment combination which is statistically similar to V_1P_3treatment combination (Table 13).

4.13. Biological yield

Due to different variety significant variation was observed on biological yield (Appendix VI). The maximum biological yield (2.38 t ha^{-1}) was recorded from V_3 (BARI Masur-7) variety and minimum (1.74 t ha^{-1}) from V_1 variety (Table 11). Datta, *et al.* (2013) found the similar results.

Table 11.Effect of variety on seed yield, stover yield, biological yield and harvest index of lentil

Variety	Seed yield ($t\ ha^{-1}$)	Stover yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest Index (%)
V_1	0.81 c	0.92 c	1.73 c	46.82 a
V_2	0.96 b	1.09 b	2.05 b	46.83 a
V_3	1.05 a	1.35 a	2.40 a	43.75 b
LSD $_{(0.05)}$	**0.03**	**0.05**	**0.08**	**0.69**
CV %	**4.60**	**5.47**	**4.94**	**4.77**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance

V_1: BARI Masur-5, V_2: BARI Masur-6, V_3: BARI Masur-7

Due to potassium application, significant variation was found on biological yield (Appendix VI).The maximum biological yield (2.20 $t\ ha^{-1}$) was recorded from P_4 (40 kg K_2O ha^{-1}) treatment and the minimum biological yield (1.92 $t\ ha^{-1}$) was found from P_1 (25 kg K_2O ha^{-1}) treatment (Table 12). Higher amount of potassium application can increase the biological yield of the plant (Crook *et al.,* 1999).

Interaction effects of variety and potassium showed significant differences on biological yield (Appendix VI).At harvest the maximum biological yield (2.57 $t\ ha^{-1}$) was recorded from V_3P_4 (BARI Masur-7 with 40 kg K_2O ha^{-1}) treatment combination which is statistically similar to V_3P_3 treatment combination. On the other hand the minimum biological yield (1.65 $t\ ha^{-1}$) was recorded from V_1P_1 (BARI Masur-5 with 25 kg K_2O ha^{-1}) treatment combination which is statistically similar to V_1P_2 and V_1P_3 treatment combination (Table 13).

Table 12.Effect of potassium on seed yield, stover yield, biological yield and harvest index of lentil

Potassium	Seed yield ($t\ ha^{-1}$)	Stover yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest Index (%)
P_1	0.82 d	0.99 d	1.92 c	47.65 a
P_2	0.88 c	1.07 c	2.03 b	45.84 b
P_3	0.93 b	1.13 b	2.09 b	45.64 b
P_4	0.99 a	1.20 a	2.20 a	45.18 b
LSD (0.05)	**0.04**	**0.05**	**0.09**	**0.79**
CV %	**4.60**	**5.47**	**4.94**	**4.77**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance

P_1: 25 kg K_2O ha^{-1}, P_2: 30 kg K_2O ha^{-1}, P_3: 35 kg K_2O ha^{-1}, P_4: 40 kg K_2O ha^{-1}

4.14. Harvest index

Due to different variety significant variation was observed on harvest index (Appendix VI). The maximum (47.00 %) was recorded from V_1 (BARI Masur-5) variety which is statistically similar to V_2 and minimum (44.48 %) was found from V_3 (Table 11). Datta*et al.* (2013) found the similar results.

Due to potassium application, significant variation was found on harvest index (Appendix VI).The maximum harvest index (47.65 %) was recorded from P_1 (25 kg K_2O ha^{-1}) treatment and the minimum (45.18 %) was found from P_4 (40 kg K_2O ha^{-1}) treatment which is statistically similar to P_2 and P_3 treatment (Table 12). Higher amount of potassium application can increase the harvest index of the plant (Crook *et al.,* 1999).

Table 13.Interaction effects of variety and potassium on seed yield, stover yield, biological yield and harvest index of lentil

Treatment	**Seed yield ($t\ ha^{-1}$)**	**Stover yield ($t\ ha^{-1}$)**	**Biological yield ($t\ ha^{-1}$)**	**Harvest Index (%)**
V_1P_1	0.72 g	0.84 f	1.65 i	49.17 a
V_IP_2	0.81 f	0.97de	1.79 ghi	45.61 de
V_1P_3	0.80 f	0.90 ef	1.70 hi	47.32 b
V_1P_4	0.84 ef	0.99 de	1.83 fgh	45.89 cde
V_2P_1	0.90 de	1.00 de	1.90 fg	47.31 b
V_2P_2	0.93 cd	1.04 d	1.98 ef	47.25 bc
V_2P_3	1.00 bc	1.15 c	2.15 de	46.39 bcd
V_2P_4	1.01 bc	1.18 c	2.19 cd	46.08 bcd
V_3P_1	1.03 b	1.18 c	2.22 cd	46.48 bcd
V_3P_2	1.04 b	1.29 b	2.33 bc	44.65 ef
V_3P_3	1.04 b	1.37 ab	2.41 ab	43.21 g
V_3P_4	1.12 a	1.45 a	2.57 a	43.57 fg
LSD $_{(0.05)}$	**0.07**	**0.10**	**0.17**	**0.66**
CV %	**4.60**	**5.47**	**4.94**	**4.77**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance

