INFLUENCE OF LOWER SEED RATE ON THE PERFORMANCE OF MUNGBEAN AND BLACKGRAM

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CERTIFICATE

This is to certify that the thesis entitled "**Influence of Lower Seed Rate on the Performance of Mungbean and Blackgram**" 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 in AGRONOMY**, embodies the result of a piece of bonafide research work carried out by **Mohammad Asif Iqbal**, Registration number: **00938** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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TO

MY BELOVED PARENTS

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ABSTRACT

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, during the period from March to May 2007 to study the influence of lower seed rate on the growth and yield of mungbean and blackgram. The experiment consists of two factors. Factor A: Crops BARI mung 6 and BARI mash 1; Factor B: Seed rate, 30 kg seeds ha^{-1} (recommended dose), 27 kg seeds ha^{-1} (10% less than recommended dose), 24 kg seeds ha^{-1} (20% less than recommended dose), 21 kg seeds ha^{-1} (30% less than recommended dose) and 18 kg seeds ha^{-1} (40% less than recommended dose). The two factors experiment was laid out in Split plot Design with three replications. At 20, 30, 40, 50 DAS and at harvest the tallest plant (18.30 cm, 35.70 cm, 42.74 cm, 55.69 cm and 67.96 cm), maximum number of pods per plant (20.24), maximum pod length (6.98 cm), maximum seed yield per hectare (1.13 ton) and maximum stover yield per hectare (1.39 ton) was recorded from blackgram, while the shortest plant (15.64 cm, 30.45 cm, 36.51 cm, 50.91 cm and 61.55 cm), minimum number of pods per plant (18.10), minimum pod length (6.16 cm), minimum seed yield per hectare (1.01 ton) and minimum stover yield per hectare (1.24 ton) was found from mungbean. At 20, 30, 40, 50 DAS and at harvest the tallest plant (18.61 cm, 35.33 cm, 42.42 cm, 57.05 cm and 69.59 cm), maximum number of pods per plant (20.87), maximum pod length (6.95 cm), maximum seed yield per hectare (1.20 ton) and maximum stover yield per hectare (1.49 ton) was recorded from 2 kg seeds ha^{-1} while, the shortest plant (16.03 cm, 31.40 cm, 37.53 cm, 49.81 cm and 60.93 cm), minimum number of pods per plant (17.53), minimum pod length (6.04 cm), minimum seed yield per hectare (0.91 ton) and minimum stover yield (1.12 ton) was found from S_5. At 20, 30, 40, 50 DAS and harvest the tallest plant (20.62 cm, 38.15 cm, 45.56 cm, 60.29 cm and 73.65 cm), maximum number of pods per plant (22.88), maximum pod length (7.39 cm), maximum seed yield per hectare (1.24 ton) and maximum stover yield per hectare (1.55 ton) was recorded from C_2S_2, where as the shortest plant (13.40 cm, 26.60 cm, 32.14 cm, 44.57 cm, 53.18 cm), minimum number of pods per plant (14.17), minimum pod length (5.36 cm), minimum seed yield per hectare (0.81 ton) and minimum stover yield (1.01 ton) was found from C_1S_5.

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Introduction

Chapter-I

INTRODUCTION

Bangladesh grows various types of pulse crops namely mungbean, blackgram, grass pea, lentil. chickpea, fieldpea and cowpea which are important for cheapest source of easily digestible dietary protein. Pulse protein is rich in amino acids like isoleucine, leucine, lysine, valine etc. According to FAO (1999) a minimum intake of pulse by a human should be 80 g per head per day, whereas it is only 14.19 g in Bangladesh (BBS, 2006). This is because of the fact that national production of the pulses is not adequate to meet the national demand.

Among the pulse crops, mungbean (*Vigna radiata* L.) is one of the most important pulse crops in Bangladesh. It has good digestibility, flavor, and high protein content. The variety BARImung6 yielded higher and contains 47.3% carbohydrates, 20.93% protein, 10% moisture, 4% mineral and 3% vitamins (Khan, 1981). In Bangladesh mungbean ranks third in acreage and production but ranks first in consumer choice. Blackgram (*Vigna mungo* L.) is another most important pulse in Bangladesh with good digestibility, flavor, and high protein content. Blackgram grain contains 47.3% carbohydrates, 25.05% protein, 10% moisture, 4% mineral and 3% vitamins (Kaul, 1982). Mungbean and blackgram are potentially useful in improving cropping pattern as the crops can be grown as a catch crop due to its rapid growth and early maturing characteristics. The crops can also fix atmospheric nitrogen through the symbiotic relationship between the host roots and soil bacteria and thus improves soil fertility. It may play an important role to supplement protein in the cereal-based low-protein diet of the people of Bangladesh, but the acreage and production of this crop are steadily declining (BBS, 2006). However, the crops are the least cared crops.

The green plants of mungbean and blackgram can also be used as animal feed and the residues of these crops can be used as green manure. Being a short duration crop it fits well into the intensive cropping system (Ahmed *et al.*, 1978). These crops are cultivated with minimum land preparation and without fertilizer application and insect, diseases or weed control. All these factors are responsible for low yield of mungbean and blackgram. Kharif-I especially in dry season is not favorable for mungbean germination. Kharif-II period is occupied by T-aman. Cultivation of high yielding varieties of wheat and winter rice has occupied considerable land suitable for mungbean cultivation.

Seed rate influences the yield and yield contributing characteristics (Singh and Singh, 1987). Higher than recommended seed rate generally increases plant population resulting intra crop competition thereby affecting the yield. On the other hand, lower seed rate may reduce the yield drastically as the grain yield is positively correlated with plant population (Vukadinovic *et al.*, 1986). In the development of appropriate management practices for mungbean and blackgram, plant population plays an important role. Plant population is one of the most important yield contributing factors which can be manipulated to maximize yield. 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 ha^{-1} (Shukla and Dixit, 1996).

Optimum plant population ensures normal plant growth because of efficient utilization of moisture, light, space and nutrients, thus increases the yield of crop. Pieces of broken or damaged seed one half the original size or less, straw. Chaffs, stone, dust, nematode gall, dead or living units are also mixed with the seed that reduces the optimum population and hence it is also considered by percent with the seed rate calculation (ISTA, 1985). It is necessary to test how much contamination is acceptable in the form of other seed and inert matter without sacrifice yield (Wignell, 1983).

Mungbean yield was affected by population density and they found that 33 plants m^{-2} was optimum for highest yield during Kharif-1 season which was identical with 29 plants m^{-2} meter contributed by higher plant population. The 25 plants m^{-2} failed to give higher yield though it produced higher number of pods/plant and seed weight. Mungbean grown at very high population failed to produce yield because of high rate of mortality. The performance of blackgram grown in different mixed and intercrop combinations under variable seed rate ratio and planting geometry (Hamid, 1989).

Considering the above circumstances, in optimum plant population of these two crops the present investigation has been undertaken to determine the effect of different seed rate with the following objectives:

i. To identify the impact of lower seed rate that effect in plant population, growth, yield attributes and yield of mungbean and blackgram.

ii. To compare the field performance of mungbean and blackgram.

iii. To determine the interaction effect between seed rate and crop of mungbean and blackgram.

Chapter 2
Review of literature

Chapter-II

REVIEW OF LITERATURE

Mungbean and blackgram are the two most important pulse crops in Bangladesh and as well as many countries of the world. These crops have conventional less concentration by the researchers on various aspects because normally it grows without less care or management practices. For that a very few studies on the related growth, yield and development of these crops have been carried out in our country as well as many other countries of the world. So the research work so far done in Bangladesh is not adequate and conclusive. Nevertheless, some of the important and informative works and research findings related to the seed rate on the growth and yield of mungbean and blackgram so far been done at home and abroad have been reviewed under the following headings-

2.1 Yield contributing characters and yield

Tickoo *et al.* (2006) carried out an experiment with mungbean cultivars Pusa 105 and Pusa Vishal sown at 22.5 and 30 cm spacing and supplied with 36-46 and 58-46 kg NP ha^{-1} in a field experiment conducted in Delhi, India during the kharif season of 2000. Cultivar Pusa Vishal recorded higher biological and grain yield (3.66 and 1.63 t/ha, respectively) compared to cv. Pusa 105. NP rates had no significant effects on both the biological and grain yield of the crop. Row spacing at 22.5 cm resulted in higher grain yields in both crops than 30 cm.

A field experiment was conducted by Manpreet *et al.* (2004) in Ludhiana, Punjab, India, during summer 2000 to investigate the response of mungbean genotypes (SML 134, SML 357 and SML 668) to P application (0, 20, 40 and 60 kg P_2O_5/ha) under irrigated conditions. Yield attributes such as number of branches per plant and pods per plant were significantly higher in SML 357 and SML 134, whereas pod length and 100-seed weight were higher in SML 668, which accounted for higher grain yield in this cultivar compared to SML 134 but was at par with SML 357. The straw yield showed the reverse trend with significantly higher value for SML 134, thus lowering the harvest index significantly compared to SML 668 and SML 357.

Satish *et al.* (2003) conducted an experiment in Haryana, India in 1999 and 2000 to investigate the response of mungbean cultivars Asha, MH 97-2, MH 85-111 and K 851 to different P levels (0, 20, 40 and 60 kg P_2O_5/ha). Results revealed that the highest dry matter content in the leaves, stems and pods was obtained in Asha and MH 97-2. MH 97-2 and Asha produced significantly more number of pods and branches/plant compared to MH 85-111 and K 851.

2.2 Effect of seed rate on yield contributing characters and yield of mungbean and blackgram

Tickoo *et al.* (2006) carried out an experiment on mungbean cultivars Pusa 105 and Pusa Vishal were sown at 22.5 and 30 m spacing and was supplied with 36-46 and 58-46 kg NP/ha in a field experiment conducted in Delhi, India during the kharif season of 2000. Cultivar Pusa Vishal recorded higher biological and grain yield

(3.66 and 1.63 t/ha, respectively) compared to cv. Pusa 105. Differences in the values of the parameters examined.

Plant population can play an important role on the growth and yield of mungbean cultivar. In Bangladesh condition it was found that a plant density of 30 × 10 cm resulted in the highest seed yield compared to 20 × 20 and 40 × 30 cm (Sarkar *et al.*, 2004).

In India, the effect of plant density on the growth and yield of mungbean genotypes was documented in a field study and observed that higher number of branches and pods per plant were at low plant populations compared to high plant populations, while leaf area index was higher at high populations compared to low populations. Seed yield was highest at 3.33 lakh ha^{-2} (Sekhen *et al.*, 2002).

Hasanuzzaman (2001) conducted a field experiment in Bangladesh with mungbean and found that number of branches $plant^{-1}$, pods $plant^{-1}$, seed yield $plant^{-1}$ and 1000 seed weight were highest in lower plant population.

In an experiment conducted by Miranda *et al.* (1997) in Brazil (using *Vigna radiata cv.* Ouro verde and different plant densities of 100,000, 200,000, 300,000, 400,000 or 500,000 plants ha^{-1}). They reported that average number of seeds pod^{-1} and pod length decreased with increasing density. A stand density of 300,000 plants ha^{-1} gave the highest average seed yields of 0.94 t ha^{-1}.

In an experiment El-Habbasha *et al.* (1996) reported that increasing plant density increased plant height but decreased branch and leaf number plant^{-1}, dry weight of shoots, pod yield plant^{-1} and number of pods plant^{-1} of mungbean.

