INFLUENCE OF SOWING TIME AND SEED RATE ON THE GROWTH AND YIELD OF BARI Mung-6

CHAITY DEY PUJA

DEPARTMENT OF AGRONOMY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

JUNE, 2020

INFLUENCE OF SOWING TIME AND SEED RATE ON THE GROWTH AND YIELD OF BARI Mung-6

BY

CHAITY DEY PUJA

Registration No. 12-04888

A Thesis

Submitted to the Department of Agronomy, Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka in partial
fulfillment of the requirement for the degree of

MASTER OF SCIENCE (MS)

IN

AGRONOMY

SEMESTER: JANUARY-JUNE, 2020

APPROVED BY:

Prof. Dr. A.K.M. Ruhul Amin
Supervisor

Dr. Babu Lal Nag
Co-Supervisor

Prof. Dr. Md. Shahidul Islam
Chairman
Examination Committee

DEPARTMENT OF AGRONOMY
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar
Dhaka-1207

CERTIFICATE

This is to certify that the thesis entitled, ***"INFLUENCE OF SOWING TIME AND SEED RATE ON THE GROWTH AND YIELD OF BARI Mung-6"*** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE IN AGRONOMY,*** *embodies the result of a piece of bona fide research work carried out by* ***Chaity Dey Puja,*** *Registration No.***12-04888** *under my supervision and my 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, as has been availed of during the course of this investigation has duly been acknowledged.

Date:

Place: Dhaka, Bangladesh

Prof. Dr. A.K.M. Ruhul Amin
Department of Agronomy
Sher-e-Bangla Agricultural University,
Dhaka-1207

Dedication

I dedicate my thesis to my parents whose efforts and ever willing support have made this dream come true

ACKNOWLEDGEMENT

*Firstly, The author is expressing her deepest gratitude to the **"Almighty God",** the most merciful and altruistic who has made her capable to perform this research work and to submit the thesis successfully for the degree of Master of Science (M.S.) in Agronomy, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh.*

*The author would like to express her earnest devotion, appraisal and immense indebtedness to her respected research supervisor, **Prof. Dr. A.K.M. Ruhul Amin**, Department of Agronomy, Sher-e- Bangla Agricultural University, Dhaka, Bangladesh, for his sincere guidance, cordial suggestion, constant encouragement and selfless support throughout the study.*

*It is the author's pleasure to express her sincere appreciation and heartfelt gratitude to her research co-supervisor **Dr. Babu Lal Nag,** Former Director (Support Service), Bangladesh Agricultural Research Institute, Gazipur, Dhaka, Bangladesh for his constructive criticisms, valuable suggestions and co-operation during the whole period of her research work.*

*The author is also much obliged to **Prof. Dr. Md. Shahidul Islam**, Chairman, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka for providing all the arrangements to conduct the experiment.*

The author extends her deepest respect and boundless gratitude to all the respected teachers of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for their valuable teaching, countless co-operation and inspirations throughout the study and research work.

*The author is also grateful to "**Ministry of Science & Technology**" for funding the research as a fellow of "National Science and Technology (NST) Fellowship" program in the year 2018 that supported her a lot to conduct the research smoothly.*

*Special thanks goes to her fellow mates and friends **Md. Rakibul Hasan Nitol, Md. Atiqur Rahman Shaon**, **Biplabi Biswas** and **Sayeda Farhin Tamanna.** The whole journey might be very difficult without their encouragement and co-operation.*

*The author wants to acknowledge the helpful co-operation of **"Regional Pulse Research Centre", BARI,** Madaripur for providing her all the facilities to conduct the research successfully. She truly appreciates the assistance offered by the staffs of Regional Pulse Research Center, BARI, Madaripur and Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh who have helped her during her study and research work.*

Finally, the author recalls her infinite indebtedness to her beloved parents and her family for their moral support and boundless affection.

The author

INFLUENCE OF SOWING TIME AND SEED RATE ON THE GROWTH AND YIELD OF BARI MUNG-6

ABSTRACT

The experiment was conducted at Regional Pulse Research Centre, BARI, Madaripur, Bangladesh during the period of March to June, 2018 to evaluate the influence of sowing time and seed rate on the growth and yield of BARI Mung-6 for achieving higher yield. The experiment comprised two factors: Factor A: Sowing time (3 times) as - T_1= Sowing on 01 March, 2018, T_2= Sowing on 10 March, 2018 and T_3= Sowing on 20 March, 2018; and Factor B: Seed rate (4 levels) as - S_1= 20 kg seeds ha^{-1}, S_2= 25 kg seeds ha^{-1}, S_3= 30 kg seeds ha^{-1} and S_4= 35 kg seeds ha^{-1}. The experiment was laid out in split-plot design with four replications. Data were recorded on different morphological, yield contributing characters and yield of BARI Mung-6. Results revealed that T_2 (10 March) gave the highest seed yield (1.33 t ha^{-1}). This may be attributed to the maximum number of pods plant^{-1} (32.39), pod length (9.12 cm), number of seeds pod^{-1} (13.10), weight of 100-seed (5.34 g). Considering seed rate, S_3 (30 kg ha^{-1}) was the highest seed yielder (1.32 t ha^{-1}) which may perhaps the maximum number of pods plant^{-1} (32.32), pod length (9.38), number of seeds pod^{-1} (13.08), weight of 100-seed (5.30 g). Among the treatment combinations, the maximum number of pods plant^{-1} (34.5) and weight of 100-seed (5.51 g) were found from T_2S_3 which was statistically similar with T_2S_4, T_3S_3. In case of seed yield, the highest seed yield (1.43 t ha^{-1}) was exhibited from T_2S_3 treatment combination which was statistically similar with T_2S_4, T_3S_2, T_3S_3. From the present study it may be concluded that, the mungbean grower may cultivate BARI Mung-6 under prevailing climatic condition of greater Faridpur region in the month of March 10-20 along with 25-35 kg ha^{-1} seed rate to get the maximum seed yield.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF PLATES

ABBREVIATIONS AND ACRONYMS

A	=	Ground Area
AEZ	=	Agro-Ecological Zone
ANOVA	=	Analysis of Variance
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
BINA	=	Bangladesh Institute of Nuclear Agriculture
BRRI	=	Bangladesh Rice Research Institute
CGR	=	Crop Growth Rate
cm	=	Centimeter
CV %	=	Percentage of Coefficient of Variance
cv.	=	Cultivar
DAF	=	Days After Flowering
DAS	=	Days After Sowing
DM	=	Dry Matter
et al.	=	and others
etc.	=	Etcetera
FAOSTAT	=	Food and Agriculture Organization Corporate Statistical Database
g	=	Gram
HI	=	Harvest Index
i.e.	=	id est (L), that is
kg ha^{-1}	=	Kilogram per hectare

LAI	=	Leaf Area Index
LSD	=	Least Significance Difference
m	=	Meter
m^2	=	meter squares
NAR	=	Net Assimilation Rate
No.	=	Number
Ns	=	Non significant
RGR	=	Relative Growth Rate
SAU	=	Sher-e-Bangla Agricultural University
T	=	Ton
t ha^{-1}	=	Tons per hectare
TDM	=	Total Dry Matter
%	=	Percent
°C	=	Degree Celsius

CHAPTER I

INTRODUCTION

Bangladesh is predominantly an agriculture based country. About 84% of the total population live in the rural areas and are directly engaged in a wide range of agricultural production. Nutritional security is a great concern for its growing population. Demand of diversified foods is a newer challenge to traditional agriculture. Along with cereals, legume crops play a key role in agriculture and provide essential components of the daily diets of the people of Bangladesh.

Bangladesh has suitable agro-ecological conditions for production of a number of pulses. Due to its short duration and drought tolerant nature, it can fit well in the existing cropping systems. Low input and minimum care are required for its production. With removal or reduction of the yield gaps of different crop species and with emphasis on the increased production of pulses can increase the income level of poor farmers which can ensure the reduction of poverty at grass-root level with increase nutritional food security at local levels (Rahman and Zilani, 2009).

The major food legumes grown in Bangladesh are lathyrus, lentil, chickpea, black gram and mung bean and they contribute more than 95% to the total pulse production in the country (Rahman, 1998). Occupying about 4% to the total cropped area, pulses contribute 2% to the total grain production in Bangladesh (BBS, 2010). The average value of pulse production (1537.7 kg ha^{-1}) is very low comparing the value of other countries of the world (FAOSTAT, 2013). About 6.01 million metric tons of pulse will be required to meet the present requirement of Bangladesh. Annually import of pulses in Bangladesh is approximately 1317983.279 tons (BBS, 2016). An increase in pulse production is badly needed to meet the national demand.

In Bangladesh per capita consumption is 10.0g where 45.0g is recommended by World Health Organization (BBS, 2015). Due to acute shortage of grain legumes, Protein malnutrition is a serious health problem in Bangladesh. For alleviating human malnutrition for the poorest segment of the country's population, pulses have been identified as crops with exceptional potential.

Mungbean is one of the most important food grain legume crops containing high quality vegetable protein, satisfactory amounts of minerals and vitamins. It contains 24% protein (Lee *et al*., 1997), 26% moisture, 4% minerals and 3% vitamins (Kaul, 1982). It also contains 59.9% carbohydrate, 348 kilo calorie energy, 1.2 gm fat, 49 mg β-carotene, 75 mg calcium, 8.5 mg iron and 0.72 mg thiamine per 100 g of split dal (Afzal *et al*., 2004). Mungbean protein is considered to be easily digestible. Green pods and seeds can be cooked as vegetables. Containing quality protein, minerals and vitamins, Mungbean is inseparable ingredient in the diets of a vast majority of population.

Mungbean is also distinguished by its ability to improve the physical, chemical and biological properties of soil. These legumes have the ability to fix atmospheric nitrogen in symbiotic association with Rhizobium bacteria, which enables them to meet their own nitrogen requirement and also benefit the succeeding crops (Ali, 1992). The haulms are used for fodder and the bean husks and small broken pieces are useful as a feed concentrate. The crops are also grown for hay, green manure and cover crop. So it can be considered as an indispensable component of sustainable agriculture.

In 2018-2019 the total production of pulses in Bangladesh was 378000 tons from an area of 350607.29 ha (BBS, 2019). Mungbean occupies 41295.55 ha of total land and production was 34000 tons among the pulses contributing 11.78 % and 8.99% of the total pulse area and production, respectively in the country. In terms of both acreage and production it occupies third position after lentil and blackgram (BBS, 2019).

In Bangladesh the area under pulse production has decreased continuously for the last few years (Shahjahan, 2002). Farmers lost interest to produce mung bean in spite of having high market value to this crop due to lack of proper knowledge. Applying best agronomic practices such as proper sowing time and optimum seed rate, the yield and quality of mung bean can be ameliorated.

Time of sowing is one of the most important non-monetary factor affecting the duration of vegetative, reproductive and maturity periods (Soomro and Khan, 2003). It is also the single most important input influencing the yield of mung bean (Asghar Malik *et al*., 2006). The agro-ecological condition of Bangladesh is favorable for growing mungbean in the winter season although it is grown both in summer and winter seasons in many countries of the world (Bose, 1982). Due to diversified agro-ecological conditions, optimum sowing time may vary from one variety to another and one region to another (Sarkar *et al*., 2004). So determination of optimum sowing time for mungbean is inevitable. Delayed sowing after March and early sowing before February reduce yield of summer mungbean (Chovatia *et al*., 1993). So there must be a specific sowing date to obtain maximum yield for mungbean.

Optimum seed rate plays an important role in contributing to the high yield as compared to normal population. Higher seeding rate significantly enhanced leaf and shoots vigor per unit area, leaf area index, dry matter accumulation, crop growth rate and finally grain yield. Duration of grain filling is influenced by sowing time and seed rate. It may also affect the yield of crop (Hamid *et al*., 1991).

Therefore, knowledge on the rate and duration of grain filling in mungbean is helpful to predict its yield. Plant growth analysis is considered to be standard approach to study of growth and productivity (Wilson, 1981). So the present study was undertaken to determine the optimum sowing time and seed rate for getting maximum yield. Keeping all the points in mind mentioned above, the present research work was undertaken with the following objectives:

i. To identify the optimum sowing time and seed rate of BARI Mung-6 at greater Faridpur region (AEZ 12)
ii. To estimate crop growth pattern of BARI Mung-6 at different seed rate and sowing time for achieving higher yield.

CHAPTER II

REVIEW OF LITERATURE

Mungbean is one of the most important legume crops in Bangladesh as well as many countries of the world. A good number of research works on mungbean have been performed extensively in several countries for improvement of growth, yield and development of this crop. In Bangladesh, little attention has so far given for the improvement of mungbean. Nevertheless, some of the important and informative works and research findings related to the sowing time and seed rate on the growth and yield of mungbean so far been done at home and abroad have been reviewed and discussed in this chapter.

2.1 Effect of sowing time on morpo-physiological characters of mungbean

Chaitanya and Chandrika (2003) conducted trials in India with chickpea cultivars ICCV 10, ICCV 2 and Annigeri 1 which were sown in 15 October, 1 November, I5 November and 1 December. The highest plant height (32.9 cm), number of primary branches plant^{-1} (3.4), number of secondary branches plant^{-1} (8.2), number of pods per plant^{-1} (18.0), number of seeds pod^{-1} (1.24) and seed yield (0.54 t ha^{-1}) were observed with 1 November sown seeds rather than other dates.

Hussain *et al*. (2004) carried out a field trial at Peshawar (Pakistan) on the effects of sowing date (15 April, 15 May, 15 June, 15 July and 15 August) on performance of mungbean. They found that 15 April took more number of days to emergence, showed maximum plant height and gave the highest grain yield.

Jahan and Adam (2012) carried out a field experiment at Dhaka (Bangladesh) to study the effect of time of sowing (15 March, 15 April and 15 May) on the growth and yield of mungbean and found that 15 April sown crop had maximum plant height (68.4 cm), leaves per plant (29.33), total dry matter per plant (17.99 g), branches per plant (8.17), pods per plant (11.33), pod length (8.78 cm), seeds per pod (11.17), 1000-seed weight (46.52 g), grain yield per plant (5.33 g), grain yield per ha (1.77t) and harvest index (29.58%). The grain yield decreased by

36.8 and 49.9% when the crop was sown early (15 March) or late (15 May) due to production of lower yield components.

Muhammad *et al*. (2005) conducted a field experiment at Dera Ismail Khan(Pakistan), with seven sowing dates (15 April, 1 May, 15May, 1 June, 15 June, 1 July and 1 August) of mungbean and found that sowing on 1 May resulted in the highest number of branches per plant, pods per plant, 1000 grain weight and grain yield.

Rehman *et al*. (2009) carried out a field experiment at Peshawar (Pakistan) to evaluate the effect of sowing dates (30 March, 15 April, 15 May, 15 June and 15 July). The crop attained maximum plant height under 15 May sowing. Highest grain yield was recorded for early planting of 30 March.

Sharma *et al*. (2007) from Ludhiana reported maximum grain yield in early sowing (10 July) as compared to late sowings (26 July and 10 August) due to favourable temperature, which resulted into better plant height, increased number of branches per plant, higher number of pods per plant and higher 1000 seed weight. The late planting affected the growth and yield attributing characters.

Yadav and Nagarajan (1995) reported that late sowing crop harvested under humidity (>70%) and high air temperature (25-35°C) conditions was responsible for poor germination and vigor of the harvested mungbean seed. Early harvested mungbean showed best quality than that of late sowing.

Yadav *et al*. (1998) reported that forty chickpea (desi and kabuli) cultivars were sown in November and December in New Delhi. Delayed sowing decreased seed yield in both desi and kabuli types. This reduction in kabuli types was noticed in number of branches, relative growth rate and biomass production. The reduction in seed yield was due to reduction in pod number, seeds pod^{-1} and seed weight.

2.2 Effect of sowing time on yield attributes and yield of mungbean

Soomro and Khan (2003) at Islamabad (Pakistan) found that the early sowing (5 July) showed maximum (9.2 cm) pod length, followed by 15 July sown crop (8.5 cm), and least pod length (5.1 cm) was observed in last sowing (5 August) so it was concluded that first week of July was the ideal time of sowing.

Sarker *et al*. (2004) observed that pod length of mungbean was significantly influenced by sowing time.

Allam (2002) conducted an experiment to evaluate the performance of lentil cv. Giza 9 under various sowing date and reported that sowing on 1 November gave higher number of pod plant^{-1}, number of seed pod^{-1} and seed yield plant^{-1}.

Andrews *et al*. (2001) conducted an experiment in Canterbury, New Zealand on mungbean using five sowing dates. Predicted time to flowering was within 7 days of actual time i.e. 15 September to flowering and predicted seed yields of lentil were within 9% of actual yield and actual yields range from 1.40 to 1.65 t ha^{-1}.

Auld *et al*. (1988) carried out a field trial with 10 cultivars planted in late April, early May and late May to determine the effect of sowing date on yield components and seed yield. Seedling dry weight accumulation was more rapid in kabuli lines than desi lines. Planting in late April gave the highest seed yields than planting in late May (34 and 5% in 1982 and 1984, respectively).

Auskalnis and Dovydaities (1998) reported that the highest mean seed yield of 3.84t ha^{-1} was given by early sowing of 1.2 million seeds ha^{-1}. Yield decreases with delayed sowing were the greatest at the lowest sowing rates.

Aziz and Abdul (1989) conducted a field experiment on leaf less pea *cv*. Filby with three sowing times i.e. 20 April, 5 May and 5 June. They reported that the highest seed yield (5.606 t ha^{-1}) occurred from early sowing and that was declined (1.005 t ha^{-1}) with later sowing.

Bhattacharya and Pandey (1999) reported that chickpea grown under normal sowing (30 0ctober) produced maximum seed yield (2.4 t ha^{-1}) whereas lower seed yield (1.23 t ha^{-1}) was obtained from late sowing (28 November).

Bukhtiar *et al*. (1991a) observed that the higher harvest index (HI) of 42.3% in lentil *cv*. AARIL344 and 41.4% in lentil *cv*. AARIL337 was obtained from 23November sowing. The lower HI (25.1%) was recorded in lentil *cv*. AARIL355 sown on 26 September. The last week of October was found better with an optimum range from the end of September to 2nd week of November.

Bukhtiar *et al*. (1991b) found that the last week of October proved the better sowing date at which blackgram *cv*. AARIL496 (1694 and 6125 kg ha^{-1}) sowing in the 2^{nd} week of November blackgram *cv*. AARIL344 (1427 and 1365 kg ha^{-1}). The overall mean seed yield for cultivars was higher (1236.5kg ha^{-1}) in blackgram *cv*. AARIL496 followed by blackgram *cv*. AARIL344 (1222.4 kg ha^{-1}). The lowest mean yield (493.2 kg ha^{-1}) was recorded in blackgram *cv*. AARIL355.

Chahal (1998) at Ludhiana (Punjab) conducted an experiment with four sowing dates and the grain yield of the mungbean sown on 25 June, 7 July, 22 July and 6 August was 764, 905, 623 and 481 kg ha^{-1} respectively. The crop sown on 7 July provided significantly higher grain yield, recording 18, 45 and 88 percent increased as compared to yield under 25 June, 22 July and 6 August sown crops. Total dry matter accumulation, number of pods per plant, number of grains per pod and 1000 grain weight in case of 7 July sown crop were significantly higher than other three planting dates.

Choi *et al*. (1991) in Kwangju (Korea) tested three sowing dates (21 May, 15 June and 10 July) and reported that 15 June gave the highest number of pods $plant^{-1}$ and highest grain yield.

Dahiya *et al*. (1988) reported that chickpea cv. H 208 and C 235 were sown at 15 days intervals from 5 October to 19 November. The highest seed yields were 1.50 t ha^{-1} in 1983-84 and 1.36 t ha^{-1} in 1984-85 when sown on 20 October.

Dixit *et al.* (1992) conducted a field experiment with chickpea cv. Radhey and Ujjain 21 which were sown on 5 and 26 October, 16 November and 7 and 28 December at Powarkheda, Madhya Pradesh in the 1985-87. They reported that seed yields from the respected sowing dates were 1.51, 1.90, 1.93, 1.44 and 1.09 t ha^{-1}. Yield in both years was highest with sowing on 26 October and 16 November and lowest form 28 December.

El-Nagar and Galal (1997) carried out an experiment with lentils in 1993-95 at Assuit, Egypt which were sown 1, 15 November and 1 December and were harvested at physiological maturity or one or two weeks late and reported that delaying harvesting by one or two weeks after physiological maturity decreased seed yield by 19.7% and 33.6%, respectively. The delay in sowing decreased seed yield.

Farghali and Hussein (1995) carried out an experiment on 23 accessions of mungbean grown under different sowing time (15 February, 15 May and 15 August) at Assuit, Egypt and observed that 15 May sown crop was superior to 15 February and 15 August sowings with respect to number of cluster per plant, number of seeds per pod and 1000 grain weight. The highest number of pods per plant and total grain yield were obtained from the 15 August sowing date.

Farrag (1995) conducted a field study on mungbean at EI-Mania, Egypt and reported that 1 May sowing gave the earliest maturity and a significant increase in total grain yield, number pf pods $plant^{-1}$, number of grains $plant^{-1}$, 1000 grain weight compared to 15 March and 15 June sowings.

Fraz *et al*. (2006) reported that maximum grain yield in late sowing date (3^{rd} week of July) as compared to early sowing (3^{rd} week of June and 1^{st} week of July) due to higher number of pods $plant^{-1}$, number of grain pod^{-1}, 1000 grain weight and harvest index.

Fraz *et al*. (2006) reported that higher pods $plant^{-1}$ was observed in late sowing (3^{rd} week of July) as compared to early sowing (3^{rd} week of June) at Faisalabad (Pakistan).

