EFFECT OF POPULATION DENSITY AND VARIETY ON GROWTH AND YIELD OF MUNGBEAN

BY

PROMITA SHIKHA ROY

REGISTRATION NO. 00941

A Thesis

Submitted to the Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka,
In partial fulfilment of the requirements
for the degree of

MASTER OF SCIENCE (M S)
IN
AGRONOMY

SEMESTER: JANUARY-JUNE, 2008

Approved by:

Dr. Md. Hazrat Ali Professor **Supervisor**	**Md. Obaidul Islam** Assistant Professor **Co-Supervisor**

Dr. Md. Jafar Ullah
Professor

Chairman
Examination Committee

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

PABX: +88029144270-9
Fax: +88029112649
Web site: www.sau.edu.bd

Ref: *Date:* ....

CERTIFICATE

This is to certify that the thesis entitled **"EFFECT OF POPULATION DENSITY AND VARIETY ON GROWTH AND YIELD OF MUNGBEAN"** 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(M.S) in Agronomy embodies the result of a piece of bonafide research work carried out by *Protima Shikha Roy Registration No. 00941,* under my supervision and guidance. No part of this thesis has been submitted to anywhere for any other degree or diploma.

I further certify that any help or sources of information as has been availed of during the course of this inquire have been duly acknowledged and the contents & style of the thesis have been approved and recommended for submission.

Dated:
Dhaka, Bangladesh

ProfessorDr. Md. Hazrat Ali
Department of Agronomy
Sher-e-Bangla Agricultural University
Dhaka-1207

DEDICATED

TO

MY BELOVED PARENTS

ACKNOWLEDGEMENTS

All praises are devoted to Almighty "God" Who is the supreme authority of this universe, and who enables the author to complete the research work and submit the thesis for the degree of Master of Science (M S) in Agronomy.

Guidance, help and co-operation have received from several persons during the tenure of the study, for the cause of which the author is grateful to all of them. Although it is not possible to mention every one by name, it will be an act of ungratefulness some of the names is not mentioned here.

The author would like to acknowledge the untiring inspiration, encouragement and invaluable guidance provided by his respected teacher and supervisor Professor ***Dr. Md. Hazrat Ali,*** *Department of Agronomy Sher-e-Bangla Agricultural University (SAU), Dhaka. His constructive criticisms, continuous supervision and valuable suggestions were helpful in completing the research and writing up the manuscript.*

The author would like to express his heartiest appreciation, ever indebtedness and deep sense of gratitude to his co-supervisor ***Md. Obaidul Islam,*** *Assistant Professor, Department of Agronomy Sher-e-Bangla Agricultural University (SAU), Dhaka.*

The author is especially thankful to all of his teachers of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka for their appreciation and help during the period of the study.

Heartiest thanks and gratitude are due to the officials of Sher-e-Bangla Agricultural University Farm Division of Sher-e-Bangla Agricultural University for their support to conduct the research.

The author feels proud to express his unreserved gratitude to Mohammad Mahmudul Hasan (Robin) for his keen help as well as heartiest co-operation and encouragement.

Finally the author is very much grateful to his heartiest husband Nabin and other members of the family and relatives for their sacrifice, inspiration, encouragement, endless love and continuous blessing for educating to the postgraduate level.

May God protect them all.

December, 2008

ABSTRACT

The experiment was conducted at the Agronomy field laboratory, Sher-e-Bangla Agricultural University, Dhaka during April 10 to July 15, 2007 to study the effect of different population density viz, (25cm x 5cm, 25cm x 10cm, 25cm x 15cm and 25cm x 20cm) 80, 40, 25 and 20 plants m^{-2} respectively on the growth, yield, and yield attributes of four summer mungbean varieties (BARImung-4, BARImung-2, BARImung-5 and BINAmung-5). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data on growth and yield parameters were recorded from vegetative growth to Maturity. All the collected data were statistically analyzed and the mean differences among the treatments were compared by Duncan's Multiple Range Test (DMRT). The results showed that all the growth, yield and yield attributes were significantly influenced by the population density. Lower population density, 25cm x 20cm (20 plants m^{-2}) produced the highest root length, number of nodules and leaves plant^{-1},RGR at 66 days to maturity, number of branches and pods plant^{-1}, pod length, number of seeds pod^{-1}, 1000-seed weight, seed yield plant^{-1} and harvest index. Yield performance of individual plant was significantly higher at lower population density, 25cm x 20cm (20 plants m^{-2}) while the total seed yield was higher at the population density of 25cm x 10cm (40 plants m^{-2}). The highest seed yield (1124 Kg ha^{-1}) was obtained from 25cm x 10cm (40 plants m^{-2}) which was significantly different from 80, 25 and 20 plants m^{-2}. Higher population density, 25cm x 5cm (80 plants m^{-2}) produced the highest plant height, CGR,RGR at 56-65 DAS. It was concluded that out of the four population densities, 25cm x 10cm (40 plants m^{-2}) appeared to be optimum population density for seed yield in summer mungbean. Among the varieties BINAmung-5 showed better performance than the others. The highest seed yield (1640 kg ha^{-1}) was obtained from BINAmung-5 with 25cm x 10cm (40 plants m^{-2}). From the results of the experiment, it could be concluded that, for obtaining maximum seed yield of BINAmung-5, might be grown with 40 plants m^{-2} in summer season.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Chapter 1
Introduction

CHAPTER-1

INTRODUCTION

Mungbean *(Vigna radiata* L. Wilzeck) is one of the most important pulse crop grown in Bangladesh for its high digestibility, good flavour and high protein content. It belongs to the family Leguminosae and sub-family Papilionaceae. It is widely grown in India, Pakistan, Bangladesh, Myanmar, Thailand, Philippines, China, Indonesia, Srilanka, East and Central Africa, USA and Australia. In a developing country like Bangladesh, there is a serious nutritional crisis of cereal based diet. It can improve the overall nutritional value; it is an excellent supplemental protein source for rice diet. It is considered as a poor man's meat. It contains 51% carbohydrate, 26% protein, 10% moisture, 4% minerals and 3% vitamins (Kaul, 1982). The high lysine content makes it a good supplementary food rice-based diet because lysine is usually the first limiting amino acids (Chen *et al.* 1987).

In Bangladesh, it is generally used as "Dal" or vegetable soup and often fed to babies but in many countries sprouted seeds are widely used as vegetables. The green plants and hay are used as animal feed and residues as manure. It is also used as green manuring crop to improve soil fertility. It can increase soil fertility through biological nitrogen fixation. So, this may be considered as inevitable component of sustainable agriculture. Among the pulses in Bangladesh mungbean ranks fifth in acreage and second in market price. Mungbean cultivation covers an area of 24,292 hectares producing about 18,000 metric tons (BBS, 2005).The average production of mungbean in Bangladesh is about 652 kg ha^{-1}, which is lower than that of India and other countries of the world.

The agro-ecological condition of Bangladesh is favourable for mungbean cultivation almost throughout the year. The crop is usually cultivated during rabi season, but because of poor yield and marginal profit as compared to cereal crops, farmers prefer growing wheat to mungbean during rabi season. Besides, the release of high yielding cultivars of cereals have pushed this crop to marginal and sub-marginal lands of less productivity and made its cultivation less remunerative. Recently, Bangladesh Agricultural Research Institute (BARI) has developed six and Bangladesh Institute of Nuclear Agriculture (BINA) has developed seven photo-insensitive high yielding cultivars mungbean, which are getting attention to the farmers. During kharif season the crop fits well into the existing cropping system of many areas in Bangladesh.

In coastal area of Noakhali and Barisal Region mungbean is sown in last week of January after T.aman rice. Mungbean is also be sown after wheat, pulses and potato in other parts of the country

Mungbean has a special importance in intensive crop production system of the country for its short growing period. Summer mungbean can tolerate a high temperature not exceeding 40°c. It is reported to be drought tolerant and can be cultivated in areas of low rainfall (Kay, 1979). In India mungbean gives the highest yield under summer planting (Singh and Yadav, 1978).

The daily consumption of pulses in Bangladesh is only 12g per head while Food and Agriculture Organization (FAO,1988) recommended per capita consumption of 45g pulse per day to fulfill the protein requirement (BARI, 2000). To provide the above mentioned requirement of 45g per capita per day, production is to be increased even more than three folds (BARI, 2000).

Low yield of mungbean in this country is probably due to low yielding potentiality and also due to lack of appropriate agronomic practices specially plant population per unit area. In the development of appropriate management practices for mungbean, population density plays an important role as it is one of the most important yield contributing characters (Babu and Mitra, 1989). In lower plant population, individual plant performance is better than that of higher plant population but within tolerable limit higher plant population produces higher yield per hectare (Shukla and Dixit, 1996). Therefore, optimum plant population ensures normal plant growth because of efficient utilization of moisture, light, space and nutrients, thus increases the yield of crop.

In Bangladesh, several studies were conducted on population density and cultivar performance separately, but reports are few on the combined response of these factors on summer mungbean. Considering the above facts, the study has been undertaken with the following objectives:

1. to study the effect of population density on growth and yield of summer mungbean.
2. to evaluate the performance of four varieties of summer mungbean.
3. to find out the optimum population density for higher yield of summer mungbean varieties.

Chapter 2
Review of Literature

CHAPTER-2

REVIEW OF LITERATURE

Investigation on mungbean as affected by the plant population is in progress in many countries of the world especially in the South Asia in order to obtain higher crop yield. Bangladesh Agricultural University (BAU), Bangladesh Agricultural Research Institute (BARI) and Bangladesh Institute of Nuclear Agriculture (BINA) have started extensive research on varietal development and overall improvement of this crop. Effect of population density on growth, yield and yield contributing characters of mungbean and other related crops at home and abroad have been reviewed in this chapter.

2.1 Effect of population density on morphological characters

2.1.1 Plant height (cm)

Hasanuzzaman (2001) studied with five population density (15, 30, 45, 60 and 75 plants m^{-2}) of mungbean and observed that increasing plant population significantly increased plant height. The tallest plant (46.69 cm) was obtained from 75 plants m^{-2} and the shortest (36.65 cm) was found from 15 plants m^{-2}.

El-Habbasha *et al.* (1996) reported that increasing population density increased plant height. Similar result was also reported by Ulemale *et al.* (2003) in sunnhemp, Akther (1999), Gumber *et al.* (1998), Najafi *et al.* (1997) and Yadav *et al.* (1990) in pea.

Muesca and Oria (1981) observed that with a dense stand (25 plants m^{-2}) plant height was the highest (68cm) in mungbean.

2.1.2 Root length (cm)

Rahman(2005)studied with four population densities (20,30,40 and 50 plants $m^{-2)}$ of Soybean and observed that in increasing plant population significantly decreased root length .Root length was the greatest(21.09cm)at the lowest density(20plants $m^{-2)}$ and the shortest 17.62 cm)was at the highest density (50 plants m^{-2}).Similar result was also reported by Barua (2006) in sunnhemp and Begum(2002)in sesame.

2.1.3 Number of nodules $plant^{-1}$

Rana (2004) studied with three population density (30, 45 and 60 plants m^{-2}) of mungbean and observed that number of nodules $plant^{-1}$ significantly increased at lower plant population. The highest number of nodules $plant^{-1}$ (18.51) was produced in 30 plants m^{-2} and the lowest (9.64) was in 60 plants m^{-2}. Similar result was also reported by Ulemale *et al.* (2003) and Anisuzzaman (2005) in pea.

Hasanuzzaman (2001) studied with five population density (15, 30, 45, 60 and 75 plants m^{-2}) of mungbean and observed that number of nodules $plant^{-1}$ significantly increased at lower plant population. The highest number of nodules $plant^{-1}$ (12.58) was produced in 15 plants m^{-2} and the lowest (6.85) was in 75 plants m^{-2}.

2.1.4 Number of leaves $plant^{-1}$

Barua (2006) studied with five population densities (15, 25, 30, 35 and 55 plants m^{-2}) of sunnhemp and observed that number of leaves $plant^{-1}$ significantly increased at lower plant population. The highest number of leaves $plant^{-1}$ (332) was produced in 15 plants m^{-2} and the lowest (191.3) was in 55 plants m^{-2}.

Ahmed *et al.* (1981) obtained the highest number of leaves $plant^{-1}$ at lowest density in mungbean. Similar result was also reported by Anisuzzaman (2005) in pea, Ulemale *et al.* (2003) in sunnhemp, Gumber *et al* (1998) in pea, Ibrahim (1996) and El-Habbasha *et al.* (1996) in pea.

2.2 Effect of population density on growth parameters

2.2.1 Total dry weight $plant^{-1}$

Haque (2003) studied with four population densities (25, 33, 50 and 100 plants

m^{-2} in chickpea and observed that total dry weight $plant^{-1}$ decreased significantly with increasing population density. Total dry weight $plant^{-1}$ was the maximum (6.5 g) at the lowest density (25 plants m^{-2}) and the minimum (5.1 g) was at the highest density (100 Plants m^{-2}).