Tomar and Tiwari (1996) conducted a field trial in the season of 1983 and 1984 to study the response of green gram genotypes to plant density. They found that mean yield increased with increasing plant density up to 800,000 plants ha^{-1}.

At Joydebpur, Haque (1995) carried out a field trial on *Vigna radiata* cultivar BM7703 using populations of 250000, 333333, 400000 or 500000 plants ha^{-1} and found that 333333 plants ha^{-1} (approximately 33 plants m^{-2}) gave the highest seed yield.

Mimber (1993) carried out a field trial on *Vigna radiata* cultivar Walet using 400000, 600000 or 800000 plant populations ha^{-1} and found that yield increased with increasing plant population.

In Thailand, Pookpakdi and Pataradilok (1993) investigated the response of mungbean genotypes to plant population densities sown at 200,000, 400,000 and 800,000 ha^{-1}.They observed that yield was generally increased with increasing plant density, while pod number plant^{-1} decreased with increasing density.

In a field experiment in 1983-84, Tomar *et al.* (1993) using 4 cultivars of mungbean at populations of 400,000, 600,000, 800,000 or 1,000,000 plants ha^{-1} found that a population of 1,000,000 plants ha^{-1} (approximately 100 plants m^{-2}) gave higher yield than any other plant populations.

Singh *et al.* (1991) carried out a field experiment to study the effect of spacing and seed rate on yield of green gram. They reported that plant population increased with increasing seed rate and highest seed yield of 0.55 t/ha was obtained from 32 kg/ha seed rates.

Working with 3 plant population densities of mungbean, Trung and Yoshida (1985) found that increasing DM production. LAI, seed yield and pod number per unit area but it had little effect on average number or weight of seeds pod^{-1} or 1000 seed weight.

Singh and Singh (1990) conducted a field trial in the summer on silty clay loam soil at Pantnagar, where mungbeans cv. Pusa Baishakhi, Type-1, ML 26/10/3 and UMP 79-1-2 were sown at populations of 400,000, 500,000 or 600,000 plants ha^{-1} in 1: 1 (square), 1:2 (rectangular) or 1:4 (deep rectangular) sowing patterns. They reported that plant population did not affect seed yield.

Singh and Singh (1988) reported that cultivation of 4 mungbean (*Vigna radiata)* cultivars at a density of 400,000, 500,000 or 600,000 plants ha^{-1} gave similar average seed yields of 1.13-15 t ha^{-1}.

A high plant population (400,000 plants ha^{-1}) as compared to low plant population (200,000 plants ha^{-1}) produced maximum seed yield in trials of Singh and Malhotra (1983) and Maheshwari *et al.* (1974) in North India. They reported that maximum bean yield was obtained from a population of 300,000 to 400,000 plants ha^{-1}.

Brathwaite (1982) noticed that increasing crop density decreased pod size and number of branches plant^{-1}, but days to flowering, maturity, plant height and pod quality remained unaffected. He recommended crop density of 148,000 plants ha^{-1}.

Muesca and Oria (1981) observed that the number of days to flowering of mungbean was not affected by plant density. With a dense stand (25 plants m^{-2}) plant height was the highest (68 cm) and pod set was the greatest (484 plot^{-1}). Seed yield was the highest (369 g plot^{-1}) at the lowest density of 10 plants m^{-2}.

Hoq and Hossain (1981) in an experiment observed significant effect of plant density on the height of mungbean. It has been observed from a large number of trials conducted on grain legumes in India that they respond favorably to increased plant population from 100,000 to 500,000 plants ha^{-1} depending upon the growth conditions (Saini and Das, 1979).

Beech and Wood (1978) conducted several studies and reported a higher plant population up to 450,000 plants ha^{-1} gave higher yields in mungbean under good management conditions. Cagampang *et al.* (1977) determined the optimum plant population of mungbean in the range of 300,000 to 400,000 plants ha^{-1} in the wet season and 400,000 to 500,000 plants ha^{-1} in the dry season.

Tsiung (1978) reported that in mungbean the 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.

Milthorpe and Moorby (1974) and Okigbo (1979) observed that, the crop growth rate increased with the age of plant. Williams (1967) noticed that in the early stage of growth closer spacings showed higher crop growth rates and yield but in later stages all except the widest spacing gave constant yield in mungbean. The higher LAI and crop growth rates were obtained at higher density than at lower plant density (Sprent *et al.*, 1977).

2.3 Combined effect of cultivar and plant population

Sarkar *et al.* (2004) conducted on experiment in Bangladesh with five mungbean cultivars (BARIMung-2, BARIMung-3, BARIMung-4, BARIMung-5 and BINAMung-2) and three plant densities (20 × 20, 30 × 10 and 40 × 30 cm) and found that BINAMung-2 had the highest number of branches per plant at a spacing of 40 x 30 cm. They recorded the highest number of pods per plant in BARIMung-3 at a spacing of 30 × 10 cm. Pod length was greatest in BARIMung-5 at a density of 20 × 20 cm. The highest 1000-seed weight was obtained by BARIMung-5 at densities of 20 × 20 and 30 × 10 cm. At a density of 30 × 10 cm BARIMung-2 produced the highest seed yield and harvest index. The lowest seed yield and harvest index were recorded for BARIMung-3 at a density of 40 × 30 cm.

Sekhon *et al.* (2002) conducted field experiments in India with three plant populations (3.33, 2.22 and 167 lakh ha^{-1}) to determine the effect of plant density on the growth and yield of mungbean genotypes. They observed that among the genotypes, ML 613 was the best in terms of yield and yield component values at a higher population of 3.33 lakh ha^{-1}.

Borah (1994) conducted a field experiment to study the performance of green gram genotypes under different seed rates (sown at 20, 30 and 35 kg ha^{-1}) during summer season. He found that seed yield increased consistently with increase in seed rate.

Thakuria and Saharia (1990) conducted a field trial with two green gram cultivars grown at 222,000 and 330,000 plants ha^{-1} and obtained average seed yields of 19 and 680 kg ha-^{1}, respectively.

Singh and Singh (1990) observed in a field trial in the summer on silty clay loam soil at Pantnagar, where mungbeans cv. Pusa Baishakhi, Type-1 ML 26/10/3 and UMP 79-1-2 were sown at populations of 400000, 500000 or 600000 plants ha^{-1}. Seed yield was highest in cv. UMP 79-1-2 (1.21 t ha^{-1}) and lowest in cv. Type-1 (1.06 t). Plant population did not affect seed yield.

Jain *et al.* (1988) conducted a field experiment with 4 mungbean cultivars at 4 spacing in 1985-86, ML 131 gave the highest average seed yields of 1.83 t ha^{-1} compared with 1.74 and 1.70 t ha^{-1} for other cultivars. Crops grown in rows 30 cm apart (333,000 plants ha^{-1}) gave yields of 1.86 t ha^{-1} compared with 1.50 and 1.70 t ha^{-1} in crops grown in rows 15, 22.5 or 37.5 cm apart.

Singh and Singh (1988) reported that cultivation of 4 mungbean (*Vigna radiata*) cultivars at a density of 400 000, 500 000 or 600 000 plants ha^{-1} gave similar average seed yields of 1.13-1.15 t ha^{-1}. CV UPM 79-1-2 and ML26/10/3 gave yields of 1.21 and 1.18 t ha^{-1}, respectively, compared with 1.06-1.12 t for 2 other cultivars.

Panwar and Sirohi (1987) studied on the effect of plant population on seed yield and its components in mungbean. They used 4 cultivars and two plant population of mungbean. They showed that the yield ha^{-1} and number of seeds pod^{-1} on branches increased with increasing plant density in all cultivars whereas yield $plant^{-1}$ and number of flowers $plant^{-1}$, pods $plant^{-1}$ and pods $branch^{-1}$ decreased in all cultivars.

While working with 2 mungbean cultivars Neciosup (1986) observed that the number of pods ha^{-1} and 1000-seed weight were higher in the higher population. He also showed that yield increased proportionally with increasing population.

In a population study, involving two varieties, Jewani and Saini (1981) found that the highest yield of mungbean was obtained in the dry season with 400,000 plants ha^{-1}, followed by 5,00,000 and 6,00,000 plants ha^{-1}. On the other hand, during wet season planting, a population density of 300,000 plants ha^{-1} appeared to be best for both the varieties. Subramaniam and Palaniappan (1981) showed that irrigated blackgram cultivar CO_2 grown at 500,000 plants ha^{-1} gave significantly higher seed yields than when grown at 333,333 plants ha^{-1}.

In a study the highest yield was obtained by broadcast sowing with 46 and 36 kg ha^{-1} in case of blackgram and mungbean, respectively (Anonymous, 1982). It was also noted that the yield increased progressively with the rise in seed rate. This increase was mainly due to the increase in plant population per unit area.

A high plant population (400,000 plants ha^{-1}) as compared to low plant population (200,000 plants ha^{-1}) produced maximum grain yield in trials of Singh and Malhotra (1983). They reported that maximum bean yield was obtained from a population of 300,000 to 400,000 plants ha^{-1}.

Singh *et al.* (1985) reported that different seed rates influenced the seed yield significantly. The higher grain yield obtained with 50 kg seed ha^{-1} over 20, 30 and 40 kg ha^{-1} could be attributed to more number of plants per unit area. Seed rates did not affect the other yield contributing characters.

While working with 2 mungbean cultivars Neciosup (1986) observed that the number of pods ha^{-1} and 1000-seed weight were higher in the higher population. He also showed that yield increased proportionally with increasing population.

Panwar and Sirohi (1987) studied on the effect of plant population on grain yield and its components in mungbean. They used 4 cultivars and two plant population of mungbean. They showed that the yield ha^{-1} and number of seeds pod^{-1} on branches increased with increasing plant density in all cultivars whereas yield $plant^{-1}$ and number of flowers plant-^{1}, pods $plant^{-1}$ and pods $branch^{-1}$ decreased in all cultivars.

Thakuria and Saharia (1990) conducted a field trial with two green gram cultivars grown at 222,000 and 330,000 plants ha^{-1} and obtained average cultivars grown at 222,000 and 330,000 plants ha^{-1} and obtained average seed yields of 619 and 680 kg ha^{-1} respectively.

Singh and Singh (1995) conducted a field experiment in summer 1992 at Pantnagar, Uttar pradesh using 4 cultivars each of mungbean and blackgram sown at 20, 25 and 30 kg seed ha^{-1}, and 30, 35 and 40 kg seed ha^{-1} respectively and found that yield increased with increasing seed rate in both the crop.

At Gazipur, Talukder *et al.* (1993) conducted a field trial to investigate the effect of crop density (33 and 50 plants m^{-2}) and time of weeding on mungbean. They found that weed population and dry biomass of weeds at a crop density of 50 plants m^{-2} were 20% and 13% less, respectively than those at a crop density of 33 plants m^{-2}. However, a crop density which was considerably high but less than the maximum was found to produce lower yields than the minimum density.

While working with *Vigna radiata* cultivar K-851 at a rate of 20, 30 or 40 kg seed ha^{-1} Tomar *et al.* (1995) found that absolute growth rate, relative growth rate, net assimilation rate and dry matter (DM) accumulation at all growth stages were highest at a seed rate of 20 kg ha^{-1}.