Gurung *et al*. (1996d) found that average seed yields of blackgram crops sown on 10 and 25 October were 1274 and 1591 kg ha^{-1}, respectively which were significantly higher than other sowing dates. Blackgram seed yield was greatly reduced if sowing was advanced from 10 October to 25 September (533 kg ha^{-1}) or delayed from 25 October to 9 November (597 kg ha^{-1}). The straw yields of blackgram were also higher from October sowings.

Harpal *et al*. (2002) conducted field trials during 1999 and 2000 in Gurdaspur, Punjab, India where chickpea cultivars P 13 and GL 769 were sown on 10 October, 20 October, 30 October, 10 November and 20 November. They reported that GL 769 sown on 10 October gave highest grain yield (1410.00 kg ha^{-1}) in 1999 and (1414.27 kg ha^{-1}) in 2000 than other treatments.

Iliadis (1998) carried out field trials in 1987-91 at Greece with 6 chickpea cultivars which were sown in autumn (end of November) or spring (beginning of March). Yields were consistently higher between 26 and 33 % with autumn sown crops than the spring sown crop.

Inderjit *et al*. (2005) conducted a field experiment on sandy-loam soil of Gurdaspur, Panjab, India, during the winter season 1998-2000 to study the effect of different sowing date of lentil (*Lens culinaris cv.* LG 308). Significantly higher mean seed yield was obtained in lentil sown on 10 November (15.7 q ha^{-1}) and that sown on 10 November using 37.5 kg seed ha^{-1} (15.9 q ha^{-1}).

Jovaisiene *et al*. (1998) conducted field trials at 1995-97 and pea *cv*. Odin were sown early or 5 or 10 days later at 0.8,1.0 &1.2 million seeds ha^{-1}. The highest seed yield of 3.73 t ha^{-1} was given by early sowing of 1.0 million seeds ha^{-1}. Yield decreased with later sowing were the greatest at the minimum seeding rate.

Kumar *et al*. (1988) observed that chickpea sown in early November, mid-November and early December at Zainapora gave best yield (1.0-1.3 t $ha^{-1)}$ in mid-November than others.

Mian *et al*. (2002) reported that number of branches plant^{-1}, number of pods plant^{-1}, number of seed pod^{-1}, 1000 seed weight and seed yield were significantly influenced by the dates of sowing in mungbean.

Monem *et al*. (2012) conducted a field experiment at Varamin (Iran) on mungbean which was sown on 5 May, 20 May and 6 June and found that sowing on 5 May was significantly superior to 20 May and 6 June sowings due to higher number of seeds per pod, harvest index and grain yield.

Patel *et al*. (1999) observed that three chickpea cultivars were sown in Gujarat on 30 October, 15 or 30 November and 15 December 1994. Seed yield was highest with sowing on 15 November and lowest at the last sowing date.

Poma *et al*. (1990) carried out a field experiment with three chickpea lines sown in mid-December and at their successive 28-38 days intervals. They observed average seed yield, 1000 seed weight and plant height of three chickpea lines decreased with delayed sowing.

Poniedizialek *et al*. (1999) conducted experiments on chickpeas during 1997-98 in the Krakow Area using 3 sowing dates from 17 April to 14 May. Yield decreased as sowing was delayed from 17 April to 14 May.

Porsa *et al*. (2002) conducted trials on 6 chickpea cultivars with treatment that comprised of 3 sowing dates. i.e. 4 December, 3 January and 3 April. Although seed yield in 4 December (34.1 gm^{2}) and 3 January (32.3 gm^{2}) increased compared to 3 April (29.6 gm^{2}) but the differences were not significant.

Rahman and Sarkar (1997b) reported that the highest (1.85 t ha^{-1}) and the lowest (0.75 t ha^{-1}) seed yields of mungbean were obtained from cultivars ILX 87052 and Utfala, respectively. Higher seed yields were achieved through the contribution of higher total dry matter, more pods per plants and bigger seeds as well as August in Chakwal (Pakistan), sowing on 4 and 14 July gave greater grain yield and yield components and sowing thereafter greatly reduced grain yield.

Razzaque *et al*. (2005) tested sowing of mungbean in Hazipur (Bangladesh) from January to May and reported that 15 February gave highest grain yield.

Researchers from BRRI (1996) conducted field trials on the performance of edible podded pea sown at 10, 20, 30 November,10, 20, 30 December 1996 and 9, 19 January 1997. The higher vegetable pod yield (13.56 t ha^{-1}) and seed yield (1.42 t ha^{-1}) were obtained when pea was sown on 20 November than other dates. Its vegetable and seed yield also started to decline significantly after November sowing and January sowing produced 1.13 and 0.58 t ha^{-1} vegetable and 0.14 and 0.66 t ha^{-1} seed respectively.

Sadeghipour (2008) and Sarker *et al*. (2004) reported that number of seeds pod^{-1} was affected by sowing date.

Sadeghipour (2008) reported from Tehran (Iran) that crop sown on 29 June gave maximum grain yield because number of pods $plant^{-1}$ and 1000 seed weight were increased, while crop sown on 30 May produced minimum grain yield due to decreased number of pods $plant^{-1}$.

Saini and Faroda (1997) observed that chickpeas *cv*. II 68 were sown during the 3rd week in October or 1st or 3rd week in November. The optimum sowing date was 1st week in November, producing the highest seed yield of 2.76 t ha^{-1}.

Sarah (1998) carried out field trials with chickpea in Assam during 1996-97 which was sown in 15 and 30 October, 15 November and 30 December. The maximum yield of chickpea was recorded in October sown crops.

Saxena and Singh (1977) found that gram sown on 30 October gave highest yield and delay in sowing beyond 30 October reduced the seed yield.

Saxena and Yadav (1975) reported that the seed yield of greengram was significantly influenced by different date of sowing. Greengram sown on 30 October gave highest yield whereas delay in sowing beyond 30 October reduced the seed yield.

Seijoon *et al*. (2000) also found similar results and stated that the increased harvest index with late sowing could be related to high assimilate use efficiency due to increased sink capacity. Differences in harvest index under different sowing dates of mungbean have also been reported by other researchers Kabir and Sarkar (2008), Miah *et al*. (2009), Jahan and Adam (2012).

Sekhon *et al*. (1994) reported that sowing dates had no significant effect on seed yield and seed yield of lentil ranges from 2.04 t ha^{-1} and the lowest rate was 1.20 t ha^{-1}.

Sekhon *et al.* (2004) conducted a field experiment at Ludhiana (Punjab) with four sowing dates of 8, 16, 24 July and 1 August. They reported that 8 and 16 July sowings gave significantly higher grain yield. In another trial by these researchers 10 and 25 July sowings gave more yield than 10 August sowing.

Sharma and Sharma (2002) carried out an experiment with four chickpea genotypes namely KPG 59, POB I, HC I and BG 256 were sown in three sowing dates i.e. 25 October, 10 November and 25 November. The crop planted in 25 November gave the highest seed yield of 725kg ha^{-1} than delayed sown by 30 days resulted a decrease in grain yield up to 6.5 kg ha^{-1} day^{-1}.

Sharma *et al*. (1988) conducted a field trial at Gwalior (Madhya Pradesh) with mungbean that was sown on 13 July, 23 July, 2 August and 12 August and found that delay in sowing decreased grain yield.

Shukla & Kohli (1992) conducted an experiment on five garden pea cultivars with different sowing times at Kalpa and Solan in Himachal Pradesh. Later sowing resulted in earlier flowering at both locations. In a field trial with three pea cultivars e.g. Karina, Puget & Davina & three sowing time (15 December, 1 & 27 February). Seed yield were 8.03,8.70 & 7.20 t ha^{-1} (Karina>Davina>Puget) with increase in late sowing time.

Siddique *et al*. (2002) conduced an experiment with chickpea and found that the highest yield obtained when seeds were sown on 25 January followed by 05 February and 15 January and the lowest in 5 march planting. The lowest yield obtained from early and delay planting. The lower seed yield plant^{-1} at the last sowing was due to significant decrease in the number of seeds pod^{-1} and 1000 seed weight of chickpea.

Singh and Dhingra (1993) conducted an experiment at Bathinda (Punjab) on mungbean which was sown on 1, 10, 20 or 30 July and found that higher grain yield was obtained from the 1 July sown crop which was significantly higher than grain yield obtained from 20 July and 30 July sown crop but was statistically at par with 10 July sowing. The higher grain yield from the early sowing was due to higher number of primary branches plant^{-1}, pods plant^{-1}, seeds pod^{-1} and 1000 seed weight.

Singh and Sekhon (2007) conducting an experiment at Ludhiana (Punjab) reported that in one experiment the mungbean crop sown on 8 July recorded the highest yield (3780 kg ha^{-1}) which was significantly higher than the yield recorded with the crop sown on 16 July (1650 kg ha^{-1}), 24 July (1426 kg ha^{-1}) and 1 August (1426 kg ha^{-1}) and in another experiment 25 July sowing produced the highest grain yield (1309 kg ha^{-1}), 10 July (1293 kg ha^{-1}) and both being significantly superior to 10 August sowing (1179 kg ha^{-1}). Lower yield under delayed sowing was the result of reduction in number of pods plant^{-1}, 1000 seed weight and the biological yield.

Singh and Yadav (1989) studied the yield performance of five dwarf pea cultivars with three sowing dates i.e. 10, 25 October and 10 November. They obtained an average seed yield of 0.60, 1.09 and 1.55 t ha^{-1} and 1.39, 1.84, 2.09 t ha^{-1} in 1984 and 1985 respectively. Grain weight plant^{-1} & 1000 grain weight increased with delay in sowing. The *cv*. KPSDI when sown on 10 November gave the highest yield of 2.74 t ha^{-1}.

Singh *et al*. (2012a) conducted a field experiment at Varanasi (Uttar Pradesh) which was sown on 1 July, 16 July, 1 August and 16 August. However, mungbean sown on 1 August (683 kg ha^{-1}) recorded maximum grain yield compared to those which were sown on 1 July (557 kg ha^{-1}) and had comparatively lower disease (48.9%) than crop sown on 16 July (56.0%).

Singh *et al*. (2012b) conducted a field experiment at Ludhiana (Pakistan) during kharif season for evaluation of date of sowing for mungbean. The crop was sown on two different dates (last week of July and first week of August). The plant height, number of pods $plant^{-1}$, seeds $plant^{-1}$ and 1000 seed weight was significantly higher when mungbean sown in last week of July as compared to first week of August and resulted higher grain yield.

Sugui and Sugui (2002) conducted an experiment in Ilocos Norte, Philippines during 1998-1999 to determine the best sowing date (15 October, 13 November, 15 January and 15 February) for chickpea cultivars ICCV 2 and ICCV 5. The mean seed yield of two cultivars was highest (1670 kg ha^{-1}) for 15 November planting followed by 15 October (1237 kg ha^{-1}) and 15 December planting (1144 kg ha^{-1}). Seed yield was affected significantly by sowing time.

Suresh and Padaganur (1991) at Dharward evaluated sowing dates of 8 June, 23 June, 8 July and 23 July, and reported that the early sown date had the highest grain yield.

Thakar and Dhingra (1993), Yadav *et al*. (1995) and Rakash *et al*. (2000) stated that seed yield of mungbean cultivars decreased with delay in sowing time. They reported that mungbean crop sown on 15^{th} March had higher number of pods $plant^{-1}$, seeds pod^{-1} and higher grain yield. Raza *et al*. (1995) observed that mungbean yields were higher in crop sown in June and July.

Tiwari and Tripathi (1995) conducted an experiment with chickpea cv. JG 74 that was sown on during 1^{st} and 4^{th} week in November and 2^{nd} week in December. They found decrease in seed yield for delay sowing.

Trivedi and Vyas (2000) stated that kabuli chickpea cv. L 550 and ICCC 32 were sown on 10 November, 20 November and 30 November in a field during winter 1990-91 and 1991-92 at Khargone, Madhya Pradesh. Yield and yield component values decreased with delayed sown crop and were greater in ICCC 32 than L 550.

Yadav *et al*. (1999) reported that forty chickpea genotypes belonging to the kabuli and desi types subdivided into tall and bushy were evaluated under normal and late sowing. Total biomass was reduced by late sowing. Seed yield was reduced in kabuli bushy than desi tall types under late sowing.

2.3 Effect of seed rate on morpho-physiological characters of mungbean

Ball *et al*. (2000) reported that lower seed rate produced lower dry matter per unit area than higher seed rate which resulting lower CGR. Similar result was also reported by Seiter et al in soybean.

Begum (2008) carried out a field experiment with four mungbean cultivars which was grown at 30, 40, 50 and 60 kg seeds ha^{-1}that decreased TDM $plant^{-1}$ and RGR with increased plant density and increased LAI.

Begum (2008) studied the effect of seed rate on LAI and observed that LAI increased with increasing seed rate in mungbean. Similar result was also reported by Tomar et al. (1995).

Chowdhury (1999) carried out an experiment with mungbean at the rate of 15, 20, 25 and 30 kg ha^{-1} and reported that branch number decreased with increasing seed rate.

EI-Dubey *et al*. (2002) reported that LAI increased with increasing seed rate due to the total number of leaves and leaf area per unit increased with increasing seed rate up to certain levels.

Mimber (1993) reported that leaf area $plant^{-1}$ and RGR increased with increasing seed rate but seed yield and yield component $plant^{-1}$decreased with increasing seed rate. Similarly, Tremblay *et al*. (2002) observed that RGR was greater in higher seed rate than lower seed rate.

Panwar and Sirohi (1987) studied the effect of seed rate on grain yield and its components in mungbean and found that DM production ha^{-1} increasing with increasing seed rate whereas DM and yield $plant^{-1}$decreased.

Rahman and Miah (1995) carried out an experiment and observed that the lowest seed rate produced the highest total dry matter plant^{-1}and absolute growth rate while higher seed rate produced higher dry matter per unit area as well as crop growth rate.

Singh and Singh (1995) conducted an experiment with four mungbean varieties at 20, 25 and 30 kg ha^{-1}and found that plant height increased with increasing seed rates. Similar result was also observed by Borah (1994) through conducting an experiment with mungbean genotypes sown at 20, 30 and 35 kg ha^{-1}.

Singh *et al.* (1991) observed the effect of different seed rate on growth and yield of mungbean and reported that most of the growth and physiological parameters decreased with increasing seed rate, while crop growth rate increased with increasing seed rate. Similar result was also reported by Haque (1995) in mungbean.

Singh *et al*. (2003) carried out an experiment to determine the effect of three seed rates i.e. 15, 20 and 25 kg ha^{-1} on mungbean and observed that branch number decreased with increasing seed rate.

Singh *et al*. (2003) reported that the greater LAI was observed in higher seed rate compared to lower seed rate.

Trung and Yoshida (1985) worked with three mungbean cultivars and three seed rates 25, 35 and 45 kg ha^{-1} and found that increasing seed rate increased DM production per unit area but decreased DM plant^{-1}.

2.4 Effect of Seed Rate on Yield Attributes and Yield of Mungbean

Afzal *et al.* (1988) carried out a field experiment on small seeded lentil at the sowing rate of 20, 30 and 40 kg ha^{-1}. They reported that these were no significant differences in seed yield due to different seed rate. They also recommended application of 20 kg seed ha^{-1}.

Agsakalli and Olgum (1999) carried out a field experiment on red lentil cv. Malagrit at the seed rates of 150, 200, 250, 300 and 400 seeds m^2. They reported that the highest yield of 995 kg ha^{-1} was obtained from a sowing rate of 300 seeds m^{-2}.

Ahlawat *et al*. (1983) conducting a field experiment on lentil observed that increasing seed rate from 40 to 60-80 kg ha^{-1} produced a 20% to 50% increase in the seed yields of three lentil cultivars sown on 15 and 30 December, while seeds sown on 1 December had the highest yields with a sowing rate of 40 kg ha^{-1}.

Anonymous (1982) reported that the highest yield was obtained by broadcasting sowing with 46 and 36 kg ha^{-1}in case of black gram and mung bean respectively. It was also noted that the yield increased progressively with the rise in seed rate.

Borah (1994) conducted a field experiment to evaluate the performance of green gram genotypes under different seed rates (20, 30 and 35 kg ha^{-1}) during summer season and found that the highest seed yield was recorded in 35 kg ha^{-1}. Similar result was also reported by Singh *et al*. (1991) that seed yields were 0.32, 0.48 and 0.55 t ha^{-1} for 16, 24 and 32 kg ha^{-1} seed rates, respectively.

Borah (1994) observed that number of pods plant decreased with increasing seed rate but total number of pods per unit area increased with increasing seed rate up to certain levels. Similar result was also reported by EI-Habbasha *et al*. (1996) in mungbean.

Borah (1994) reported that number of seeds pod^{-1} decreased with increasing seed rateup to certain levels. Similar result was also reported by EI-Habbasha et al. (1996) in mungbean.

Chowdhury (1999) found that seed rate had effect of grain size and reported that 1000 grain weight decreased with increasing seed rate in mungbean.

Chowdhury (1999) reported that the greater number of seeds pod^{-1} was observed in lower seed rates of 20 kg ha^{-1} over 25 and 30 kg ha^{-1}.

Dwivedi *et al*. (1997) conducted a field experiment during winter season of 1990 and 1991 on lentil to evaluate effect of seed rate. They reported that higher seed rate (40kg ha^{-1}) gave significantly higher seed yield than lower seed rate (30 and 35 kg ha^{-1}).

EI-Nagar and Galal (1997) conducted a field experiment on lentil cv. Giza 9 during 1993-95 at Assuit, Egypt. They used three seed rates at 30, 45 and 60 kg seed feddan^{-1}. They reported that seed yield increased with increasing seed rate. Mean seed yield was highest with the rate of 60 kg seed feddan^{-1} (1.28 t feddan^{-1}).

Hasan (2000) and Singh *et al.* (1991) observed that seed rates had effect on pod size and mentioned that pod length decreased with increasing seed rate in mungbean.

Hasan (2000) conducted a field experiment with mungbean to determine the optimum seed rate i.e. 20, 25 and 30 kg ha^{-1} and reported that 25 kg ha^{-1} produced the highest yield.

Hasan (2000) observed that 1000 grain weight was not influenced by seed rate.

Hasan (2000) reported that the different seed rates influenced the pod production significantly, the greater number of pods plant^{-1} was observed in lower seed rates of 20 kg ha^{-1} over 25 and 30 kg ha^{-1}.

Jain *et al*. (1996) conducted a field experiment during 1984-85 in soybean. They used three seed rates 80, 90 and 100 kg ha^{-1}. They reported that mean seed yield increased with increase in seed rate. Mean seed yield were 1.79, 1.96 and 2.06 t ha^{-1} at the 80, 90 and 100 kg ha^{-1} seed rate.

Karim *et al.* (1987) carried out an experiment on lentil at central research farm, BARI, Joydebpur, Gazipur. They reported that grain yield was not affected significantly by the different seed rates.

Khare *et al*. (1991) reported that sowing rates of 20, 30, 40 kg seed ha^{-1} produced seed yields of 0.91, 1.06 and 0.96 t ha^{-1} respectively. The highest seed yield 1.24 t ha^{-1} and net returns were obtained at the 30 kg ha^{-1} seed rate.

Kntar *et al*. (1994) sown lentil at seed rate of 50, 62, 85 and 125 kg seed ha^{-1}. It was observed that the seed yields increased from 0.94 to 1.12 t ha^{-1} with increase in sowing time.

Krarup (1984) carried out a field experiment on lentil and observed that increasing seed rate linearly decreased average yield $plant^{-1}$ through reducing the number of branches and pods $plant^{-1}$. Seed rate did not affect the number of seeds pod^{-1}.

Malik and Singh (1996) conducted an experiment with three cultivars of lentil and three seed rates of 40, 50 and 60 kg seed ha^{-1}. They observed that seed yield increased with increase in seed rate.

Rahman *et al*. (2016) conducted an experiment to determine the optimum seed rate of three mungbean varieties (BARI Mung-6, Binamung-5 and Binamung-8) which were tested against five seeding rates (20, 25, 30, 35 and 40 kg ha^{-1}). The highest number of pods $plant^{-1}$ (40.73), pod length (8.08 cm), seed yield (888.17 kg ha^{-1}) and stover yield (1874.25 kg ha^{-1}) were obtained from BINA mung-5 Whereas the highest number of seeds pod^{-1} (9.68) and 1000-seed weight (37.14) were obtained from BARI Mung-6 at 35 kg ha^{-1}. The highest number of $pods^{-1}$ (40.3) was counted from 20kg ha^{-1} and the lowest value (33.0) was from 40 kg ha^{-1}.

Researchers from BARI (1985) conducted experiments on lentil L-5 with three seed rates (20, 30 and 40 kg ha^{-1}) at Ishurdi, Jashore and Joydebpur and found that the highest seed rate 40 kg ha^{-1} decreased the number of pods $plant^{-1}$ with no significant increase in the yield.

Researchers from BINA (1998) conducted an experiment with mungbean to know the effect of seed rate on yield and yield related attributes and reported that seed rate had slight effect of pod size. The pod length was greater in low seed rate (25 kg ha^{-1}) than in higher seed rate (30-40 kg ha^{-1}) but non-significant difference with each other. Similar result was also reported by Singh *et al*. (1985)

who reported that pod length was greater in lower seed rate than in higher seed rates in mungbean.

Rizk *et al.* (1986) conducted an experiment on lentil cv Giza 9 during the 1980-81. They used three seed rates at 40, 60 and 80 kg ha^{-1}. They found that increase in seed rate to 80 kg ha^{-1} gave significant increase in 1000 seed weight and straw yield ha^{-1}.