Trung and Yoshida (1985) observed that total dry weight $plant^{-1}$ decreased significantly with increasing population density in mungbean. Similar result was also reported by Barua (2006) and Najafi *et al.* (1997) in sunnhemp.

2.2.2 Crop Growth Rate (CGR)

Hasanuzzaman (2001) studied with five population density (15, 30, 45, 60 and 75 plants m^{-2}) of mungbean and observed that CGR significantly increased with the increase in plant densities. The highest CGR (14.12 gm^{-2} d^{-1}) was produced in 75 plants m^{-2} and the lowest (7.43 gm^{-2} d^{-1}) was in 15 plants m^{-2} during 51-65 DAS.

Akther (1999) noticed that in the early stage of growth closer spacing showed higher crop growth rates in pea. Similar result was also reported by Rana (2004) in mungbean and Begum (2002) in sesame.

Babu *et al.* (1988) observed that in mungbean CGR showed an initial lag phase in the crop growth, reached a peak between 46-60 DAS and then declined. The maximum CGR of 30.8 gm^{-2} d^{-1} decreased by 30% when the plant density decreased by 50%.

Singh (1982) found in mungbean that CGR showed consistent increases with the increase in plant densities at almost all the growth stages.

2.2.3 Relative Growth rate (RGR)

Rana (2004) studied with three population density (30, 45 and 60 plants m^{-2}) of mungbean and observed that RGR significantly decreased with increasing population density. The highest RGR (109.87 $mgg^{-1}d^{-1}$) was produced in 30 plants m^{-2} and the lowest (97.97 $mgg^{-1}d^{-1}$) was in 60 plants m^{-2} during 36-50 DAS.

Begum (2002) studied with four population densities (16, 20, 25 and 100 plants m^{-2}) in sesame and observed that RGR decreased with increasing population density. It was 77.5 and 66.4 $mgg^{-1}d^{-1}$ at 16 plants m^{-2} and 100 plants m^{-2}, respectively during 45-75 DAS. Similar result was also reported by Anisuzzaman (2005) and Yadav *et al.* (1990) in pea.

2.3 Effect of population density on yield and yield contributing characters

2.3.1 Number of branches and number of pods $plant^{-1}$

Sekhon *et al.* (2002) reported that increasing plant density decreased number of branches and pods $plant^{-1}$ of mungbean. Similar result was also reported by Sarkar *et al.* (2004), Ulemale *et al.* (2003), Akther (1999), El-Habbasha *et al.* (1996), Najafi *et al.* (1997) and Brathwaite (1982).

Hasanuzzaman (2001) studied with five population density (15, 30, 45, 60 and 75 plants m^{-2}) of mungbean and observed that number of branches and pods $plant^{-1}$ significantly increased at lower plant population. The highest number of branches and pods $plant^{-1}$ (3.85 and 11.96) was produced in 15 plants m^{-2} and the lowest (1.73 and 6.67) was in 75 plants m^{-2}.

2.3.2 Pod length and number of seeds pod^{-1}

Anisuzzaman (2005) studied with five population densities (10, 15, 20, 25 and 30 plants m^{-2}) of pea and observed that pod length and number of seeds pod^{-1} significantly increased at lower plant population. The highest pod length and number of seeds pod^{-1} was produced in 10 plants m^{-2} and the lowest was in 30 plants m^{-2}.

Miranda *et al.* (1997) reported that pod length and number of seeds pod^{-1} decreased with increasing density in mungbean. Similar result was also reported by Anisuzzaman (2005), Sarkar *et al.* (2004), Akther (1999), El-Habbasha *et al.* (1996), Singh and Yadav (1989) in pea and Brathwaite (1982).

2.3.3 1000-seed weight

Sarkar *et al.* (2004) studied with three plant densities (20 x 20, 30 x 10 and 40 x 30 cm) and found that the highest 1000-seed weight was obtained at density of 20 x 20cm. Similar result was also reported by Rana (2004), Akther (1999) and Singh and Yadav (1989) in pea.

Hasanuzzaman (2001) studied with five population densities (15, 30, 45, 60 and 75 plants m^{-1}) of mungbean and observed that 1000-seed weight significantly increased at lower plant population. The highest 1000-seed weight (26.48 g) was produced in 15 plants m^{-2} and the lowest (23.43 g) was in 75 plants m^{-2}.

2.3.4 Seed yield plant^{-1}

Rana (2004) studied with three population densities (30, 45 and 60 plants m^{-2}) of mungbean and observed that seed yield plant^{-1} significantly increased at lower plant population. The highest seed yield plant^{-1} (2.56 g) was produced in 30 plants m^{-2} and the lowest (1.53 g) was in 60 plants m^{-2}.

El-Habbasha *et al.* (1996) reported that increasing plant density decreased seed yield plant^{-1} in pea. Similar result was also reported by Anisuzzaman (2005) in pea, Ulemale *et al.* (2003) in sunnhemp, Hasanuzzaman (2001) in mungbean and Singh and Yadav (1989) in pea.

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

Sarkar *et al.* (2004) studied with three plant densities (20 x 20, 30 x 10 and 40 x 30 cm) and found that a plant density of (30 x 10) cm resulted in the highest seed yield compared to 20 x 20 and 40 x 30 cm.

Sekhon *et al.* (2002) studied with three plant populations (3.33, 2.22 and 167 lakh ha^{-1}) and observed that seed yield was the highest at 3.33 lakh ha^{-1}. Similar result was also reported by Rana (2004) and Hasanuzzaman (2001) in mungbean, Jain *et al.* (1988), Singh and Malhotra (1983).

Jeswani and Saini (1981) found that the highest yield of mungbean was obtained in the dry season with 4,00,000 plants ha^{-1}, followed by 5,00,000 and 6,00,000 plants ha^{-1}. Similar result was also reported by Haque (1995), Singh and Yadav (1989) in pea.

Beech and Wood (1978) conducted several studies and reported a higher plant population up to 4,50,000 ha^{-1} gave higher yield in mungbean under good management conditions. Similar result was also reported by Yadav *et al.* (1990) in pea.

2.3.6 Total dry matter (Kg ha^{-1})

Rana (2004) studied with three population density (30, 45 and 60 plants m^{-2}) and observed that TDM significantly increased with increasing population density. The highest TDM (2942.46 kg ha^{-1}) was produced in 60 Plants m^{-2} and the lowest (2448.34 kg ha^{-1}) was in 30 plants m^{-2}.

In mungbean, Trung and Yoshida (1985) found that increasing plant density increased TDM production. Similar result was also reported by Barua (2006) in sunnhemp, Haque (2003) in pea, Hasanuzzaman (2001) in mungbean, Akther (1999) in pea and Abbas *et al.* (1994) in soybean.

2.3.7 Harvest index (HI)

Sarkar *et al.* (2004) studied with three plant densities (20 x 20, 30 x 10 and 40 x 30 cm) and found that at a density of 30 x 10 cm produced the highest harvest index. The lowest harvest index was recorded for at a density of 40 x 30cm.

Hasanuzzaman (2001) studied with five population densities (15, 30, 45, 60 and 75 plants m^{-2}) of mungbean and observed that significantly the highest HI (30.06 %) was produced in 45 plants m^{-2} and the lowest (18.62 %) was in 75 plants m^{-2}. Similar result was also reported by Rana (2004) in mungbean.

Tsiung (1978) reported that in mungbean harvest index declined before the maximum grain yield was attained, usually from the lowest density. He further reported that there was an increase in harvest index up to density giving the higher grain yield. All studies were consistent in showing a progressive decline in harvest index at densities above the maximum grain yield.

Chapter 3

Materials and Methods

CHAPTER-3

MATERIALS AND METHODS

The details of different materials used and methodologies followed in the experimental period are presented in this chapter under the following heads:

3.1 Plant materials

Four varieties of summer mungbean namely Barimung-4, Barimung-2, Barimung-5 and Binamung-5 were used as plant materials. The varieties have been developed by Bangladesh Agricultural Research Institute (BARI) and Bangladesh Institute of Nuclear Agriculture (BINA). The seeds were collected from BARI, Gazipur and BINA, Mymensingh.

3.2 Experimental treatments

The experiment consisted of the following treatments

A. Mungbean varieties: 4

1. BARImung-4
2. BARImung -2
3. BARImung -5
4. BINAmung-5

B. Population density: 4

1. 25cm x 5 cm (80 plants m^{-2})
2. 25cm x 10 cm (40 plants m^{-2})
3. 25cm x 15 cm (25 plants m^{-2})
4. 25cm x 20 cm (20 plants m^{-2})

3.3 Experimental site

The experiment was conducted at the Agronomy farm, Sher-e-Bangla Agriculturl University, Dhaka from April 10 to July 15, 2007.

3.4 Location

The experiment was conducted at the Central Farm of the Sher-e-Bangla Agricultural University, Dhaka during April to July 2007. The site was located in 90.2^{O}N and 23.5^{0}E Latitude. The altitude of the location was 8.2 m from the sea level (The Meteorological Department of Bangladesh, Agargaon , Dhaka-1207).

3.5 Soil

The experimental site was located in the Modhupur Tract (AEZ-28) and it was a high land with adequate irrigation facilities. The soil texture was silty clay with a pH 5.6. Soil samples of the experimental plot were collected from a depth of 0 to 30 cm before conducting the experiment. Soil analyzed in the Soil Resources Development Institute (SRDI) Farmgate, Dhaka have been presented in (Appendix I).

3.6 Climate and weather

The climatic condition of the site is sub-tropical, which is characterized by high temperature and heavy rainfall during kharif season and scanty rainfall associated with moderately low temperature during rabi season. Weather data of the experimental site has been presented in Appendix II.

3.7 Land preparation

The experimental land was ploughed three times by a power tiller followed by laddering to have a good tilth. All the weeds and stubbles were removed from the field.

3.8 Fertilizer application

Recommended doses of fertilizer were as urea, TSP (Triple Superphosphate) and MP (Muriate of Potash) at the rate of 30, 70 and 35 kg ha^{-1} respectively. The whole amount of TSP, MP and urea were applied as basal dose at the time of final land preparation.

3.9 Experimental design

The experiment was laid out in Randomized Complete Block Design (RCBD). There were 16 treatments (4 cultivars x 4 population density) and each treatment was replicated 3 times.

3.10 Layout of the experiment

Initially, the experimental area was divided into three blocks to represent three replications. Each block was divided into 16 sub-plots. The blocks were 1 m apart and the distance between unit plots was 0.5m. The plot size was 3.5m x 2.5m and the total number of plots was 48.

3.11 Seed sowing

The percentage of germination of the collected seeds was tested in the laboratory for getting proper population in the plot before sowing in the field. The germination percentage of seeds were 80%. Three seeds per hole were sown of 3cm depth at spacing of 25cm x 5cm, 25cm x 10 cm, 25cm x 15cm, 25cm x 20cm to get 80, 40, 25 and 20 plants m^{-2} on Appril 10, 2007. Emergence of seedling was completed by 3 days after sowing (DAS).

3.12 Gap filling

The ungerminated hole were resown just after emergence of seedlings in order to fill in the gaps. Soon after emergence of the seedlings there was an attack of cut-worm that damaged some seedlings. During seed sowing, few seeds were sown in the border of the plots. The damaged seedlings were transplanted after 15 DAS with the excess seedlings.

3.13 Thinning

Seedlings were cut by a pair of scissors keeping the healthiest one in each hole at 15 days after establishment of seedling.

3.14 Weeding

Two hand weeding were done at 20 and 35 days after sowing.

3.15 Insect control

The mungbean plants were infested by cutworm and pod borer. Hand picking of cutworm larvae and Malathion 57EC was sprayed @ 560 ml ha^{-1} at the stage of 50% pod formation as control measures.

3.16 Plant sampling

Plant samples were collected from the plot at physiological maturity on 65 DAS. At each harvest three plants were selected randomly from each plot. The selected plants were uprooted carefully by a "khurpi" and root, stem and leaves of each plant were separated. After separation, the plant parts were oven dried at 80 ± 2°C for 48 hours.

3.17 Harvesting and processing

Maturity of crops was determined when 80% of the pods turned brown colour. The Crops were harvested plot-wise on july15,2007 and were bundled separately, tagged and brought to a clean threshing floor. Then the pods were separated from the plants manually and sun dried for two days. Seeds were separated from the pods with the help of bamboo sticks and sun dried for reducing the moisture to about 14% level. The dried seeds and straw were cleaned and weighed plot-wise.

3.18 Data recording

The following data were recorded:

A. Morphological characters

1. **Plant height (cm):** Plant height was measured from the ground level to the tip of the leaf apex of the plant.
2. **Root length (cm):** Root length was measured from the ground level to the tip of the longest root.
3. **Number of nodules $plant^{-1}$:** The roots of the uprooted plants were washed carefully and nodules from the lateral and tap roots were counted.
4. **Number of leaves $plant^{-1}$:** Number of leaves produced by the plant was counted manually.