From the reviews cited and discussed above, it can be concluded that lower seed rate play a remarkable role for the growth, yield and yield component of mungbean and blackgram

Chapter 3
Materials and methods

Chapter-III

MATERIALS AND METHODS

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from March to May 2007 to study the influence of lower seed rate on the growth and yield of mungbean and blackgram. This chapter includes materials and methods that were used in conducting the experiment. It consists of a short description of locations of the experimental site, characteristics of soil, climate, materials used for the experiments, treatment of the investigation, layout and design of the experiment, land preparation, manuring and fertilizing, intercultural operations, irrigation, harvesting, data collection procedure and statistical analysis etc. The details regarding materials and methods of this experiment are presented below under the following headings -

3.1 Experimental site

The experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The experimental site is situated between $23^0 74'$N latitude and $90^0 35'$E longitude (Anon., 1989) and presented in Appendix I.

3.2 Soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28 and posses shallow red brown terrace soil. The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI, Khamarbari, Dhaka and presented in Appendix II.

3.3 Climate

The climate of experimental site was subtropical, characterized by three distinct seasons, the monsoon or the rainy season from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979). Meteorological data related to the temperature, relative humidity and rainfalls during the period of the experiment was collected from the Bangladesh Meteorological Department (Climate Division), Sher-e-Bangla Nagar and presented in Appendix III.

3.4 Planting material

The variety BARImung6 and BARImash1 were used as the test crop. Both the seeds were collected from the Pulse Section of Bangladesh Agricultural Research Institute, Joydevpur, Gazipur.

BARImung6 is a recommended variety of mungbean, which was developed BARI and recommended by the national seed board. It grows both in kharif and rabi season. Life cycle of this variety ranges from 60 to 65 days. The variety is resistant to diseases, insects and pest attack. The variety is resistant to *Cercospora* leaf spot and yellow mosaic virus. Maximum seed yield is 1.1-1.4 ton/ha. Seeds contain 20.93% protein and 49.46% Carbohydrate (BARI, 2004).

BARImash1 was used as the test crop. The seeds were collected from the Pulse Section of Bangladesh Agricultural Research Institute, Joydevpur, Gazipur. It is a recommended variety of blackgram, which was developed by BARI and recommended the national seed board. It grows both in kharif and rabi season. Life cycle of this variety ranges from 65 to 70 days. Maximum seed yield is 1.2-1.5 ton/ha (BARI, 2004).

3.5 Land preparation

The land was irrigated before ploughing. After having zoe condition the land was first opened with the tractor drawn disc plough. Ploughed soil was then brought into desirable fine tilth by 4 operations of ploughing, harrowing and laddering. The stubble and weeds were removed. The first ploughing and the final land preparation were done on 20 February and 28 February 2007, respectively. Experimental land was divided into unit plots following the design of experiment.

3.6 Fertilizer application

Well decomposed cowdung was applied at the time of final land preparation. The sources of fertilizers used for N, P and K were urea (40 kg N/ha), TSP (60 kg P_2O_5/ha), MP (80 kg K_2O/ha), respectively (BARI, 2004). The entire amounts of urea, TSP, MP were applied during final land preparation.

3.7 Treatments of the experiment

The experiment consists of two factors:

Factor A: Crops

i. Mungbean (BARImung6) - C_1
ii. Blackgram (BARImash 1) - C_2

Factor B: Seed rate (30 kg ha^{-1} for furrow cultivation, BARI, 2007)

i. 30 kg seeds ha^{-1} - S_1
ii. 27 kg seeds ha^{-1} (10% less than recommended dose) - S_2
iii 24 kg seeds ha^{-1} (20% less than recommended dose) - S_3
iv. 21 kg seeds ha^{-1} (30% less than recommended dose) - S_4
v. 18 kg seeds ha^{-1} (40% less than recommended dose) - S_5

There were 10 treatment combinations such as C_1S_1, C_1S_2, C_1S_3, C_1S_4, C_1S_5, C_2S_1, C_2S_2, C_2S_3, C_2S_4 and C_2S_5.

3.8 Experimental design and lay out

The experiment was laid out in a Split plot design with three replications. An area of 22 m × 18.5 m was divided into three equal blocks. Each block was divided into 10 plots where crop was assigned in the main plot and seed rate in the sub plot at random. There were 30 unit plots altogether in the experiment. The size of each plot was 4.0 m × 2.5 m. The distance maintained between blocks and plots were 1.0 m and 0.5 m respectively. The layout of the experiment shown in Figure 1.

3.9 Sowing of seeds in the field

The seeds of mungbean and blackgram were sown on March 10, 2007. Seeds were treated with Bavistin before sowing the seeds to control the seed borne diseases. The seeds were sown in solid rows in the furrows having a depth of 2-3 cm. Row to row distance was 30 cm.

3.10 Intercultural operations

3.10.1 Irrigation and weeding

Irrigation was done as per requirements. The crop field was weeded twice; first weeding was done at 15 DAS and second weeding was done at 30 DAS.

3.10.2 Protection against insect and pest

At early stage of growth few worms (*Agrotis ipsilon*) and virus vectors (jassid) attacked the young plants and at later stage of growth pod borer (*Maruca testulalis*) attacked the plant. Diazinon 50EC was sprayed at the rate of 1litre/ha to control the attack.

3.11 Crop sampling and data collection

Ten plants from each treatment were randomly sampled and marked with sample card. The data of plant height and number of leaves per plant were recorded from sampled plants at an interval of 10 days which was started from 20 DAS. The number of pods plant^{-1}, pod length and number of seeds pod^{-1} were recorded from 10 sample plants from each plot. The nodule number per 5 plants of each plot was collected at 30 DAS. Seed yield and stover yield was collected from inner lines (6 m^2) leaving the border areas after properly drying. The weights of 1000 seeds were recorded from seeds randomly collected from each plot, properly counted and oven dried to a moisture content of 12%.

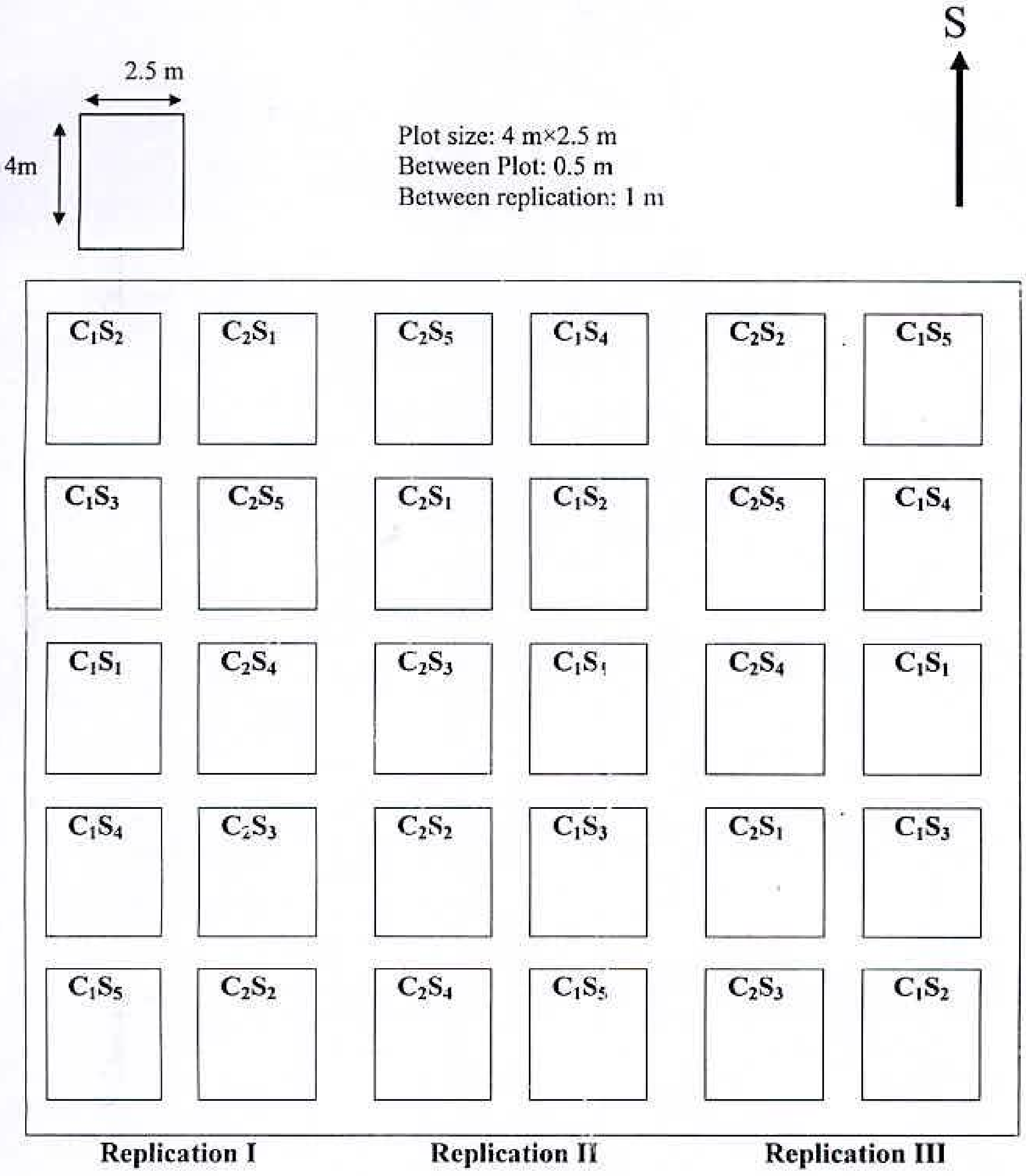


Figure-01. Experimental layout

3.12 Harvest and post harvest operations

Harvesting was done when 90% of the pods became brown to black in color. The matured pods were collected by hand picking from a pre demarcated area of three linear at the center of each plot.

3.13 Data collection

The following data were recorded

i. Plant height (cm) at 20, 30, 40 and 50 DAS and at harvest
ii. Number of leaves per plant at 20, 30, 40 and 50 DAS and at harvest
iii. Number of nodules per plant
iv. Number of plants population m^{-2}
v. Number of pods per plant
vi. Pod length (cm)
vii. Number of seeds per pod
viii. 1000- seed weight (g)
ix. Seed yield (t ha^{-1})
x. Stover yield (t ha^{-1})
xi. Harvest index

3.14 Procedure of data collection

3.14.1 Plant height (cm)

The heights were measured with a meter scale from the ground level to the top of the plants and the mean height was expressed in cm. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot starting from 20 DAS to 50 DAS and at harvest at 10 days interval.

3.14.2 Number of leaves per plant

The leaves (trifoliate) were counted from selected plants. The average number of leaves per plant was determined. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot starting from 20 DAS to 50 DAS and at harvest at 10 days interval.

3.14.3 Number of plant population m^{-2}

Number of total plants m^{-2} from each plot was counted and the mean number was expressed on per m^2 basis. Data were recorded at the middle area of 1 m^2 area from each plot.

3.14.4 Number of pods per plant

Number of total pods of selected plants from each plot was counted and the mean number was expressed on per plant basis. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot.

3.14.5 Pod length

Pod length of selected plants from each plot was counted and the mean length was expressed on per pod basis. Data were recorded as the average of 10 pods selected at random from the inner rows plant of each plot.

3.14.6 Number of seeds per pod

The number of seeds in each pod was also recorded from randomly selected pods at the harvest. Data were recorded as the average of 10 pods selected at random from the inner rows of each plot.

3.14.7 Weight of 1000-seed (g)

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

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

The seeds collected from 6.0 m^2 of each plot were sun dried properly. The weight of seeds was taken and converted into the yield t ha^{-1}.