Roy and Rahman (1992), grown two lentil cultivars (lentil-5 and lentil-81124) under 3 sowing rates (10, 20 and 30 kg seed ha^{-1}) in a field trial. They observed that seed yield increased linearly with increasing sowing rates. Apparent harvest index was influenced only by sowing rates.

Sekhon *et al* (1994) conducted an experiment with three seed rates of 22.5, 30 and 37.5 kg ha^{-1}. Sowing rate has no significant effect on seed yield. However, seed yields of lentil ranged from 1.04 to 1.20 t ha^{-1} due to seed rate of 45 to 75 kg ha^{-1} in year two.

Sharma (1996) conducted a field trials on lentil *cv*. Pant L 639 where seeds sown at the rate of 20, 40 and 60 kg ha^{-1}. Average seed yield increased with increase in seed rate.

Sharma and Singh (1986) conducted an experiment on lentil *cv*. 1.9-12 during the winter season of 1975-77. They found that grain yield increased with the increase in seed rate up to 40 kg ha^{-1}. Further increase in seed rate from 40 to 60 kg ha^{-1} didn't affect the yield significantly. The lower seed rate 20 kg ha^{-1} was not high enough to compensate the overall advantage due to more number of plants under high seed rate.

Sharma and Singh (1994) conducted a field experiment during 1982-84 on lentil *cv*. Pant 639 was sown at 20, 40 and 60 kg seed ha^{-1}. They reported that seed yield increased with increased sowing rate.

Shoaib (1992) using five seed rates (160, 220, 340 and 400 plants m^{-2}) of lentil at new Delhi during 1984-86 found that seed yield increased as plant density increased. The highest yield was 2.25 t ha^{-1} in the 1986-87 growing season at a seed density of 400 m^{-2}.

Siddique *et al*. (1998) conducted a field experiment on lentil during 1994-95. They used six seed rates (20, 40, 60, 80, 100 and 120 kg ha^{-1}) and reported that biological yield was (236g m^{-2}) increased up to 60 kg ha^{-1} and harvest index was (36%) increased up to 40 kg seed ha^{-1} and 1000 seed weight (3.56g) was increased up to 40 kg ha^{-1}.

Singh and Singh (1995) conducted a field experiment in Patnagar, Uttar Pradesh, India using four cultivars of mungbean sown at 20, 25 and 30 kg ha^{-1} and found that yield increased with increasing seed rate due to increase number of pod production per unit area.

Singh and Singh (1995) conducted a field trial during summer 1992 on mungbean. They used three seed rates 20, 25 and 30 kg seed ha^{-1}. They stated that yield of mungbean increased with increase in seed rate. The highest seed yield 1.32 t ha^{-1} was obtained at the rate of 30 kg ha^{-1}.

Singh and Singh (1995) observed that the highest number of pods $plant^{-1}$ at low seed rate than those of higher seed rates.

Singh and Singh (1995) reported that seed rates had no great influence on pod length in mungbean.

Singh *et al.* (1985) observed that different seed rates influenced the seed yield significantly. The higher grain yield obtained with 50 kg ha^{-1} over 20, 30 and 40 kg ha^{-1} could be attributed to more numbers of plants per unit area.

Singh *et al*. (1991) carried out a field experiment to study the effect of seed rate on yield of green gram. They reported that plant population increased with increasing seed rate and seed yields were 0.32, 0.48 and 0.55 t ha^{-1} with 16, 24 and 32 kg ha^{-1} seed rates respectively.

Singh *et al*. (1994) observed that seed yield of lentil was significantly higher with the seed rate of 60 kg ha^{-1} over the seed rate of 40 kg ha^{-1}.

Singh *et al*. (2003) carried out an experiment to determine the effect of three seed rates i.e. 15, 20 and 25 kg ha^{-1} on mungbean and reported that seed rate had no significant influence on pod length. Similar result was reported by Chowdhury (1999) in mungbean.

Singh *et al*. (2003) set up an experiment to determine the effects of seed rates i.e. 15, 20 and 25 kg ha^{-1} on yield and yield attributes in mungbean and reported that seed yield increased with increasing seed rate in mungbean.

Tomar and Singh (1991) reported that lentil gave the highest yield with a sowing rate of 70 kg seed ha^{-1}.

Tomar and Tiwari (1996) and BINA (1998) reported that seed rate had no significant effect on 1000 seed weight in mungbean.

Tomar *et al*. (1995) observed that the highest seed yield of mungbean wasrecorded at a seed rate of 20 kg ha^{1} and was decreased with increasing seed rate (30 or 40 kg ha^{-1}) due to lesser number of pods plant in mungbean cv. K-851. Further, Tomar *et al* (1996) worked with other variety to determine the effect of seed rate (20, 30 and 40 kg ha^{-1}) on seed yield and observed that seed yield and net return of mungbean was higher with seed rate of 40 kg ha^{-1} than those with seed rate of 20 and 30 kg ha^{-1} despite pods $plant^{-1}$ was higher in 20 and 30 kg ha^{-1}.

Tomar *et al*. (1996) used three seed rates 20, 30 and 40 kg ha^{-1} in a field trial in the 1986-87 summer seasons.They reported that seed yield and harvest index in mungbean were higher with the seed rate of 40 kg ha^{-1} but the branch number were highest with 20 kg seeds ha^{-1}

Venkateswarlu and Ahlawat (1993) carried a field trial with lentil cv. Part L 1406. Seed rates of 40 and 60 kg seed ha^{-1} was sown and observed that seed yield increased slightly with increase in sowing rate.

Watt and Singh (1992) investigated optimum seed rate and observed the seed yield of lentil increased up to 60 kg seed ha^{-1} and then decreased with higher seed rate.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the field of Regional Pulse Research Centre, Madaripur, Bangladesh during the period from March to June 2018 to evaluate the “Influence of sowing time and seed rate on the growth and yield of BARI Mung-6”. This chapter presents a brief statement of materials and methods that were used in conducting the experiment along with statistical analysis.

3.1 Experimental site

The research work was carried out in the research field of Regional Pulse Research Centre, Madaripur (90°12´ E longitude and 23°17´ N latitude) with an elevation of 10m from the sea level under the Agro-ecological Zone, Low Ganges River Floodplain (AEZ 12) (Appendix I).

3.2 Climate

The experimental site was geographically located under the subtropical climate, characterized by three distinct seasons. Meteorological data related to the temperature, relative humidity, maximum rainfall was recorded during the period of the experiment from the Bangladesh Meteorological Department, Sher-e-Bangla Nagar, presented in Appendix II.

3.3 Planting materials

BARI Mung-6, a high yielding variety of mungbean was used in this study. It was released by Bangladesh Agricultural Research Institute, Joydebpur, Gazipur in 2003. Plant height ranges from 40 to 45 cm, photo insensitive, short lifespan (75-80 days) and can be grown in Kharif-I, Kharif-II and late Rabi. Its yield potentially is about 1.62 t ha^{-1} under proper management. The variety is resistant to *cercospora* leaf spot and yellow mosaic virus.

3.4 Experimental design and layout

The experiment was laid out in Split Plot Design with four replications. The total number of plots was 48, each measuring 2.4m×3.0m (7.2m^2). Row to row and plant to plant spacing of the plot was 30cm and 10cm, respectively. The layout of the experiment is presented in Appendix III.

3.5 Treatments

The experiment comprised of two factors:

Factor A: Three sowing time i.e.

i. 1 March
ii. 10 March and
iii. 20 March

Factor B: Four seed rates i.e.

i. 20 kg ha^{-1}
ii. 25 kg ha^{-1}
iii. 30 kg ha^{-1} and
iv. 35 kg ha^{-1}

3.6 Land preparation

The plot selected for the experiment was prepared thoroughly by ploughing with a power tiller on 28 February, 2018. Ploughing and cross ploughing were done five times followed by laddering to obtain a good tilth. Finally, experimental plot was divided into unit plots following the design of experiment.

3.7 Fertilizer application

The plot was fertilized with Urea, TSP, MP, Gypsum@ 40, 80, 30, 50 kg ha^{-1}. All the fertilizers were applied at basal doses during land preparation.

3.8 Seed sowing

Seeds were sown in research field at different sowing times i.e. 1 March, 10 March and 20 March as per treatment. Seeds were placed at about 3-4cm depth from the soil surface maintaining 30 cm row to row distance.

3.9 Intercultural operations

Different intercultural operations were done as per requirements. First weeding was done at 20 days and second weeding was done at 45 days after sowing. Irrigation was given when and as necessary. Ripcord 10 EC @ 1 ml L^{-1} was applied two times against fruit and shoot borer.

3.10 Crop sampling and data collection

3.10.1 Growth parameters

To obtain data on growth characteristics, five plants from each plot were selected as random and were tagged for data collection. The plants were separated into leaves, stems and roots and the corresponding dry weights were recorded after oven drying at 80±2°C for 72 hours. The growth analyses like crop growth rate, relative growth rate, net assimilation rate were carried out following the formulae of Hunt (1978).

i. Crop growth rate (CGR): Rate of dry matter production per unit of time per unit area.

   i.e. CGR= $\frac{1}{A} \times \frac{W2-W1}{T2-T1}$ g m^{-2} day^{-1}

   Where $W_1$and $W_2$are the dry matter (DM) at time T_2 and T_1 respectively.

   A= ground area

ii. Relative growth rate (RGR): Rate of dry matter production per unit of dry matter per unit of time.

   i.e. RGR= $\frac{\ln W2 - \ln W1}{T2-T1}$ g g^{-1} day^{-1}

iii. Net assimilation rate (NAR): Rate of dry matter production per unit of total leaf area per unit of time.

i.e. $NAR = \frac{W2 - W1}{T2 - T1} \times \frac{logeA2 - logeA1}{A2 - A1}$ g m^{-2} d^{-1}

Where W_2 and W_1 are plant dry weights at times T_1 and T_2, $\log_e A_1$ and $\log_e A_2$ are the natural logs of leaf areas A_1 and A_2.

3.11 Harvesting

Five randomly selected crops from each plot were cut at the ground level with sickle and tagged carefully for recording morphological and yield contributing data. Then the pods were harvested manually of each plot regarding their sowing time and the whole harvesting procedure was completed at 7 May, 2019. At last, all of the harvested pods were weighed carefully and kept apart in properly tagged gunny bags.

3.12Data Collection

Data were collected on the following parameters-

3.12.1 Morpho-physiological characters

i. plant height
ii. Number of branches plant^{-1}
iii. Leaf area index
iv. Total dry matter plant^{-1}

3.12.2 Yield contributing characters and yield

i. Number of pods plant^{-1}
ii. Number of seeds pod^{-1}
iii. Pod length (cm)
iv. 100 seed weight (g)
v. Seed yield (t ha^{-1})
vi. Stover yield (t ha^{-1})
vii. Biological yield (t ha^{-1})
viii. harvest index (%)

3.13 Data collection procedure

3.13.1 Morphological characters

i. **Plant height**

Five plants were randomly selected from each plot and measured from base of the plant to the tip of the main shoot with the help of scale and was expressed in centimeters but height data were taken 30, 40, 50 DAS and at harvest.

ii. **Number of branches plant^{-1}**

The branches were counted from the 5 randomly selected plant at 30, 40 and 50 DAS respectively and average branches plant^{-1} was calculated.

iii. **Leaf area index**

The leaf area of each sample was measured by LICOR automatic leaf area meter (LI 2000 USA).

iv. **Total dry matter plant^{-1}**

The total dry matter was collected from summation of stem, root, leaves, pod dry weight per plant.

3.13.2 Yield contributing characters and yield

i. **Number of pods plant^{-1}**

Pods of five randomly selected plants were counted from each replication and then the average number of pods plant^{-1} was recorded.

ii. **Number of seeds pod^{-1}**

The number of seeds pod^{-1}was calculated from five randomly selected plants. Data were taken from 30 pods of each replication and recorded the average data.

iii. **Pod length (cm)**

The length of randomly selected 10 pods from each replication were measured and then divided by ten to get single pod length in centimeter.

iv. **100 seed weight (g)**

One hundred clean dried seed were taken from the seed stock and weighed by using digital electronic balance and expressed in gram after harvest.

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

The plants of the 1.0 m^2 area plot were harvested for measuring seed yield and then the plot wise seed yield was converted into t ha^{-1}.

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

The stover of the harvested 1 m^2 crop in each plot was sun dried to get a Type equation here.constant weight and then the plot wise stover yield was converted to t ha^{-1}.

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

The total of seed yield and stover yield is termed as biological yield and it was determined by using the following formula:

biological yield (t ha^{-1}) = seed yield (t ha^{-1})+ stover yield (t ha^{-1})

viii. **Harvest index (%)**

Harvest index was measured from the ratio of grain yield to biological yield and expressed in percentage. It was determined by using following formula:

$$\text{Harvest index (\%)} = \frac{\text{grain yield}}{\text{biological yield}} \times 100$$

ix. **Grain filling pattern**

The data was recorded of grain filling pattern at an interval of three days starting from 3 DAF (Days after flowering) up to grain maturity at different sowing time and seed rate.

3.14 Statistical analysis

The data recorded for different parameters were statistically analyzed with the help of MSTAT-C software to determine the significant dissimilation among several treatments on growth, yield and yield contributing characters of mungbean. The collected data were computed and analyzed statistically using the analysis of variance (ANOVA) technique and the mean differences were adjusted by Least Significance Difference (LSD) test at 5% level of probability (Gomez & Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

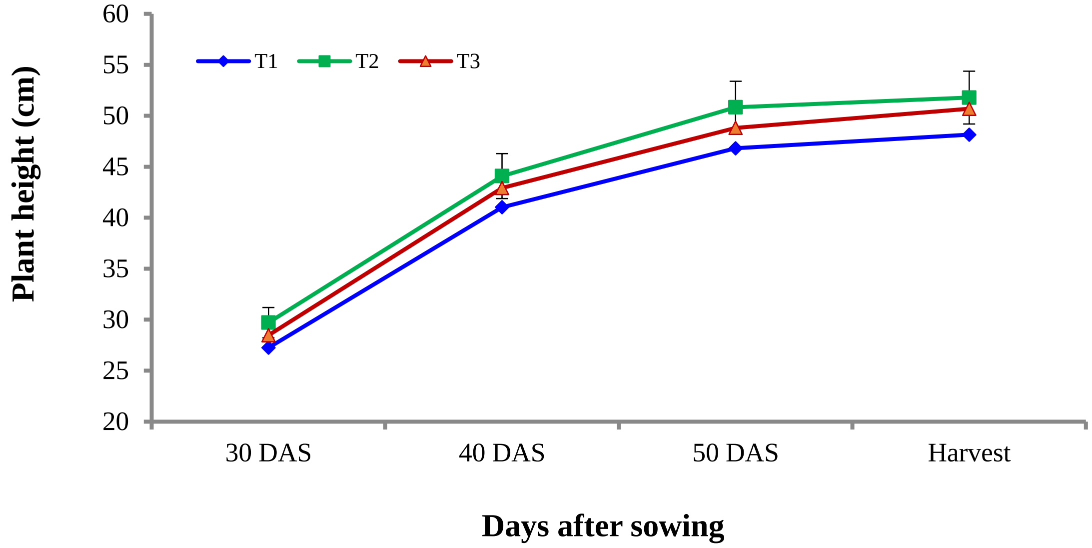
The experiment was conducted to assess the influence of sowing time and seed rate on the growth and yield of BARI Mung-6. The analyses of variance (ANOVA) of the data on different yield contributing characters and yield are presented in Appendix IV-XII. The findings have been presented and discussed with the help of different table and graphs with possible interpretations was given under the following headings and sub-headings:

4.1 Plant height

Plant height of BARI Mung-6 at 30, 40, 50 DAS (days after sowing) and at harvest showed statistically significant differences due to different sowing time (Figure 1). The figure indicated that plant height of mungbean showed an increasing trend with the advances of growth stages. The rate of increase was much higher in the early stage 15 DAS, 30 DAS after that the rate of increase was much slower. However, at 30, 40, 50 DAS and harvest, the tallest plant (29.71, 44.09, 50.84 and 51.79 cm, respectively) was observed from T_2 (Sowing on 10 March, 2018) which was statistically similar (28.47, 42.92, 48.81 and 50.69 cm, respectively) to T_3 (Sowing on 20 March, 2018), whereas the shortest plant (27.25, 41.03, 46.81 and 48.15 cm, respectively) was found from T_1 (Sowing on 01 March, 2018). Miah *et al*. (2009) reported that 2^{nd} March sowing enhanced the vegetative growth of mungbean that might be due to suitable temperature prevailing accompanied by higher soil moisture content due to sufficient rainfall in April. Jahan and Adam (2012) found that 15 April sown crop had maximum plant height (68.4 cm) of mungbean.

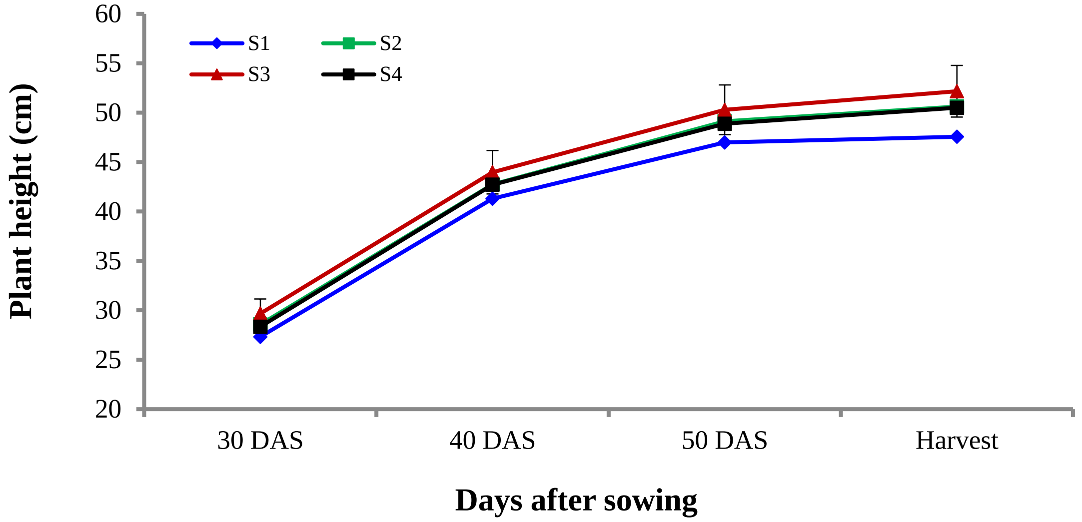
Statistically significant variation was recorded in terms of plant height of BARI Mung-6 at 30, 40, 50 DAS and harvest due to different seed rate (Figure 2). At 30, 40, 50 DAS and harvest, the tallest plant (29.67, 43.97, 50.29 and 52.17 cm, respectively) was recorded from S_3 (30 kg seeds ha^{-1}) which was statistically similar (28.57, 42.74, 49.12 and 50.62 cm, respectively) to S_2 (25 kg seeds ha^{-1})

and (28.34, 42.71, 48.88 and 50.50 cm, respectively) to S_4 (35 kg seeds ha^{-1}), while the shortest plant (27.32, 41.29, 46.99 and 47.56 cm, respectively) was observed from S_1 (20 kg seeds ha^{-1}).



T_1= Sowing on 01 March, 2018; T_2= Sowing on 10 March, 2018
T_3= Sowing on 20 March, 2018

Figure 1. Effect of sowing time on plant height of BARI Mung-6. ($LSD_{0.05}$ = 1.553, 2.120, 3.059 and 2.827 for 30, 40, 50 DAS and at harvest, respectively).



S_1= 20 kg seeds ha^{-1}; S_2= 25 kg seeds ha^{-1}
S_3= 30 kg seeds ha^{-1}; S_4= 35 kg seeds ha^{-1}

Figure 2. Effect of seed rate on plant height of BARI Mung-6. ($LSD_{0.05}$ = 1.560, 1.709, 2.296 and 2.756 for 30, 40, 50 DAS and at harvest).

Combined effect of sowing time and seed rate showed statistically significant differences on plant height of BARI Mung-6 at 30, 40, 50 DAS and harvest (Table 1). At 30, 40, 50 DAS and harvest, the tallest plant (32.77, 46.79, 53.48 and 55.25 cm, respectively) was observed from T_2S_3 (Sowing on 10 March, 2018 and 30 kg seeds ha^{-1}) and the shortest plant (26.48, 39.15, 43.39 and 44.77 cm, respectively) was recorded from T_1S_1 (Sowing on 01 March, 2018 and 20 kg seeds ha^{-1}) treatment combination.

4.2 Number of branches plant^{-1}

Number of branches plant^{-1} of BARI Mung-6 at 30, 40, 50 DAS and harvest showed statistically significant differences due to different sowing time (Table 2). At 30, 40, 50 DAS and harvest, the maximum number of branches plant^{-1} (1.80, 3.54, 4.53 and 4.65, respectively) was recorded from T_2 which was statistically similar (1.70, 3.44, 4.39 and 4.46, respectively) to T_3, while the minimum number (1.66, 3.26, 4.26 and 4.34, respectively) was observed from T_1. Mian *et al*. (2002) reported that number of branches plant^{-1} were significantly influenced by the dates of sowing in mungbean which support the present findings.

Different seed rate varied significantly in terms of number of branches plant^{-1} of BARI Mung-6 at 30, 40, 50 DAS and harvest (Table 2). The table indicates that at 30, 40, 50 DAS and harvest, the maximum number of branches plant^{-1} (1.80, 3.52, 4.60 and 4.73, respectively) was found from S_3 which was statistically similar (1.72, 3.45, 4.38 and 4.45, respectively) to S_4, whereas the minimum number (1.67, 3.33, 4.22 and 4.30, respectively) was recorded from S_1, which was statistically similar (1.70, 3.35, 4.37 and 4.45, respectively) to S_2.