B. Growth parameters

1. **Total dry weight (g) plant^{-1}:** The total dry weight was calculated from the summation of dry weight of root, stem (with pods) and leaves per plant.
2. **Crop Growth Rate (CGR):** CGR is the increase in plant dry matter per unit area of land per unit time (Hunt, 1978). The CGR values were calculated by using the following formula —

$$CGR = \frac{W_2 - W_1}{T_2 - T_1} \ gm^{-2}d^{-1}$$

Where,

W_1 = Total plant dry weight at the time T_1 and

W_2 = Total plant dry weight at the time T_2

3. **Relative Growth Rate (RGR):** RGR is the increase in plant dry matter per unit time per unit of dry matter investment (Hunt, 1978). The RGR values were calculated by using the following formula

$$RGR = \frac{W_2 - W_1}{W_1 \ (T_2 - T_1)} \ mg \ g^{-1}d^{-1}$$

Where,

W_1 = Total plant dry weight at the time T_1 and

W_2 = Total plant dry weight at the time T_2

C. Yield and yield contributing characters:

1. **Number of branches plant^{-1}:** All the branches developed from main stem of the plant were counted manually.
2. **Number of pods plant $^{-1}$:** Pods picked up from the plants were counted. The number of pods was divided by number of plant and thus number of pod plant^{-1} was found out.

3. **Pod length (cm):** Average lengths measured from randomly selected 10 pods of each plot.

4. **Number of seeds pod^{-1}:** Seeds pod^{-1} was recorded from 10 randomly selected pods and then the average number was calculated.

5. **1000-seed weight (g)**: One thousand clean dried seeds were counted from each plot and weighed by using an electrical balance.

6. **Seed yield plant^{-1}**: Grains obtained from each plant were sun dried and weighed carefully by using an electrical balance.

7. **Seed yield (kg ha^{-1}):** Seed yield was recorded plot wise and yield was then converted in to hectare.

8. **Biological Yield(kg ha^{-1}):** Seed and Straw yield were all together recorded as biological yield. The biological yield was calculated with the following formula :Biological yield =seed yield Straw yield.

9. **Harvest index (HI):** HI was calculated with the following formula (Gardner *et al.* 1985).

$$HI (\%) = \frac{E_y}{B_y} \times 100$$

Where,

E_y = Economic yield i.e. seed yield

B_y = Biological yield i.e. total dry matter yield

3.19 Data analysis technique

The collected data were statistically analyzed to find out the level of significance using MSTATC package programme developed by Russel (1986). The mean differences were compared by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

Chapter 4
Results and Discussion

CHAPTRER- 4

RESULTS AND DISCUSSION

Effects of population density on growth and yield of mungbean varieties have been presented and discussed in this chapter under the following heads:

4.1 Effect on the morphological characters of mungbean

4.1.1 Plant height

4.1.1.1 Effect of population density :

Plant height differed significantly with population density at maturity (Fig. 1). The tallest plants (52.94cm) were found in the highest population density, 25cm x 5cm (80 plants m^{-2}) and the shortest plants (35.17cm) were in the lowest population density, 25cm x 20cm (20 plants m^{-2}). There was a progressive increase in plant height with the increase in population density. This positive relationship of plant height with population density might be due to competition for sunlight and other related factors. The present results are in agreement with the result of El-Habbasha *et al.* (1996).

4.1.1.2 Effect of variety :

There was a highly significant variation on plant height among the varieties at maturity (Fig. 2). BINA mung-5 produced taller plants (44.90cm) and BARI mung-2 produced shortest plants (38.67cm) than the others. This variation in plant height might be attributed to the genetic characters. Similar findings were obtained by Farghali and Hossein (1995).

4.1.1.3 Interaction effect of varieties and population density

Plant height was highly significant due to the interaction of variety x population density (Fig. 3). The maximum plant height (56.03cm) was found in V_4 with 25cm x 5cm (80 plants m^{-2}) and the minimum (32.05cm) was in V_2 with 25cm x 15cm (25 plants m^{-2}).

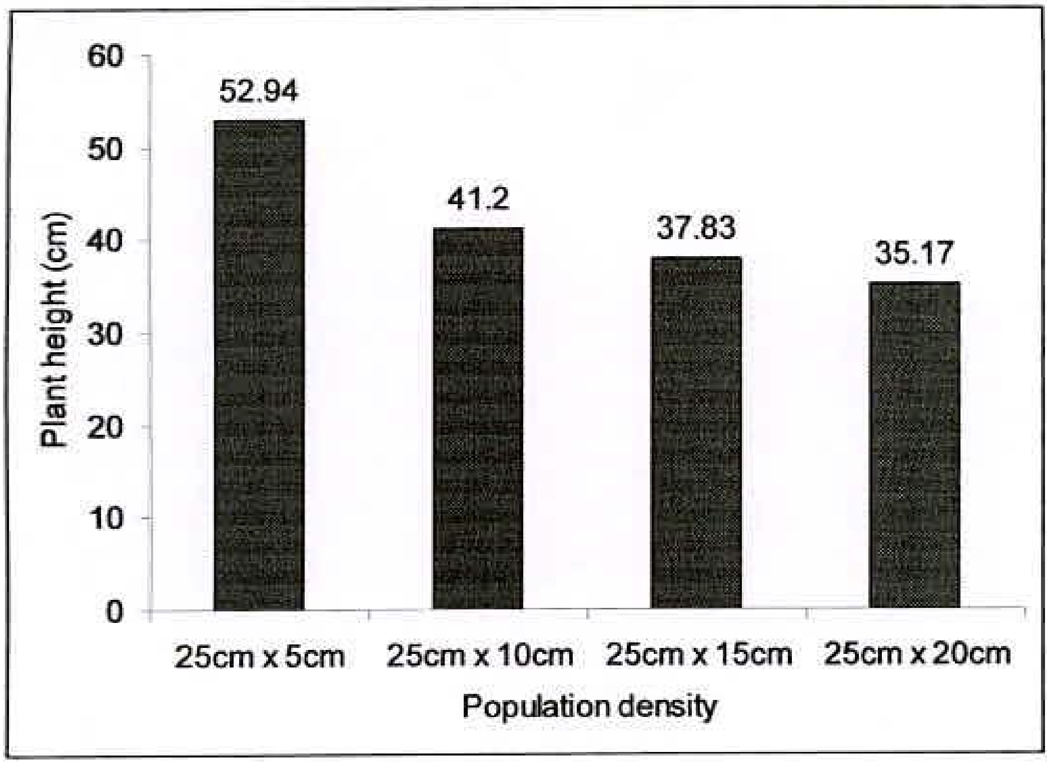

Fig. 1 Plant height of mungbean influenced by population density

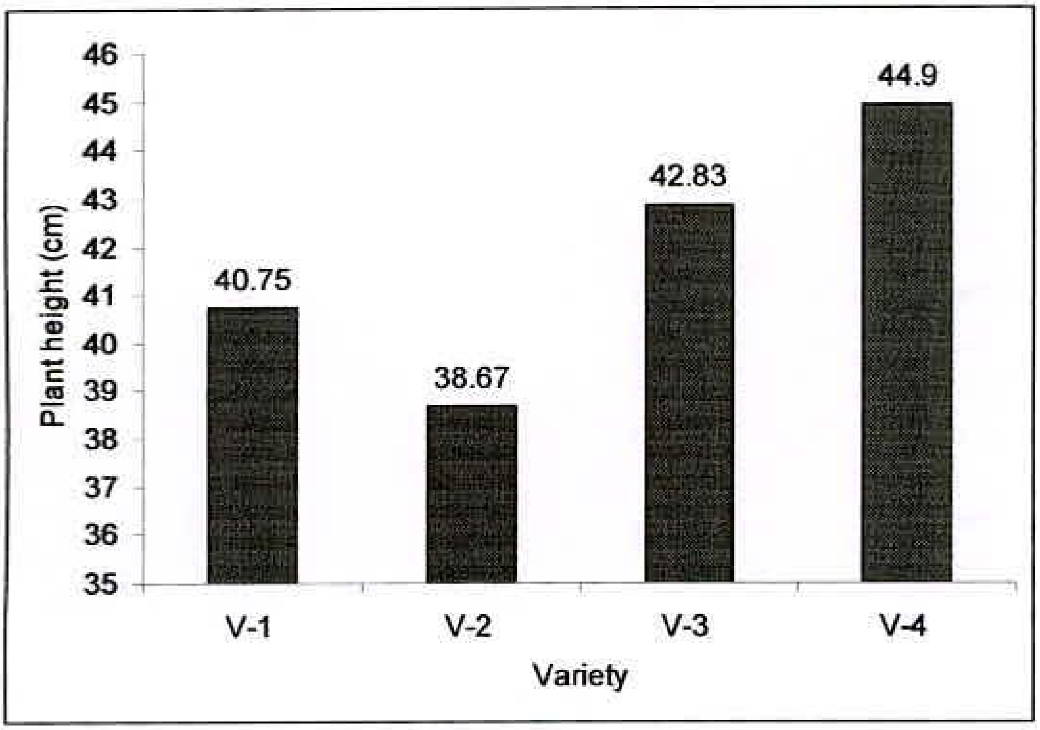

Fig. 2 Plant height of mungbean influenced by variety

V_1 = BARI mung-4 V_2 = BARI mung-2

V_3 = BARI mung-5 V_4 = BINA mung-5

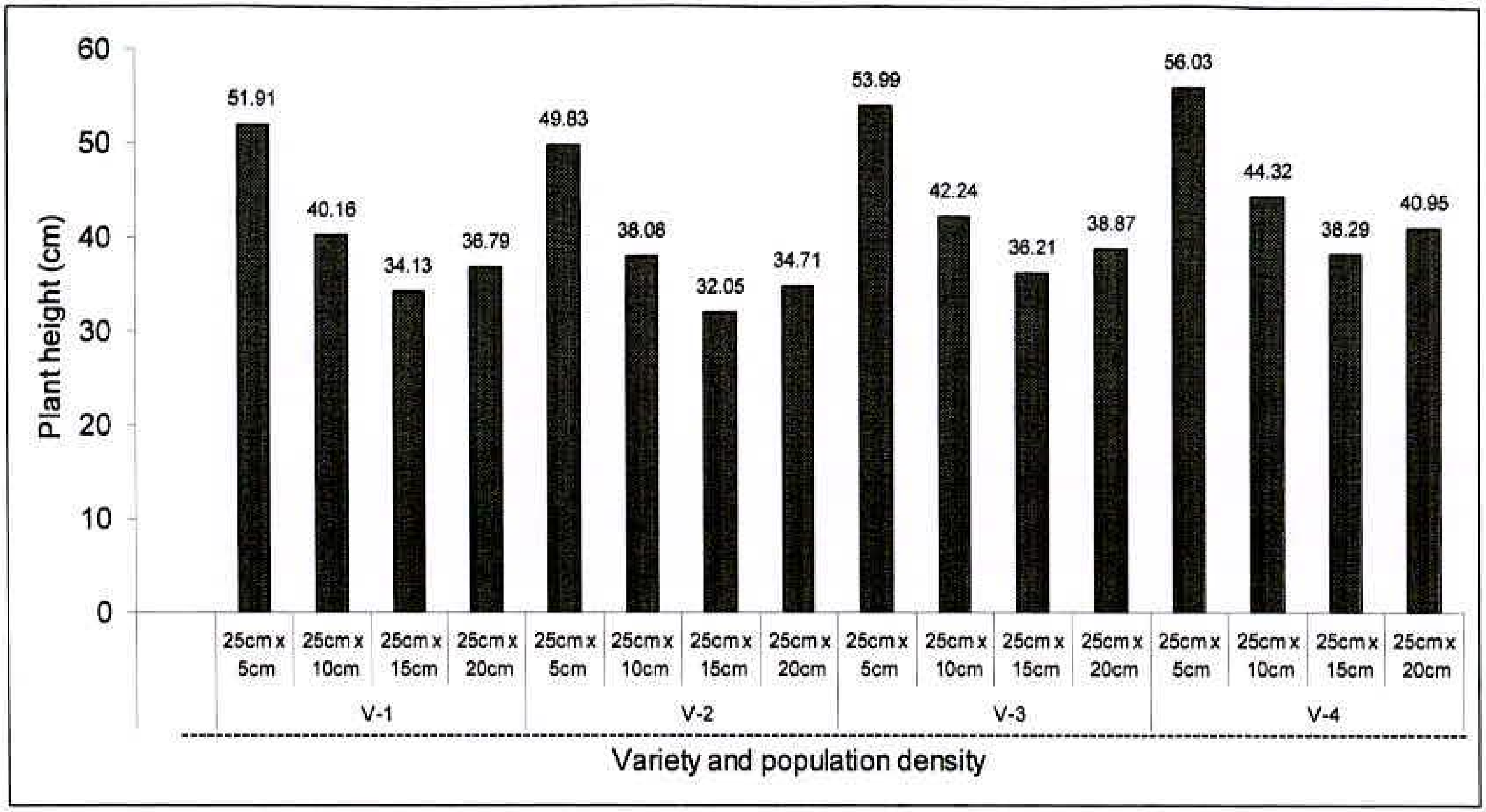

Fig. 3 Plant height of mungbean influenced by interaction of population density and variety

V_1 = BARI mung-4 V_2 = BARI mung-2

V_3 = BARI mung-5 V_4 = BINA mung-5

4.1.2. Root length

4.1.2.1 Effect of population density :

Population density showed a highly significant influence on root length (Table 1). Root length was the longest (16.50cm) at the lowest density 25cm x 20cm (20 plants m^{-2}) and the shortest (10.81) at the highest density 25cm x 5cm (80 plants m^{-2}) (Table 1). Length of root decreased with increasing population density.