V_1: BARI Masur-5, V_2: BARI Masur-6, V_3: BARI Masur-7, P_1: 25 kg K_2O ha^{-1}, P_2: 30 kg K_2O ha^{-1}, P_3: 35 kg K_2O ha^{-1}, P_4: 40 kg K_2O ha^{-1}

Interaction effects of variety and potassium showed significant differences on harvest index (Appendix VI).At reproductive stage the maximum harvest index (49.17 %) was recorded from V_1P_1 (BARI Masur-5 with 25 kg K_2O ha^{-1}) treatment combination and the minimum (43.21 %) was recorded from V_3P_3 (BARI Masur-7 with 35 kg K_2O ha^{-1}) treatment combination which is statistically similar to V_3P_4 treatment combination (Table 13).

4.15. Relationship between exudation rate and yield contributing characters including yields

Analyses of functional relationship revealed that a significant positive relationship exhibited between exudation rate (ER) and pods plant^{-1} (Figure 3). The equation, y = 1.7659x + 30.675 gave a good fit to the data and the value of coefficient of determination (R^2 = 0.9527) showed that the fitted regression line had a significant regression coefficient. It also indicated that 95.27 % pods plant^{-1} was attributed due to ER.

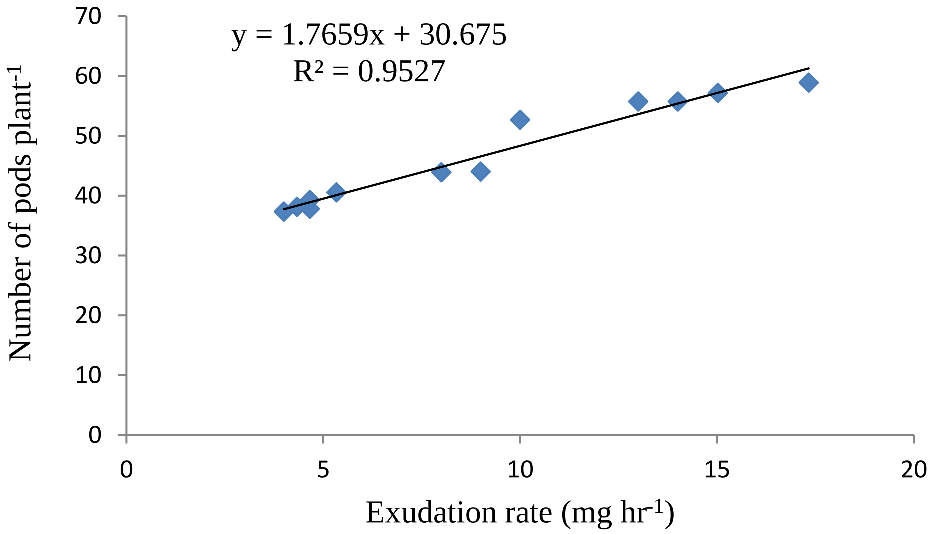

Fig 3.Functional relationship between exudation rate and number of pods plant^{-1} under residual soil moisture condition

A significant positive relationship was found between ER and seeds pod^{-1} (Figure 4). The equation, y = 0.0196x + 1.3696 gave a good fit to the data and the value of coefficient of determination (R^2 = 0.7147) showed that the fitted regression line had a significant regression coefficient. It also indicated that 71.47 % seeds per pod was attributed due to ER.