Statistically significant variation was recorded due to the combined effect of sowing time and seed rate on number of branches plant^{-1} of BARI Mung-6 at 30, 40, 50 DAS and harvest (Table 3). It can be inferred from the result that at 30, 40, 50 DAS and harvest, the maximum number of branches plant^{-1} (1.95, 3.70, 4.90 and 5.10, respectively) was recorded from T_2S_3, while the minimum number (1.55, 3.05, 3.85 and 3.95, respectively) was observed from T_1S_1 treatment combination.

Table 1. Combined effect of sowing time and seed rate on plant height of BARI Mung-6 at different days after sowing (DAS) and at harvest

Treatments	Plant height (cm) at			
	30 DAS	40 DAS	50 DAS	Harvest
T_1S_1	26.48 c	39.15 d	43.39 e	44.77 e
T_1S_2	27.34 bc	40.67 cd	46.96 c-e	48.01 c-e
T_1S_3	27.13 bc	42.17 b-d	47.94 b-d	48.07 c-e
T_1S_4	28.03 bc	42.12 b-d	48.97 b-d	51.74 a-d
T_2S_1	28.27 bc	41.86 b-d	49.81 a-d	49.76 b-e
T_2S_2	28.16 bc	42.71 bc	48.71 b-d	49.97 a-e
T_2S_3	32.77 a	46.79 a	53.48 a	55.25 a
T_2S_4	29.63 b	45.00 ab	51.34 a-c	52.19 a-d
T_3S_1	27.22 bc	42.87 bc	47.77 b-d	48.15 c-e
T_3S_2	30.20 ab	44.83 ab	51.70 ab	53.88 ab
T_3S_3	29.12 bc	42.94 bc	49.46 a-d	53.19 a-c
T_3S_4	27.35 bc	41.01 cd	46.34 de	47.56 de
$LSD_{(0.05)}$	2.70	2.96	3.97	4.77
CV(%)	6.54	4.78	5.62	6.55

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

T_1= Sowing on 01 March, 2018
T_2= Sowing on 10 March, 2018
T_3= Sowing on 20 March, 2018

S_1= 20 kg seeds ha^{-1}
S_2= 25 kg seeds ha^{-1}
S_3= 30 kg seeds ha^{-1}
S_4= 35 kg seeds ha^{-1}

Table 2. Effect of sowing time and seed rate on number of branches plant^{-1} of BARI Mung-6 at different days after sowing (DAS) and at harvest

Treatments	Number of branches plant^{-1} at			
	30 DAS	40 DAS	50 DAS	Harvest
Sowing time				
T_1	1.66 b	3.26 b	4.26 b	4.34 b
T_2	1.80 a	3.54 a	4.53 a	4.65 a
T_3	1.70 ab	3.44 ab	4.39 ab	4.46 ab
$LSD_{(0.05)}$	0.095	0.197	0.169	0.214
CV(%)	6.37	6.68	4.44	5.51
Seed rate				
S_1	1.67 b	3.33 b	4.22 b	4.30 b
S_2	1.70 b	3.35 b	4.37 b	4.45 b
S_3	1.80 a	3.52 a	4.60 a	4.73 a
S_4	1.72 ab	3.45 ab	4.38 ab	4.45 ab
$LSD_{(0.05)}$	0.08	0.13	0.23	0.21
CV(%)	5.94	4.74	6.34	5.80

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

T_1= Sowing on 01 March, 2018

T_2= Sowing on 10 March, 2018

T_3= Sowing on 20 March, 2018

S_1= 20 kg seeds ha^{-1}

S_2= 25 kg seeds ha^{-1}

S_3= 30 kg seeds ha^{-1}

S_4= 35 kg seeds ha^{-1}

Table 3. Combined effect of sowing time and seed rate on number of branches plant^{-1} of BARI Mung-6 at different days after sowing (DAS) and at harvest

Treatments	Number of branches plant^{-1} at			
	30 DAS	40 DAS	50 DAS	Harvest
T_1S_1	1.55 c	3.05 d	3.85 c	3.95 c
T_1S_2	1.65 bc	3.15 cd	4.40 b	4.45 b
T_1S_3	1.70 bc	3.45 ab	4.50 ab	4.60 b
T_1S_4	1.75 b	3.40 bc	4.30 b	4.35 b
T_2S_1	1.75 b	3.50 ab	4.40 b	4.50 b
T_2S_2	1.80 b	3.50 ab	4.40 b	4.50 b
T_2S_3	1.95 a	3.70 a	4.90 a	5.10 a
T_2S_4	1.70 bc	3.45 ab	4.40 b	4.50 b
T_3S_1	1.70 bc	3.45 ab	4.40 b	4.45 b
T_3S_2	1.65 bc	3.40 bc	4.30 b	4.40 b
T_3S_3	1.75 b	3.40 bc	4.40 b	4.50 b
T_3S_4	1.70 bc	3.50 ab	4.45 b	4.50 b
$LSD_{(0.05)}$	0.14	0.23	0.40	0.37
CV(%)	5.94	4.74	6.34	5.80

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

T_1= Sowing on 01 March, 2018

T_2= Sowing on 10 March, 2018

T_3= Sowing on 20 March, 2018

S_1= 20 kg seeds ha^{-1}

S_2= 25 kg seeds ha^{-1}

S_3= 30 kg seeds ha^{-1}

S_4= 35 kg seeds ha^{-1}

4.3 Dry matter content plant^{-1}

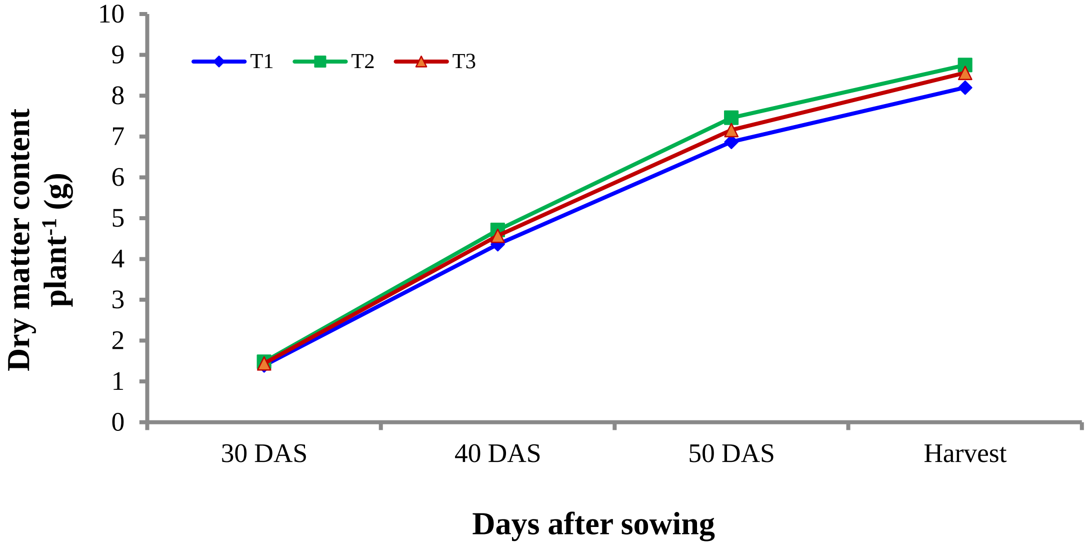
Different sowing time varied significantly in terms of dry mater content of BARI Mung-6 at 30, 40, 50 DAS and harvest (Figure 3). The figure shows a steady increasing trend of dry matter content plant^{-1} with the advances of growth stages and the highest increase was found at harvest time irrespective of sowing time. However, at 30, 40, 50 DAS and harvest, the highest dry matter content plant^{-1} (1.48, 4.71, 7.46 and 8.75 g, respectively) was observed from T_2 which was statistically similar (1.44, 4.57, 7.16 and 8.56 g, respectively) to T_3 and the lowest (1.39, 4.36, 6.87 and 8.20 g, respectively) from T_1. Jahan and Adam (2012) found that 15 April sown crop had maximum total dry matter plant^{-1} (17.99 g).

Statistically significant variation was found on dry matter content plant^{-1} of BARI Mung-6 at 30, 40, 50 DAS and harvest due to different seed rate (Figure 4). It can be inferred from the figure that irrespective of seed rates, dry matter content plant^{-1} increased radically with the advances of growth stages. At 30, 40, 50 DAS and harvest, the highest dry matter content plant^{-1} (1.47, 4.69, 7.40 and 8.79 g, respectively) was found from S_3 which was statistically similar (1.44, 4.54, 7.20 and 8.55 g, respectively) to S_2 and (1.44, 4.54, 7.17 and 8.54 g, respectively) to S_4, while the lowest (1.40, 4.41, 6.88 and 8.15 g, respectively) was found from S_1.

Dry matter content plant^{-1} of BARI Mung-6 at 30, 40, 50 DAS and harvest showed statistically significant differences due to the combined effect of sowing time and seed rate (Table 4). At 30, 40, 50 DAS and harvest, the highest dry matter content plant^{-1} (1.55, 4.99, 7.89 and 9.25 g, respectively) was found from T_2S_3, whereas the lowest (1.33, 4.17, 6.38 and 7.78 g, respectively) was recorded from T_1S_1 treatment combination.

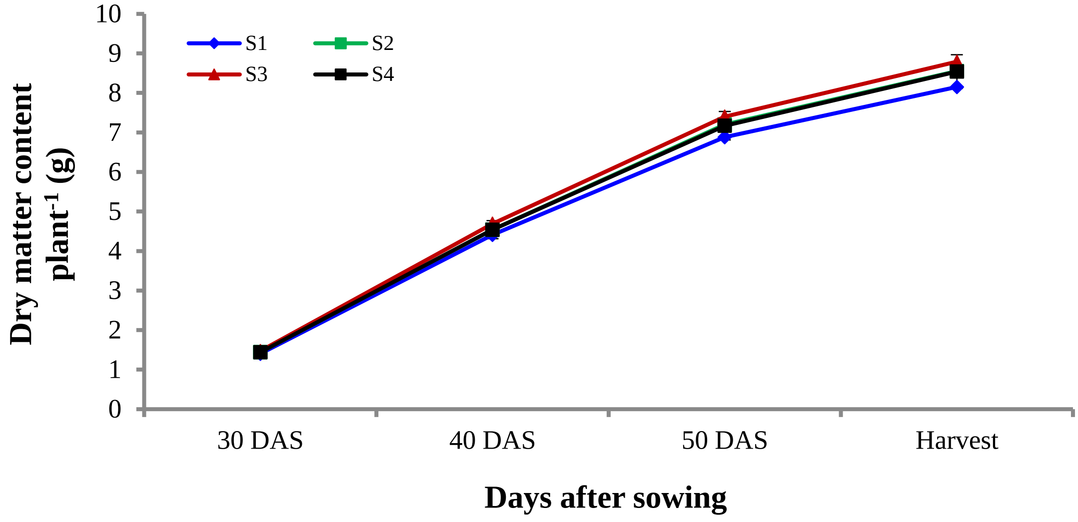
4.4 Leaf area

Leaf area of BARI Mung-6 at 30, 40, 50 DAS and harvest showed statistically significant differences due to different sowing time (Table 5). At 30, 40, 50 DAS and harvest, the highest leaf area (14.83, 24.00, 31.56 and 34.88 cm^2, respectively) was obtained from T_2 which was statistically similar (14.60, 23.41, 31.09 and 34.59 cm^2, respectively) to T_3, whereas the lowest (14.22, 22.06, 29.50 and 33.57 cm^2, respectively) was recorded from T_1.



T_1= Sowing on 01 March, 2018; T_2= Sowing on 10 March, 2018
T_3= Sowing on 20 March, 2018

Figure 3. Effect of sowing time on dry matter content plant^{-1} of BARI Mung-6. (LSD$_{0.05}$ = 0.061, 0.215, 0.662 and 3.83 for 30, 40, 50 DAS and at harvest, respectively).



S_1= 20 kg seeds ha^{-1}; S_2= 25 kg seeds ha^{-1}

S_3= 30 kg seeds ha^{-1}; S_4= 35 kg seeds ha^{-1}

Figure 4. Effect of seed rate on dry matter content plant^{-1} of BARI Mung-6. ($LSD_{0.05}$ = 0.046, 0.172, 0.323 and 0.395 for 30, 40, 50 DAS and at harvest, respectively).

Table 4. Combined effect of sowing time and seed rate on dry matter content (g) of BARI Mung-6 at different days after sowing (DAS) and at harvest

Treatments	Dry matter content plant^{-1} (g) at			
	30 DAS	40 DAS	50 DAS	Harvest
T_1S_1	1.33 d	4.17 d	6.38 d	7.78 d
T_1S_2	1.39 cd	4.32 cd	6.90 b-d	8.15 cd
T_1S_3	1.43 bc	4.50 b-d	7.05 bc	8.21 b-d
T_1S_4	1.42 bc	4.45 b-d	7.14 bc	8.67 a-c
T_2S_1	1.42 b-d	4.49 b-d	7.27 bc	8.43 b-d
T_2S_2	1.44 bc	4.56 bc	7.18 bc	8.51 a-d
T_2S_3	1.55 a	4.99 a	7.89 a	9.25 a
T_2S_4	1.49 ab	4.79 ab	7.52 ab	8.80 a-c
T_3S_1	1.44 bc	4.58 bc	7.00 bc	8.22 b-d
T_3S_2	1.49 ab	4.74 ab	7.53 ab	8.98 ab
T_3S_3	1.44 bc	4.59 bc	7.27 bc	8.90 a-c
T_3S_4	1.39 cd	4.38 cd	6.83 cd	8.14 cd
$LSD_{(0.05)}$	0.08	0.29	0.56	0.68
CV(%)	3.97	4.49	5.39	5.53

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

T_1= Sowing on 01 March, 2018

T_2= Sowing on 10 March, 2018

T_3= Sowing on 20 March, 2018

S_1= 20 kg seeds ha^{-1}

S_2= 25 kg seeds ha^{-1}

S_3= 30 kg seeds ha^{-1}

S_4= 35 kg seeds ha^{-1}

Table 5. Effect of sowing time and seed rate on leaf area plant^{-1} (cm^2) of BARI Mung-6 at different days after sowing (DAS) and at harvest

Treatments	Leaf area (cm^2)			
	30 DAS	40 DAS	50 DAS	Harvest
Sowing time				
T_1	14.22 b	22.06 b	29.50 b	33.57 b
T_2	14.83 a	24.00 a	31.56 a	34.88 a
T_3	14.60 ab	23.41 ab	31.09 a	34.59 a
$LSD_{(0.05)}$	0.37	1.44	1.34	0.84
CV(%)	3.01	7.21	5.07	2.83
Seed rate				
S_1	14.34 b	22.43 b	29.93 b	33.53 b
S_2	14.53 ab	23.30 ab	30.78 ab	34.39 ab
S_3	14.82 a	23.79 a	31.57 a	35.19 a
S_4	14.51 ab	23.11 ab	30.59 ab	34.30 ab
$LSD_{(0.05)}$	0.31	0.83	1.05	1.12
CV(%)	2.57	4.32	4.10	3.92

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

T_1= Sowing on 01 March, 2018
T_2= Sowing on 10 March, 2018
T_3= Sowing on 20 March, 2018

S_1= 20 kg seeds ha^{-1}
S_2= 25 kg seeds ha^{-1}
S_3= 30 kg seeds ha^{-1}
S_4= 35 kg seeds ha^{-1}

Different seed rate showed statistically significant differences in terms of leaf area of BARI Mung-6 at 30, 40, 50 DAS and harvest (Table 5). Data presented in table shows that at 30, 40, 50 DAS and harvest, the highest leaf area (14.82, 23.79, 31.57 and 35.19 cm^2, respectively) was attained from S_3 which was statistically similar (14.53, 23.30, 30.78 and 34.39 cm^2, respectively) to S_2 and (14.51, 23.11, 30.59 and 34.30 cm^2, respectively) to S_4, while the lowest (14.34, 22.43, 29.93 and 33.53 cm^2, respectively) from S_1.

Statistically significant variation was recorded in terms of leaf area of BARI Mung-6 at 30, 40, 50 DAS and harvest due to the combined effect of different levels of sowing time and seed rate (Table 6). At 30, 40, 50 DAS and harvest, the highest leaf area (15.30, 25.18, 33.15 and 36.77 cm^2, respectively) was obtained from T_2S_3 and the lowest (13.91, 21.23, 28.78 and 31.97 cm^2, respectively) was found from T_1S_1 treatment combination.

4.5 Crop growth rate (CGR)

Different sowing time varied significantly in terms of crop growth rate (CGR) of BARI Mung-6 at 30-40 DAS and 40-50 DAS, but 50 DAS-harvest varied non-significantly (Table 7). At 30-40 DAS, 40-50 DAS, 50 DAS-harvest, the highest CGR (0.32, 0.28 and 0.14 g $m^{-2}day^{-1}$, respectively) was attained from T_2, while the lowest (0.30, 0.25 and 0.12 g $m^{-2}day^{-1}$, respectively) was observed from T_1.

Statistically significant variation was recorded in terms of CGR of BARI Mung-6 at 30-40 DAS but non-significant for 40-50 DAS and 50 DAS-harvest due to different seed rate (Table 7). At 30-40 DAS, 40-50 DAS and 50 DAS-harvest, the highest CGR (0.32, 0.28 and 0.15 g $m^{-2}day^{-1}$, respectively) was obtained from S_3 and the lowest (0.30, 0.25 and 0.12 g $m^{-2}day^{-1}$, respectively) was found from S_1.

Combined effect of sowing time and seed rate showed statistically significant differences on CGR of BARI Mung-6 at 30-40 DAS but non-significant for 40-50 DAS and 50 DAS-harvest (Table 8). At 30-40 DAS, 40-50 DAS and 50 DAS-harvest, the highest CGR (0.34, 0.29 and 0.16 g $m^{-2}day^{-1}$, respectively) was recorded from T_2S_3, whereas the lowest (0.28, 0.22 and 0.11 g m^{-2} day^{-1}, respectively) was found from T_1S_1 treatment combination.

Table 6. Combined effect of sowing time and seed rate on leaf area (cm^2) of BARI Mung-6 at different days after sowing (DAS) and at harvest

Treatments	Leaf area (cm^2)			
	30 DAS	40 DAS	50 DAS	Harvest
T_1S_1	13.91 e	21.23 e	28.78 d	31.97 c
T_1S_2	14.16 de	22.38 de	29.40 cd	33.84 bc
T_1S_3	14.49 b-e	22.42 de	30.14 cd	34.37 b
T_1S_4	14.34 c-e	22.20 de	29.68 cd	34.11 bc
T_2S_1	14.50 b-e	23.06 b-d	30.07 cd	33.75 bc
T_2S_2	14.52 b-e	23.33 b-d	30.74 b-d	33.72 bc
T_2S_3	15.30 a	25.18 a	33.15 a	36.77 a
T_2S_4	15.00 ab	24.45 ab	32.27 ab	35.30 ab
T_3S_1	14.62 b-d	23.00 b-d	30.92 bc	34.86 ab
T_3S_2	14.90 a-c	24.19 a-c	32.19 ab	35.60 ab
T_3S_3	14.68 b-d	23.77 a-d	31.41 a-c	34.43 b
T_3S_4	14.19 de	22.70 c-e	29.83 cd	33.49 bc
$LSD_{(0.05)}$	0.54	1.45	1.82	1.95
CV(%)	2.57	4.32	4.10	3.92

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

T_1= Sowing on 01 March, 2018
T_2= Sowing on 10 March, 2018
T_3= Sowing on 20 March, 2018

S_1= 20 kg seeds ha^{-1}
S_2= 25 kg seeds ha^{-1}
S_3= 30 kg seeds ha^{-1}
S_4= 35 kg seeds ha^{-1}

Table 7. Effect of sowing time and seed rate on Crop Growth Rate (g m^{-2} day^{-1}) of BARI Mung-6 at different days after sowing (DAS) and at harvest

Treatments	Crop Growth Rate-CGR (g $m^{-2}day^{-1}$)		
	30-40 DAS	40-50 DAS	50 DAS-Harvest
Sowing time			
T_1	0.30 c	0.25 b	0.12
T_2	0.32 a	0.28 a	0.14
T_3	0.31 b	0.26 b	0.13
$LSD_{(0.05)}$	0.009	0.009	--
CV(%)	3.22	3.82	7.46
Seed rate			
S_1	0.30 b	0.25	0.12
S_2	0.31 b	0.27	0.13
S_3	0.32 a	0.28	0.15
S_4	0.31 b	0.26	0.14
$LSD_{(0.05)}$	0.009	--	--
CV(%)	4.93	10.41	12.86

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

T_1= Sowing on 01 March, 2018

T_2= Sowing on 10 March, 2018

T_3= Sowing on 20 March, 2018

S_1= 20 kg seeds ha^{-1}

S_2= 25 kg seeds ha^{-1}

S_3= 30 kg seeds ha^{-1}

S_4= 35 kg seeds ha^{-1}

Table 8. Combined effect of sowing time and seed rate on Crop Growth Rate (g m^{-2} day^{-1}) of BARI Mung-6 at different days after sowing (DAS) and at harvest

Treatments	Crop Growth Rate-CGR (g $m^{-2}day^{-1}$)		
	30-40 DAS	40-50 DAS	50 DAS-Harvest
T_1S_1	0.28 f	0.22	0.11
T_1S_2	0.29 ef	0.26	0.13
T_1S_3	0.31 de	0.26	0.14
T_1S_4	0.30 de	0.27	0.15
T_2S_1	0.31 de	0.28	0.12
T_2S_2	0.31 cd	0.26	0.13
T_2S_3	0.34 a	0.29	0.16
T_2S_4	0.33 b	0.27	0.13
T_3S_1	0.31 b-d	0.24	0.12
T_3S_2	0.33 bc	0.28	0.14
T_3S_3	0.31 b-d	0.27	0.14
T_3S_4	0.30 d-f	0.25	0.13
$LSD_{(0.05)}$	0.015	--	--
CV(%)	4.93	10.41	12.86

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

T_1= Sowing on 01 March, 2018

T_2= Sowing on 10 March, 2018

T_3= Sowing on 20 March, 2018

S_1= 20 kg seeds ha^{-1}

S_2= 25 kg seeds ha^{-1}

S_3= 30 kg seeds ha^{-1}

S_4= 35 kg seeds ha^{-1}

4.6 Relative growth rate (RGR)

Relative growth rate (RGR) of BARI Mung-6 at 30-40 DAS, 40-50 DAS and 50 DAS-harvest showed statistically non-significant differences (Table 9). At 30-40 DAS, 40-50 DAS, 50 DAS-harvest, the highest RGR (0.116, 0.046 and 0.018 mg $g^{-1}day^{-1}$, respectively) was found from T_2, whereas the lowest (0.114, 0.045 and 0.017 mg $g^{-1}day^{-1}$, respectively) was recorded from T_1.