4.1.2.2 Effect of variety:

Varieties differed significantly in their root length (Table 2).V_4 and V_3 produced longer (15.35cm and 14.47cm) root length than those of V_1 and V_2 (13.55cm and 12.71cm).

4.1.2.3 Interaction effect of varieties and population density

Root length was significant due to the interaction of variety x population density (Table 3). The maximum root length (17.85cm) was found in V_4 with 25cm x 20cm (20 plants m^{-2}) and the minimum (9.49cm) was in V_2 with 25cm x 5cm (80 plants m^{-2}).

4.1.3 Number of nodules plant $^{-1}$

4.1.3.1 Effect of population density :

The difference in number of nodules plant^{-1} due to population density was statistically highly significant (Table 1). The highest number of nodules plant^{-1} (16.63) was observed in the lowest density, 25cm x 20cm (20 plants m^{-2}) and the lowest (6.84) was at the highest density, 25cm x 5cm (80 plants m^{-2}). In general, number of nodules plant^{-1} increased at lower population density and it was probably due to availability of more space, nutrition, air and water to the plant.

4.1.3.2 **Effect of variety :**

Number of nodules plant^{-1} was significantly affected by varieties (Table 2). V_4 showed higher number of nodules plant^{-1} (13.95) and lowest V_2 (8.78) compared to the others (Table 2). A similar result was found by Shamnugarn *et al.* (1983).

Table 1. Effect of population density on the morphological characters of Mungbean

Population density	Root length (cm)	No. nodules plant^{-1}	No. leaves plant^{-1}
25cm x 5 cm	10.81 c	6.84 d	10.16 d
25cm x 10 cm	13.12 b	11.59 c	15.26 c
25cm x 15 cm	15.64 a	12.43 b	18.06 b
25cm x 20 cm	16.50 a	14.63 a	20.27 a
Level of significance	0.01	0.01	0.01
LSD	1.012	0.671	0.827

In a column, figures bearing uncommon letter(s) are significantly different at $p \leq 0.05$ by DMRT

Table 2. Effect of varieties on the morphological characters of Mungbean

Variety	Root length (cm)	No. nodules plant^{-1}	No. leaves plant^{-1}
V_1	13.55 bc	10.51 c	15.01 c
V_2	12.71 c	8.78 d	13.16 d
V_3	14.47 ab	12.25 b	16.86 b
V_4	15.35 a	13.95 a	18.71 a
Level of significance	0.01	0.01	0.01
LSD	1.012	0.671	0.827

In a column, figures bearing uncommon letter(s) are significantly different at $p \leq 0.05$ by DMRT

V_1 = BARI mung-4 V_2 = BARI mung-$_2$

V_3 = BARI bmung-5 V_4 = BINA mung-$_5$

Table 3. Interaction effect of varieties and population density on the morphological characters of Mungbean

Variety	Population density	Root length (cm)	No. nodules plant^{-1}	No. leaves plant^{-1}
	25cm x 5 cm	10.37 ij	5.98 k	9.23 j
	25cm x 10 cm	12.68 fg	10.72 g	14.33 g
V_1	25cm x 15 cm	15.20 cd	11.57 f	17.13 d
	25cm x 20 cm	15.96 bc	13.77 cd	19.35 c
	25cm x 5 cm	9.49 j	4.26 l	7.38 k
	25cm x 10 cm	11.80gh	8.96 i	12.48 h
V_2	25cm x 15 cm	14.32 de	9.85 h	15.28 f
	25cm x 20 cm	15.21 cd	12.05 ef	17.50 cd
	25cm x 5 cm	11.25 hi	7.70 j	11.08 i
	25cm x 10 cm	13.56 ef	12.51e	16.18 e
V_3	25cm x 15 cm	16.08 bc	13.29 d	18.98 d
	25cm x 20 cm	16.97 ab	15.49 b	21.20 ab
	25cm x 5 cm	12.13 gh	9.43 hi	12.93 h
	25cm x 10 cm	14.44 de	14.16 c	18.03de
V_4	25cm x 15 cm	16.96 ab	15.01 b	20.83 b
	25cm x 20 cm	17.85 a	17.21 a	23.05 a
Level of significance		0.01	0.01	0.01
LSD		1.012	0.671	0.827

In a column, figures bearing uncommon letter(s) are significantly different at $p \leq 0.05$ by DMRT

V_1 = BARI mung-4 V_2 = BARI mung-2

V_3 = BARI mung-5 V_4 = BINA mung-5

4.1.3.3Interaction effect of variety and population density

Number of nodules plant^{-1} was statistically significant due to the interaction of variety x population density (Table 3). The maximum nodules plant^{-1} (17.21) was found in V_4 with 25cm x 20cm (20 plants m^{-2}) and the minimum (4.26) was in V_2 with 25cm x 5cm (80 plants m^{-2}).

4.1.4 Number of leaves plant $^{-1}$

4.1.4.1 Effect of population density :

A highly significant variation in number of leaves plant^{-1} was observed with population density (Table 1). The highest number of leaves plant^{-1} (20.27) was found in the lowest population density, 25cm x 20cm (20 plants m^{-2}) and the lowest number of leaves plant^{-1} (10.16) was recorded at the highest population density, 25cm x 5cm (80 plants m^{-2}). The number of leaves increased might be due to available more nutrition, air and water to the plant.

4.1.4.2 Effect of variety:

Number of leaves plant^{-1} differed significantly among the varieties (Table 2). Higher number of leaves plant^{-1} (18.71) was noticed in V_4 and lower (13.16) in V_2 compare to others. This variation might be due to the different genetic makeup of the varieties.

4.1.4.3 Interaction effect of varieties and population density

Combined effect of varieties x population density on number of leaves plant^{-1} was statistically significant (Table 3). The higher leaves plant^{-1} (23.05) was found in V_4 with 25cm x 20cm (20 plants m^{-2}) and the lower (7.38) was in V_2 with 25cm x 5cm (80 plants m^{-2}).

4.2 Effect on the growth parameters

4.2.1 Crop growth rate (CGR)

4.2.1.1 Effect of population density:

The variation in CGR due to population density was statistically highly significant at all growth stages (Table 4). CGR increased with the increasing population density. The highest CGR (19.83 $gm^{-2}d^{-1}$) was obtained from 25cm x 5cm (80 plants m^{-2}) and the lowest (12.70 $gm^{-2}d^{-1}$) from 25cm x 20cm (20 plants m^{-2}) at 56-65 DAS. But during 66 DAS to maturity CGR decreased with the increasing population density (2.86, 2.63, 2.61 $gm^{-2}d^{-1}$) for 25, 40 and 20 plants m^{-2}, respectively. This result is in conformity with the results of Singh (1982). The CGR during vegetative stage to maturity declined mainly because of leaf abscission.

4.2.1.2 Effect of variety :

CGR value varied significantly among the varietes at different growth stages (Tabile 5).The higher CGR value of 77.80 during 56-65 DAS and 6.71during 66 DAS to maturity were observed with the variety BIN Amung -5.The lower CGR value was observed with the variety BIN Amung -2 at different growth stages.

4.2.1.3 Interaction effect of variety and population density

Interaction effect of variety x population density was found highly significant (Table 6). The maximum CGR value of 22.15 was obtained in V_4 with 25cm x 5cm (80 plants m^{-2}) and minimum of 10.45 was found in V_2 with 25cm x 20cm (20 plants m^{-2}) at 56-65 DAS but 66 DAS to maturity maximum CGR value 3.21was found in V_4 with 25cm x 15cm and least value of 1.41 was obtained in V_2 with 25cm x 5cm (80 plants $m^{-2)}$.

4.2.3 Relative Growth Rate (RGR)

4.2.3.1 Effect of population density

Population density showed a significant variation in respect of RGR at all growth stages (Table 4). The highest RGR (77.82 mg $g^{-1}d^{-1}$) was obtained from 25cm x 5cm (80 plants m^{-2}) and the lowest (73.58 mg $g^{-1}d^{-1}$) was obtained from

25cm x 20cm (20 plants m^{-2}) at 56-65 DAS. But during 66 DAS to maturity RGR showed vice-versa response (Table 4).

4.2.3.2 Effect of variety :

The effect of varieties on RGR was statistically significant at all sampling dates (Table 5). RGR was maximum (77.80 mg $g^{-1}d^{-1}$) in case of V_4 and the lowest (73.60 and 4.11 mg $g^{-1}d^{-1}$) was in V_2 at 56-65 DAS and 66 DAS to maturity, respectively.

4.2.3.3 Interaction effect of variety and population density

Combined effect of variety x population density on RGR was statistically significant at all growth periods (Table 6). The maximum RGR of 79.92 and minimum of 71.48 was obtained in V_4 with 25cm x 5cm (80 plants m^{-2}) and V_2 with 25cm x20cm (20 plants m^{-2}) at 56-65 DAS respectively.

Table 4. Effect of population density on the growth characters of Mungbean

Population density	Crop Growth Rate (CGR) at		Relative Growth Rate (RGR) at	
	56-65 DAS	66 DAS- maturity	56-65 DAS	66 DAS- maturity
25cm x 5 cm	19.83 a	1.78 b	77.82 a	4.11 d
25cm x 10 cm	16.96 b	2.63 a	76.42 ab	4.99 c
25cm x 15 cm	14.68 c	2.86 a	74.99 bc	5.83 b
25cm x 20 cm	12.70 d	2.61 a	73.58 c	6.69 a
Level of significance	0.01	0.01	0.01	0.01
LSD	0.936	0.302	1.728	0.503

In a column, figures bearing uncommon letter(s) are significantly different at $p \leq 0.05$ by DMRT

Table 5. Effect of variety on the growth characters of Mungbean

Variety	Crop Growth Rate (CGR) at		Relative Growth Rate (RGR) at	
	56-65 DAS	66 DAS- maturity	56-65 DAS	66 DAS- maturity
V_1	15.27 c	2.35 bc	75.00 bc	4.96 c
V_2	13.77 d	2.13 c	73.50 c	4.11 d
V_3	16.81 b	2.57 ab	76.40 ab	5.84 b
V_4	18.31 a	2.84 a	77.80 a	6.71 a
Level of significance	0.01	0.01	0.01	0.01
LSD	0.936	0.302	1.728	0.503

In a column, figures bearing uncommon letter(s) are significantly different at $p \leq 0.05$ by DMRT

V_1 = BARI mung-4 V_2 = BARI mung-2

V_3 = BARI mung-5 V_4 = BINA mung-5

Table 6. Interaction effect of varieties and population density on the morphological characters of Mungbean

Variety	Population density	Crop Growth Rate (CGR) at		Relative Growth Rate (RGR) at	
		56-65 DAS	66 DAS-maturity	56-65 DAS	66 DAS- maturity
V_1	25cm x 5 cm	19.01 c	1.65 fg	77.12 bc	3.63 f
	25cm x 10 cm	16.20 ef	2.51 cd	75.72 cd	4.56 e
	25cm x 15 cm	13.90 hi	2.74 bc	74.30 de	5.40 d
	25cm x 20 cm	11.95 j	2.50 cd	72.88 ef	6.26 c
V_2	25cm x 5 cm	17.51 d	1.41 g	75.72 cd	2.78 g
	25cm x 10 cm	14.70 gh	2.29 de	74.30 de	3.71 f
	25cm x 15 cm	12.40 j	2.52 cd	72.88 ef	4.55 e
	25cm x 20 cm	10.45 j	2.28 de	71.48 f	5.40 d
V_3	25cm x 5 cm	20.65 b	1.87 f	78.52 ab	4.58 e
	25cm x 10 cm	17.70 d	2.73 bc	77.12 bc	5.41 d
	25cm x 15 cm	15.45 fg	2.96 ab	75.70 cd	6.25 c
	25cm x 20 cm	13.45 i	2.72 bc	74.28 de	7.11 b
V_4	25cm x 5 cm	22.15 a	2.19 e	79.92 a	5.43 d
	25cm x 10 cm	19.22 c	2.99 ab	78.52 ab	6.28 c
	25cm x 15 cm	16.95 de	3.21 a	77.08 bc	7.13 b
	25cm x 20 cm	14.93 g	2.97 ab	75.68 cd	7.98 a
Level of significance		0.01	0.01	0.01	0.01
LSD		0.963	0.302	1.728	0.503

In a column, figures bearing uncommon letter(s) are significantly different at $p \leq 0.05$ by DMRT

V_1 = BARI mung-4 V_2 = BARI mung-2

V_3 = BARI mung-5 V_4=BINAmung-5

4.3 Effect on the yield and yield contributing characters

4.3.1 Number of branches plant^{-1}

4.3.1.1 Effect of population density :

A highly significant variation in the number of branches plant^{-1} was found in different population density (Table 7). The maximum number of branches plant^{-1} (4.53) was recorded in 25cm x 20cm (20 plants m^{-2}) which was statistically similar (3.89) to 25cm x 15cm (25 plants m^{-2}) and the minimum (2.38) was in 25cm x 5cm (80 plants m^{-2}). In general, number of branches plant^{-1} increased at lower population density and it was probably due to availability of more space, nutrition, water and light to the plant. The present result is similar with the report of Sekhon *et al.* (2002).