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

The stover collected from 6.0 m^2 of each plot was sun dried properly. The weight of stover was taken and converted into the yield t ha^{-1}.

3.14.10 Harvest index

The harvest index was calculated using the following formula

$$\text{Harvest Index (\%)} = \frac{\text{Grain Yield}}{\text{Biological Yield}} \times 100$$

3.14.11 Number of nodules per plant

Number of total nodules of selected plants from each plot was counted and the mean number was expressed as per plant basis. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot.

3.15 Statistical analysis

The data obtained for different parameters were statistically analyzed using MSTAT software to find out the significant difference at the influence of seed rate on the growth and yield of mungbean and blackgram. The mean values of all the characters were calculated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the treatment combinations means was estimated by the Least significant difference test (LSD) at 5% level of probability (Gomez and Gomez, 1984).

Chapter 4
Results & Discussion

Chapter-IV

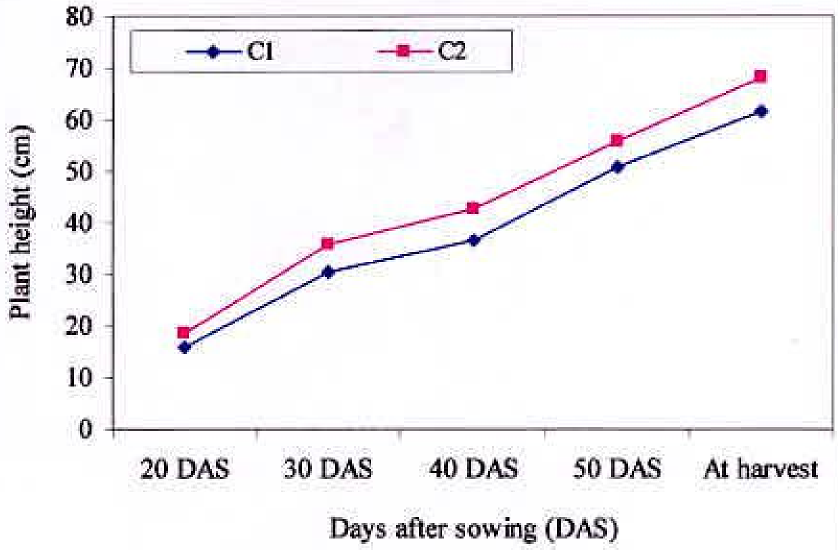
RESULTS AND DISCUSSION

The present study was conducted to determine the influence of lower seed rate on the yield attributes and yield of mungbean and blackgram. Data on different yield contributing characters and yield were recorded to find out the optimum seed rate of mungbean and blackgram. The analysis of variance (ANOVA) of the data on different yield components and yield are given in Appendix IV-VII. The results have been presented and discussed, and possible interpretations given under the following headings-

4.1 Plant height

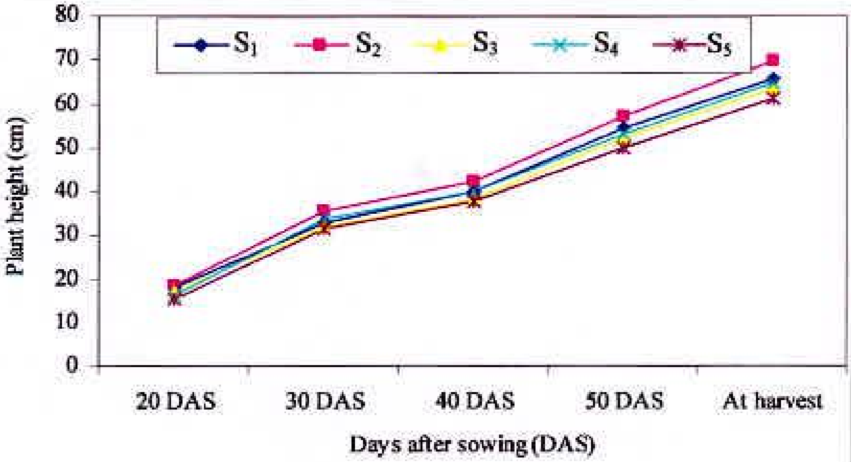
4.1.1 Effect of crop

Plant height varied significantly for the cultivar of mungbean and blackgram at 20, 30, 40, 50 and harvest (Appendix IV). At 20 DAS, the longer plant (18.30 cm) was recorded from C_2 (blackgram), while the shorter plant (15.64 cm) was found from C_1 (mungbean). The longer plant (35.70 cm) was recorded in C_2 and the shorter plant (30.45 cm) was recorded from C_1 at 30 DAS. At 40 DAS, the longer plant (42.74 cm) was recorded from C_2 and the shorter plant (36.51 cm) was recorded from C_1. The longer plant (55.69 cm) was recorded from C_2 where as the shorter plant (50.91 cm) was obtained from C_1 at 50 DAS. At harvest, longer plant (67.96 cm) was recorded in C_2 and the shorter plant (61.55 cm) was observed from C_1 (Figure 2). It was revealed that different cultivar had different plant height and with the increase of time plant height also increased. Edwin *et al.* (2005) reported maximum plant height (61.20 cm) for green gram.



C_1: BARI mung 6 C_2: BARI mash 1

Figure-2: Plant height for mungbean and blackgram crops ($LSD_{0.05}$ =2.472, 4.629, 5.817, 2.693, 3.908 at 20, 30, 40, 50 DAS respectively)



S_1: 30 kg seeds ha^{-1} S_2: 27 kg seeds ha^{-1}

S_3: 24 kg seeds ha^{-1} S_4: 21 kg seeds ha^{-1}

S_5: 18 kg seeds ha^{-1}

Figure-3: Effect of different seed rate on plant height of mungbean and blackgram ($LSD_{0.05}$= 1.742, 2.2022, 1.993, 3.949, 3.103 at 20, 30, 40 and 50 DAS respectively)

4.1.2 Effect of seed rate

Significant variation was recorded for plant height of mungbean and blackgram for different seed rate at 20, 30, 40, 50 DAS and at harvest (Appendix IV). The tallest plant (18.61 cm) was found from S_2 (27 kg seeds ha^{-1}) which was statistically similar (17.88 cm, 17.21 cm) to S_1 (30 kg seeds ha^{-1}) and S_3 (24 kg seeds ha^{-1}) at 20 DAS where as the shortest plant (16.03 cm) was observed from S_5 (18 kg seeds ha^{-1}) which was statistically similar (16.03 cm) to S_4 (21 kg seeds ha^{-1}). At 30 DAS, the tallest plant (35.33 cm) was found from S_2 which was closely followed (33.01 cm and 33.73 cm) by S_1 and S_4 and the shortest plant (31.40 cm) was obtained from S_5 which was statistically similar (31.93 cm) to S_3. At 40 DAS, the longest plant (42.42 cm) was recorded from S_2 which was closely followed (40.08 cm and 40.02 cm) by S_4 and S_1 whereas the shortest plant (37.53 cm) was recorded from S_5 which was statistically similar (38.07 cm) to S_3. The longest plant (57.05 cm) was observed from S_2 which was statistically similar (54.18 cm and 53.17 cm) to S_1 and S_4. On the other hand, the shortest plant (49.81 cm) was recorded from S_5 which was statistically similar (52.27 cm) with S_3 at 50 DAS. At harvest, the longest plant (69.59 cm) was found from S_2 which was closely followed (65.41 cm and 64.69 cm) by S_1 and S_4 whereas the shortest plant (60.93 cm) was recorded from S_5 which was statistically similar (63.15 cm) to S_3 (Figure 3). It was revealed that higher than recommended seed rate generally increases plant population resulting intra crop competition thereby affecting the growth and reduce plant height (Vukadinovic *et al.*, 1986). Talukder *et al.* (1993) reported that plant height was highest for optimum plant population than the highest and lowest population.

Table 1. Interaction effect of crop and seed rate on plant height of mungbean and blackgram

Treatments	Plant height (cm) at				
	20 DAS	30 DAS	40 DAS	50 DAS	At harvest
C_1S_1	16.12 c	29.22 cd	35.76 e	52.20 bc	63.00 cd
C_1S_2	16.60 bc	32.51 b	39.28 d	53.80 bc	65.54 bc
C_1S_3	15.37 cd	28.32 d	34.17 ef	49.44 cd	59.78 d
C_1S_4	16.68 bc	35.63 a	41.18 cd	54.52 abc	66.24 bc
C_1S_5	13.40 d	26.60 d	32.14 f	44.57 d	53.18 e
C_2S_1	19.64 a	36.79 a	44.27 ab	56.16 ab	67.82 bc
C_2S_2	20.62 a	38.15 a	45.56 a	60.29 a	73.65 a
C_2S_3	19.04 ab	35.54 a	41.97 bcd	55.11 abc	66.53 bc
C_2S_4	15.38 cd	31.84 bc	38.98 d	51.83 bc	63.13 cd
C_2S_5	16.82 bc	36.20 a	42.93 abc	55.04 abc	68.68 b
$LSD_{(0.05)}$	2.463	2.860	2.819	5.584	4.388
Level of significance	*	*	**	*	**
CV(%)	8.39	6.99	10.11	6.05	9.91

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

Here, C_1: BARImung6, C_2: BARImash1, S_1: 30 kg seeds ha^{-1}, S_2: 27 kg seeds ha^{-1}, S_3: 24 kg seeds ha^{-1}, S_4: 21 kg seeds ha^{-1}, S_5: 18 kg seeds ha^{-1}

4.1.3 Interaction effect of crop and seed rate

Interaction effect of crop and seed rate showed statistically significant variation for plant height at 20, 30, 40, 50 DAS and at harvest (Appendix IV). At 20 DAS, the tallest plant (20.62 cm) was recorded from C_2S_2 (blackgram + 27 kg seeds ha^{-1}) that similar to C_2S_1 and C_2S_3 where as the shortest plant (13.40 cm) plant was found from C_1S_5 (mungbean + 18 kg seeds ha^{-1}) that similar to C_1S_3 and C_2S_4. The tallest plant (38.15 cm) was recorded from C_2S_2 with statistically similar to C_2S_1, C_2S_5, C_1S_4 and C_2S_3 while the shortest plant (26.60 cm) was obtained from C_1S_5 at 30 DAS that similar to C_1S_3 and C_1S_1. At 40 DAS, the tallest plant (45.56 cm) was recorded from C_2S_2 with similar to C_2S_1 and C_2S_5 and the shortest plant (32.14 cm) was observed from C_1S_5 that similar to C_1S_3. The longest plant (60.29 cm) was recorded from C_2S_2 that similar to C_2S_1, C_2S_3, C_2S_5 and C_1S_4 again the shortest plant (44.57 cm) plant was recorded from C_1S_5 at 50 DAS that similar to C_1S_3. At harvest, the tallest plant (73.65 cm) was found from C_2S_2. On the other hand the shortest plant (53.18 cm) was recorded from C_1S_5 (Table 1).