Different seed rate showed statistically significant differences in terms of RGR of BARI Mung-6 at 30-40 DAS, 40-50 DAS and 50 DAS-harvest (Table 9). At 30-40 DAS, 40-50 DAS and 50 DAS-harvest, the highest RGR (0.116, 0.047 and 0.018 mg $g^{-1}day^{-1}$, respectively) was observed from S_3, while the lowest (0.114, 0.044 and 0.016 mg $g^{-1}day^{-1}$, respectively) was found observed from S_1.

Statistically non-significant variation was recorded in terms of RGR of BARI Mung-6 at 30-40 DAS, 40-50 DAS and 50 DAS-harvest due to combined effect of sowing time and seed rate (Table 10). At 30-40 DAS, 40-50 DAS and 50 DAS-harvest, the highest RGR (0.117, 0.048 and 0.020 mg $g^{-1}day^{-1}$, respectively) was obtained from T_2S_3 and the lowest (0.111, 0.042 and 0.015 mg $g^{-1}day^{-1}$, respectively) was found from T_1S_1 treatment combination.

4.7 Net Assimilation Rate (NAR)

Net assimilation rate (NAR) of BARI Mung-6 at 30-40 DAS, 40-50 DAS and 50 DAS-harvest showed statistically non-significant differences (Table 11). But at 30-40 DAS, 40-50 DAS, 50 DAS-harvest, the highest NAR (0.018, 0.011 and 0.005 g $m^{-2}day^{-1}$, respectively) was recorded from T_2 and the lowest (0.016, 0.009 and 0.003 g $m^{-2}day^{-1}$, respectively) was obtained from T_1.

Statistically non-significant variation was recorded in terms of NAR of BARI Mung-6 at 30-40 DAS, 40-50 DAS and 50 DAS-harvest due to different seed rate (Table 11). However, at 30-40 DAS, 40-50 DAS and 50 DAS-harvest, the highest NAR (0.018, 0.011 and 0.005 g $m^{-2}day^{-1}$, respectively) was observed from S_3, whereas the lowest (0.016, 0.009 and 0.003 g $m^{-2}day^{-1}$, respectively) was recorded from S_1.

Table 9. Effect of sowing time and seed rate on Relative Growth Rate (RGR) of BARI Mung-6 at different days after sowing (DAS) and harvest

Treatments	Relative Growth Rate-RGR (mg $g^{-1}day^{-1}$)		
	30-40 DAS	40-50 DAS	50 DAS-Harvest
Sowing time			
T_1	0.114	0.045	0.017
T_2	0.116	0.046	0.018
T_3	0.115	0.045	0.016
$LSD_{(0.05)}$	--	--	--
CV(%)	3.76	7.65	9.34
Seed rate			
S_1	0.114	0.044	0.016
S_2	0.115	0.046	0.017
S_3	0.116	0.047	0.018
S_4	0.115	0.045	0.017
$LSD_{(0.05)}$	--	--	--
CV(%)	3.57	8.28	11.30

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

T_1= Sowing on 01 March, 2018

T_2= Sowing on 10 March, 2018

T_3= Sowing on 20 March, 2018

S_1= 20 kg seeds ha^{-1}

S_2= 25 kg seeds ha^{-1}

S_3= 30 kg seeds ha^{-1}

S_4= 35 kg seeds ha^{-1}

Table 10. Combined effect of sowing time and seed rate on Relative Growth Rate (RGR) of BARI Mung-6 at different days after sowing (DAS) and at harvest

Treatments	Relative Growth Rate-RGR (mg $g^{-1}day^{-1}$)		
	30-40 DAS	40-50 DAS	50 DAS-Harvest
T_1S_1	0.111	0.042	0.015
T_1S_2	0.114	0.047	0.017
T_1S_3	0.115	0.045	0.015
T_1S_4	0.114	0.047	0.019
T_2S_1	0.115	0.046	0.016
T_2S_2	0.115	0.045	0.017
T_2S_3	0.117	0.048	0.020
T_2S_4	0.116	0.045	0.016
T_3S_1	0.116	0.043	0.016
T_3S_2	0.116	0.046	0.018
T_3S_3	0.116	0.046	0.020
T_3S_4	0.114	0.044	0.017
$LSD_{(0.05)}$	--	--	--
CV(%)	3.57	8.28	11.30

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

T_1= Sowing on 01 March, 2018
T_2= Sowing on 10 March, 2018
T_3= Sowing on 20 March, 2018

S_1= 20 kg seeds ha^{-1}
S_2= 25 kg seeds ha^{-1}
S_3= 30 kg seeds ha^{-1}
S_4= 35 kg seeds ha^{-1}

Table 11. Effect of sowing time and seed rate on Net Assimilation Rate (NAR) of BARI Mung-6 at different days after sowing (DAS) and harvest

Treatments	Net Assimilation Rate-NAR (g $m^{-2}day^{-1}$)		
	30-40 DAS	40-50 DAS	50 DAS-Harvest
Sowing time			
T_1	0.016	0.009	0.003
T_2	0.018	0.011	0.005
T_3	0.017	0.010	0.004
$LSD_{(0.05)}$	--	--	--
CV(%)	5.46	8.44	11.15
Seed rate			
S_1	0.016	0.009	0.003
S_2	0.017	0.010	0.004
S_3	0.018	0.011	0.005
S_4	0.017	0.010	0.004
$LSD_{(0.05)}$	--	--	--
CV(%)	4.55	9.84	12.34

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

T_1= Sowing on 01 March, 2018
T_2= Sowing on 10 March, 2018
T_3= Sowing on 20 March, 2018

S_1= 20 kg seeds ha^{-1}
S_2= 25 kg seeds ha^{-1}
S_3= 30 kg seeds ha^{-1}
S_4= 35 kg seeds ha^{-1}

Combined effect of sowing time and seed rate showed statistically non-significant differences on NAR of BARI Mung-6 at 30-40 DAS, 40-50 DAS and 50 DAS-harvest (Table 12). Numerically at 30-40 DAS, 40-50 DAS and 50 DAS-harvest, the highest NAR (0.018, 0.012 and 0.004 g m^{-2} day^{-1}, respectively) was found from T_2S_3 and the lowest (0.015, 0.008 and 0.003 g m^{-2} day^{-1}, respectively) was observed from T_1S_1 treatment combination.

4.8 Number of pods plant^{-1}

Different sowing time showed statistically significant differences in terms of n of pods plant^{-1} of BARI Mung-6 (Table 13). The maximum number of pods plant^{-1} (32.39) was found from T_2 which was statistically similar (31.88) to T_3, while the minimum number (28.98) was recorded from T_1. Mian *et al*. (2002) reported that number of pods plant^{-1} were significantly influenced by the dates of sowing in mungbean which correlated with the present findings.

Number of pods plant^{-1} of BARI Mung-6 varied significantly due to different seed rate (Table 13). The maximum number of pods plant^{-1} (32.32) was found from S_3 which was statistically similar (31.08 and 30.82, respectively) to S_2 and S_4, whereas the minimum number (30.10) was recorded from S_1.

Statistically significant variation was recorded in terms of number of pods plant^{-1} of BARI Mung-6 due to the combined effect of sowing time and seed rate (Table 14). The maximum number of pods plant^{-1} (34.50) was found from T_2S_3 which was statistically similar with T_2S_4, T_3S_3, T_3S_2 and T_3S_1, while the minimum number (28.00) was observed from T_1S_1 treatment combination which was statistically similar to T_1S_2, T_1S_3, T_1S_4, T_2S_1 and T_3S_4.

4.9 Pod length

Pod length of BARI Mung-6 showed statistically significant differences due to different sowing time (Table 13). The longest pod (9.39 cm) was found from T_2 which was statistically similar (9.12 cm) to T_3, whereas the shortest pod (8.56 cm) was recorded from T_1. Jahan and Adam (2012) found that 15 April sown crop had maximum pod length (8.78 cm).

Table 12. Combined effect of sowing time and seed rate on Net Assimilation Rate (NAR) of BARI Mung-6 at different days after sowing (DAS) and harvest

Treatments	Net Assimilation Rate-NAR (g $m^{-2}day^{-1}$)		
	30-40 DAS	40-50 DAS	50 DAS-Harvest
T_1S_1	0.015	0.008	0.003
T_1S_2	0.016	0.010	0.004
T_1S_3	0.017	0.010	0.004
T_1S_4	0.017	0.010	0.005
T_2S_1	0.017	0.010	0.004
T_2S_2	0.017	0.010	0.004
T_2S_3	0.018	0.012	0.004
T_2S_4	0.017	0.010	0.006
T_3S_1	0.017	0.009	0.004
T_3S_2	0.017	0.010	0.004
T_3S_3	0.017	0.010	0.005
T_3S_4	0.016	0.009	0.004
$LSD_{(0.05)}$	--	--	--
CV(%)	4.55	9.84	12.34

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

T_1= Sowing on 01 March, 2018

T_2= Sowing on 10 March, 2018

T_3= Sowing on 20 March, 2018

S_1= 20 kg seeds ha^{-1}

S_2= 25 kg seeds ha^{-1}

S_3= 30 kg seeds ha^{-1}

S_4= 35 kg seeds ha^{-1}

Table 13. Effect of sowing time and seed rate on different yield attributes of BARI Mung-6

Treatments	Pods plant^{-1} (No.)	Pod length (cm)	Weight of 100 seeds (g)
Sowing time			
T_1	28.98 b	8.56 b	5.04 b
T_2	32.39 a	9.39 a	5.34 a
T_3	31.88 a	9.12 ab	5.15 ab
$LSD_{(0.05)}$	2.37	0.59	0.22
CV(%)	8.85	7.60	5.04
Seed rate			
S_1	30.10 b	8.91 b	5.04 b
S_2	31.08 ab	8.90 b	5.21 ab
S_3	32.32 a	9.38 a	5.30 a
S_4	30.82 ab	8.89 b	5.17 ab
$LSD_{(0.05)}$	1.48	0.36	0.16
CV(%)	5.69	4.79	3.88

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

T_1= Sowing on 01 March, 2018

T_2= Sowing on 10 March, 2018

T_3= Sowing on 20 March, 2018

S_1= 20 kg seeds ha^{-1}

S_2= 25 kg seeds ha^{-1}

S_3= 30 kg seeds ha^{-1}

S_4= 35 kg seeds ha^{-1}

Table 14. Combined effect of sowing time and seed rate on different yield attributes of BARI mung-6

Treatments	Pods plant^{-1} (No.)	Pod length (cm)	Weight of 100 seeds (g)
T_1S_1	28.00 f	8.40 de	5.01 c
T_1S_2	29.45 d-f	8.44 de	5.06 c
T_1S_3	29.85 c-f	9.02 b-e	5.09 bc
T_1S_4	28.60 ef	8.37 e	5.00 c
T_2S_1	30.60 b-f	9.10 b-d	5.06 c
T_2S_2	31.45 b-e	9.04 b-e	5.40 ab
T_2S_3	34.50 a	9.88 a	5.51 a
T_2S_4	33.00 ab	9.55 ab	5.40 ab
T_3S_1	31.70 a-d	9.23 a-c	5.06 c
T_3S_2	32.35 a-d	9.23 a-c	5.16 bc
T_3S_3	32.60 a-c	9.23 a-c	5.29 a-c
T_3S_4	30.85 b-f	8.78 c-e	5.10 bc
$LSD_{(0.05)}$	2.56	0.62	0.29
CV(%)	5.69	4.79	3.88

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

T_1= Sowing on 01 March, 2018
T_2= Sowing on 10 March, 2018
T_3= Sowing on 20 March, 2018

S_1= 20 kg seeds ha^{-1}
S_2= 25 kg seeds ha^{-1}
S_3= 30 kg seeds ha^{-1}
S_4= 35 kg seeds ha^{-1}

Statistically significant variation was recorded in terms of pod length of BARI Mung-6 due to different seed rate (Table 13). The longest pod (9.38 cm) was observed from S_3 which was followed by other seed rate but the shortest pod (8.89 cm) was found from S_4.

Combined effect of sowing time and seed rate showed statistically significant differences on pod length of BARI Mung-6 (Table 14). The longest pod (9.88 cm) was recorded from T_2S_3 which was statistically similar withT_2S_4, T_3S_2, T_3S_2 and T_3S_3(9.55, 9.23, 9.23 and 9.23cm, respectively) and the shortest pod (8.37 cm) was observed from T_1S_4 treatment combination which was statistically at par with T_1S_1, T_1S_2, T_1S_3, T_2S_2 and T_3S_4 combinations.

4.10 Number of seeds pods^{-1}

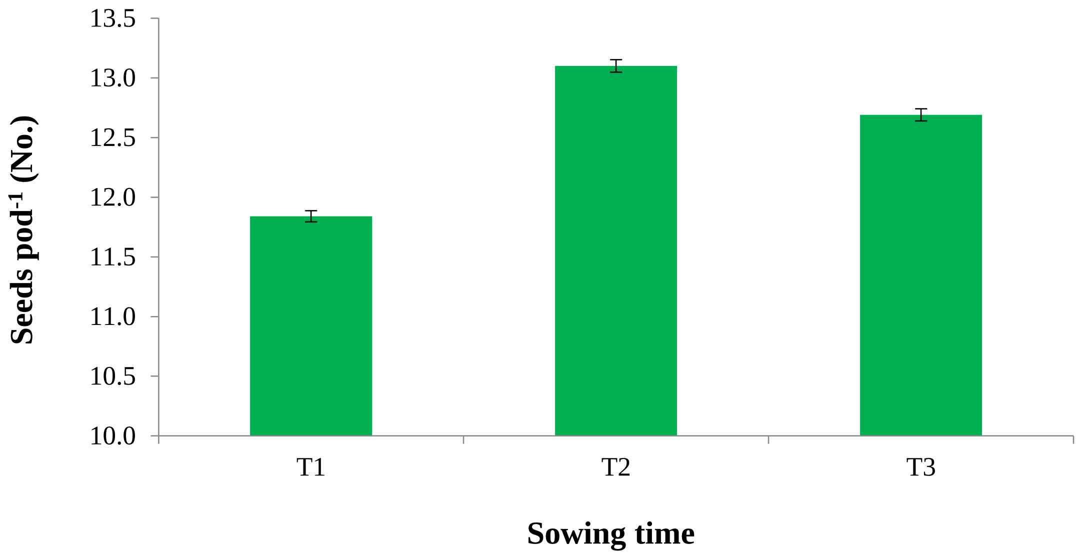
Statistically significant variation was recorded in terms of number of seeds pod^{-1} of BARI Mung-6 due to different sowing time (Table 13). The table indicates that maximum number of seeds pod^{-1} (13.10) was observed from T_2 which was statistically at par (12.69) to T_3, while the minimum number (11.84) was found from T_1. The results agreed with the findings of Jahan and Adam (2012) in mungbean.

Different seed rate varied significantly in terms of number of seeds pod^{-1} of BARI Mung-6 (Figure 6). The maximum number of seeds pod^{-1} (13.08) was recorded from S_3 which was followed by other seed rate and the minimum number (12.05) was observed from S_1.

Number of seeds pod^{-1} of BARI Mung-6 showed statistically significant differences due to the combined effect of sowing time and seed rate (Figure 7). It can be inferred from the figure that the maximum number of seeds pod^{-1} (13.95) was observed from T_2S_3, whereas the minimum number (11.50) from T_1S_4 treatment combination.

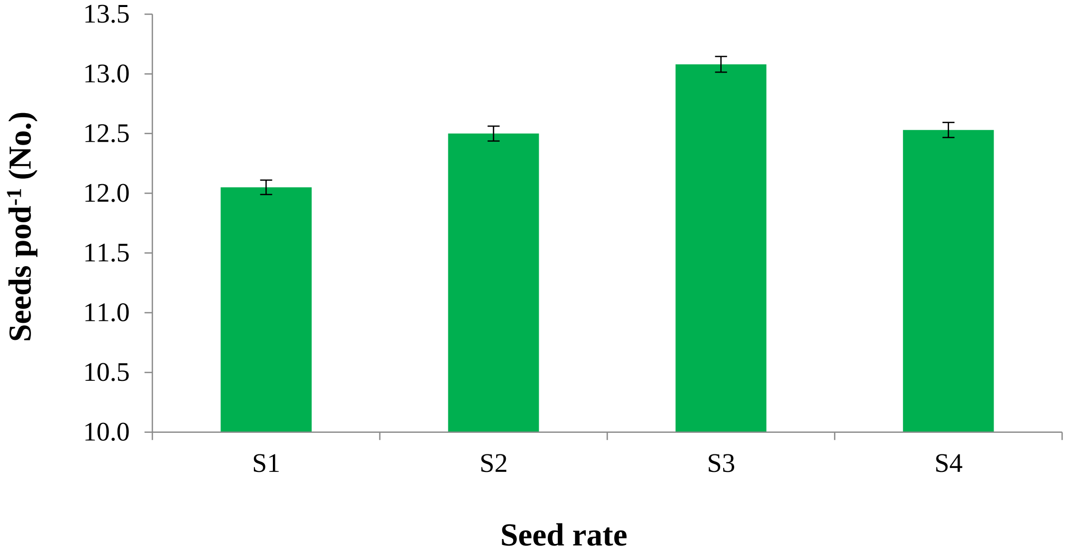
4.11 Weight of 100 seeds

Weight of 100 seeds of BARI Mung-6 showed statistically significant differences due to different sowing time (Table 13). The highest weight of 100 seeds (5.34 g) was found from T_2 which was statistically similar (5.15 g) to T_3, whereas the lowest weight (5.04 g) was observed from T_1. Jahan and Adam (2012) found that 15 April sown crop had maximum 1000-seed weight (46.52 g) of mungbean.



T_1= Sowing on 01 March, 2018; T_2= Sowing on 10 March, 2018
T_3= Sowing on 20 March, 2018

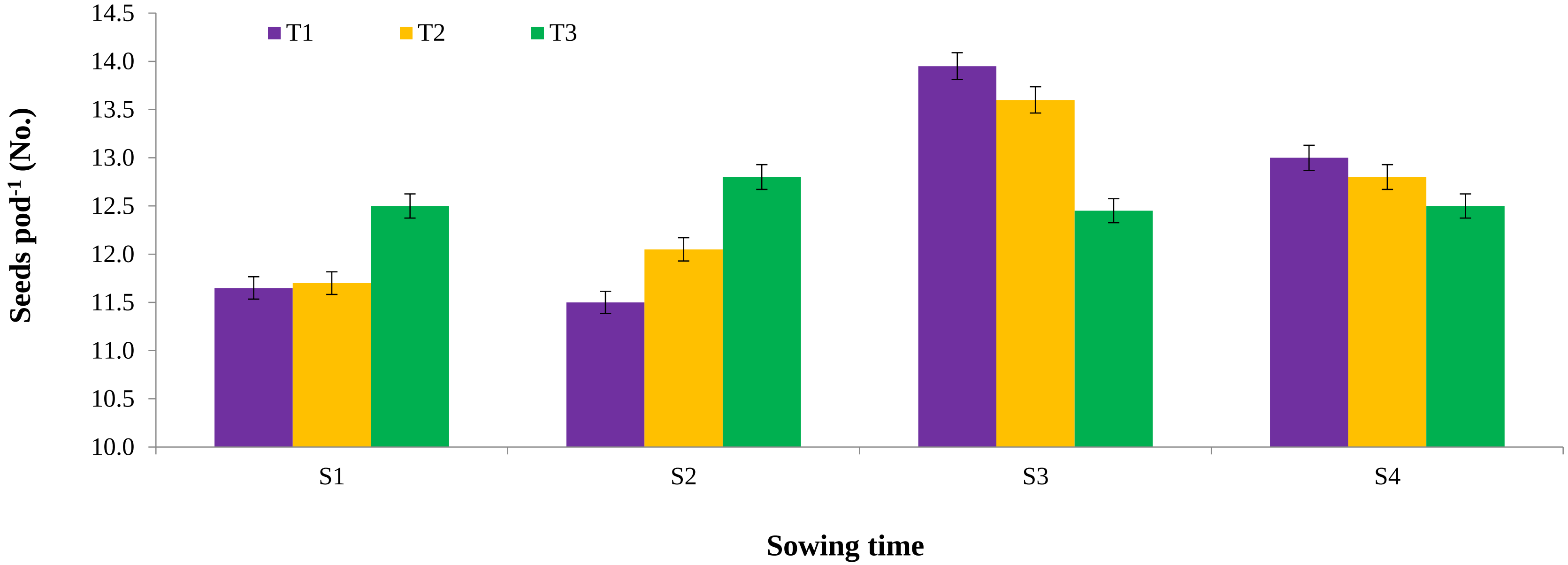
Figure 5. Effect of sowing time on number of seeds pod^{-1} of BARI Mung-6. ($LSD_{0.05}$ = 0.853).