4.3.1.2 Effect of variety :

Statistically a highly significant variation in number of branches plantl^{-1} was observed due to variation in varieties (Table 8). Higher number of branches plant^{-1} (4.78) was recorded in V_4 and the lower (average of 3.16) was observed in V_1, V_2 and V_3.

4.3.1.3 Interaction effect of variety and population density:

Interaction effect of variety x population density on number of branches plant^{-1} was statistically significant (Table 9). Higher number of branches plant^{-1} (5.83) was recorded in V_4 with 25cm x 20cm (20 plants m^{-2}) and the lower (1.42) was observed in V_2 with 25cm x 5cm (80 plants m^{-2}).

4.3.2 Number of pods plant^{-1}

4.3.2.1 Effect population density :

Population density showed a highly significant influence on the number of pods plant^{-1} (Table 7). The maximum number of pods plant^{-1} (12.49 and 11.82) was produced in 25cm x 20cm (20 plants m^{-2}) and 25cm x 10cm (40 plants m^{-2}) and the minimum (7.86) was in 25cm x 5cm (80 plants m^{-2}). Number of pods $plant^{-1}$ decreased with increasing population density. It could probably by the availability of more space, water, light and nutrient in the thinly populated crop resulted in the production of more pods $plant^{-1}$. A similar result was found by Sekhon *et al.* (2002).

4.3.2.2 Effect of variety :

A highly significant variation was also found for varieties (Table 8). V_4 produced the maximum (12.78) number of pods $plant^{-1}$ and the minimum (8.71) was in V_2.

4.3.2.3 Interaction effect of variety and population density

Significant variation was obtained due to combination of variety x population density on the number of pods $plant^{-1}$ (Table 9). Highest number of pods $plant^{-1}$ (14.51) was recorded in V_4 with 25cm x 20cm (20 plants m^{-2}) and the lowest (5.74) was observed in V_2 with 25cm x 5cm (80 plants m^{-2}).

4.3.3 Pod length :

4.3.3.1 Effect of population density :

The difference in pod length due to population density was statistically highly significant (Table 7). The longest pod (7.07cm) was produced by 25cm x 20cm (20 plants m^{-2}) and the shortest pod (5.26cm) was in 25cm x 5cm (80 plants m^{-2}). The result was similar with the result documented by Miranda *et al.* (1997) who noticed that pod length decreased with increasing population density. Production of shorter pods at the highest population density was probably due to hard competition for nutrient, water and light in closer spacing.

4.3.3.2 Effect of variety :

Varieties showed a highly significant difference in pod length (Table 8). Longer pod length (7.06cm) was observed in V_4 and shorter (5.26cm) was in V_2. This result is in agreement with the result of Sarkar *et al.* (2004) who reported that pod length differed from variety to variety. The probable reason of this difference could be the genetic make-up of the variety which was influenced primarily by heredity.

Table 7. Effect of population density on yield and yield contributing characters of Mungbean

Population density	No. branche/plant	No. pods/ plant	Pod length (cm)	No. seeds/ pod	1000 seed weight (g)	Seed yield/ plant	TDM/ plant (g)	Harvest Index (%)
25cm x 5 cm	2.38 c	7.86 c	5.26 d	6.33 d	23.39 d	1.16 d	7.80 d	14.87 d
25cm x 10 cm	3.45 b	11.82 ab	5.87 c	9.23 b	25.80 c	2.81 b	15.15 a	18.54 b
25cm x 15 cm	3.89 ab	10.90 b	6.45 b	8.36 c	26.70 b	2.43 c	13.99 b	17.38 c
25cm x 20 cm	4.53 a	12.49 a	7.07 a	9.80 a	27.57 a	3.37 a	12.67 c	26.59 a
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
LSD	0.911	0.923	0.204	0.235	0.864	0.252	0.462	1.00

In a column, figures bearing uncommon letter(s) are significantly different at $p \leq 0.05$ by DMRT

Table 8. Effect of variety on yield and yield contributing characters of Mungbean

Variety	No. branches/plant	No. pods/ plant	Pod length (cm)	No. seeds/ pod	1000 seed weight (g)	Seed yield/ plant	TDM/plant (g)	Harvest Index (%)
V_1	3.16 b	10.14 c	5.86 c	7.84 c	25.38 c	2.02 c	11.88 c	17.09 c
V_2	2.73 b	8.71 d	5.26 d	7.09 d	24.48 d	1.51 d	10.73 d	13.67 d
V_3	3.59 b	11.43 b	6.46 b	9.53 b	26.33 b	2.87 b	13.03 b	21.19 b
V_4	4.78 a	12.78 a	7.06 a	10.21 a	27.26 a	3.56 a	14.18 a	25.52 a
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
LSD	0.911	0.923	0.204	0.235	0.864	0.252	0.462	1.00

In a column, figures bearing uncommon letter(s) are significantly different at $p \leq 0.05$ by DMRT

V_1 = BARI mung-4 V_2 = BARI mung-2 V_3 = BARI mung-5 V_4 = BINA mung-5

Table 9. Interaction effect of varieties and population density on the yield and yield contributing characters of Mungbean

Variety	Population density	No. branches/ plant	No. pods/ plant	Pod length (cm)	No. seeds/ Pod	1000 seed weight (g)	Seed yield/plant (g)	TDM/ plant (g)	Harvest Index (%)
V_1	25cm x 5 cm	1.85 hi	7.37 h	4.96 f	5.75k	22.85 k	0.94j	7.23i	13.00h
	25cm x 10 cm	3.12 efg	11.15 e	5.57 e	8.66f	25.35 gh	2.45f	14.56c	16.82f
	25cm x 15 cm	3.56 def	10.21 f	6.15 d	7.69h	26.25 ef	2.06gh	13.42d	15.35g
	25cm x 20 cm	4.10 bcd	11.81 d	6.77 c	9.23e	27.10 de	2.85e	12.29e	23.18d
V_2	25cm x 5 cm	1.42 i	5.74 i	4.36 g	4.60l	21.95 l	0.58k	6.08j	9.53j
	25cm x 10 cm	2.69 fgh	9.80 f	4.97 f	7.52h	24.45 ij	1.80h	13.43d	13.40h
	25cm x 15 cm	3.13 efg	8.84 g	5.55 e	6.18j	25.35 gh	1.38i	12.27e	11.28i
	25cm x 20 cm	3.67 cde	10.46 ef	6.17 d	8.09g	26.20 fg	2.28fg	11.14f	20.47e
V_3	25cm x 5 cm	2.28 gh	8.48 g	5.56 e	6.90i	23.93 j	1.40i	8.38h	16.71f
	25cm x 10 cm	3.55 def	12.50 cd	6.17 d	9.80d	26.25 ef	3.22d	15.72b	20.48e
	25cm x 15 cm	3.99 bcde	11.58 d	6.75 c	9.18e	27.15 cd	2.89e	14.57c	19.83e
	25cm x 20 cm	4.53 bc	13.16 bc	7.37 b	10.37c	28.01 bc	3.82c	13.44d	28.42b
V_4	25cm x 5 cm	3.98 bcde	9.85 f	6.16 d	8.05g	24.83 hi	1.97h	9.53g	20.67e
	25cm x 10 cm	4.42 bcd	13.81 ab	6.77 c	10.93b	27.15 cd	4.10b	16.87a	24.30c
	25cm x 15 cm	4.89 b	12.95 bc	7.36 b	10.36c	28.05 b	3.76c	15.72b	23.92cd
	25cm x 20 cm	5.83 a	14.51 a	7.97 a	11.50a	29.00 a	4.84a	14.59c	33.17a
Level of significance		0.01	0.01	0.01	0.01	NS	0.01	0.01	0.01
LSD		0.911	0.923	0.204	0.235	0.864	0.252	0.462	1.00

In a column, figures bearing uncommon letter(s) are significantly different at p≤0.05 by DMRT

V_1 = BARI mung-4 V_2 = BARI mung-2

V_3 = BARI mung-5 V_4 = BINA mung-5

4.3.3.3 Interaction effect of variety and population density

Combined effect of variety x population density was significant on pod length (Table 9). Highest pod length (7.97) was recorded in V_4 with 25cm x 20cm (20 plants m^{-2}) and the lowest (4.36) was observed in V_2 with 25cm x 5cm (80 plants m^{-2}).

4.3.4 Number of seeds pod^{-1}

4.3.4.1 Effect of population density:

Population density showed a highly significant effect on number of seeds pod^{-1} (Table 7). The highest number of seeds pod^{-1} (9.80) was recorded in 25cm x 20cm (20 plants m^{-2}) and the lowest (6.33) was in 25cm x 5cm (80 plants m^{-2}). Number of seeds pod^{-1} decreased gradually with the increasing population density probably due to intense competition for the above and below ground resources. Similar result was reported by Miranda *et al.* (1997).

4.3.4.2 Effect of variety:

Varieties significantly influenced the number of seeds pod^{-1} (Table 8). The maximum number of seed pod^{-1} (10.21) was obtained in V_4 while the minimum (7.09) was in V_2. A similar result was also found by Infante *et al.* (2003).

4.3.4.3 Interaction effect of variety and population density

Interaction effects of variety x population density on number of seeds pod^{-1} were statistically highly significant (Table 9). The highest number of seed pod^{-1} (11.50) was obtained in V_4 with 25cm x 20cm (20 plants m^{-2}) and the lowest (4.60) was in V_2 with 25cm x 5cm (80 plants m^{-2}).

4.3.5 1000-seed weight

4.3.5.1 Effect of population density:

Population density showed a highly significant effect on 1000-seed weight (Table 7). The highest 1000-seed weight (27.57g) was found in 25cm x 20cm (20 plants m^{-2}) and the lowest (23.39g) was in 25cm x 5cm (80 plants m^{-2}). Higher weight of 1000-seed was obtained with lower plant population. This might be due to availability of more nutrition, water and light to the plant at lower density which provided scope for increased photosynthetic activities and translocation of more metabolites to the seed sink.

4.3.5.2 Effect of variety :

Varieties also showed highly significant effect on 1000-seed weight (Table 8). V_4 produced maximum 1000-seed weight (27.26g) whereas, V_2 had the minimum (24.48g). Similar result was reported by Sarkar *et al.* (2004).

4.3.5.3 Interaction effect of varietY and population density

Combined effect of variety x population density was significant on 1000-seed weight (Table 9). The maximum 1000-seed weight (29.00g) was found in V_4 with 25cm x 20cm (20 plants m^{-2}) and the lower (21.95g) was in V_2 with 25cm x 5cm (80 plants m^{-2}).

4.3.6 Seed yield plant^{-1}

4.3.6.1Effect of population density;

The difference in seed yield plant^{-1} due to population density was statistically significant (Table 7). The maximum seed yield plant^{-1} (3.37g) was obtained in 25cm x 20cm (20 plants m^{-2}) and the minimum was (1.16g) in 25cm x 5cm (80 plants m^{-2}). Seed yield plant^{-1} increased with the decrease of population density. Similar trend was also reported by Hasanuzzaman (2001). It might be due to more number of pod plant^{-1}, seed pod^{-1} and 1000-seed weight from healthy plants in lowest population density.

4.3.6.2 Effect of variety:

A highly significant variation on seed yield plant^{-1} was observed among the varieties (Table 8). V_4 produced the highest seed yield plant^{-1} (3.56g) and the lowest (1.51g) was in V_2.