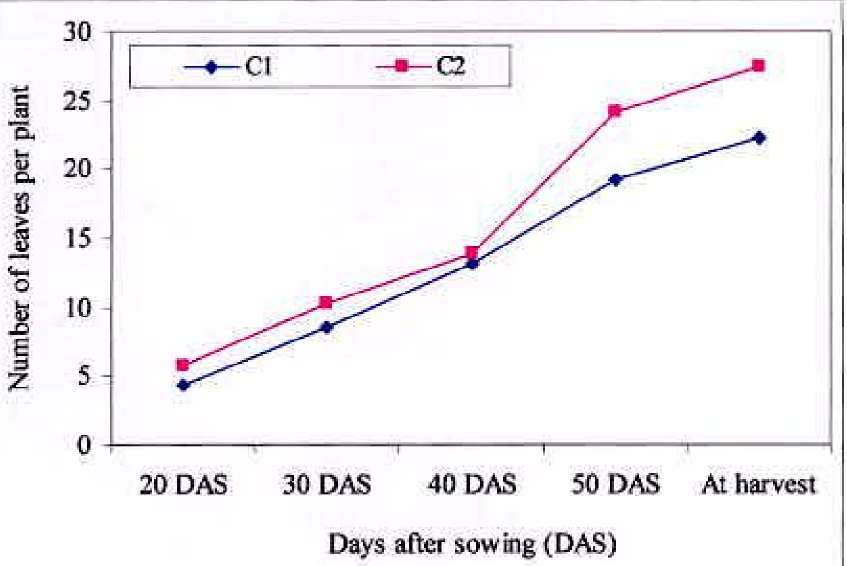
4.2 Number of leaves per plant

4.2.1 Effect of crop

At 20, 30, 40, 50 DAS and harvest number of leaves per plant varied significantly for mungbean and blackgram (Appendix V). At 20 DAS, the higher number of leaves per plant (5.74) was recorded from C_2 (blackgram), and the lower number of leaves per plant (4.39) was found from C_1 (mungbean). The higher number of leaves per plant (10.29) was recorded in C_2 and the lower (8.51) was recorded from C_1 at 30 DAS. At 40 DAS, the higher number of leaves per plant (13.78) was recorded from C_2 and the lower (13.10) was found from C_1. The higher number of leaves per plant (24.15) was recorded from C_2 where as the lower (19.18) were obtained from C_1 at 50 DAS. At harvest, higher number of leaves per plant (27.35) was recorded in C_2 while the lower (22.16) was observed from C_1 (Figure 4).

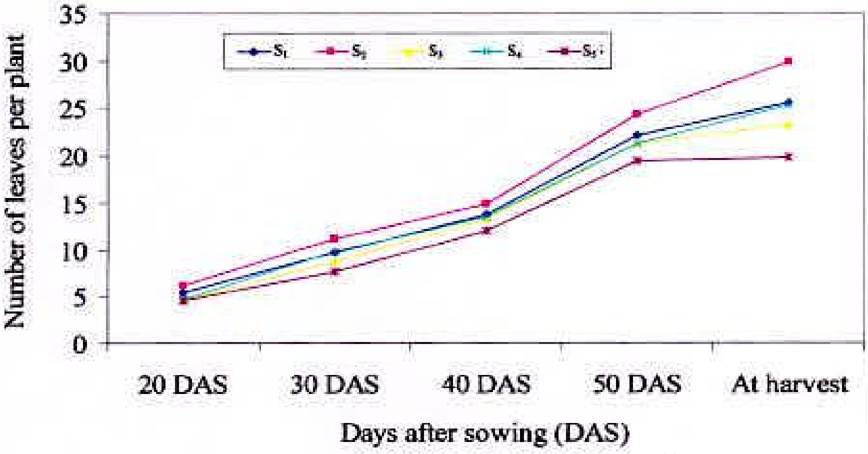
4.2.2 Effect of seed rate

Number of leaves per plant of mungbean and blackgram showed statistically significant differences due to different seed rates at 20, 30, 40, 50 DAS and at harvest (Appendix V). The highest number of leaves per plant (6.20) was recorded from S_2 (27 kg seeds ha^{-1}) which was closely followed (5.35) by S_1(30 kg seeds ha^{-1}) at 20 DAS. Again, the lowest number of leaves per plant (4.53) was observed from S_5 (18 kg seeds ha^{-1}) which was statistically similar (4.59 and 4.64) to S_3 (24 kg seeds ha^{-1}) and S_4 (21 kg seeds ha^{-1}). At 30 DAS, the highest number of leaves per plant (11.20) was found from S_2 which was closely followed (9.82 and 9.67) by S_4 and S_1 while the lowest number of leaves per plant (7.61) was obtained from S_5 which was closely followed (8.70) by S_3. At 40 DAS, the highest number of leaves per plant (14.80) was recorded from S_2 which was closely followed (13.70, 13.45 and 13.21) by S_1, S_4 and S_3 whereas the lowest (12.05) was recorded from S_5. The highest number of leaves per plant (24.33) was observed from S_2 at 50 DAS. On the other hand the lowest (19.36) was recorded from S_5. At harvest, the highest number of leaves per plant (29.90) was found from S_2 while the lowest number of leaves per plant (19.73) was recorded from S_5 which was statistically similar (23.24) to S_3 (Figure 5).



C_1: BARI mung 6 C_2: BARI mash 1

Figure-4: Number of leaves per plant for mungbean and blackgram crops (LSD $_{0.05}$= 1.083, 0.784, 0.211, 0.099, 2.984 at 20, 30, 40 and 50 DAS respectively)



S_1: 30 kg seeds ha^{-1} S_2: 27 kg seeds ha^{-1}

S_3: 24 kg seeds ha^{-1} S_4: 21 kg seeds ha^{-1}

S_5: 18 kg seeds ha^{-1}

Figure-5: Effect of different seed rate on number of leaves per plant for mungbean and blackgram (LSD $_{0.05}$= 0.480, 0.623, 0.701, 1.408, 2.020 at 20, 30, 40 and 50 DAS respectively)

4.2.3 Interaction effect of crop and seed rate

Number of leaves per plant at 20, 30, 40, 50 DAS and harvest showed statistically significant interaction effect between crop and seed rate (Appendix V). At 20 DAS, the highest number of leaves per plant (6.58) was recorded from C_2S_2 (blackgram + 27 kg seeds ha^{-1}) that was similar to C_2S_1 where as the lowest number of leaves per plant (3.22) was found from C_1S_5 (mungbean + 18 kg seeds ha^{-1}) that similar to C_1S_3. The highest number of leaves per plant (12.35) was recorded from C_2S_2 and the lowest number of leaves per plant (7.09) was obtained from C_1S_5 at 30 DAS which was similar to C_1S_3. At 40 DAS, the highest number of leaves per plant (15.32) was recorded from C_2S_2 while the lowest number of leaves per plant (11.03) was observed from C_1S_5. The highest number of leaves per plant (27.85) was recorded from C_2S_2 and the lowest (16.53) number of leaves per plant was recorded from C_1S_5 at 50 DAS. At harvest, the highest number of leaves per plant (30.02) was found from C_2S_2 that was similar to C_2S_1 while the lowest number of leaves per plant (18.32) was recorded from C_1S_5 (Table 2) which was similar to C_1S_3, C_1S_1 and C_2S_5.

Table 2. Interaction effect of crop and seed rate on number of leaves per plant of mungbean and blackgram

Treatments	Number of leaves per plant at				
	20 DAS	30 DAS	40 DAS	50 DAS	At harvest
C_1S_1	4.30 ef	8.38 e	13.71 bc	19.78 ef	21.14 de
C_1S_2	5.82 bc	10.04 bcd	14.28 b	20.81 de	27.80 bc
C_1S_3	3.85 fg	7.79 ef	12.86 c	18.61 f	19.86 e
C_1S_4	4.76 de	9.26 d	13.65 bc	20.15 def	23.68 d
C_1S_5	3.22 g	7.09 f	11.03 d	16.53 g	18.32 e
C_2S_1	6.40 ab	10.95 b	13.68 bc	24.55 b	30.02 ab
C_2S_2	6.58 a	12.35 a	15.32 a	27.85 a	32.00 a
C_2S_3	5.33 cd	9.62 cd	13.56 bc	23.89 bc	26.61 c
C_2S_4	4.53 ef	10.38 bc	13.26 bc	22.27 cd	26.97 c
C_2S_5	5.85 bc	8.13 e	13.07 c	22.19 cd	21.14 de
$LSD_{(0.05)}$	0.679	0.881	0.991	1.991	2.856
Level of significance	**	**	*	*	*
CV(%)	7.76	8.17	6.26	5.31	6.67

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

Here, C_1: BARImung6, C_2: BARImash1, S_1: 30 kg seeds ha^{-1}, S_2: 27 kg seeds ha^{-1}, S_3: 24 kg seeds ha^{-1}, S_4: 21 kg seeds ha^{-1}, S_5: 18 kg seeds ha^{-1}

4.3 Number of nodules per plant

4.3.1 Effect of crop

The number of nodules per plant varied significantly for the cultivar of mungbean and blackgram (Appendix VII). The maximum number of nodules per plant (22.45) was recorded from C_2 (blackgram) where as the minimum number of nodules per plant (20.60) was recorded from C_1 as mungbean (Figure 6).

4.3.2 Effect of seed rate

The number of nodules per plant of mungbean and blackgram showed statistically significant differences due to different seed rates (Appendix VII). The highest number of nodules per plant (22.95) was found from S_4 (21 kg seeds ha^{-1}) which was statistically similar (21.20) to S_5 (18 kg seeds ha^{-1}). The minimum number of nodules per plant (18.20) was recorded from S_1 (30 kg seeds ha^{-1}) which was statistically similar (20.50 and 20.55) to S_3 (24 kg seeds ha^{-1}) and S_2 as 27 kg seeds ha^{-1} (Figure 7).

4.3.3 Interaction effect of crop and seed rate

The different seed rate of mungbean and blackgram showed statistically significant variation for number of nodules per plant (Appendix VII). The maximum number of nodules per plant (23.60) was recorded from C_2S_3 (blackgram + 24 kg seeds ha^{-1}) and the minimum number of nodules per plant (18.20) plant was obtained from C_1S_1 as mungbean + 30 kg seeds ha^{-1} (Figure 8).