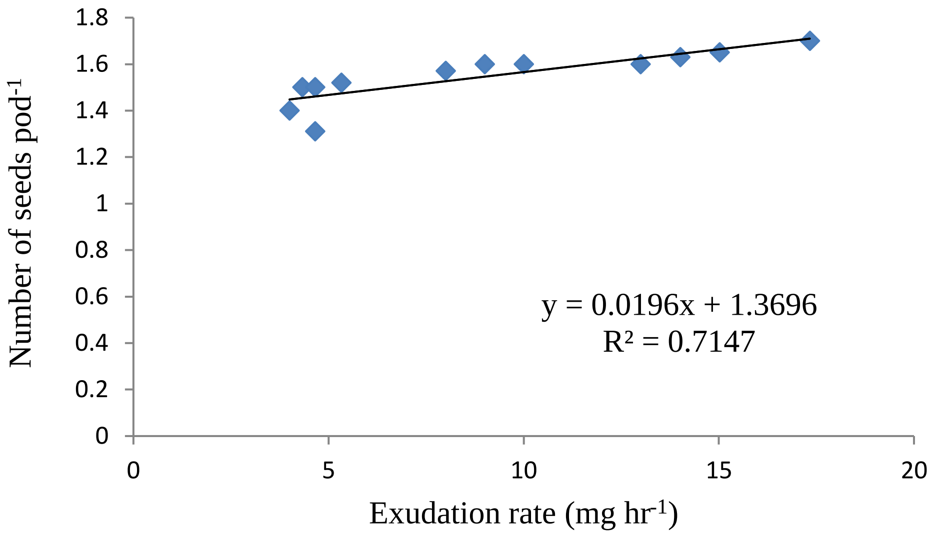

Fig 4. Functional relationship between exudation rate and number seeds of pod^{-1} under residual soil moisture condition

A significant positive relationship was found between ER and 1000-seed weight (Figure 5). The equation, y = 0.2076x + 17.575 gave a good fit to the data and the value of coefficient of determination (R^2 = 0.9017) showed that the fitted regression line had a significant regression coefficient. It also indicated that 90.17 % 1000 seed weight was attributed due to ER.

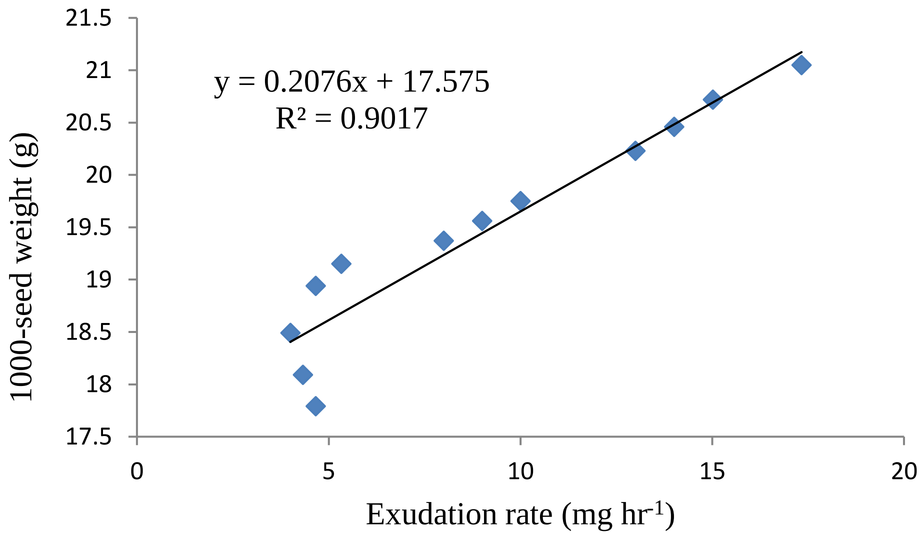

Fig 5. Functional relationship between exudation rate and 1000-seed weight under residual soil moisture condition

A significant positive relationship was found between ER and stover yield (Figure 6). The equation, y = 0.0386x + 0.7617gave a good fit to the data and the value of coefficient of determination (R^2 = 0.9300) showed that the fitted regression line had a significant regression coefficient. It also indicated that 93.00 % stover yield was attributed due to ER.

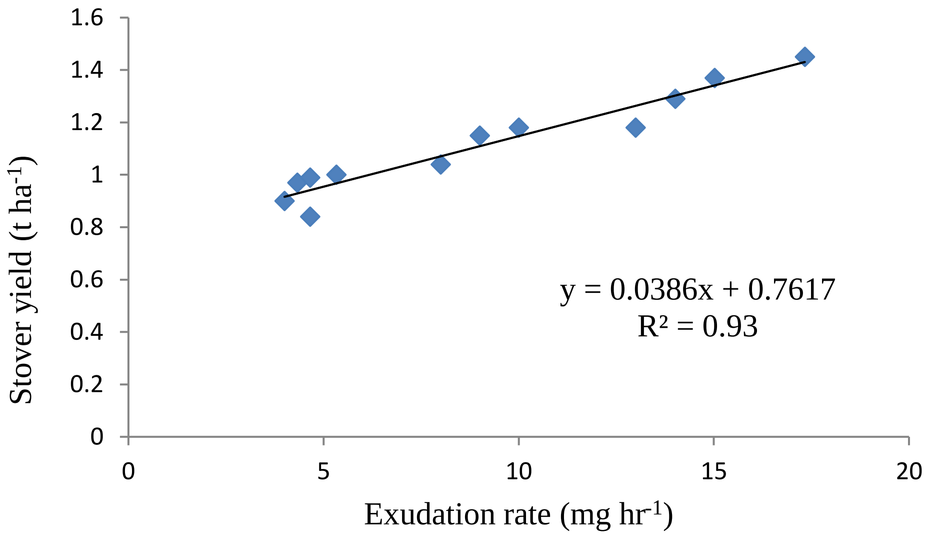

Fig 6. Functional relationship between exudation rate and stover yield under residual soil moisture condition

There is highly significant positive relationship which was found between ER and seed yield (Figure 7). The equation, y = x gave the best fit to the data and the value of coefficient of determination (R^2 = 1.00) showed that the fitted regression line had a significant regression coefficient. It also indicated that 100 % seed yield was attributed due to ER.