S_1= 20 kg seeds ha^{-1}; S_2= 25 kg seeds ha^{-1}

S_3= 30 kg seeds ha^{-1}; S_4= 35 kg seeds ha^{-1}

Figure 6. Effect of seed rate on number of seeds pod^{-1} of BARI Mung-6. ($LSD_{0.05}$ = 0.536).



T_1= Sowing on 01 March, 2018; T_2= Sowing on 10 March, 2018
T_3= Sowing on 20 March, 2018

S_1= 20 kg seeds ha^{-1}; S_2= 25 kg seeds ha^{-1}
S_3= 30 kg seeds ha^{-1}; S_4= 35 kg seeds ha^{-1}

Figure 7. Combined effect of sowing time and seed rate on number of seeds pod^{-1} of BARI Mung-6. (LSD$_{0.05}$ = 0.929).

Statistically significant variation was recorded in terms of weight of 100 seeds of BARI Mung-6 due to different seed rate (Table 13). The highest weight of 100 seeds (5.30 g) was recorded from S_3 which was statistically similar (5.21 g and 5.17 g, respectively) to S_2 and S_4, while the lowest weight (5.04 g) was recorded from S_1.

Combined effect of sowing time and seed rate exhibited statistically significant differences on weight of 100 seeds of BARI Mung-6 (Table 14). The highest weight of 100 seeds (5.51 g) was found from T_2S_3 which was statistically similar with T_2S_2, T_2S_4 and T_3S_3 combinations (5.40, 5.40 and 5.29g, respectively) and the lowest weight (5.00g) was recorded from T_1S_4 treatment combination followed by T_1S_1, T_1S_2, T_2S_1, T_3S_1, T_1S_3 and T_3S_3.

4.12 Seed yield

Different sowing time showed statistically significant differences in terms of seed yield of BARI Mung-6 (Table 15). The highest seed yield (1.33 t ha^{-1}) was recorded from T_2 which was statistically similar (1.26 t ha^{-1}) to T_3, while the lowest seed yield (1.17 t ha^{-1}) was found from T_1. Hussain *et al*. (2004) reported that seeds sowing in 15 April gave the highest grain yield. Jahan and Adam (2012) reported that grain yield decreased by 36.8 and 49.9% when the crop was sown early (15 March) or late (15 May) due to production of lower yield components. Miah *et al*. (2009) reported that the highest seed yield of mungbean was obtained from 2nd March sowing that might be due to suitable temperature prevailing accompanied by higher soil moisture content due to sufficient rainfall in April, which enhanced the vegetative as well as reproductive growth of the crop.

Seed yield of BARI Mung-6 gave statistically significant differences due to different seed rate (Table 15). The highest seed yield (1.32 t ha^{-1}) was observed from S_3 which was statistically similar (1.26 and 1.25 t ha^{-1}, respectively) to S_2 and S_4, whereas the lowest seed yield (1.19 t ha^{-1}) was recorded from S_1.

Table 15. Effect of sowing time and seed rate on yield and harvest index of BARI Mung-6

Treatments	Seed yield ($t\ ha^{-1}$)	Stover yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest index (%)
Sowing time				
T_1	1.17 b	2.06 b	3.23 b	36.14
T_2	1.33 a	2.17 a	3.50 a	38.02
T_3	1.26 ab	2.14 a	3.40 a	36.99
$LSD_{(0.05)}$	0.11	0.07	0.14	0.06
CV(%)	10.41	3.94	4.87	6.89
Seed rate				
S_1	1.19 b	2.04 b	3.22 b	36.70
S_2	1.26 ab	2.14 a	3.40 a	36.94
S_3	1.32 a	2.19 a	3.50 a	37.54
S_4	1.25 ab	2.12 ab	3.37 ab	37.01
$LSD_{(0.05)}$	0.08	0.09	0.15	0.04
CV(%)	7.79	5.60	5.36	4.91

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

T_1= Sowing on 01 March, 2018

T_2= Sowing on 10 March, 2018

T_3= Sowing on 20 March, 2018

S_1= 20 kg seeds ha^{-1}

S_2= 25 kg seeds ha^{-1}

S_3= 30 kg seeds ha^{-1}

S_4= 35 kg seeds ha^{-1}

Statistically significant variation was observed in terms of seed yield of BARI Mung-6 due to the combined effect of sowing time and seed rate (Table 16). The highest seed yield (1.43 t ha^{-1}) was found from T_2S_3 which was statistically at par with T_2S_4, T_3S_2, T_3S_3, T_1S_4, T_2S_1 and T_2S_2 combinations, while the lowest seed yield (1.04 t ha^{-1}) was observed from T_1S_1 combination which was statistically similar with T_1S_1, T_1S_2 and T_3S_4 combinations.

4.13 Stover yield

Stover yield of BARI Mung-6 showed statistically significant differences due to different sowing time (Table 15). The highest stover yield (2.17 t ha^{-1}) was observed from T_2 which was statistically similar (2.14 t ha^{-1}) to T_3, whereas the lowest stover yield (2.06 t ha^{-1}) was recorded from T_1. The report was consistent with findings of Sharma and Sharma (2002) who reported that the lowest stover yield was obtained from early and delay sowing of mungbean.

Statistically significant variation was recorded in terms of stover yield of BARI Mung-6 due to different seed rate (Table 15). The highest stover yield (2.19 t ha^{-1}) was observed from S_3 which was statistically similar (2.14 and 2.12 t ha^{-1}, respectively) to S_2 and S_4, while the lowest stover yield (2.04 t ha^{-1}) from S_1.

Combined effect of sowing time and seed rate existed statistically significant differences on stover yield of BARI Mung-6 (Table 16). The highest stover yield (2.30 t ha^{-1}) was found from T_2S_3 which was statistically similar with T_1S_4, T_2S_4, T_3S_2 and T_3S_3 combinations, whereas the lowest stover yield (1.99 t ha^{-1}) was observed from T_1S_1 treatment combination which was at par with all the combination except T_2S_4, T_3S_2 and T_2S_3.

4.14 Biological yield

Different sowing time exerted statistically significant differences in terms of biological yield of BARI Mung-6 (Table 15). The highest biological yield (3.50 t ha^{-1}) was recorded from T_2 which was statistically similar (3.40 t ha^{-1}) to T_3 and the lowest biological yield (3.23 t ha^{-1}) was observed from T_1. The result confirmed with the findings of Singh and Sekhon (2007).

Table 16. Combined harvest effect of sowing time and seed rate on yield and harvest index of BARI Mung-6

Treatments	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
T_1S_1	1.04 d	1.99 d	3.03 f	34.31
T_1S_2	1.17 b-d	2.05 cd	3.21 d-f	36.22
T_1S_3	1.20 bc	2.08 cd	3.28 c-f	36.63
T_1S_4	1.27 a-c	2.13 a-d	3.40 b-e	37.39
T_2S_1	1.27 a-c	2.07 cd	3.34 b-e	38.12
T_2S_2	1.29 a-c	2.10 b-d	3.39 b-e	38.04
T_2S_3	1.43 a	2.30 a	3.73 a	38.29
T_2S_4	1.33 ab	2.21 a-c	3.54 a-c	37.61
T_3S_1	1.24 bc	2.05 cd	3.30 c-f	37.66
T_3S_2	1.32 ab	2.29 ab	3.61 ab	36.56
T_3S_3	1.32 ab	2.19 a-d	3.51 a-d	37.71
T_3S_4	1.15 cd	2.03 cd	3.17 ef	36.05
$LSD_{(0.05)}$	0.14	0.17	0.26	0.07
CV(%)	7.79	5.60	5.36	4.91

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

T_1= Sowing on 01 March, 2018
T_2= Sowing on 10 March, 2018
T_3= Sowing on 20 March, 2018

S_1= 20 kg seeds ha^{-1}
S_2= 25 kg seeds ha^{-1}
S_3= 30 kg seeds ha^{-1}
S_4= 35 kg seeds ha^{-1}

Biological yield of BARI Mung-6 varied significantly due to different seed rate (Table 15). The highest biological yield (3.50 t ha^{-1}) was found from S_3 which was statistically similar (3.40 and 3.37 t ha^{-1}, respectively) to S_2 and S_4, whereas the lowest biological yield (3.22 t ha^{-1}) was recorded from S_1.

Statistically significant variation was observed in terms of biological yield of BARI Mung-6 due to the combined effect of sowing time and seed rate (Table 16). The highest biological yield (3.73 t ha^{-1}) was observed from T_2S_3which was statistically similar with the combinations of T_3S_2, T_3S_3 and T_2S_4, while the lowest biological yield (3.03 t ha^{-1}) was recorded from T_1S_1 treatment combination which was at par with T_1S_2, T_1S_3 and T_3S_1 combinations.

4.14 Harvest index

Statistically non-significant variation was observed in terms of harvest index of BARI Mung-6 due to different sowing time (Table 15). However, numerically the highest harvest index (38.02%) was observed from T_2 and the lowest harvest index (36.14%) was recorded from T_1. Similar result was also reported by Jahan and Adam (2012).

Different seed rate exerted statistically non-significant variation was recorded in terms of harvest index of BARI Mung-6 (Table 15). Numerically the highest harvest index (37.54%) was recorded from S_3, while the lowest harvest index (36.70%) was found from S_1.

Harvest index of BARI Mung-6 showed statistically non-significant differences due to the combined effect of sowing time and seed rate (Table 16). The highest harvest index (38.29%) was recorded from T_2S_3 followed by T_2S_2 (38.04%) and the lowest harvest index (34.31%) was observed from T_1S_1 treatment combination.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted during the period from March to June, 2018 at Regional Pulse Research Centre, BARI, Madaripur, Bangladesh to assess the influence of sowing time and seed rate on the growth and yield of BARI Mung-6. The experiment consisted of two factors: Factor A: Sowing time (3 times) as - T_1= Sowing on 01 March, 2018, T_2= Sowing on 10 March, 2018, T_3= Sowing on 20 March, 2018; and Factor B: Seed rate (4 levels) as - S_1= 20 kg seeds ha^{-1}, S_2= 25 kg seeds ha^{-1}, S_3= 30 kg seeds ha^{-1}, S_4= 35 kg seeds ha^{-1}. The two factors experiment was laid out in split-plot design with four replications. Data were recorded on different yield contributing characters and yield of BARI Mung-6 and observed statistically significant different for different characters for different treatments and their combined effect.

For different sowing date, at 30, 40, 50 DAS and harvest, the tallest plant (29.71, 44.09, 50.84 and 51.79 cm, respectively) was observed from T_2, whereas the shortest plant (27.25, 41.03, 46.81 and 48.15 cm, respectively) found from T_1. At 30, 40, 50 DAS and harvest, the maximum number of branches plant^{-1} (1.80, 3.54, 4.53 and 4.65, respectively) was recorded from T_2, while the minimum number (1.66, 3.26, 4.26 and 4.34, respectively) from T_1. At 30, 40, 50 DAS and harvest, the highest dry matter content plant^{-1} (1.48, 4.71, 7.46 and 8.75 g, respectively) was observed from T_2 and the lowest (1.39, 4.36, 6.87 and 8.20 g, respectively) from T_1. At 30, 40, 50 DAS and harvest, the highest leaf area (14.83, 24.00, 31.56 and 34.88 cm^2, respectively) was obtained from T_2, whereas the lowest (14.22, 22.06, 29.50 and 33.57 cm^2, respectively) from T_1. At 30-40 DAS, 40-50 DAS, 50 DAS-harvest, the highest CGR (0.32, 0.28 and 0.14 g m^{-2}day^{-1}, respectively) was attained from T_2, while the lowest (0.30, 0.25 and 0.12 g m^{-2}day^{-1}, respectively) from T_1. At 30-40 DAS, 40-50 DAS, 50 DAS-harvest, the highest RGR (0.116, 0.046 and 0.018 mg g^{-1}day^{-1}, respectively) was found from T_2, whereas the lowest (0.114, 0.045 and 0.017 mg g^{-1}day^{-1}, respectively) from T_1. At 30-40 DAS, 40-50 DAS, 50 DAS-harvest, the highest NAR (0.018, 0.011 and 0.005 g m^{-2}day^{-1}, respectively) was recorded from T_2 and the lowest (0.016, 0.009 and 0.003 g m^{-2}day^{-1}, respectively) from T_1.

The maximum number of pods plant^{-1} (32.39) was found from T_2, while the minimum number (28.98) from T_1. The longest pod (9.39 cm) was found from T_2, whereas the shortest pod (8.56 cm) from T_1. The maximum number of seeds pod^{-1} (13.10) was observed from T_2, while the minimum number (11.84) from T_1. The highest weight of 100 seeds (5.34 g) was found from T_2, whereas the lowest weight (5.04 g) from T_1. The highest seed yield (1.33 t ha^{-1}) was recorded from T_2, while the lowest (1.17 t ha^{-1}) from T_1. The highest stover yield (2.17 t ha^{-1}) was observed from T_2, whereas the lowest (2.06 t ha^{-1}) from T_1. The highest biological yield (3.50 t ha^{-1}) was recorded from T_2 and the lowest (3.23 t ha^{-1}) from T_1. The highest harvest index (38.02%) was observed from T_2 and the lowest (36.14%) from T_1.

In case of different seed rate, at 30, 40, 50 DAS and harvest, the tallest plant (29.67, 43.97, 50.29 and 52.17 cm, respectively) was recorded from S_3, while the shortest plant (27.32, 41.29, 46.99 and 47.56 cm, respectively) from S_1. At 30, 40, 50 DAS and harvest, the maximum number of branches plant^{-1} (1.80, 3.52, 4.60 and 4.73, respectively) was found from S_3, whereas the minimum number (1.67, 3.33, 4.22 and 4.30, respectively) from S_1. At 30, 40, 50 DAS and harvest, the highest dry matter content plant^{-1} (1.47, 4.69, 7.40 and 8.79 g, respectively) was found from S_3, while the lowest (1.40, 4.41, 6.88 and 8.15 g, respectively) was observed from S_1. At 30, 40, 50 DAS and harvest, the highest leaf area (14.82, 23.79, 31.57 and 35.19 cm^2, respectively) was attained from S_3, while the lowest (14.34, 22.43, 29.93 and 33.53 cm^2, respectively) from S_1. At 30-40 DAS, 40-50 DAS and 50 DAS-harvest, the highest CGR (0.32, 0.28 and 0.15 g m^{-2}day^{-1}, respectively) was obtained from S_3 and the lowest (0.30, 0.25 and 0.12 g m^{-2}day^{-1}, respectively) from S_1. At 30-40 DAS, 40-50 DAS and 50 DAS-harvest, the highest RGR (0.116, 0.047 and 0.018 mg g^{-1}day^{-1}, respectively) was observed from S_3, while the lowest (0.114, 0.044 and 0.016 mg g^{-1}day^{-1}, respectively) observed from S_1. At 30-40 DAS, 40-50 DAS and 50

DAS-harvest, the highest NAR (0.018, 0.011 and 0.005 g $m^{-2}day^{-1}$, respectively) was observed from S_3, whereas the lowest (0.016, 0.009 and 0.003 g $m^{-2}day^{-1}$, respectively) from S_1.

The maximum number of pods $plant^{-1}$ (32.32) was found from S_3, whereas the minimum number (30.10) from S_1. The longest pod (9.38 cm) was observed from S_3 and the shortest pod (8.89 cm) from S_4. The maximum number of seeds pod^{-1} (13.08) was recorded from S_3, whereas the minimum number (12.05) from S_1. The highest weight of 100 seeds (5.30 g) was recorded from S_3, while the lowest weight (5.04 g) from S_1. The highest seed yield (1.32 t ha^{-1}) was observed from S_3, whereas the lowest (1.19 t ha^{-1}) from S_1. The highest stover yield (2.19 t ha^{-1}) was observed from S_3, while the lowest (2.04 t ha^{-1}) from S_1. The highest biological yield (3.50 t ha^{-1}) was found from S_3, whereas the lowest (3.22 t ha^{-1}) from S_1. The highest harvest index (37.54%) was recorded from S_3, while the lowest (36.70%) from S_1.

Due to the combined effect of different levels of sowing time and seed rate, at 30, 40, 50 DAS and harvest, the tallest plant (32.77, 46.79, 53.48 and 55.25 cm, respectively) was observed from T_2S_3 and the shortest plant (26.48, 39.15, 43.39 and 44.77 cm, respectively) from T_1S_1. At 30, 40, 50 DAS and harvest, the maximum number of branches $plant^{-1}$ (1.95, 3.70, 4.90 and 5.10, respectively) was recorded from T_2S_3, while the minimum number (1.55, 3.05, 3.85 and 3.95, respectively) from T_1S_1. At 30, 40, 50 DAS and harvest, the highest dry matter content $plant^{-1}$ (1.55, 4.99, 7.89 and 9.25 g, respectively) was found from T_2S_3, whereas the lowest (1.33, 4.17, 6.38 and 7.78 g, respectively) from T_1S_1. At 30, 40, 50 DAS and harvest, the highest leaf area (15.30, 25.18, 33.15 and 36.77 cm^2, respectively) was obtained from T_2S_3 and the lowest (13.91, 21.23, 28.78 and 31.97 cm^2, respectively) from T_1S_1. At 30-40 DAS, 40-50 DAS and 50 DAS-harvest, the highest CGR (0.34, 0.29 and 0.16 g $m^{-2}day^{-1}$, respectively) was recorded from T_2S_3, whereas the lowest (0.28, 0.22 and 0.11 g $m^{-2}day^{-1}$, respectively) from T_1S_1. At 30-40 DAS, 40-50 DAS and 50 DAS-harvest, the highest RGR (0.117, 0.048 and 0.020 mg $g^{-1}day^{-1}$, respectively) was obtained from T_2S_3 and the lowest (0.111, 0.042 and 0.015 mg $g^{-1}day^{-1}$, respectively) from T_1S_1. At 30-40 DAS, 40-50 DAS and 50 DAS-harvest, the highest NAR (0.018, 0.012 and 0.004 g $m^{-2}day^{-1}$, respectively) was found from T_2S_3 and the lowest (0.015, 0.008 and 0.003 g $m^{-2}day^{-1}$, respectively) from T_1S_1 treatment combination.

The maximum number of pods $plant^{-1}$ (34.50) was found from T_2S_3, while the minimum number (28.00) was observed from T_1S_1 treatment combination. The longest pod (9.88 cm) was recorded from T_2S_3 and the shortest pod (8.37 cm) from T_1S_4 treatment combination. The maximum number of seeds pod^{-1} (13.95) was observed from T_2S_3, whereas the minimum number (11.50) from T_1S_4 treatment combination. The highest weight of 100 seeds (5.51 g) was found from T_2S_3 and the lowest weight (5.01 g) from T_1S_1. The highest seed yield (1.43 t ha^{-1}) was found from T_2S_3 which was statistically similar with T_2S_4, T_3S_2, T_3S_3, while the lowest (1.04 t ha^{-1}) from T_1S_1 treatment combination. The highest stover yield (2.30 t ha^{-1}) was found from T_2S_3 and the lowest (1.99 t ha^{-1}) from T_1S_1 treatment combination. The highest biological yield (3.73 t ha^{-1}) was observed from T_2S_3, while the lowest (3.03 t ha^{-1}) from T_1S_1 treatment combination. The highest harvest index (38.29%) was recorded from T_2S_3 and the lowest (34.31%) from T_1S_1 treatment combination.

It may be concluded that, the mungbean grower may cultivate BARI Mung-6 under prevailing climatic condition of greater Faridpur region in the month of March 10-20 along with 25-35 kg ha^{-1} seed rate to get the maximum seed yield.

Considering the results of the present experiment, further studies in the following areas may be suggested:

- The mungbean grower may cultivate BARI Mung-6 under prevailing climatic condition of greater Faridpur region in the month of March 10-20 along with 25-35 Kg ha^{-1} seed rate to get the maximum seed yield.

- For the adaptability of present results it is needed to be replicated in different agro-ecological zones (AEZ) of Bangladesh.

- Other production inputs such as fertilizers and manures may be used for further study to standardize the best agronomic management practices.

REFERENCE

Afzal, M.A., Bakr M.A., Hamid, A., Haque, M.M. and Akhtar, M.S. (2004). Mungbean in Bangladesh. Lentil, Blackgram and Mungbean Development Pilot Project. Pulses Research Centre, BARI, Gazipur- 1701. **23**: 60.

Afzal, M., Khan, A.G. and Ali,A. (1988). Response of small seeded lentil to different seeding rates (*lens culinaris*). *Lens-Newsl.* **15**(2): 10-11.

Agsakalli, A. and Olgum, M. (1999). Determination of optimum seed rate for red lentil Malazgrit-89. Anadolu. **9**(1): 31-43.

Ahlawate, I.P.S., Singh, A. and Saraf, C.S. (1983). Higher seed rate of increase yields of late sown lentil. *Indian Farming*, **33**(3): 28-29.

Ali, M. (1992). Effect of summer legumes on productivity and nitrogen economy of succeeding rice (*Oryza sativa*) in sequential cropping. *Ind. J. Agril. Sci*. **62**: 466-467.

Allam, A.Y. (2002). Effect of sowing dates, seeding rates and nitrogen sources on yield, yield components and quality of lentil. *Assiut. J. Agril*. Sci. **33**(5): 131-144.

Andrews, M., McKenzie, B.A., Joyce, A. and Andrews, K.P. (2001a). The potential of lentil as a seed legume crop in the UK: an assessment based on a crop growth model. *Ann. Appl. Biol.* **139**(3): 293-300.