4.3.6.3 Interaction effect of variety and population density

Seed yield plant^{-1} was highly significant due to the interaction of variety x population density (Table 9). The maximum seed yield plant^{-1} (4.84g) was found in V_4 with 25cm x 20cm (20 plants m^{-2}) and the lower (0.58g) was in V_2 with 25cm x 5cm (80 plants m^{-2}).

4.3.7 Total Dry Weight Plant^{-1}

4.3.7.1 Effect of population density:

A highly significant variation in total dry weight plant^{-1} was observed in different population density (Table 7). The maximum total dry weight plant^{-1} (15.15g) was observed in the population density, 25cm x 10cm (40 plants m^{-2}) and the minimum (7.80g) was in the highest population density, 25cm x 5cm (80 plants m^{-2}).

4.3.7.2 Effect of variety:

Mungbean varieties showed a highly significant influence on the total dry weight plant^{-1} (Table 8). The maximum total dry weight plant^{-1} (14.18g) was produced by V_4 and the minimum (10.73g) was in V_2.

4.3.7.3 Interaction effect of variety and population density

A highly significant variation in total dry weight plant^{-1} was recorded due to combined effect of varieties x population density (Table 9). The maximum total dry weight plant^{-1} (16.87g) was in the combination of V4 with 25cm x10cm (40 plants m^{-2}) and the minimum (6.08) was in V2 with 25cm x 5cm (80 plants m^{-2}).

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

4.3.8.1 Effect of population density:

Plant population showed a highly significant impact on seed yield (Fig. 4). The highest seed yield (1124 kg ha^{-1}) was obtained in 25cm x 10cm (40 plants m^{-2}) and the lowest (608 kg ha^{-1}) was in 25cm x 15cm (25 plants m^{-2}). Increase in seed yield with increasing the population density up to a certain limit and there after the response was negative, this result was in agreement with the findings of Mimber (1993).

4.3.8.2 Effect of variety:

Variety had remarkable influence on seed yield (Fig. 5). V_4 produced higher seed yield (1281kg ha^{-1}) than the others. It might be due to higher number of seed pod^{-1}, pod length and 1000-seed weight.

4.3.8.3 Interaction effect of variety and population density

Interaction effect of cultivar x population density was statistically significant (Fig. 6). The maximum seed yield (1640 kg ha^{-1}) was observed in V_4 with 25cm x 10cm (40 plants m^{-2}) and the minimum was (346 kg ha^{-1}) in V_2 with 25cm x 15cm (25 plants m^{-2}).

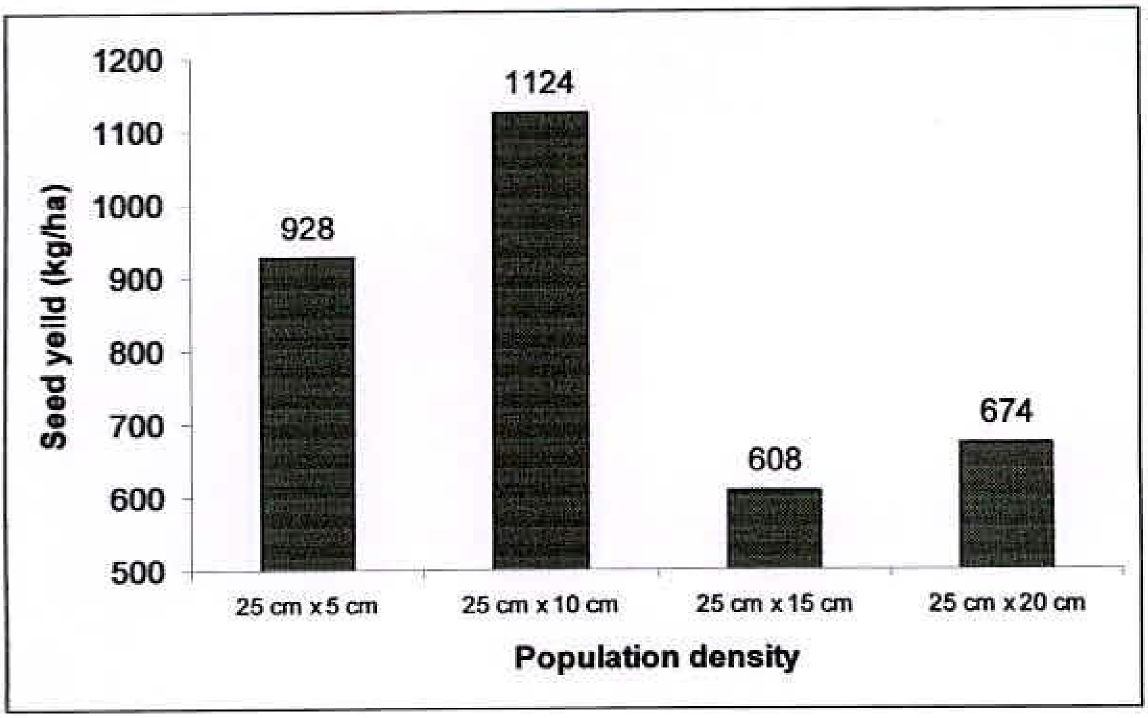

Fig. 4 Seed yield (kg ha^{-1}) of mungbean as influenced by population density

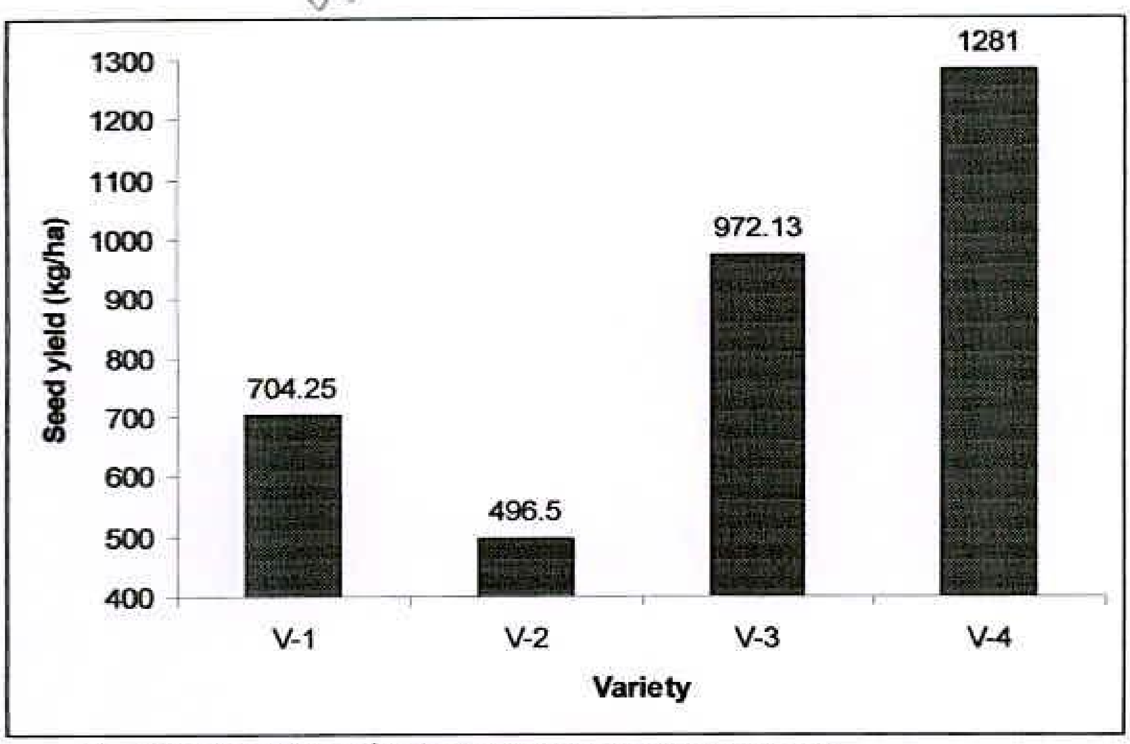

Fig. 5 Seed yield (kg ha^{-1}) of mungbean as influenced by variety

V_1 = BARI mung-4 V_2 = BARI mung-2

V_3 = BARI mung-5 V_4 = BINA mung-5

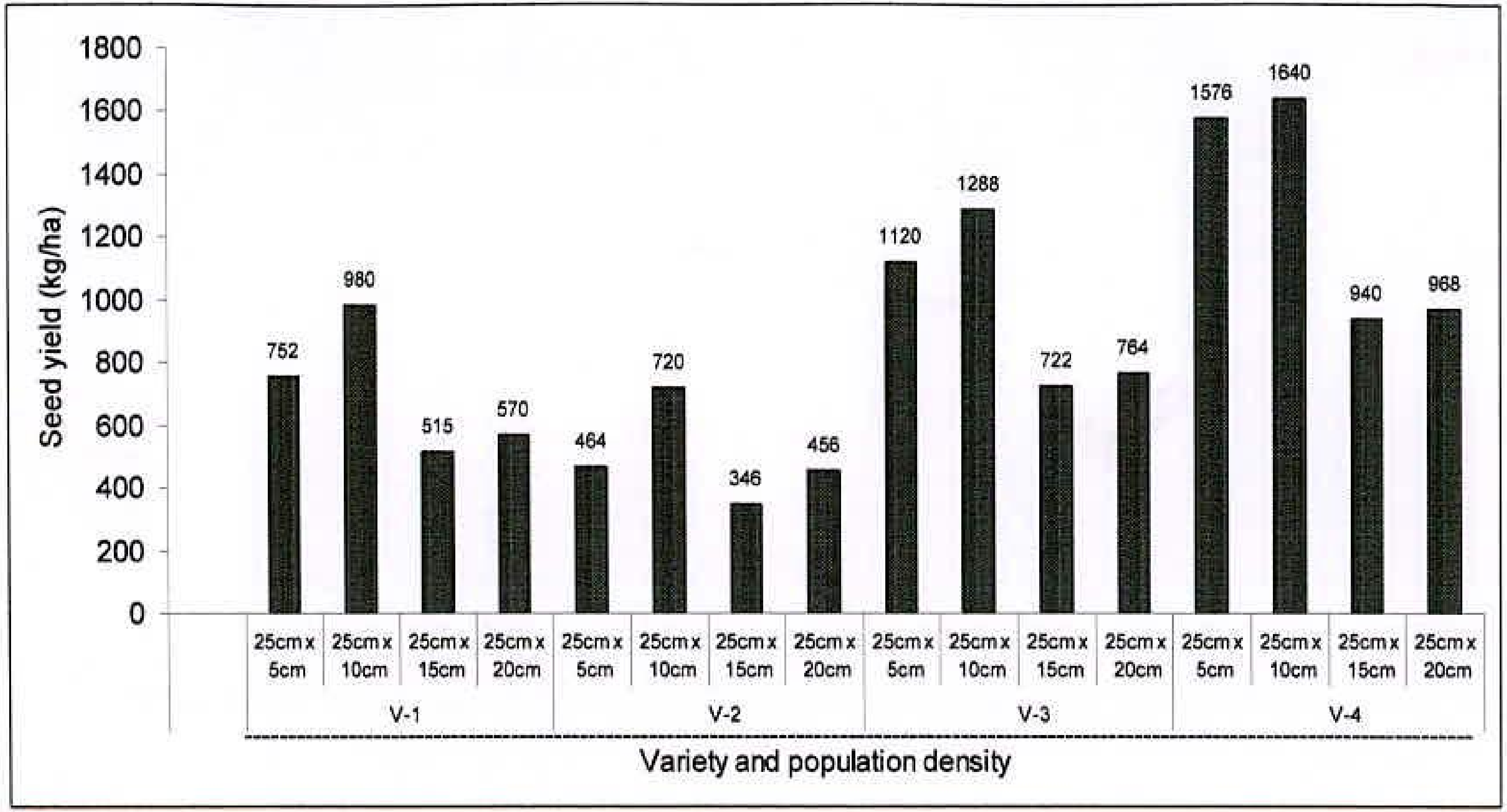

Fig. 6 Seed yield (kg ha^{-1}) of mungbean as influenced by interaction of population density and variety

V_1 = BARI mung-4 V_2 = BARI mung-2

V_3 = BARI mung-5 V_4 = BINA mung-5

4.3.9Biological yield (kg ha^{-1})

4.3.9.1Effect of population density:

A highly significant effect of population density on biological yield (kg ha^{-1}) was observed in the present experiment (Fig. 7). The highest biological yield (6058 kg ha^{-1}) was obtained from 25cm x 10cm (40 plants m^{-2}) which was statistically similar to that of 25cm x 5cm (80 plants m^{-2}) and the lowest was (2573 kg ha^{-1}) in 25cm x 20cm (20 plants m^{-2}). Biological yield increased with increasing population density upto a certain limit but there after biological yield decreased with the increase of population density.

4.3.9.2Effect of varity:

Significant variation on biological yield (Kg ha$^{-1)}$ was observed among the varieties (Fig. 8).Barimung-4(V_4) gave higher (5055 kg ha^{-1}) and Barimung-2 (V_2) gave lower (3883 kg ha^{-1}) biological yield.