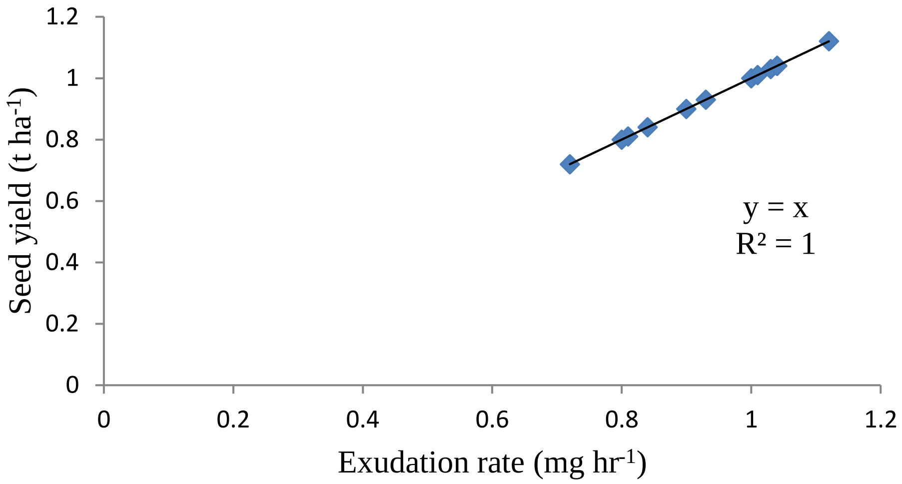

Fig 7. Functional relationship between exudation rate and seed yield under residual soil moisture condition

4.16. Relationship between relative water content and yield contributing characters including yields

A significant positive relationship was found between relative water content and number of pods plant^{-1} (Figure 8). The equation, y = 2.9632x - 172.68 gave the best fit to the data and the value of coefficient of determination (R^2 = 0.9240) showed that the fitted regression line had a significant regression coefficient. It also indicated that 92.40 % pods plant^{-1} was attributed due to relative water content.

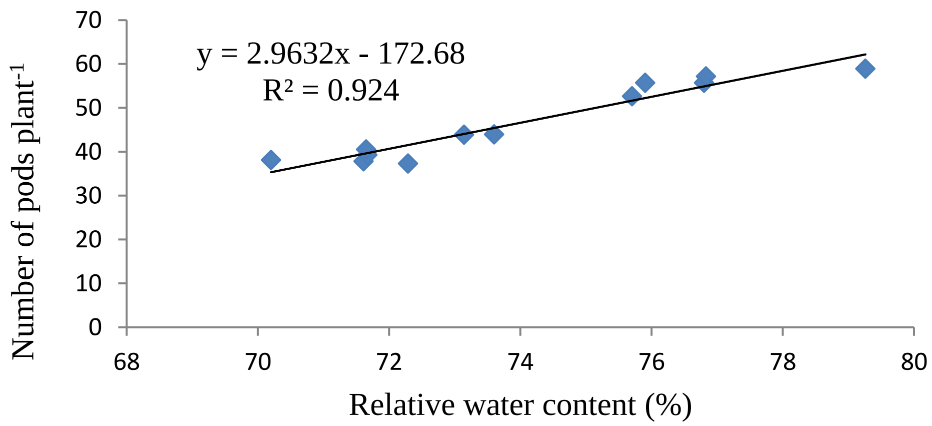

Fig 8. Functional relationship between relative water content and number of pods plant^{-1} under residual soil moisture condition

A significant positive relationship was found between relative water content and number of pods plant^{-1} (Figure 9). The equation, y = 0.0312x - 0.7603 gave the best fit to the data and the value of coefficient of determination (R^2 = 0.6215) showed that the fitted regression line had a significant regression coefficient. It also indicated that 92.40 % pods plant^{-1} was attributed due to relative water content.