Anonymous, (1982). Agricultural Year Book of Bangladesh, Bangladesh Bureau of Statistics, Statistics Division, Ministry of Planning, Govt. People's Republic of Bangladesh. p: 121.

Auld, V.L., Bettis, B.L. and Crock, J.E. (1988). Planting date and temperature effects on germination, emergence and seed yield of chickpea. *Agron*. *J.* **80**(6): 909-914.

Auskalins, A. and Dovydaities, V. (1998). The dependence of pea crop density and productivity on seed rate and sowing time on the light loam. *Zemdirbystw.* **63**(10): 143-155.

Aziz, F.H. and Abdul, K.S. (1989). Effect of dates of sowing and densities of leafless pea. *ZANCO. Iraq*. **2**(1): 31-48.

Ball, R.A., Purcell, L.C. and Vories, E.D. (2000). Optimizing soybean plant population for short season production system in the Southern USA. *Crop Sci*. **40**: 757-764.

BARI (Bangladesh Agricultural Research Institite), (1985). Annual Report Bangladesh Agric. Res. Institute, Joydebpur, Gazipur. pp. 151-158.

BBS. (2010). Statistical Year Book of Bangladesh. Statistics Division, Ministry of Planning, Government of the Peoples Republic of Bangladesh. Dhaka. pp: 64-79 and 353.

BBS. (2015). Bangladesh Bureau of Statistics. Yearbook of Agricultural Statistics, Statistics Division, Ministry of Planning, GOB.

BBS. (2016). Year book of Agricultural Statistics-2015, Min. Plan., Govt. People's Republic of Bangladesh, Dhaka. pp. 97-107.

BBS. (2019). Bangladesh Bureau of Statistics. Yearbook of Agricultural Statistics, Statistics Division, Ministry of Planning, GOB.

Begum, M.N. (2008). Optimizing seed rate for some summer mungbean varieties. M.S. Thesis. Dept. Agron., Bangladesh Agril Univ., Mymensingh.

Bhattacharya, A. and Pandey, P.S. (1999). Physiological studies in chickpea varieties: effect of temperature and time of sowing. *Indian J. Pulses Res*. **12**(1): 57-64.

BINA (1998). Annual Report of 1997-98. Bangladesh Inst. Nuclear Agric. (BINA), Mymensingh. p. 42.

Borah, U.K. (1994). Performance of green gram genotypes under different seed rates during summer season. *J. Agril. Sci. Sco, North East India,* **7** (1): 79-81.

Bose, R.D. (1982). Studies in Indian Pulses. *Indian J. Agric. Sci*. **52**: 604– 624.

BRRI. (1996). Effect of time of sowing on the performance of bush bean and edible podded pea. *In.* Proc. Of BRRI. Ann. Inter. Rev. Rice Farming System Division. pp. 7-8, 19-20.

Bukhtiar, B.A., Khan, M.H. and Tufail, M. (1991). Sowing time effect on seed yield and yield components of chickpea and blackgram. *J. Agril. Res. Lahore*. **29**(3): 347-356.

Bukhtiar, B.A., Naseem, A.K.H. and Tufail, M. (1991). Sowing time effect on seed yield and yield components of lentil varieties. *J. Agril. Res. Lahore*. **29**(3): 347-356.

Chahal, S.S. (1998). Effect of sowing date on the growth, yield and quality of mungbean cultivars under irrigated conditiond. M.Sc. Thesis. Punjab Agricultural University, Ludhiana, India.

Chaitanya, S.K. and Chandrika, V. (2003). Response of chickpea genotypes to different dates of sowing in alfisoil of Chittagong District, Andhra Pradesh, India. *Intl. Chic. Pig. pea Newsl.* **10**: 8-9.

Choi, K.J., Lee, Y.S., Choi, H.K., Kim, T.S. and Lee, U.J. (1991) Study on the varietal variation for some agronomic characters under different sowing dates. Res. Rep. Rural Develop Admin. *Upland Ind. Crops*. **33**:15-22.

Chovatia, P.K., Ahlawat, R.P.S. and Trivedi, S.J. (1993). Growth and yield of summer green gram as affected by different dates of sowing, Rhizobium inoculation and levels of phosphorus. *Indian J. Agron*. **38**: 492–494.

Chowdhury, A.S. (1999). Effect of seed rate and weeding regime on the yield and yield contributing characters of summer mungbean. M. S. Thesis, Dept. Agron., Bangladesh Agril. Univ., Mymensingh.

Dahiya, S.S., Faroda, A.S. and Singh, J.P. (1988). Effect of varieties, sowing time and seedling depth on yield attributes and yield of chickpeas under rained conditions. *Haryana J. Agron*. **4**(2): 116-118.

Dixit, J.P., Dubey, O.P. and Soni, N.P. (1992). Effect of sowing date and irrigation on yield and nutrient uptake by chickpea cultivars under Tawa Command Area. *Indian J. Agron*. **38**(2): 227-231.

Dwivedi, D.K., Singh, H., Dubey, J. and Sah, A.K. (1997). Response of lentil (*Lens culinaris*) to fertility and seed rates as paira crop under rainfed low land condition in north-eastern Bihar. *Indian. J. Agron*., **42** (3): 488-489.

El-Nagar, G.R. and Galal, A.H. (1997). Effect of sowing time, seeding rate and harvesting time on yield and quality of lentil. *Assiut. J. Agril. Sci*. **28**(2): 135-144.

FAOSTAT (2013). Food and agriculture organization. URLhttp://faostat.

Farghali, M.A. and Hussein, H.A. (1995). Potential of genotypic and seasonal effects on growth and yield of mungbean. *Assuit. J. Agric. Sci*. **26**: 13-21.

Fraz, R.A., Iqbal, J. and Bakhsh, M.A.A.H.A. (2006). Effect of sowing dates and planting patterns on growth and yield of mungbean *cv*.M-6. *Int. J. Agric. Biol*. **8**: 363-365.

Gomez, A.K. and Gomez, A.A. (1984). Statistical procedure for agricultural research. 2nd Ed. IRRI, Los Benos, Philippines. pp. 207-215.

Gurung, G.B., Hamed, M.F. and Gomez, Y.K.P. (1996d). Effect of sowing time on seed yield of blackgram under rainfed condition at Pakhribas Agricultural Centre. PAC Technical Paper, Pakhribas Agricultural Centre. **175**: 29-32.

Hamid, A., Agata, W., Moniruzzaman, A.F.M. and Miah, A.A. (1991). Physiological aspects of yield improvement in mungbean. pp. 87-94. In: Proceedings of the Second National Workshop on Pulses, 6-8 Jan, 1989, Joydebpur, Bangladesh.

Harpal, S., Inderjit, S. and Gulshan, M. (2002). Effect of different dates of sowing on the incidence of gram pod borer (1-lelicover paurinigera) on different cultivars of chickpea (Cicer arietinum). *Agril. Sci. Digest*. **22**(4): 295-296.

Hassan, S.M.M. (2000). Effect of seed rate and seed source on the yield and quality of mungbean. M.S Thesis, Dept. Agron., Bangladesh Agric. Univ., Mymensingh. p. 39.

Hunt, R. (1978). Plant growth analysis studies in biology. Edward Arnold Ltd., London. p. 67.

Hussain, A., Khalil, S.K. and Khan, H. (2004). Effect of sowing time and variety on grain yield of mungbean. *Sarhad J. Agric*. **20**(4): 481-484.

Iliadis, C. (1998). Chickpea seed yield increase by autumn sowing. 3rd European conference on grain legumes. Opportunities for high quality, healthy and added value crops to meet European demands. Valladolid, Spain. p. 149.

Inderjit, S., Virender, S. and Sekhon, H.S. (2005). Influence of row spacing and seed rate on seed yield of lentil under different sowing dates. *Indian J. Agron*. **50**(4): 308-310.

Jahan, N. and Adam, A.M.M.G. (2012). Growth and yield performance of Bari Mung-5 under different time of sowing. *J. Bangladesh Acad. Sci.* **36**: 227-31.

Jain, K.K., Agarwal, K.K. and Sharma, R.S. (1996). Response of rainfed soybean to seed rate and row spacing. *Adv. Plant Sci*. **9**(1): 69-72.

Jovaisiene, E., Bakstys, I. and Jonusiene, V. (1998). The dependence of pea crop density and productivity on seed rate and sowing time in western Lithuania. Zemdirbyste. **63**(9): 156-165.

Karim, M.F., Rahman, M.M. and Moniruzzaman, A.F.M. (1987). Effect of date of sowing and seed rate on lentil. Bangladesh Association for the Advancement of Science, Dhaka. *Proc 12th Ann. Bangladesh Sci. conf*. p. 18.

Kaul, A.K. (1982). Pulses in Bangladesh. BRAC. Farmgate, Dhaka. p. 27.

Khare, J.P., Tomas, G.S. and Tiwari, U.K. (1991). Production potential of lentil cultivars under varying seed rate and row spacing. *Mysore. J. Agril. Sci*. **25**(2): 154-156.

Kntar, F., Kiziloglu, T., Caglar, O. and Akten, S. (1994). Lentil yield in relation to *Rhizobium leguminosarum* inoculation in eastern Anatolia. *Lens-Newsl*. **21**(2): 36-40.

Krauph, H.A. (1984). The effect of sowing dates and rates on lentil component. *Lens-Newsl*. **11**(1): 18-20.

Kumar, J., Rheenen, H.A. and Saxena, N.P. (1988). A note on the prospects of winter planting of chickpeas in Kashmir valley of Jammu and Kashmir State, India. *Legume Res*. **11**(4): 196-198.

Lee, S.C., Gon, L.T., Chul, K.D., Seog, S.D., Gook, K.Y., Lee, S.C., Lim, T.G., Kim, D.C., Song, D.S., and Kim, Y.G. (1997). Varietal differences in the major chemical components and the fatty acid composition of mungbeans. *J. Crop. Sci*. **42**: 1-6.

Malik, B.P.S. and Singh, R.C. (1996). The influence of seeding rate on weed control in small rate lentils (*Lens culinaris*). *Weed Sci*. **45**(2): 154-156.

Mehandi, S., Singh, I.P., Bohra, A. and Singh, C.M. (2015). Multivariate analysis in Green gram [*Vigna radiata* (L.) Wilczek]. *Legume Res*. **38**(6): 758-762.

Mian, M.A.K., Aziz, M.A., Hossain, M.A. and Karim, M.R. (2002). Physiological behavior of mungbean cultivars due to sowing date. *Bangladesh J. Agric. Res*. **27**: 75-84.

Mimber, S.M. (1993). Influence of plant density and number per hill on growth and yield of mungbean cultivar walet. *Agrivita*, **16**(2): 78-82.

Monem, R., Mirtaheri, S.M. and Ahmadi, A. (2012). Investigation of row orientation and plantingdate on yield and yield components of mungbean. *Ann. Biol. Res.* **3**: 1764-67.

Muhammad, M., Khalil, A., Khan, H.U. and Khan, F.U. (2005). Yield performance of mungbean as affected by various sowing dates. *Ind. J. Pl Sci.* **4**: 222-26.

Panwar, J.D.S and Sirohi, G.S. (1987). Studies on the effect of plant population of grain yield and its components in mungbean. *Indian J. Plant Physol*. **30**(4): 412-414.

Patel, J.I., Patel, G.J. and Yadevendra. J.P. (1999). Performance of chickpea varieties under different dates of sowing. *Gujarat Agril Univ. Res. J.* **24**(2): 88-90

Poma, L., Sarno, R. and Nato, F. (1990). Effect of sowing date on yield and quality characteristics of chickpeas. Info. *Agrario*. **46**(40): 53-55.

Poniedzialek, M., Olechnowicz, B.B. and Skowerd, B. (1999). The effect of meterological condition in Kraeow area on the course of phenophases and yield of chickpea (*Cicer arietinum*). OgolnokrajowyZjazdagrometeorologow. Miedzyzdroje. Szczecin. Polska. 33-15 wrzesnia. Folia University Agriculturae Stetinensis. Agricultura. **79**: 185-187.

Rahman, M.L. and Zilani, M.A. (2009). Agricultural Research Priority: Vision -2030 and beyond Bangladesh Agricultural Research Council Farmgate. Dhaka, Bangladesh.

Rahman, M.M. (1998). Technology information on lentil, blackgram and mungbean , Lecture note, Training Workshop on Lentil, Blackgram and Mungbean at BARI, Joydebpur, Gazipur, February 22-23.

Rahman, M.M. and Miah, A.A. (1995). Yield determination of a promising mungbean line under various planting densities. *Pertanika J. Trop. Agric.* **18**(2): 119-124.

Rahman, M.M., Adan, M.J., Chowdhury, M.S.N., Ali, M.S. and Mahabub, T.S. (2015). Effect of phosphorus and zinc on the growth and yield of mungbean (BARI Mung-6). *Intl. J. Sci. Res.* **5**(2): 1-4.

Rahman, M.M. and Sarkar, A. (1997). Plant growth and seed yield of mungbean genotypes sown late. *Lens Newsl*. **24**(1&2): 78-84.

Rakesh, D., Prakash, O. and Ahlawat, I. (2000). Response of spring green gram to dates of sowing. *Annal. Agric. Res.*, *CCS Univ. India*. **21**: 207-10.

Ramzan, C.M., Nadeem, M.A., Khan, R.H. and Khan, M.A. (1992). Effect of sowing date on mungbean seed yield under rainfed conditions. *J. Agric. Res. Lahore*. **30**: 205-11.

Raza, A. and Hasanzadeh, A. (1995). Effect of planting date and plant density on yield, yield components and their vertical distribution in green gram (*Vigna radiata* L.). *Iranian J. Agric. Sci*. **26**(2): 19-31.

Razzaque, M.A., Rafiquzzaman, S., Kabir, A. H. M. F. and Ali, M. A. (2005). Effect of sowing time on the yield of mungbean undr rainfed condition. *J. Agric. Rural Dev*. **3**: 103-106.

Rehman, A., Khalil, S.K., Rehman, S., Haq, I., Akhtar, S., Khan, A.Z. and Shah, S.R. (2009). Phenology, plant height and yield of mungbean varieties in response to planting date. *Sarhad J. Agric*. **25**: 147-151.

Rizk, T.Y., Ashoub, M.A., Mostofa, M.T. and Hasan, M.W.A. (1986). Lentil productivity as affected by seeding rates and some herbicides. *Ann. Agric. Sci*. **31**(2): 1143-1157.

Roy, S.K. and Rahman, S.M.L. (1992). Effect of seed rate and inoculation on nodulation, growth and yield of lentils. *Legume Res.* **15**(3-4): 131-136.

Sadeghipour, O. (2008). Response of mungbean varieties to different sowing dates. *Pakistan J. Biol. Sci*. **11**: 248-250.

Saini, S.S. and Faroda, A.S. (1997). Effect of sowing time, its pattern and seed rate on growth and yield of 'H 86143' chickpea (*Cicer arietinum*) *Indian. J. Agron*. **42**(4): 645-649.

Sarkar, A.R., Kabir, H., Begum, M. and Salam, A. (2004). Yield performance of mungbean as affected by planting date, variety and plant density. *J. Agron.* **3**: 18-24.

Saxena, M.C. and Yadav, D.S. (1975). Proceeding of international workshop on seed legumes. ICRISAT. 11-16 January,1975. pp. 31-61.

Sekhon, H.S., Guriqbal, S. and Sandhu, S.S. (1994). Effect of date of sowing and seed arte on growth and yield of lentil. *Lens Newsl.* **21**(2): 22-24.

Sekhon, H.S., Singh, G. and Brar, J.S. (2002). Effect of population density and planting geometry on the growth and yield of mungbean [*Vigna radiata* L.)] genotypes. *Environ. Ecol*. **20**: 897-901.

Sekhon, H.S., Guriqbal, S.G., Sandhu, S.S. and Singh, G. (1994). Effect of date of sowing and seed rate on growth and yield of lentil. *Lens- Newsl*. **21**(2): 22-24.

Shahjahan, M. (2002). Pulses In Bangladesh: Production, Problems, Prospects, and Future Plans.

Sharma, B.B. and Singh, R.R. (1986). Response of lentil to seeding rates and fertility levels under semi-arid conditions. *Lens- Newsl*. **13**(1): 23-25.

Sharma, K.C. and Sharma, B.C. (2002). Effect of dates or sowing and row spacing's on chickpea genotypes under late sown conditions. *Adv. Plant Sci*. **15**(2): 517-523.

Sharma, M.C. (1996). Economic response of lentil to seed rate, row spacing, *Rhizobium* inoculation and chemical fertilization. *Lens-Newsl*. **23**(1-2): 15-18.

Sharma, M.C. and Singh, H.P. (1994). Growth pattern of lentil under different seed rates, row spacing and fertilizer levels. *Lens- Newsl*. **21**(2): 24-28.

Shoaib, Y.O. (1992). Effect of sowing date and seeding rate on lentil in eastern Libya. *Lens-Newsl.* **19**(2): 21-23.

Shukla, Y.R. and Kohli, U.K. (1992). Response of early pea to environment 1. Planting time, location and morphological characters. *Haryana J. Hort. Sci*. **21**(3): pp. 25-29.

Siddique, A.B., Wright, D. and Mahbub, A.S.M. (2002). Effect of sowing dates on the phenology, seed yield and yield components. *Online J. Biological Sci*. **2**: 300-303.

Siddique, K.H.M., Loss, S.P., Regan Pritcharad, D.L. (1998). Adaption of Lentil (*Lens culinaris*) to short season Mediterranean- type environments response to sowing rates. *Aust. J. Agric. Res*. **49**: 1057-1066.

Singh, A.K. and Singh, N.P. (1995). Effect of varieties and seed rates on yield of mungbean and urd bean during summer. *Indian J. Pulses Res*. **8**(1): 90-92.

Singh, G. and Sekhon, H.S. (2002). Relative contribution of different inputs in mungbean in summer and kharid seasons. *Environ. Ecol*. **20**: 757-61.

Singh, G. and Sekhon, H.S. (2005). Role of pulses in agriculture. In: Singh, G., Sekhon, H.S. and Kolar, J.S. (eds) Pulses. pp. 33-57. Aggrotech Publishing Academy, Udaipur.

Singh, G. and Sekhon, H.S. (2007). Effect of sowing date on growth and yield of mungbean varieties during kharif season. *J. Food Leg* .**20**: 59-61.

Singh, G., Sekhon, H.S., Sandhu, J.S. and Randhawa, A.S. (2003). Effect of location and seed rate on three genotype on mungbean. *Trop. Sci*. **43**: 116-120.

Singh, J.R.B., Singh, R.B. and Balai, L.P. (2012). Manipulation of sowing dates and inter-rows spacing an eco-friendly management of mungbean (*Vigna radiata* L.) web blight. *Trends Bio. Sci*. **5**: 152-53.

Singh, K.N., Bali, A.S., Shah, M.N. and Khanday, B.A. (1991). Effect of spacing and seed rate on yield of green gram. *Indian J. Agril. Sci*. **61**(5): 326-327.

Singh, R.C., Singh, M., Dahira, D.R. and Phogat, S.B. (1985). Effect of dates of sowing and seed rates on summer season urd bean. *Indian J. Agron*. **31**(2): 187-188.

Singh, R.C., Singh, M., Kumar, R. and Singh, M. (1994). Effect of seed rate and DAP application on lentil (*Lens culinaris*). *Haryana Agril. Uni. J. Res*. **24**(4): 189-190.

Singh, S., Sandhu, S.K., Dhaliwal, L.K. and Singh, I. (2012). Effect of planting geometry on microclimate, growth and yield of mungbean (*Vigna radiata* L.). *J. Agric. Phys*. **12**: 70-73.

Singh, T. and Dhingra, K.K. (1993). Response of mungbean cultivars to time of sowing under south-western region of Punjab. *J. Res. Punjab Agric. Univ.* **30**: 157-59.

Singh, V.K. and Yadav, D.S. (1989). Effect of sowing dates and plant density on dwarf peas. *Indian J. Agron*. **34**(1): 92-95.

Soomro, N.A. and Khan, H.R. (2003). Response of mungbean genotypes to different dates of sowing in kharif season under rainfed conditions. *Asian J. Plant Sci*. **2**: 377-379.

Sugui, F.P. and Sugui, C.C. (2002). Response of chickpea to dates of sowing in locos Norte, Philippines. in: *Chic. Pig. pea Newsl.* **9**: 13.

Suresh, K. and Padaganur, G.M. (1991). Effect of date of sowing on incidence of greengram powdery mildew. *Karnataka J. Agric. Sci.* **4**: 165-167.

Tan, S.Y. (1973). In: Summerfield RJ, Roberts EH, editors. Grain Legume Crops. London, UK: Collins. pp. 20-26.

Thakar, S. and Dhingra, K.K. (1993). Response of mungbean (*Vigna radiata* L.) cultivars to time of sowing under south western region of Punjab. *J. Res. Punjab Agric. Univ*. **30**(3-4): 157-159.

Tiwari, 0.P. and Tripathi, R.S. (1995). Effèct of planting date, irrigation and phosphorus on chickpea (*Cicer arietinum*) grown on clay loam soil. *Indian J. Agron*. **40**(3): 513-515.

Tomar, S.P.S. and Singh, R.R. (1991). Effect of tillage, seed rates and irrigation on the growth, yield and quality of lentil. *Indian J. Agron.* **36**(2): 143-147.

Tomar, S.S. and Tiwari, A.S. (1996). Response of greengram and blackgram genotypes to plant density. *Gujrat Agril. Univ. Res. J.* **21**: 88-92.

Tomar, S.S., Sharma, R.K., Verma, O.P., Bhadouria, S.S. and Tomar, A.S. (1996). Effect of seed rate, irrigation and phosphorus levels on the yield attributes and net return of summer mungbean. *Bhartiya Krishi Anusandhan Patrika*, **11**: 136-140.