4.3.9.3 Interaction effect of variety and population density

The interaction effect of variety x population density was statistically significant on biological yield (kg ha^{-1}) (Fig. 9). The maximum biological yield (6748 kg ha^{-1}) was observed in V_4 with 25cm x 10cm (40 plants m^{-2}) and the minimum was (2228 kg ha^{-1}) in V_2 with 25cm x 20cm (20 plants m^{-2}).

4.3.10 Harvest index (HI)

4.3.10.1 Effect of population density:

Population density showed a highly significant influence on the harvest index (Table 7). The highest HI (26.59%) was recorded at 25cm x 20cm (20 plants m^{-2}) and the lowest was (14.87 %) in 25cm x 5cm (80 plants m^{-2}). Similar result was reported by Tsuing (1978). The higher HI indicates the higher translocation ability of sources to single organ.

4.3.10.2 Effect of variety :

Varietal effect on HI was highly significant (Table 8). Higher HI was (25.52%) found in V_4 and the lower was (13.67%) in V_2. It might be due to better seed yield (1281 kg ha^{-1}). Sarkar *et al.* (2004) also observed that HI was significantly influenced by the variety.

4.3.10.3 Interaction effect of variety and population density

The interaction effect of variety x population density in relation to HI was highly significant (Table 9). The maximum HI (33.17%) was observed in the combination of V_4 with 25cm x 20cm (20 plants m^{-2}) and the minimum was (9.53%) in V_2 with 25cm x 5cm (80 plants m^{-2}).

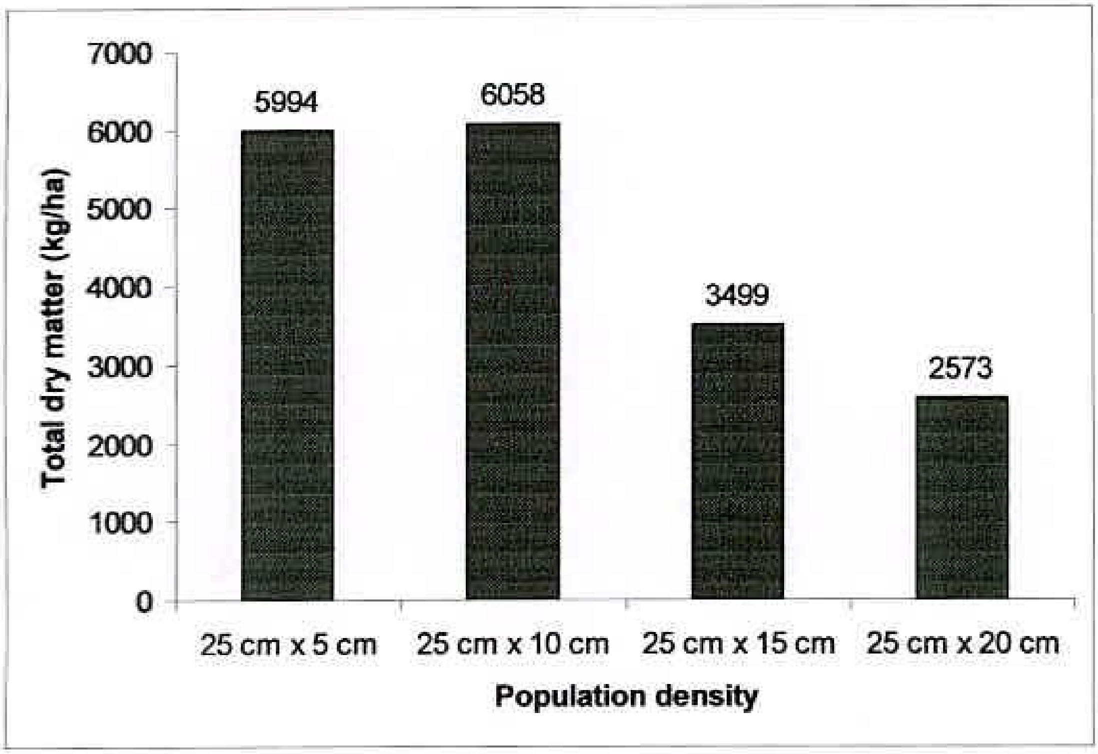

Fig. 7 Biological yield (kg ha^{-1}) of mungbean influenced by population density

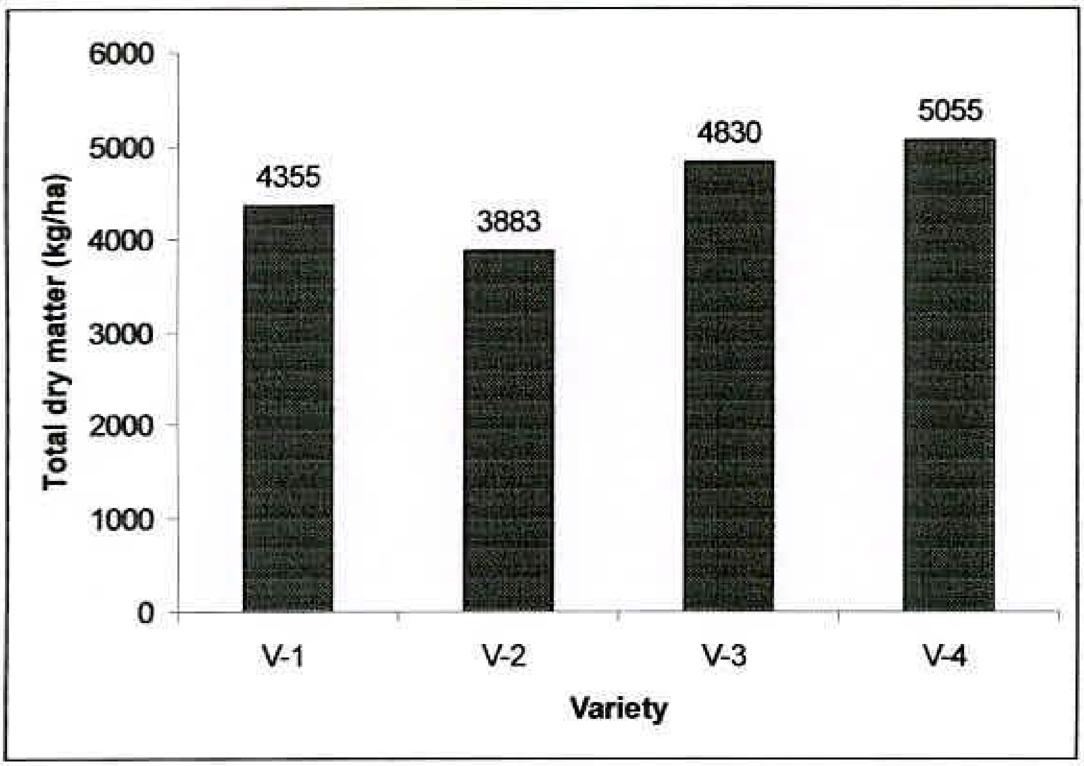

Fig. 8 Biological yield (kg ha^{-1}) of mungbean influenced by variety

V_1 = BARI mung-4 V_2 = BARI mung-2

V_3 = BARI mung-5 V_4 = BINA mung-5

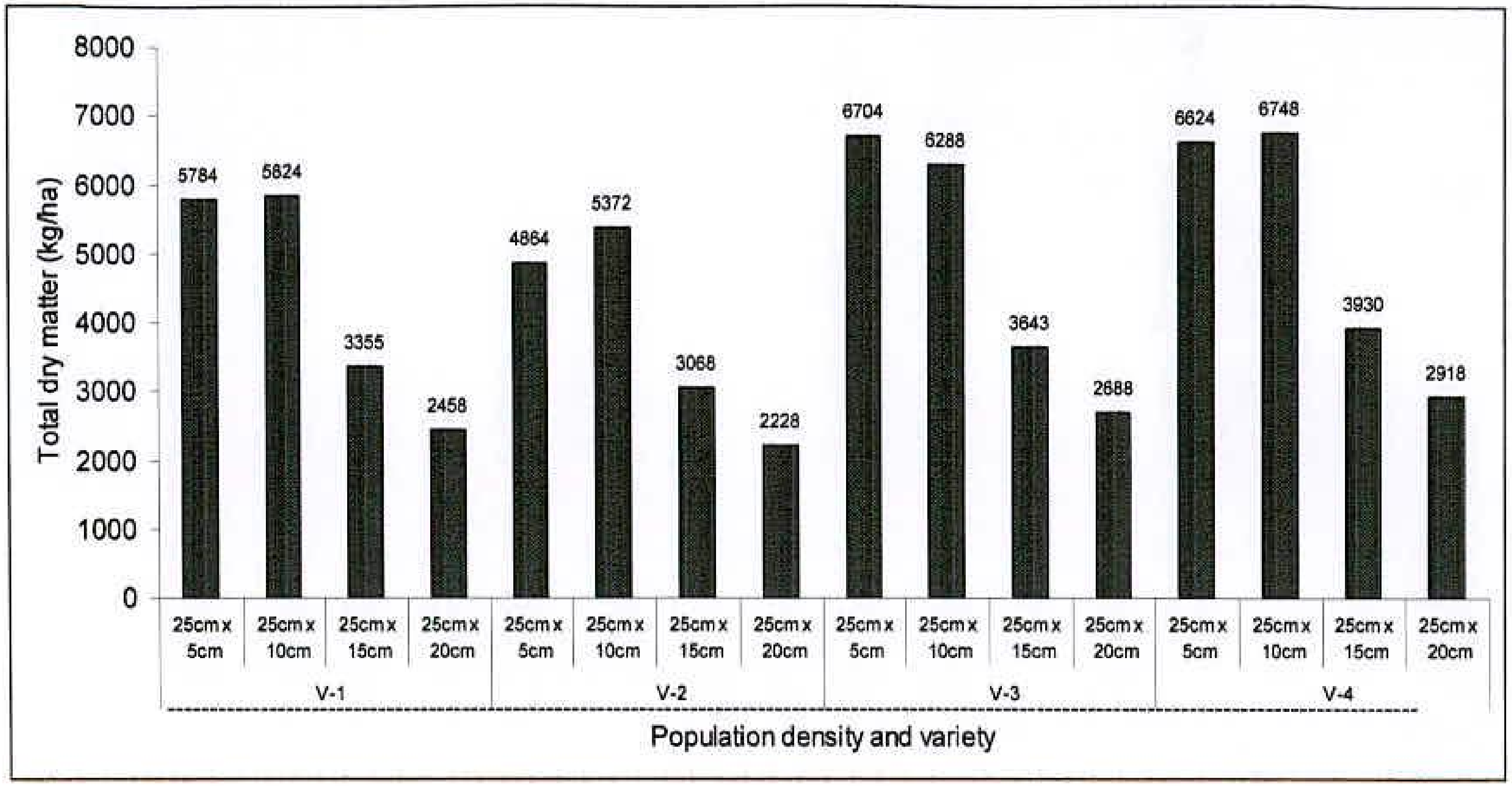

Fig. 9 Biological yield (kg ha^{-1}) of mungbean influenced by interaction of population density and variety

V_1 = BARI mung-4 V_2 = BARI mung-2

V_3 = BARI mung-5 V_4 = BINA mung-5

Chapter 5

Summary and Conclusion

CHAPTER 5

SUMMARY AND CONCLUSION

The experiment was conducted at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka, during April 10 to July 15, 2007 to study the effect of different population density viz,(25cm x 5cm, 25cm x 10cm, 25cm x 15cm and 25cm x 20cm) 80, 40, 25 and 20 plants m^{-2} on the growth, yield, and yield attributes of four summer mungbean varieties (BARI mung-4, BARI mung-2, BARI mung-5 and BINA mung-5). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The size of unit plot was 3.5m x 2.5m. The land was fertilized with Urea, TSP and MP @ 30, 70 and 35 kg ha^{-1} respectively. The seeds were sown on April 10, 2007. Intercultural operations were done as when necessary. Data on growth and yield parameters were recorded from vegetative growth to Maturity. All the collected data were statistically analyzed and the mean differences among the treatments were compared by Duncan's Multiple Range Test (DMRT).

The results showed that all the growth parameters, yield and yield attributes were significantly influenced by the population density. Lower population density 25cm x 20cm, (20 Plants m^{-2}) produced the highest root length, number of nodules and leaves $plant^{-1}$,RGR at 66 DAS to maturity number of branches and pods $plant^{-1}$, pod length, number of seeds pod^{-1}, 1000-seed weight, seed yield $plant^{-1}$ and harvest index. Higher population density, 25cm x 5cm (80 Plants m^{-2}) produced the highest plant height, CGR,RGR at 56-65 DAS.