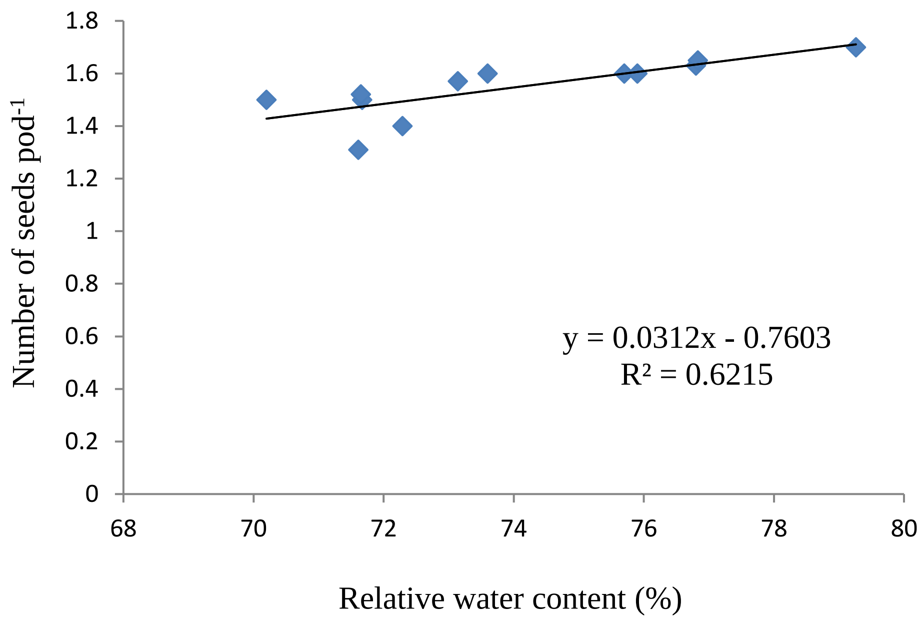

Fig 9. Functional relationship between relative water content and number of seeds pods^{-1} under residual soil moisture condition

A significant positive relationship was found between relative water content and 1000-seed weight (Figure 10). The equation, y = 0.3476x - 6.2747 gave the best fit to the data and the value of coefficient of determination (R^2 = 0.8706) showed that the fitted regression line had a significant regression coefficient. It also indicated that 87.06 % 1000- seed weight was attributed due to relative water content.

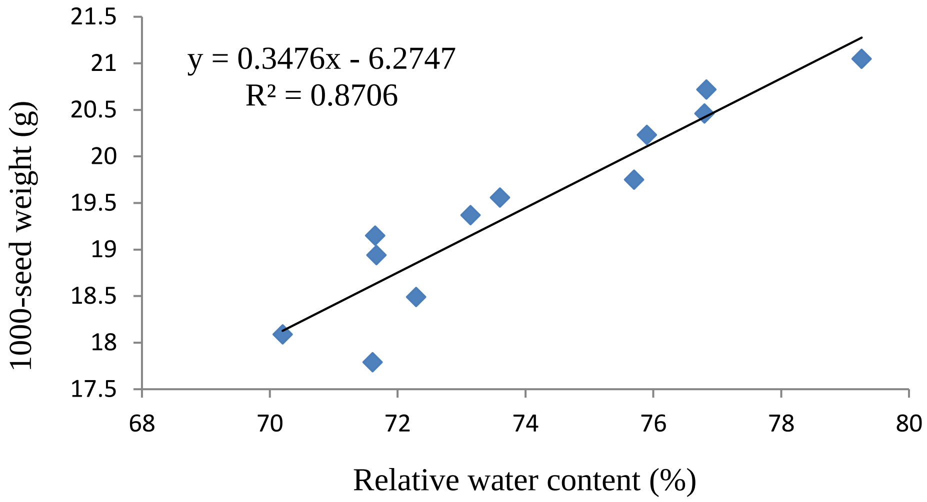

Fig 10. Functional relationship between relative water content and 1000-seed weight under residual soil moisture condition

There is a significant positive relationship which was found between relative water content and stover yield (t ha^{-1}) (Figure 11). The equation, y = 0.0636x + 3.5935 gave the best fit to the data and the value of coefficient of determination (R^2 = 0.8687) showed that the fitted regression line had a significant regression coefficient. It also indicated that 86.87 % stover yield (t ha^{-1}) was attributed due to relative water content.