Tomar, S.S., Shrivastava, U.K., Sharma, R.K., Bhadouria, S.S. and Tomar, A.S. (1995). Physiological parameters of summer mungbean as affected by seed rate, moisture regime and phosphorus levels. *Legume Res*. **18**: 125-128.

Trivadi, K.K. and Vyas. M.D. (2000). Response of Kabuli chickpea cultivars under different dates of sowing and row spacing. *Crop Res. Hisar*. **20**(1): 52-55.

Trung, B.C. and Yoshida, S. (1985). Influence of planting density on the nitrogen and grain productivity of mungbean. *Japanese J. Crop Sci*. **54**(3): 166-172.

Venkateswarlu, U. and Ahlawat, I.P.S. (1993). Effect of soil moisture regime, seed rate and phosphorus fertilizer on growth and yield attributes and yield of late sown lentils (*Lens culinaris*). *Indian J. Agron*. **38**(2): 236-243.

Watt, J. and Singh, R.K. (1992). Response of late sown lentil to seed rates, row spacing and phosphorus levels. *Indian J. Agron*. **37**(3): 592-593.

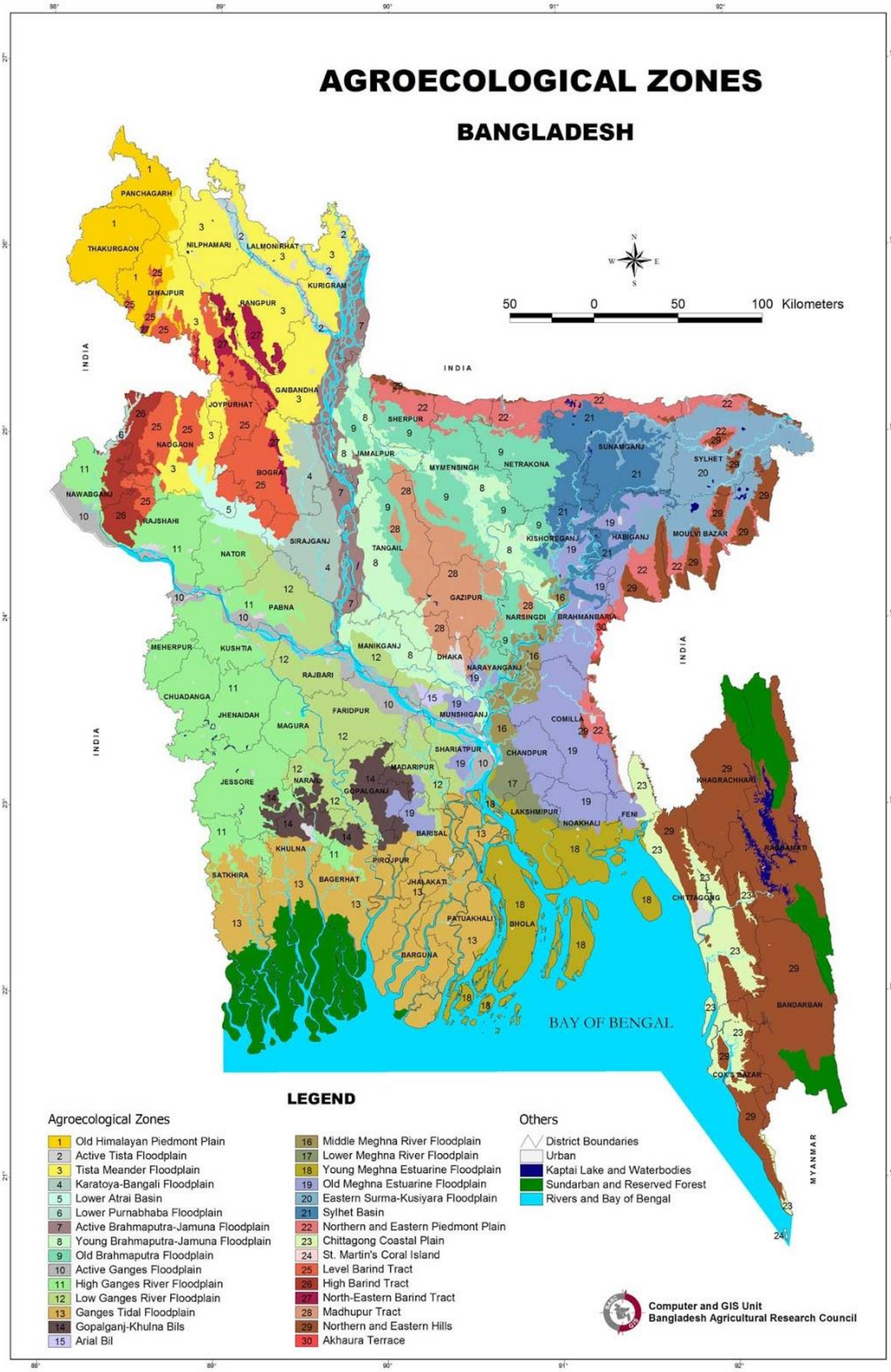
Wilson, K.A. (1981). The structure, function, and evolution of legume proteinase inhibitors. In RL Ory, Ed, Antinutrients and Natural Toxicants in Food. Food and Nutrition Press, Westport, CT.

Yadav, R.N. and Nagarajan, S. (1995). Seed yield and quality of green gram in relation to sowing time and variety under spring-summer conditions. *Seed Sci. Tech. Res*. **23**: 43-46.

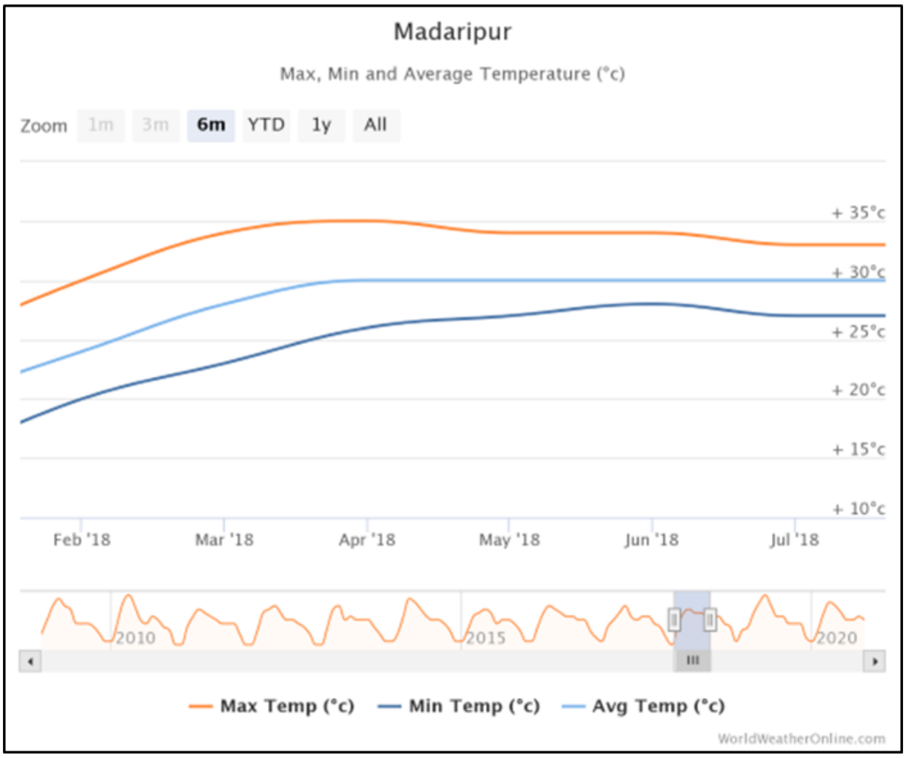
Yadav, V.S., Dhcrcnda, S. and Yadav, S.S. (1999). Morpho physiological basis of yield variation in chickpea under late planting conditions. *Annals Agril. Res*. **20**(2): 22-23.

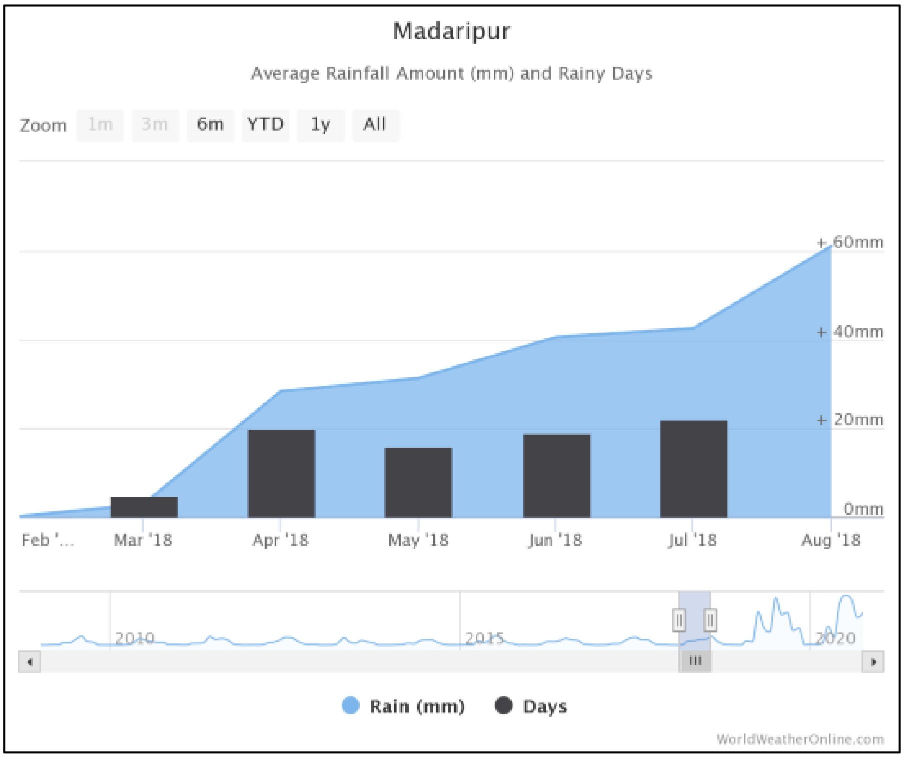
Yang, K.Y., SCS, T., Lee, T.C. (2002). Effect of cooking on in vitro iron bioavailability of various vegetables. In: Lee TC, Ho CT, editors. Bioactive Compounds in Foods: Effect of Processing and Storage. Washington DC, USA: American Chemical Society. pp. 130-142.

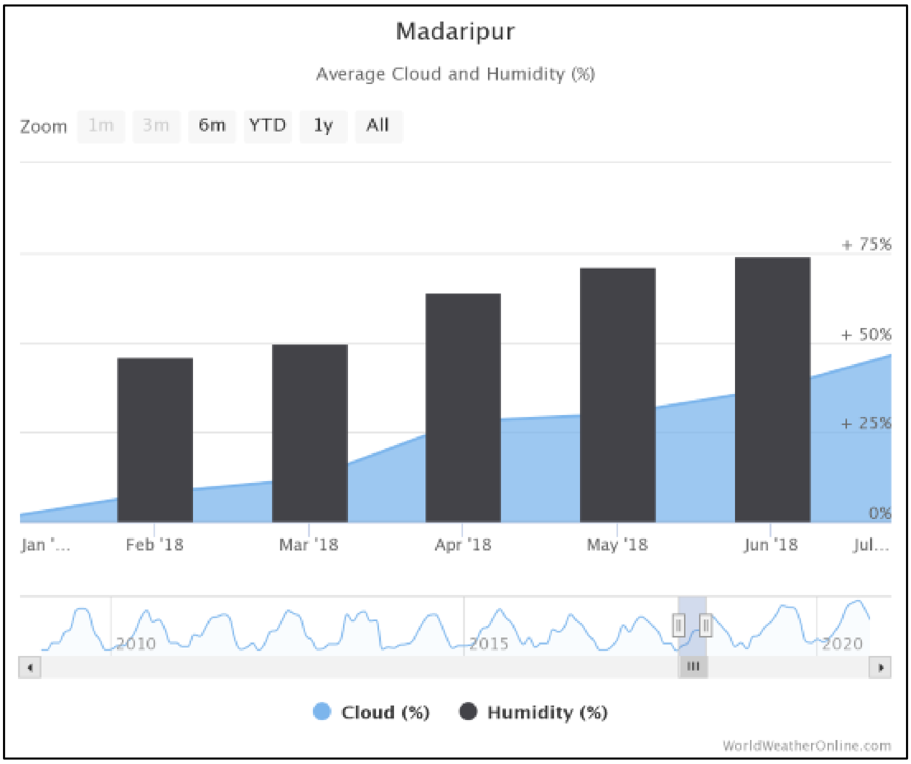
APPENDIX I. The Experimental Site Shown in AEZ of Bangladesh Map



APPENDIX II. Monthly weather data of Madaripur during experiment (from Mar'18 to June'18)

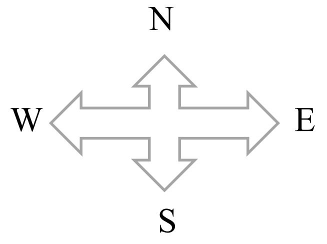



Madaripur
Average Rainfall Amount (mm) and Rainy Days
Zoom 1m 3m 6m YTD 1y All
60mm
40mm
20mm
0mm
Feb '…
Mar '18
Apr '18
May '18
Jun '18
Jul '18
Aug '18
2010
2015
2020
Rain (mm)
Days
WorldWeatherOnline.com


Madaripur
Average Cloud and Humidity (%)
Zoom 1m 3m 6m YTD 1y All
75%
50%
25%
0%
Jan '…
Feb '18
Mar '18
Apr '18
May '18
Jun '18
Jul…
2010
2015
2020
Cloud (%)
Humidity (%)
WorldWeatherOnline.com

APPENDIX III. Layout of the experiment field

T_1S_1	T_3S_1	T_2S_2	T_3S_3
T_1S_2	T_3S_3	T_2S_4	T_3S_1
T_1S_3	T_3S_2	T_2S_1	T_3S_2
T_1S_4	T_3S_4	T_2S_3	T_3S_4
T_2S_2	T_1S_3	T_3S_3	T_1S_4
T_2S_1	T_1S_2	T_3S_2	T_1S_2
T_2S_4	T_1S_4	T_3S_1	T_1S_1
T_2S_3	T_1S_1	T_3S_4	T_1S_3
T_3S_3	T_2S_2	T_1S_2	T_2S_1
T_3S_2	T_2S_3	T_1S_3	T_2S_2
T_3S_1	T_2S_1	T_1S_4	T_2S_3
T_3S_4	T_2S_4	T_1S_1	T_2S_4



Single plot area=7.2m^2

Column to column distance=0.3m

Row to row distance= 0.1m

Treatments:

T_1= 1 March

T_2= 10 March

T_3=20 March

S_1=20 kg ha^{-1}

S_2=25 kg ha^{-1}

S_3=30 kg ha^{-1}

S_4=35 kg ha^{-1}

Appendix IV. Analysis of variance of plant height at different days after sowing and at harvest of mungbean as influenced by different sowing time and seed rate

Source of variation	Degrees of freedom	Mean square			
		Plant height at			
		30 DAS	40 DAS	50 DAS	Harvest
Replication	3	1.749	5.121	0.380	2.201
Sowing time (A)	2	24.264*	38.141*	64.708*	55.976*
Error	6	3.223	6.005	12.507	10.675
Seed rate (B)	3	11.136*	14.374*	22.462*	44.503*
Interaction (A×B)	6	8.635*	11.798*	19.765*	28.790*
Error	27	3.469	4.161	7.516	10.827

*: Significant at 0.05 level of probability

Appendix V. Analysis of variance of number of branches plant^{-1} at different days after sowing and at harvest as influenced by different sowing time and seed rate

Source of variation	Degrees of freedom	Mean square			
		Number of branches plant^{-1} at			
		30 DAS	40 DAS	50 DAS	Harvest
Replication	3	0.005	0.003	0.019	0.002
Sowing time (A)	2	0.081*	0.310*	0.276*	0.396*
Error	6	0.012	0.052	0.038	0.061
Seed rate (B)	3	0.039*	0.090*	0.299*	0.393**
Interaction (A×B)	6	0.032*	0.059*	0.248*	0.209*
Error	27	0.010	0.026	0.078	0.068

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

Appendix VI. Analysis of variance of dry matter content of mungbean at different days after sowing and at harvest as influenced by different sowing time and seed rate

Source of variation	Degrees of freedom	Mean square			
		Dry matter content plant^{-1} (g) at			
		30 DAS	40 DAS	50 DAS	Harvest
Replication	3	0.004	0.049	0.009	0.037
Sowing time (A)	2	0.028*	0.489*	1.407*	1.215*
Error	6	0.005	0.062	0.175	0.196
Seed rate (B)	3	0.012*	0.159*	0.545*	0.845*
Interaction (A×B)	6	0.008*	0.112*	0.349*	0.502*
Error	27	0.003	0.042	0.149	0.222

*: Significant at 0.05 level of probability

Appendix VII. Analysis of variance of leaf area of mungbean at different days after sowing and at harvest as influenced by different sowing time and seed rate

Source of variation	Degrees of freedom	Mean square			
		Leaf area (cm^2) at			
		30 DAS	40 DAS	50 DAS	Harvest
Replication	3	0.015	0.759	0.176	0.467
Sowing time (A)	2	1.498*	15.929*	18.548*	7.585*
Error	6	0.192	2.785	2.423	0.948
Seed rate (B)	3	0.480*	3.795*	5.480*	5.540*
Interaction (A×B)	6	0.365*	2.283*	3.792*	5.395*
Error	27	0.140	0.999	1.585	1.814

*: Significant at 0.05 level of probability

Appendix VIII. Analysis of variance of Crop Growth Rate of mungbean at different days after sowing and at harvest as influenced by different sowing time and seed rate

Source of variation	Degrees of freedom	Mean square		
		Crop Growth Rate-CGR (g $m^{-2}day^{-1}$)		
		30-40 DAS	40-50 DAS	50 DAS-Harvest
Replication	3	0.0001	0.001	0.001
Sowing time (A)	2	0.003*	0.003^{NS}	0.001^{NS}
Error	6	0.0001	0.0001	0.0001
Seed rate (B)	3	0.001*	0.001^{NS}	0.0001^{NS}
Interaction (A×B)	6	0.001*	0.001^{NS}	0.001^{NS}
Error	27	0.0001	0.001	0.0001

NS: Non significant; *: Significant at 0.05 level of probability

Appendix IX. Analysis of variance of Relative Growth Rate of mungbean at different days after sowing and at harvest as influenced by different sowing time and seed rate

Source of variation	Degrees of freedom	Mean square		
		Relative Growth Rate-RGR (mg $g^{-1}day^{-1}$)		
		30-40 DAS	40-50 DAS	50 DAS-Harvest
Replication	3	0.0001	0.0001	0.0001
Sowing time (A)	2	0.0001^{NS}	0.0001^{NS}	0.0001^{NS}
Error	6	0.0001	0.0001	0.0001
Seed rate (B)	3	0.0001^{NS}	0.0001^{NS}	0.0001^{NS}
Interaction (A×B)	6	0.0001^{NS}	0.0001^{NS}	0.0001^{NS}
Error	27	0.0001	0.0001	0.0001

NS: Non significant

Appendix X. Analysis of variance of Net Assimilation Rate of mungbean at different days after sowing and at harvest as influenced by different sowing time and seed rate

Source of variation	Degrees of freedom	Mean square		
		Net Assimilation Rate-NAR (g $m^{-2}day^{-1}$)		
		30-40 DAS	40-50 DAS	50 DAS-Harvest
Replication	3	0.0001	0.0001	0.0001
Sowing time (A)	2	0.0001^{NS}	0.0001^{NS}	0.0001^{NS}
Error	6	0.0001	0.0001	0.0001
Seed rate (B)	3	0.0001^{NS}	0.0001^{NS}	0.0001^{NS}
Interaction (A×B)	6	0.0001^{NS}	0.0001^{NS}	0.0001^{NS}
Error	27	0.0001	0.0001	0.0001

NS: Non significant

Appendix XI. Analysis of variance of different yield attributes of mungbean as influenced by different sowing time and seed rate

Source of variation	Degrees of freedom	Mean square			
		Pods $plant^{-1}$ (No.)	Pod length (cm)	Seeds pod^{-1} (No.)	Weight of 100 seeds (g)
Replication	3	3.488	0.115	0.277	0.001
Sowing time (A)	2	54.181*	2.911*	6.631*	0.373*
Error	6	7.564	0.470	0.971	0.068
Seed rate (B)	3	10.236*	0.666*	2.148**	0.132*
Interaction (A×B)	6	10.100*	0.443*	0.909*	0.134*
Error	27	3.122	0.187	0.410	0.040

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

Appendix XII. Analysis of variance of yield and harvest index of mungbean as influenced by different sowing time and seed rate

Source of variation	Degrees of freedom	Mean square			
		Seed yield ($t\ ha^{-1}$)	Stover yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest index (%)
Replication	3	0.000	0.003	0.005	0.229
Sowing time (A)	2	0.103*	0.050*	0.294**	14.157^{NS}
Error	6	0.017	0.007	0.027	6.512
Seed rate (B)	3	0.034*	0.047*	0.161**	1.524^{NS}
Interaction (A×B)	6	0.025*	0.034*	0.104*	4.202^{NS}
Error	27	0.010	0.014	0.033	3.312

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

PLATES

Plate 1. Experimental view

Plate 2. Seed sowing

Plate 3. Sample tagging for collection of data

Plate 4. Flower sampling

Plate 5. Pod sampling

Plate 6. Plant height

Plate 7. Leaf Area

Plate 8. Pod length

Plate 9. Seed weight

Plate 10. Field visit