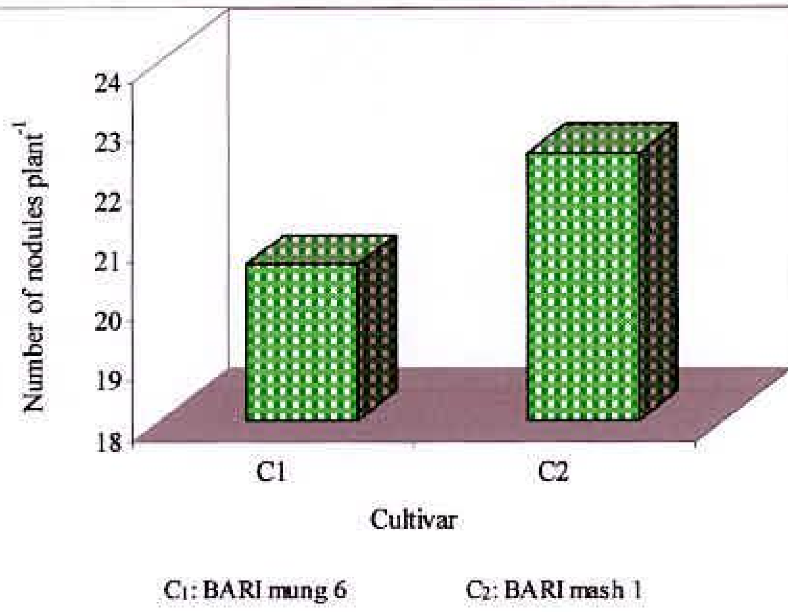


Figure 6. Number of nodules plant^{-1} for mungbean and blackgram crops ($Lsd_{0.05}$ = 1.213)

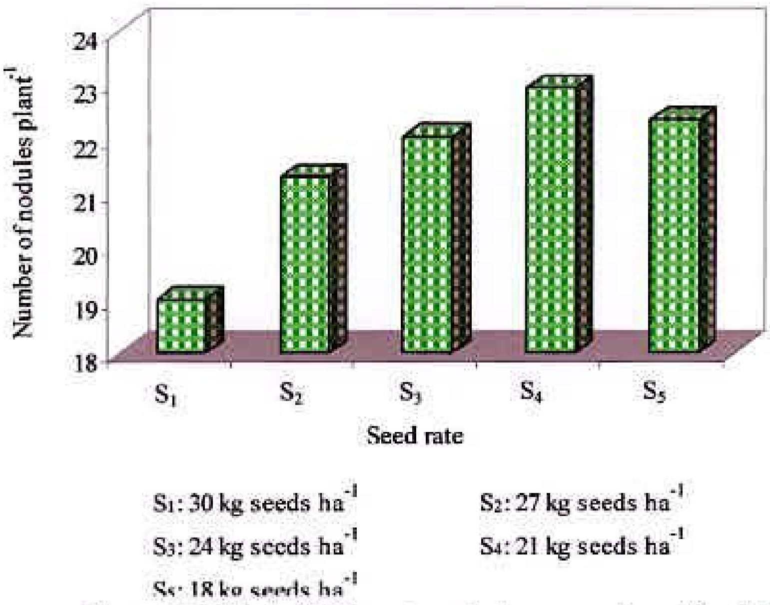
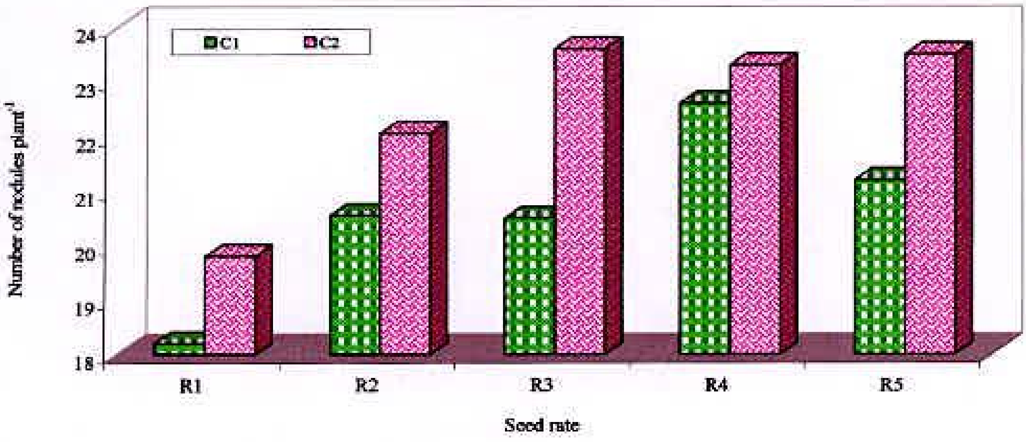


Figure 7. Effect of different seed rate on number of nodule plant^{-1} of mungbean and blackgram (Lsd0.05 = 1.728)



C_1: BARI mung 6 | C_2: BARI mash 1

S_1: 30 kg seeds ha^{-1} | S_2: 27 kg seeds ha^{-1}
S_3: 24 kg seeds ha^{-1} | S_4: 21 kg seeds ha^{-1}
S_5: 18 kg seeds ha^{-1}

Figure 8. Interaction effect of different seed rate on number of nodule $plant^{-1}$ of mungbean and blackgram (Lsd0.05 = 2.056)

4.4 Number of plant population/m^2

4.4.1 Effect of crop

Cultivar of mungbean and blackgram showed statistically significant differences for number of plant population/m^2 (Appendix V). The maximum number of plant population/m^2 (31.21) was obtained from C_2 (blackgram), where as the minimum number of plant population/m^2 (25.47) was found from C_1 (mungbean) (Table 3).

4.4.2 Effect of seed rate

Statistically significant variation was recorded due to different seed rate for number of plant population/m^2 of mungbean and blackgram (Appendix VI). The maximum number of plant population/m^2 (33.48) was found from S_1 (30 kg seeds ha^{-1}) which was closely followed (30.85) by S_2 (27 kg seeds ha^{-1}) while the minimum number of plant population/m^2 (21.74) was recorded from S_5 (18 kg seeds ha^{-1}) (Table 3).

4.4.3 Interaction effect of crop and seed rate

Interaction effect of cultivar and seed rate showed statistically significant variation for number of plant population/m^2 (Appendix VI). The maximum number of plant population/m^2 (35.46) was observed from C_2S_1 (blackgram + 30 kg seeds ha^{-1}) which was statistically similar with C_2S_2 (blackgram + 27 kg seeds ha^{-1}). On the other hand, the minimum number of plant population/m^2 (15.27) was recorded from C_1S_5 (mungbean + 18 kg seeds ha^{-1}) (Table 4).

Table 3. Effect of seed rate on number of plant population per m^2 and yield contributing characters of mungbean and blackgram crops

Treatments	Number of plant population per m^2	Number of pods per plant	Pod length (cm)	Number of seeds per pod
Cultivar				
C_1	25.47 b	18.10 b	6.16 b	7.26 b
C_2	31.21 a	20.24 a	6.98 a	7.82 a
$LSD_{(0.05)}$	4.388	1.183	0.573	0.355
Level of significance	*	*	*	*
Seed rate				
S_1	33.48 a	17.53 c	6.80 a	7.76 a
S_2	30.85 b	19.27 b	6.95 a	7.94 a
S_3	28.71 c	18.08 c	6.34 b	7.30 bc
S_4	26.92 d	20.87 a	6.71 a	7.57 ab
S_5	21.74 e	20.09 ab	6.04 c	7.14 c
$LSD_{(0.05)}$	1.570	1.051	0.290	0.363
Level of significance	**	**	**	**
CV(%)	9.53	8.48	9.59	7.93

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

Here, C_1: BARImung6, C_2: BARImash1, S_1: 30 kg seeds ha^{-1}, S_2: 27 kg seeds ha^{-1}, S_3: 24 kg seeds ha^{-1}, S_4: 21 kg seeds ha^{-1}, S_5: 18 kg seeds ha^{-1}

Table 4. Interaction effect of seed rate on number of plant population per m^2 and yield contributing characters of mungbean and blackgram crops

Treatments	Number of plant population per m^2	Number of pods per plant	Pod length (cm)	Number of seeds per pod
C_1S_1	35.99 a	14.17 d	6.20 cd	7.29 cd
C_1S_2	31.50 b	20.91 b	6.52 bc	7.68 abc
C_1S_3	22.30 e	17.89 c	5.91 d	7.03 d
C_1S_4	22.27 e	18.86 c	6.80 b	7.99 ab
C_1S_5	15.27 f	18.65 c	5.36 e	6.33 e
C_2S_1	35.46 a	20.89 b	7.39 a	8.22 a
C_2S_2	35.15 a	17.63 c	7.39 a	8.20 a
C_2S_3	31.53 b	18.28 c	6.77 b	7.57 bcd
C_2S_4	28.20 c	22.38 a	6.62 bc	7.15 cd
C_2S_5	25.71 d	21.54 ab	6.72 b	7.95 ab
$LSD_{(0.05)}$	2.221	1.487	0.410	0.514
Level of significance	**	**	**	**
CV(%)	9.53	8.48	9.59	7.93

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

Here, C_1: BARImung6, C_2: BARImash1, S_1: 30 kg seeds ha^{-1}, S_2: 27 kg seeds ha^{-1}, S_3: 24 kg seeds ha^{-1}, S_4: 21 kg seeds ha^{-1}, S_5: 18 kg seeds ha^{-1}

4.5 Number of pods per plant

4.5.1 Effect of crop

Statistically significant variation was recorded in number of pods per plant for the cultivar of mungbean and blackgram (Appendix VI). The maximum number of pods per plant (20.24) was obtained from C_2 (blackgram) and the minimum number of pods per plant (18.10) was found from C_1 (mungbean) (Table 3). Edwin *et al.* (2005) reported highest number of pods per plant (17.43) for green gram.

4.5.2 Effect of seed rate

Number of pods per plant of mungbean and blackgram varied significantly due to different seed rate (Appendix VI). The maximum number of pods per plant (20.87) was recorded from S_4 (21 kg seeds ha^{-1}) which was statistically similar (20.09) to S_5 (18 kg seeds ha^{-1}) where as the minimum number of pods per plant (17.53) was found from S_1 (30 kg seeds ha^{-1}) which was statistically similar (18.08) to S_3 (24 kg seeds ha^{-1}) (Table 3). Pookpakdi and Pataradilok (1993) reported that yield was generally increased with increasing plant density, while pod number $plant^{-1}$ decreased with increasing density. Panwar and Sirohi (1987) reported that pods $plant^{-1}$ decreased in all cultivars with increasing plant density.

4.5.3 Interaction effect of crop and seed rate

Interaction effect of cultivar and seed rate showed statistically significant variation for number of pods per plant of mungbean and blackgram (Appendix VI). The maximum number of pods per plant (22.88) was obtained from C_2S_4 (blackgram + 21 kg seeds ha^{-1}) that was similar to C_2S_5 and the minimum number of pods per plant (14.17) was found from C_1S_1 (mungbean + 30 kg seeds ha^{-1}) (Table 4).

4.6 Pod length

4.6.1 Effect of crop

Pod length varied significantly for the cultivar of mungbean and blackgram (Appendix VI). The maximum pod length (6.98 cm) was obtained from C_2 (blackgram) and the minimum pod length (6.16 cm) was found from C_1 (mungbean) (Table 3).

4.6.2 Effect of seed rate

Statistically significant differences were recorded due to different seed rate in pod length of mungbean and blackgram (Appendix VI). The maximum pod length (6.95 cm) was found from S_2 (27 kg seeds ha^{-1}) which was statistically similar (6.80 cm and 6.71 cm) to S_1 (30 kg seeds ha^{-1}) and S_4 (21 kg seeds ha^{-1}). On the other hand, the minimum pod length (6.04 cm) was recorded from S_5 (18 kg seeds ha^{-1}) (Table 3).

4.6.3 Interaction effect of crop and seed rate

Pod length showed statistically significant differences for the interaction effect of crop and seed rate (Appendix VI). The maximum pod length (7.39 cm) was observed from C_2S_2 (blackgram + 27 kg seeds ha^{-1}) and C_2S_1 (blackgram + 30 kg seeds ha^{-1}) while the minimum pod length (5.36 cm) was found from C_1S_5 (mungbean + 18 kg seeds ha^{-1}) (Table 4).

4.7 Number of seeds per pod

4.7.1 Effect of crop

The number of seeds per pod showed statistically significant differences for the cultivar of mungbean and blackgram (Appendix VI). The maximum number of seeds per pod (7.82) was recorded from C_2 (blackgram), while the minimum number of seeds per pod (7.26) was found from C_1 (mungbean) (Table 3). Nigamananda Elamathi (2007) found that the highest seeds/pod (6.80) from blackgram.