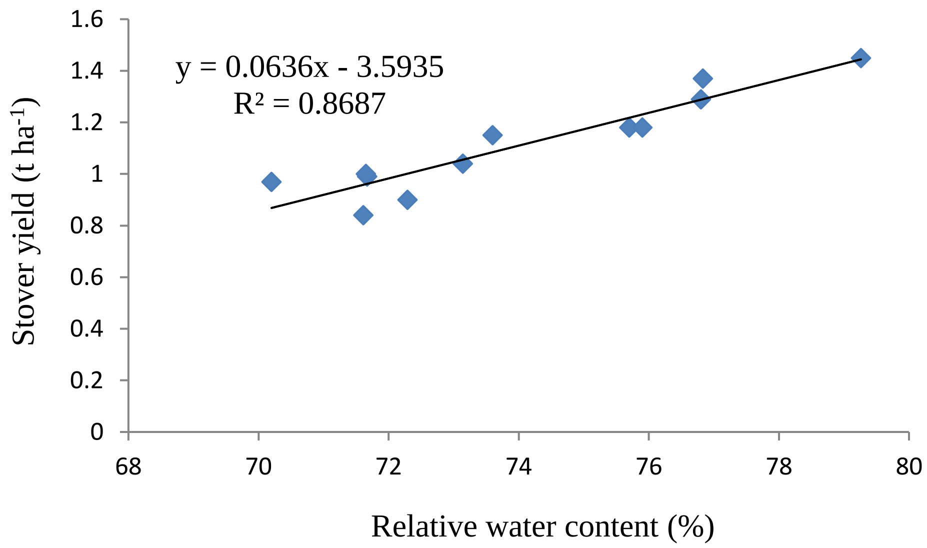

Fig 11. Functional relationship between relative water content and stover yield under residual soil moisture condition

There is a significant positive relationship which was found between relative water content and seed yield (t ha^{-1}) (Figure 12). The equation, y = 0.0397x – 2.0049 gave the best fit to the data and the value of coefficient of determination (R^2 = 0.8097) showed that the fitted regression line had a significant regression coefficient. It also indicated that 80.97 % seed yield (t ha^{-1}) was attributed due to relative water content.

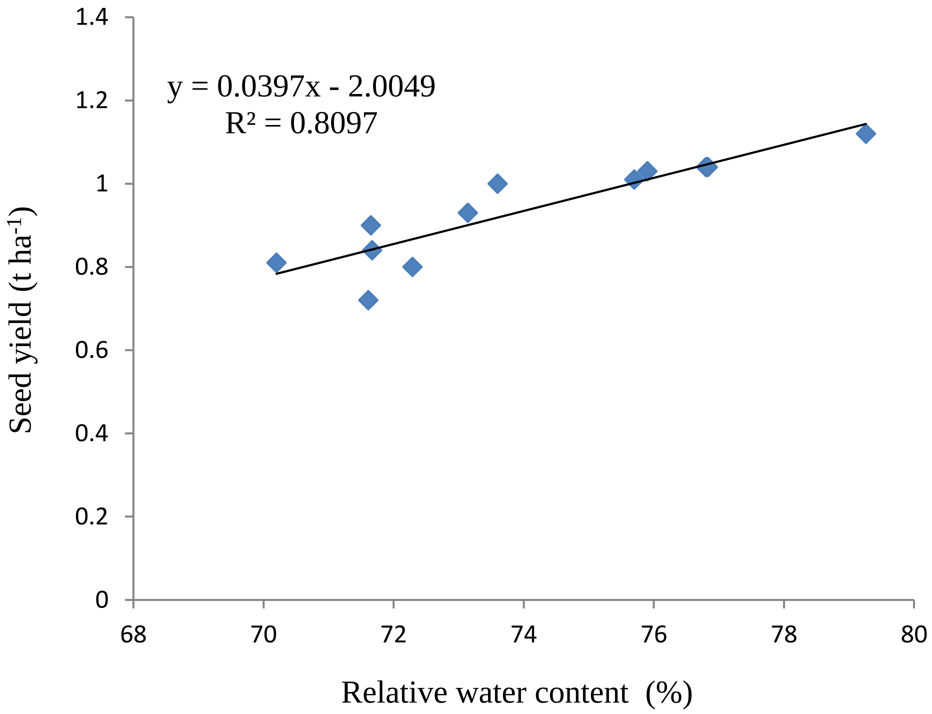

Fig 12. Functional relationship between relative water content and seed yield under residual soil moisture condition

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in the Agronomy Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from November 2015 to March 2016 to find out the effect of variety and potassium on the yield of lentil under residual soil moisture condition. The experiment consisted of two factors: Factor A: Three varieties of lentil. The varieties are V_1: BARI masur-5, V_2: BARI masur-6, V_3: BARI masur-7. Factor B: 4 doses of Potassium fertilizer, P_1 : 25 kg K_2O ha^{-1}, P_2 : 30 kg K_2O ha^{-1}, P_3 : 35 Kg K_2O ha^{-1}, P_4 : 40 Kg K_2O ha^{-1}. There were 12 treatment combinations. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth and yield contributing characters and yield were recorded to find out the optimum variety and level of potassium fertilizer for lentil.