The seed yield (Kg ha^{-1}) and HI (%) increased significantly with increasing population density from 25cm x 20cm, (20 plants m^{-2}) to 25cm x 10cm, (40 plants $m^{-2)}$. Increase in population density up to 20 plants m^{-2} decreased the seed yield (Kg ha^{-1}). Seed yield (kg ha^{-1}) was a function of yield contributing characters. Results revealed that increasing population density lowered the yield contributing characters. The lower population density, 25cm x 20cm (20 plants m^{-2}) produced the highest number of branches $plant^{-1}$, number of pods $plant^{-1}$, pod length, number of seeds pod^{-1}, 1000-seed weight and seed yield $plant^{-1}$. This was possibly due to maximum utilization of solar radiation, soil nutrient uptake and less competition among the plant population. But it did not compensate the total seed yield ha^{-1} as compared to 40 plants m^{-2}.

In 40 plants m^{-2} total seed yield ha^{-1} was maximum. This was due to the optimum plant population per unit area. This indicated that 40 plants m^{-2} balanced between increasing plant m^{-2} and decreasing yield $plant^{-1}$ and gave the maximum seed yield ha^{-1}. Higher plant population from optimum density levels was related to inter-plant competition for all elements. Too much inter-plant competition resulted less biological yield and less partition of biological yield into reproductive organs at further higher density. Thus, the highest seed yield (1124 kg ha^{-1}) was obtained from 40 plants m^{-2}. So, it appeared that 40 plants m^{-2} were the optimum population density for cultivation of seed yield of mungbean.

Varietal performance on growth, yield and yield contributing characters differed significantly all the parameters. BINAmung-5 showed higher plant height, root length, number of nodules and leaves $plant^{-1}$, CGR and RGR at 56-65 and 66 DAS to maturity, number of branches $plant^{-1}$, number of pods plant, pod length, number of seeds pod^{-1}, 1000-seed weight, seed yield $plant^{-1}$, seed yield (kg ha^{-1}) and HI (%) than the others (BARImung-4, BARI mung -2 and BARI mung -5).

The present study, interaction effect of variety and population density were found statistically significant on almost all the growth and yield parameters. The highest number seeds of $plant^{-1}$, seed yield $plant^{-1}$ (g) and harvest index (%)

was found in V_4 with 25cm x 20cm (20 plants m^{-2}) and the lowest was in V_2 with 25cm x 20cm (20 plants m^{-2}). The highest biological yield was observed in BINA mung-5(V_4) with 25cm x 10cm (40 plants m^{-2}) and the lowest was in BARI mung-2 V_2 with 25cm x 20cm (20 plants m^{-2}).

From the results of the experiment, it could be concluded that

1. All the growth and yield parameters were significantly affected by population density
2. Among the varieties BINAmung-5 showed better performance than BARI mung -4, BARI mung -2 and BARI mung-5 on growth, yield and yield attributes
3. Out of the four population density, 25cm x 10cm (40 plants m^{-2}) may be optimum population density for seed yield in summer mungbean

References

REFERENCES

Abbas, M., Singh, M.P., Nigam, K.B. and Kandalkar, V.S. 1994. Effect of phosphorus, plant density and plant type on yield and yield attributing character of soybean. Indian J. Agron., 39(2): 249-251.

Ahmed, Z.U., Shaikh, A.A.Q., Majid, M.A. and Begum, S. 1981. Correlation studies in agronomic characters of mungbean. Bangladesh J. Agril. Sci., 8(1):31-36.

Akther, N.1999. Effect of spacing and top removal on the growth, vegetable pod yield and grain yield of edible podded pea. M.S. Thesis, Dept. of Agronomy, Bangabandhu Sheik Muzibur Rahman Agricultural University, Salna, Gazipur. pp. 84.

Anisuzzaman, M. 2005. Effect of population density on the growth and yield of edible pea. M.S. Thesis, Dept. of Crop Botany, Bangladesh Agricultural University, Mymensingh.

Babu, K.G., Sai, R.S. and Garg, O.K. 1988. Effect of row spacing on growth and yield in mungbean. Legume Res., 11(2): 75-80.

Babu, K.S. and Mitra, S.K. 1989. Effect of plant density on grain yield of maize during Rabi season. Madras Agric. J. 76: 290-292.

BARI (Bangladesh Agricultural Research Institute). 2000. Moogdaler Unnata Jar. Barimoog-2 (Bangla). Lentil, blackgram and mungbean development pilot project, Bangladesh Agri. Res. Inst., Joydebpur, Gazipur. Publication No. 6.

Rahman,M.A.,Fakir,M.S.A. and Rahman,M.M.,2005.Effect of population density in soybean.MS Theiss.Dept.Crop Botany,Bangladesh Agricultural University Mymensingh.

Barua, H. 2006. Effect of density on canopy structure, growth and yield in sunnhemp. M.S. Thesis, Dept. of Crop Botany, Bangladesh Agricultural University, Mymensingh.

BBS (Bangladesh Bureau of Statistics). 2005. Monthly Statistical Bulletin of Bangladesh. March, 2005. Ministry of Planning. Govt. People's Republic of Bangladesh. Dhaka. p.57.

Beech, D.F. and Wood, I.W. 1978. Evaluation of mungbean under irrigation in northern Australia. Proc. First Intl. Mungbean Symp. August 16-19. Los Banos, Philippines. p.15

Begum, M.O. 2002. Effect of planting density on growth and yield in sesame. M.S. Thesis, Dept. of Crop Botany, Bangladesh Agricultural University, Mymensingh.

Brathwaite, R.A.I. 1982. Bodic Bean responses to changes in plant density. Agron. J. 74(4): 593596.

Chen, C.Y., Tsou, S.C.S. and Wang, H.H. 1987. Utilization pattern of mungbean in the Chinese diet. I. SW. Shanmugasundaram (ed.), Mungbeana: Proceedings of the second international symposium. Shatua, Taiwan: Asian Vegetable Research and Development Center, AVRDC Publication No. 88-304. pp. 498-507.

El-Habbasha, K.M., Adam, S.M. and Rizk, F.A. 1996. Growth and yield of pea *(Pisum sativum)* plant affected by plant density and foliar potassium application. Egyptian J. Hort. 23(1): 35-51.

FAO (Food and Agriculture Organization). 1988. Plant Resources Appraisal of Bangladesh for Agricultural Development. Rep. 2. Agroecological Regions of Bangladesh. UNDP, FAO, Rome. p.116

Farghali, M.A. and Hossein, H.A. 1995. Potential of genotypic and seasonal effects on growth and yield of mungbean. Australian J. Agric. Res. 46(2): 113-121.

Gardner, F.P., Pearce, R.B. and Mistechell, R.L. 1985. Physiology of Crop Plants. Lowa, State Univ., Press, Powa. p.66.

Gomez, K.A., Gomez, A.A. 1984. Statistical Procedure for Agricultural Research. 2nd Ed. John Wiley and Sons, New York. pp. 643-645.

Gumber, R.K., Singh, S. and Singh, K. 1998.Influence of seed rates on seed yield in deshi chickpea cultivar PDG 3. Intl. Chickpea Pigeonpea Newsl., 5;21-22.

Haque, M.A. 2003. Performance of chickpea genotypes at different population densities under late sown condition. M. S. Thesis, Department of Crop Botany, Bangladesh Agricultural University, Mymensingh.

Haque, M.M. 1995. Effect of plant population on the growth and yield of mungbean. Bangladesh J. Sci. and Ind. Res. 30(1): 63-69.

Hasanuzzaman, M. 2001. Effect of plant population and boi-fertilizer on growth and yield performance of two summer mungbean cultivars. M.S. Thesis, Dept. Agron., Bangladesh Agril. Univ., Mymensingh. pp. 109-114.

Hunt, R. 1978. Plant Growth Analysis. Edward Pub. Ltd. London. p. 67.

Ibrahim, M.E. 1996. Response of determinate and indeterminate soybean cultivars to planting pattern and density. Ann. Agric. Sci., 34(4): 1431-1456.

Infante, N., Madriz, P. and Gonzalez, T. 2003. Phases of development and yield components of three mungbean cultivars *(Vigna radiata* L. Wilezek) in Maracay, Aragua state, Venezuela. Revista-de-la-Facultad-de-Agmomia,-Universidad-del-Zulia. 20(4): 417-429. [CAB Abst. 2003/11-2004/07]

Jain, V.K., Chauhan, Y.S. and Khandekar, M.P. 1988. Effect of genotypes and row spacing on yield and quality of mungbean. Indian J. Pulses Res. 1(2):134-46-139.

Jeswani, L.M. and Saini, S.R. 1981. Summer mung technology. Indian Farming. 30(8): 73.

Kaul, A. 1982. Pulses in Bangladesh. BARC, Farmgate, Dhaka. p. 27.

Kay, D.E. 1979. Food legumes crop and product Digest No. 3. Tropical Institute, London.

Khan, 1997. Effect of different level of nitrogen on growth, yield and quality of wheat. M.S. Thesis. Dept. of Agron. Bangladesh Agric. Uuiv. Mymensing. p 19.

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

Miranda, G.V., Santos, I.C. Dos, Peluzio, J.M. and Santos, G.R. Dos. 1997. Effect of different plant densities on mungbeans and rice beans. Ohwi and Ohashi Revista. 44(252): 241-248. [Field Crop Abst. 1998. 61(2): 137]

Muesca, F. and Oria, D.V. 1981. Mungbean yield *as* affected by fertilizer rates and population density. SMARC Monitor. 2(4): 13. [Field Crop Abst. 1983. 36(1): 70]

Najafi, H., Khodabandeh, N., Poustini, K., Zeinali, H. and Pourdavaei, H. 1997. The effects of planting patterns and dates of planting on yield and yield components of soybean. Indian J. Agric. Sci., 28 (2): 73-77.

Rana, M.M. 2004. Effects of plant population and boi-fertilizer on the growth and yield of three summer mungbean cultivars. M.S. Thesis, Dept. Agron., Bangladesh Agricultural University, Mymensingh.

Russel, D.F. 1986. MSTAT-C- MSTATC Director, Crop and Soil Sci. Dept., Michigan. State Univ., USA.

Sarkar, M.A.R., Kabir, M.H., Begum, M. and Salam, M.A. 2004. Yield performance of mungbean as affected by planting date, variety and plant density. J. Agron. 3(1):18-24.

Sekhon, H.S., Guriqbal Singh, Brar, J.S. and Singh, G. 2002. Effect of population density and planting geometry on the growth and yield of mungbean *(Vigna radiata* L. Wilczek) genotypes. Environ. Ecol. 20(4): 897-901. [CAB Abst. 2002/08-2003/10]

Shanmugam, A.S., Rangasamy, S.R. and Sree Rangasamy. 1983. Studies on nitrogen fixation in nine cultivars of greengram *(Vigna radiata* L. Wilezek). Proc. Indian Nat. Sci. Acad. B. 49(3): 277-279.

Shukla, S.K. and Dixit, R.S. 1996. Nutrient and plant population management in summer greengram *(Phaseolus radiatus).* Indian J. Agron. 41(1): 78-83.

Singh, C. and Yadav, B.S. 1978. Production potential of mungbean and gaps limiting its productivity in India. Proc. First Int. Mungbean Symp. Aug. 16-19. (1977), Loss Banos, Philippines.

Singh, G.B. 1982. Effect of seasonal changes on growth parameters of greengram *(Vigna radiata* L. Wilczek). Indian J. Plant Physiol. 25(4): 382-389.

Singh, K.B. and Malhotra, R.S. 1983. Inter-relationships between yield and yield components in mungbean. Indian J. Genetics. 30(2): 244-250.

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

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

Tsiung, N.T. 1978. Responses of mungbean to sowing date in sarwak. I" Intl. Mungbean Symp. AVRDC (Asian Vegetable Research and Development Centre), Taiwan: 205-209.

Ulemale, R.B., Shivankar, R.S. and Patil, V.N. 2003. Effects of sowing dates, spacing and phosphate levels on the growth and productivity of sunnhemp. Legume Res., 26(2):121.

Yadav, R.P.D., Chaudan, D.V.S. and Yada, K.S. 1990. Effect of phosphorus, row spacing and irrigation on yield of pea. Indian J. Agron., 35 (3): 33

Appendices

APPENDICES

Appendix I Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% Clay	30
Textural Class	Silty - Clay
P^H	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source : SRDI, Farmgate, Dhaka

Appendix II. Monthly records of meteorological observation at the period of experiment (March to July, 2007)

Source : Weather Yard, Bangladesh Metrological department, Dhaka

Month	Temperature (Maximum, ^{O}C)	Temperature (Minimum, ^{O}C)	Humidity (%)	Precipitation (mm)
March	30.20	20.13	68.00	31
April	26.60	13.5	52.7	9
May	25.40	12.93	48.3	7
June	25.30	14.2	55.8	7
July	28.3	17.2	72.30	15