4.7.2 Effect of seed rate

Statistically significant differences were observed due to different seed rate in number of seeds per pod of mungbean and blackgram (Appendix VI). The maximum number of seeds per pod (7.94) was found from S_2 (27 kg seeds ha^{-1}) which was statistically similar (7.76 and 7.57) to S_1 (30 kg seeds ha^{-1}) and S_4 (21 kg seeds ha^{-1}) where as, the minimum number of seeds per pod (7.14) was observed from S_5 (18 kg seeds ha^{-1}) which was statistically similar (7.30) to S_3 (24 kg seeds ha^{-1}) (Table 3).

4.7.3 Interaction effect of crop and seed rate

Interaction effect of crop and seed rate showed statistically significant variation for number of seeds per pod of mungbean and blackgram (Appendix VI). The maximum number of seeds per pod (8.22) was observed from C_2S_1 (blackgram + 30 kg seeds ha^{-1}) that was similar to C_2S_1, C_1S_4, C_2S_5 and C_1S_2 where as the minimum number of seeds per pod (6.33) was recorded from C_1S_5 (mungbean + 18 kg seeds ha^{-1}) (Table 4).

4.8 Weight of 1000 seeds

4.8.1 Effect of crop

The weight of 1000 seeds varied significantly for the cultivar of mungbean and blackgram (Appendix VII). The maximum weight of 1000 seeds (21.77 g) was obtained from C_2 (blackgram) and the minimum weight of 1000 seeds (19.86 g) was recorded from C_1 (mungbean) (Table 5). Neciosup (1986) observed that the 1000-seed weight were higher in the higher population.

4.8.2 Effect of seed rate

The weight of 1000 seeds of mungbean and blackgram showed statistically significant differences due to different seed rate (Appendix VII). The maximum weight of 1000 seeds (22.40 g) was recorded from S_4 (21 kg seeds ha^{-1}) which was statistically similar (21.53 g) to S_5 (18 kg seeds ha^{-1}). On the other hand, the minimum weight of 1000 seeds (18.26 g) was found from S_1 (30 kg seeds ha^{-1}) (Table 5).

4.8.3 Interaction effect of crop and seed rate

Statistically significant variation was recorded for the interaction effect of cultivar and seed rate in weight of 1000 seeds (Appendix VII). The maximum weight of 1000 seeds (23.51 g) was observed from C_2S_4 (blackgram + 21 kg seeds ha^{-1}) while the minimum weight of 1000 seeds (16.29 g) was found from C_1S_1 (mungbean + 30 kg seeds ha^{-1}) (Table 6).

Table 5. Effect of seed rate on yield contributing characters and yield of mungbean and blackgram crops

Treatments	Weight of 1000 seeds (g)	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
Cultivar				
C_1	19.86 b	1.01 b	1.24 b	44.76
C_2	21.77 a	1.13 a	1.39 a	44.82
$LSD_{(0.05)}$	1.337	0.086	0.050	--
Level of significance	*	*	**	NS
Seed rate				
S_1	18.26 c	1.10 b	1.35 b	44.69
S_2	20.79 b	1.20 a	1.49 a	44.56
S_3	21.07 b	1.08 b	1.33 b	44.79
S_4	22.40 a	1.05 b	1.30 b	44.83
S_5	21.53 ab	0.91 c	1.12 c	45.05
$LSD_{(0.05)}$	0.935	0.077	0.087	--
Level of significance	**	**	**	NS
CV(%)	6.67	6.07	8.22	5.11

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

Here, C_1: BARImung6 , C_2: BARImash1, S_1: 30 kg seeds ha^{-1}, S_2: 27 kg seeds ha^{-1}
S_3: 24 kg seeds ha^{-1}, S_4: 21 kg seeds ha^{-1}, S_5: 18 kg seeds ha^{-1}

Table 6. Interaction effect of seed rate on yield contributing characters and yield of mungbean and blackgram crops

Treatments	Weight of 1000 seeds (g)	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
C_1S_1	16.29 g	1.20 a	1.49 a	44.65
C_1S_2	20.02 ef	1.16 a	1.44 a	44.63
C_1S_3	19.62 f	0.95 b	1.16 b	45.03
C_1S_4	21.30 bcde	0.92 b	1.12 bc	45.10
C_1S_5	22.05 bc	0.81 c	1.01 c	44.56
C_2S_1	20.23 def	0.99 b	1.21 b	44.93
C_2S_2	21.56 bcd	1.24 a	1.55 a	44.50
C_2S_3	22.52 ab	1.21 a	1.51 a	44.54
C_2S_4	23.51 a	1.19 a	1.48 a	44.57
C_2S_5	21.01 cdef	1.02 b	1.22 b	45.54
$LSD_{(0.05)}$	1.322	0.110	0.122	--
Level of significance	**	**	**	NS
CV(%)	6.67	6.07	8.22	5.11

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

Here, C_1: BARImung6, C_2: BARImash1, S_1: 30 kg seeds ha^{-1}, S_2: 27 kg seeds ha^{-1}
S_3: 24 kg seeds ha^{-1}, S_4: 21 kg seeds ha^{-1}, S_5: 18 kg seeds ha^{-1}

4.9 Seed yield (t/ha)

4.9.1 Effect of crop

The mungbean and blackgram showed statistically significant differences for seed yield per hectare (Appendix VII). The maximum seed yield per hectare (1.13 ton) was found from C_2 (blackgram). On the other hand the minimum seed yield per hectare (1.01 ton) was observed from C_1 (mungbean) (Table 5). Patro and Sahoo (1994) reported that yield was not significantly different between cultivars.

4.9.2 Effect of seed rate

Seed yield per hectare of mungbean and blackgram showed statistically significant differences due to different seed rates (Appendix VII). The maximum seed yield per hectare (1.20 ton) was recorded from S_2 (27 kg seeds ha^{-1}). The minimum seed yield per hectare (0.91 ton) was found from S_5 (18 kg seeds ha^{-1}) (Table 5). It was revealed that higher than recommended seed rate generally increases plant population resulting intra crop competition thereby affecting the yield where as lower seed rate may reduce the yield drastically as the grain yield is positively correlated with plant population (Vukadinovic *et al.*, 1986). Talukder *et al.* (1993) reported that a crop density which was considerably high but less than the maximum was found to produce lower yields than the minimum density.

4.9.3 Interaction effect of crop and seed rate

The statistically significant variation of seed yield per hectare was recorded for the interaction effect of cultivar and seed rate of mungbean and blackgram (Appendix VII). The maximum seed yield per hectare (1.24 ton) was obtained from C_2S_2 (blackgram + 27 kg seeds ha^{-1}) and it was similar to C_2S_3, C_1S_1, C_2S_4 and C_1S_2

whereas as the minimum seed yield per hectare (0.81 ton) was recorded from C_1S_5 (mungbean + 18 kg seeds ha^{-1}) (Table 6).

4.10 Stover yield per hectare

4.10.1 Effect of crop

The stover yield per hectare varied significantly for the cultivar of mungbean and blackgram (Appendix VII). The maximum stover yield per hectare (1.39 ton) was found from C_2 (blackgram), while the minimum stover yield per hectare (1.24 ton) was found from C_1 (mungbean) (Table 5).

4.10.2 Effect of seed rate

Stover yield per hectare of mungbean and blackgram showed statistically significant differences due to different seed rates (Appendix VII). The highest stover yield per hectare (1.49 ton) was recorded from S_2 (27 kg seeds ha^{-1}) which was closely followed (1.35 ton, 1.33 ton and 1.30 ton) by S_1 (30 kg seeds ha^{-1}), S_3 (24 kg seeds ha^{-1}) and S_4 (21 kg seeds ha^{-1}), respectively. On the other hand, the minimum stover yield per hectare (1.12 ton) was obtained from S_5 (18 kg seeds ha^{-1}) (Table 5). In lower plant population, individual plant performance is better than that of higher plant population but within tolerable limit higher plant population produces higher stover yield ha^{-1} (Shukla and Dixit, 1996).

4.10.3 Interaction effect of crop and seed rate

The interaction effect of cultivar and seed rate showed statistically significant variation for stover yield per hectare (Appendix VII). The maximum stover yield per hectare (1.55 ton) was recorded from C_2S_2 (blackgram + 27 kg seeds ha^{-1}) that was similar to C_2S_3, C_2S_4, C_1S_1 and C_1S_2 while the minimum stover yield per hectare (1.01 ton) was recorded from C_1S_5 (mungbean + 18 kg seeds ha^{-1}) that similar to C_1S_4 (Table 6).

4.11 Harvest Index

4.11.1 Effect of crop

The harvest index varied non-significantly for the cultivar of mungbean and blackgram (Appendix VII). The numerically maximum harvest index (44.82%) was found from C_2 (blackgram) and the minimum harvest index (44.76%) was found from C_1 (mungbean) (Table 5).

4.11.2 Effect of seed rate

The statistically non significant differences were recorded due to different seed rates for harvest index of mungbean and blackgram (Appendix VII). The numerically maximum harvest index (45.05 %) was found from S_5 (18 kg seeds ha^{-1}). On the other hand, the minimum harvest index (44.56%) was found from S_2 as 27 kg seeds ha^{-1} (Table 5). Tsiung (1978) reported that in mungbean the 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.

4.11.3 Interaction effect of crop and seed rate

Interaction effect of crop and seed rate showed statistically non significant variation for harvest index of mungbean and blackgram (Appendix VII). The numerically maximum harvest index (45.54%) was observed from C_2S_5 (blackgram + 18 kg seeds ha^{-1}) and the minimum harvest index (44.50%) was found from C_2S_2 (blackgram + 27 kg seeds ha^{-1}) (Table 6).

Chapter 5
Summary & Conclusion

Chapter-V

SUMMARY AND CONCLUSION

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, during the period from March to May 2007 to study the influence of seed rate on the growth and yield of mungbean and blackgram. The experiment consists of two factors. Factor A: Crops C_1: BARImung6 and C_2: BARImash1; Factor B: Seed rate, S_1: 30 kg seeds ha^{-1} (recommended dose), S_2: 27 kg seeds ha^{-1} (10% less than recommended dose), S_3: 24 kg seeds ha^{-1} (20% less than recommended dose), S_4: 21 kg seeds ha^{-1} (30% less than recommended dose) and S_5: 18 kg seeds ha^{-1} (40% less than recommended dose). The two factors experiment was laid out in Split plot design with three replications.

At 20, 30, 40, 50 DAS and at harvest the taller plant (18.30 cm, 35.70 cm, 42.74 cm, 55.69 cm and 67.96 cm) was recorded from C_2, while the shorter plant (15.64 cm, 30.45 cm, 36.51 cm, 50.91 cm and 61.55 cm) was found from C_1 at same DAS. The higher number of leaves per plant (5.74, 10.29, 13.78, 24.15 and 27.35) was recorded from C_2, while the lower (4.39, 8.51, 13.10 19.18 and 22.16) was found from C_1 at 20, 30, 40, 50 DAS and at harvest. The higher plant population/m^2 (31.21) was recorded from C_2 while the lower (25.47) was found from C_1. The maximum number of pods per plant (20.24) was recorded from C_2 (blackgram), while the minimum (18.10) was found from C_1. The maximum pod length (6.98 cm) was recorded from C_2, while the minimum (6.16 cm) was found from C_1. The maximum number of seeds per pod (7.82) was recorded from C_2, while the minimum (7.26) was found from C_1. The maximum weight of 1000 seeds (21.77 g) was recorded from C_2 while the minimum (19.86 g) was found from C_1. The maximum seed yield per hectare (1.13 ton) was recorded from C_2 while the minimum (1.01 ton) was found from C_1. The maximum stover yield per hectare (1.39 ton) was recorded from C_2 (blackgram), while the minimum (1.24 ton) was found from C_1. The maximum harvest index (44.82%) was recorded from C_2 while the (44.76%) was found from C_1. The maximum number of nodules per plant (22.45) was recorded from C_2, while the minimum (20.60) was found from C_1.