Due to variety at harvesting time the longest plant height (31.21 cm), maximum days to flowering (52.47 days), maximum days to pod maturity (91.08 days), maximum 1000-grain weight (20.61 g), maximum relative water content (77.20 %), maximum exudation rate (14.83 mg hr^{-1}), minimum days to emergence (6.34 days), maximum number of pod per plant (56.89), the highest pod length (1.04 cm), maximum number of seed per pod (1.64), maximum stover yield (1.35 t ha^{-1}), maximum seed yield (1.05 t ha^{-1}), maximum biological yield (2.38 t ha^{-1}), minimum harvest index (44.48 %) were found from V_3 variety that is BARI Masur-7. On the contrary the shortest plant height (27.31 cm), minimum days to flowering (50.16 days), minimum days to pod maturity (89.41 days), minimum 1000-seed weight (18.35 g), minimum relative water content (71.44 %), minimum exudation rate (4.41 mg hr^{-1}), maximum days to emergence (8.02 days), minimum number of pod per plant (38.12), the shortest pod length (0.93 cm), minimum number of seeds per pod (1.42), minimum stover yield (0.92 t ha^{-1}), minimum seed yield (0.81 t ha^{-1}), minimum biological yield

(1.74 t ha^{-1}), maximum harvest index (44.48 %) were found from V_1 variety that is BARI Masur-5.

Due to potassium application at harvesting time the longest plant height (30.62 cm), maximum days to flowering (51.81 days), maximum days to pod maturity (90.77 days), maximum 1000-seed weight (19.91 g), maximum relative water content (75.54 %), maximum exudation rate (10.66 mg hr^{-1}), minimum days to emergence (6.89 days), maximum number of pod per plant (50.27), the highest pod length (1.01 cm), maximum number of seed per pod (1.60), maximum stover yield (1.20 t ha^{-1}), maximum seed yield (0.99 t ha^{-1}), maximum biological yield (2.20 t ha^{-1}), minimum harvest index (45.18 %) were found from P_4 treatment that is 40 kg K_2O ha^{-1} application. On the other hand the shortest plant height (28.18 cm), minimum days to flowering (50.59 days), minimum days to 80 % pod maturity (89.66 days), minimum 1000-grain weight (19.09 g), minimum relative water content (73.05 %), minimum exudation rate (7.66 mg hr^{-1}), minimum days to emergence (7.49 days), minimum number of pod per plant (44.69), the shortest pod length (0.94 cm), minimum number of seed per pod (1.47), minimum stover yield (0.99 t ha^{-1}), minimum seed yield (0.82 t ha^{-1}), minimum biological yield (1.92 t ha^{-1}), maximum harvest index (47.65 %) were found from P_1 treatment that is 25 kg K_2O ha^{-1} application.

Due to interaction effect of variety and potassium application at harvesting time the longest plant height (34.71 cm), maximum days to flowering (53.66 days), maximum days to pod maturity (92.66 days), maximum 1000-seed weight (21.05 g), maximum relative water content (79.26 %), maximum exudation rate (17.33 mg hr^{-1}), minimum days to emergence (5.85 days), maximum number of pod per plant (58.90), the highest pod length (1.10 cm), maximum number of seed per pod (1.70), maximum stover yield (1.45 t ha^{-1}), maximum seed yield (1.12 t ha^{-1}), maximum biological yield (2.57 t ha^{-1}) were found from V_3P_4 treatment combination that is with BARI Masur-7 variety with 40 kg K_20 ha^{-1} application. Minimum harvest index (43.21 %) was obtained from V_3P_3 treatment combination which is statistically similar to V_3P_4 treatment combination. On the other hand the shortest plant height (27.00 cm), minimum days to flowering (50.00 days), minimum days to pod maturity (89.00 days), minimum 1000-seed weight (17.79 g), minimum relative water content (71.61 %), minimum exudation rate (4.66 mg hr^{-1}), minimum days to emergence (8.42 days), minimum number of pod per plant (37.31), the shortest pod length (0.90 cm), minimum number of seed per pod (1.31), minimum stover yield (0.84 t ha^{-1}), minimum seed yield (0.72 t ha^{-1}), minimum biological yield (1.65 t ha^{-1}), maximum harvest index (49.17 %) were found from V_1P_1 treatment combination that is BARI Masur-5 variety with 25 kg $k_2 0$ application. Number of pods $plant^{-1}$, number of seeds pod^{-1},1000- seed weight, stover yield and seed yield were positively related with both exudation rate and corrrelative water content.

Conclusion

Based on the result of the present study it was found that BARI Masur-7 lentil variety application with 40 kg K_2O produced the highest seed yield (1.12 t ha^{-1}) in residual moisture condition of soil. Considering the findings of the experiment, it may be concluded that -

- Irrespective of potassium application, BARI Masur-7 was the highest seed yielder compared to the other one studied.
- Irrespective of the variety increasing potassium level up to the highest level (40 kg K_2O ha^{-1}) increased the seed yield.
- BARI Masur-7 with 40 kg K_2O ha^{-1} was bestcombination regarding seed yield under residual soil moisture condition.

Recommendation

The interactive effect of potassium and lentil variety was positive up to 40 kg K_2O $ha^{-1}$and BARI Masur-7. This variety may perform better with more potassium application. Due to the limitation of my experiment, I could not set more treatment of potassium. So the recommendation is –

- Further research should be conducted by setting more treatments of potassium and other fertilizers up to a certain level with many different varieties or drought tolerant varietiesto find out the optimum levels of fertilizers to get more production and economic benefit under residual soil moisture condition.

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APPENDICES

Appendix I. Results of morphological, mechanical and chemical analysis of soil of the experimental plot

A. Morphological Characteristics

Morphological features	Characteristics
Location	Agronomy Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow redbrown terrace soil
Land Type	Medium high land
Soil Series	Tejgaon
Topography	Fairly leveled
Flood Level	Above flood level
Drainage	Well drained

B. Mechanical analysis

Constituents	Percentage (%)
Sand	28.78
Silt	42.12
Clay	29.1

C. Chemical analysis

Soil properties	Amount
Soil pH	5.8
Organic carbon (%)	0.95
Organic matter (%)	0.77
Total nitrogen (%)	0.075
Available P (ppm)	15.07
Exchangeable K (%)	0.32
Available S (ppm)	16.17

Source: Soil Resource Development Institute (SRDI)

Appendix-II.Analysis of variance of data onplant height at different days after sowing of lentil

Source of variation	Degrees of freedom (df)	Mean square of plant height				
		30 DAS	45 DAS	60 DAS	75 DAS	At harvest
Replication	2	0.332	0.332	0.332	0.332	0.332
Factor A (Variety)	2	47.409*	47.40**	47.409*	47.409*	47.409*
Factor B (Potassium)	3	11.055*	11.055*	11.055**	11.055*	11.055*
Interaction(A X B)	6	3.920**	3.920*	3.920*	3.920*	3.920**
Error	22	1.080	1.080	1.080	1.080	1.080
** : Significant at 1% level of probability; * : Significant at 5% level of probability						

Appendix-III.Analysis of variance of data on days to emergence,days to flowering and days to maturity of lentil

Source of variation	Degrees of freedom (df)		Mean square of	
		Days to emergence	Days to flowering	Days to maturity
Replication	2	5.569	0.308	0.083
Factor A (Variety)	2	8.409*	16.340**	8.758*
Factor B (Potassium)	3	0.598**	2.316*	1.992*
Interaction(A X B)	6	0.116*	0.743*	0.922*
Error	22	0.054	0.100	0.130
** : Significant at 1% level of probability; * : Significant at 5% level of probability				

Appendix-IV.Analysis of variance of data on relative water content and exudation rate of lentil

Source of variation	Degrees of freedom (df)	Mean square of	
		Relative water content	Exudation rate
Replication	2	0.520	0.028
Factor A (Variety)	2	101.945*	335.028*
Factor B (Potassium)	3	11.132*	14.000*
Interaction(A X B)	6	2.916*	4.361*
Error	22	2.721	0.331

Appendix-V.Analysis of variance of data onpod length, number of pods plant^{-1}, number of seeds pod^{-1}and 1000-seed weight of lentil

Source of variation	Degrees of freedom (df)		Mean square of		
		Pod length	No. of pods plant^{-1}	No. of seeds pod^{-1}	1000-seed weight
Replication	2	0.002	6.04E^{-28}	9.08E^{-31}	3.150
Factor A (Variety)	2	0.034*	1075.850*	0.147*	15.370*
Factor B (Potassium)	3	0.007*	53.084*	0.024*	1.150**
Interaction(A X B)	6	0.003*	18.137*	0.005*	0.036*
Error	22	0.006	2.3692	0.006	0.030
** : Significant at 1% level of probability; * : Significant at 5% level of probability					

Appendix-VI.Analysis of variance of data on seed yield, stover yield, biological yieldand harvest index of lentil

Source of variation	Degrees of freedom (df)	Mean square of			
		Seed yield	Stover yield	Biological yield	Harvest Index
Replication	2	2.360	3.440	1.360	6.78E^{-28}
Factor A (Variety)	2	0.174*	0.475*	1.214**	23.2125*
Factor B (Potassium)	3	0.009*	0.061*	0.118*	10.6111*
Interaction(A X B)	6	0.002*	0.006*	0.012*	2.48693*
Error	22	0.001	0.003	0.010	0.66609
** : Significant at 1% level of probability; * : Significant at 5% level of probability					