The tallest plant (18.61 cm, 35.33 cm, 42.42 cm, 57.05 cm and 69.59 cm) was recorded from S_2 and the shortest plant (16.03 cm, 31.40 cm, 37.53 cm, 49.81 cm and 60.93 cm) was observed from S_5 at 20, 30, 40, 50 DAS and harvest. At 20, 30, 40, 50 DAS and harvest the highest number of leaves per plant (6.20, 11.20, 14.80, 24.33 and 29.90) was recorded from S_2 and the lowest (4.53, 7.61, 12.05, 19.36 and 19.73) was observed from S_5. The highest plant population/m^2 (33.48) was recorded from S_1 and the lowest (21.74) was observed from S_5. The maximum number of pods per plant (20.87) was recorded from S_4 and the minimum (17.53) was observed from S_1. The maximum pod length (6.95 cm) was recorded from S_2 and the minimum (6.04 cm) was observed from S_5. The maximum number of seeds per pod (7.94) was recorded from S_2 and the minimum (7.14) was observed from S_5. The maximum weight of 1000 seeds (22.40 g) was recorded from S_4 (21 kg seeds ha^{-1}) and the minimum (18.26 g) was observed from S_1. The maximum seed yield per hectare (1.20 ton) was recorded from S_2 and the minimum (0.91 ton) was observed from S_5. The maximum stover yield per hectare (1.49 ton) was recorded from S_2 and the minimum (1.12 ton) was observed from S_5. The maximum harvest index (45.05 %) was recorded from S_5 and the minimum (44.56%) was observed from S_2. The maximum number of nodules per plant (22.95) was recorded from S_4 and the minimum (18.20) was observed from S_1.

At 20 DAS, the tallest plant (20.62 cm, 38.15 cm, 45.56 cm, 60.29 cm and 73.65 cm) was recorded from C_2S_2 and the shortest plant (13.40 cm, 26.60 cm, 32.14 cm, 44.57 cm, 53.18 cm) was found from C_1S_5. At 20, 30, 40, 50 DAS and at harvest, the highest number of leaves per plant (6.58, 12.35, 15.32, 27.85 and 30.02) was recorded from C_2S_2 and the lowest (3.22, 7.09, 11.03, 16.53 and 18.32) number of leaves per plant was found from C_1S_5. The highest plant population/m^2 (35.46) was recorded from C_2S_1 and the lowest (15.27) was found from C_1S_5. The maximum number of pods per plant (22.88) was recorded from C_2S_4 and the minimum (14.17) was found from C_1S_1. The maximum pod length (7.39 cm) was recorded from C_2S_2 and the minimum (5.36 cm) was found from C_1S_5. The maximum number of seeds per pod (8.22) was recorded from C_2S_1 and the minimum (6.33) was found from C_1S_5. The maximum weight of 1000 seeds (23.51 g) was recorded from C_2S_4 and the minimum (16.29 g) was found from C_1S_1. The maximum seed yield per hectare (1.24 ton) was recorded from C_2S_2 and the minimum (0.81 ton) was found from C_1S_5. The maximum stover yield per hectare ([illegible].55 ton) was recorded from C_2S_2 and the minimum (1.01 ton) was found from C_1S_5. The maximum harvest index (45.54%) was recorded from C_2S_5 and the minimum (44.50%) was found from C_2S_2. The maximum number of nodules per plant (23.60) was recorded from C_2S_3 and the minimum (18.20) plant was found from C_1S_1.

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

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional compliance and other performance.
2. Another experiment may be carried out with another seed rate for other cultivar.
3. Management practices may be included with seed rate for further study.

Chapter 6
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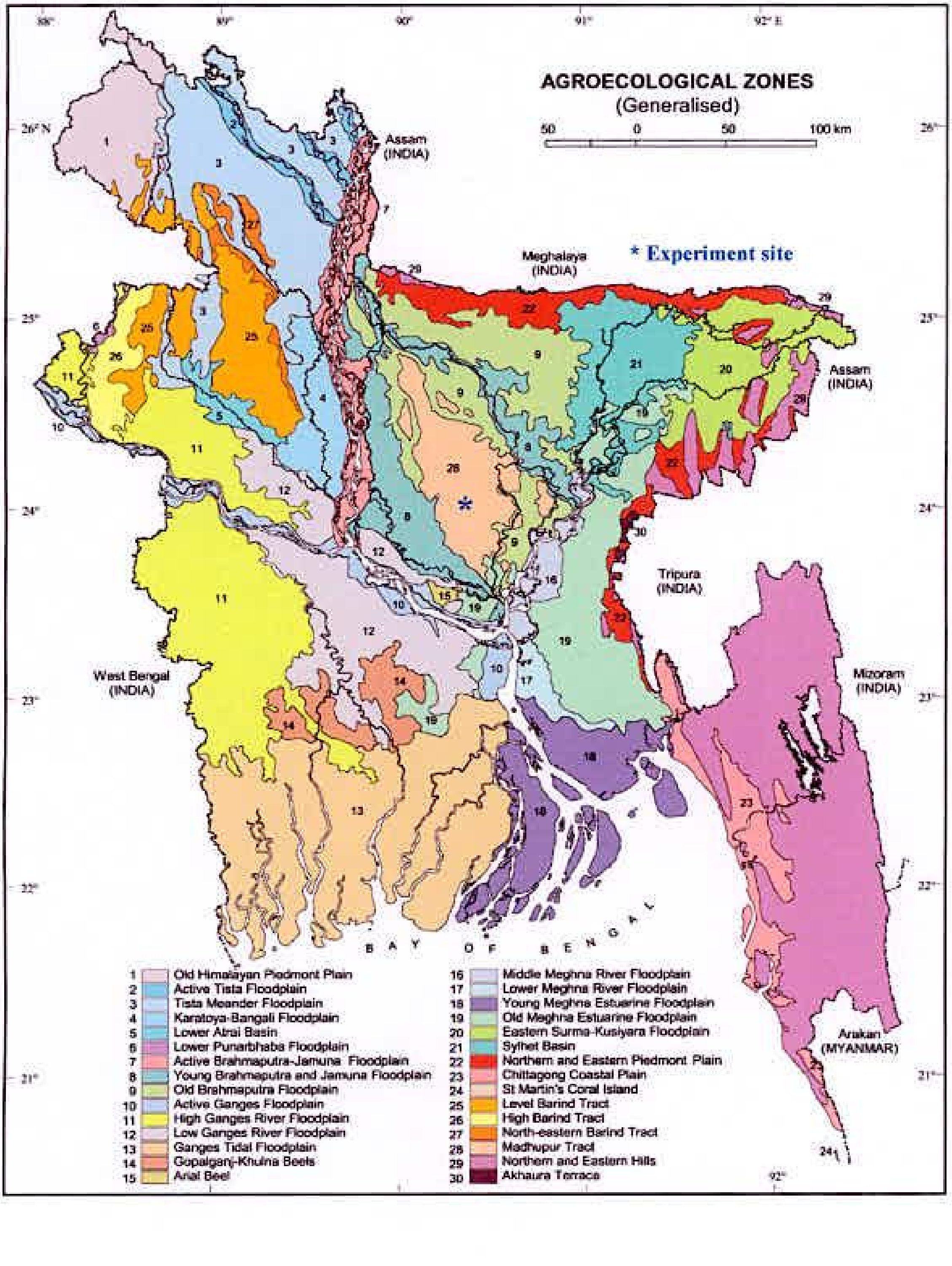
Appendices

Appendix I. Experimental location on the map of Agro-ecological Zones of Bangladesh



Appendix II. The mechanical and chemical characteristics of soil of the experimental site as observed prior to examination (0-15 cm depth)

Mechanical composition :

Particle size constitution

Sand : 26%

Silt : 45%

Clay : 29%

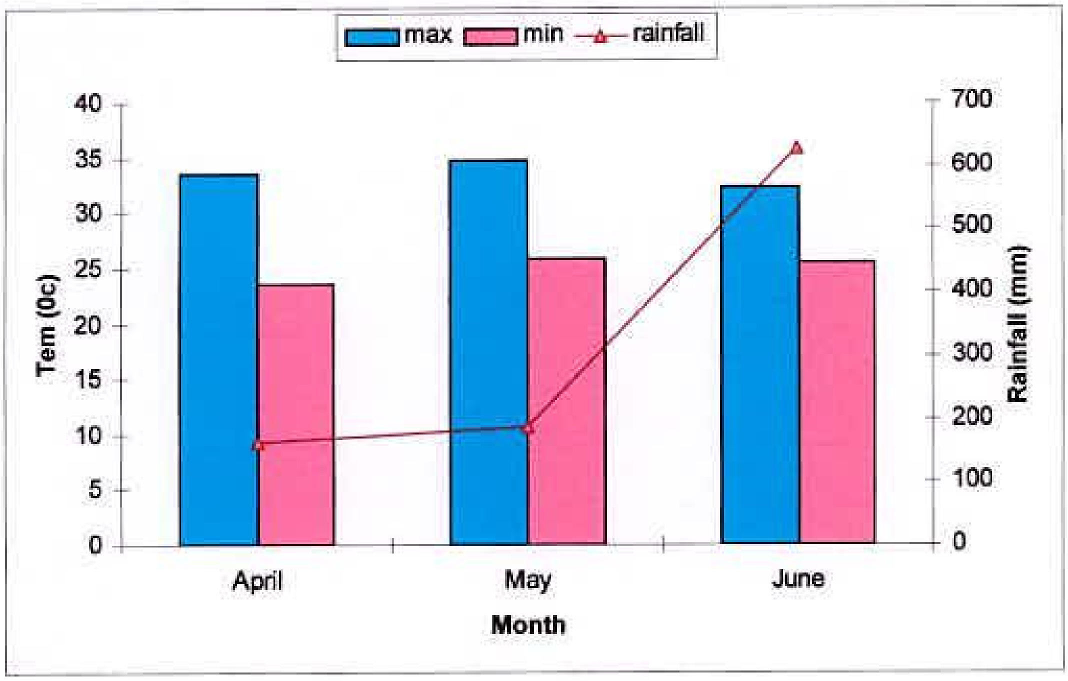
Texture : Silty clay

Chemical composition :

Soil characters	Value
p^{H}	7.1
Organic matter	1.08 %
Total Nitrogen	0.054 %
Potassium	0.27 meq/100 gm soil
Calcium	3.50 meq/100 gm soil
Magnesium	0.46 meq/100 gm soil
Phosphorus	10.46 ppm
Sulphur	18 ppm
Boron	0.04 ppm
Copper	1.60 ppm
Iron	14 ppm
Manganese	36.80 ppm
Zinc	1.84 ppm

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

Appendix III. Monthly recordes of temperature and rainfall of the experimental site during the period from April 2007 to June 2007



Source: Bangladesh Meterological Department (Climate Division), Agargao, Dhaka 1212

Appendix IV. Analysis of variance of the data on plant height as influenced by different seed rates of mungbean and blackgram

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm) at				
		20 DAS	30 DAS	40 DAS	50 DAS	At harvest
Replication	2	1.416	1.441	1.011	0.475	0.553
Crop (A)	1	53.280*	206.719*	291.346*	171.287*	308.610*
Error	2	2.476	8.679	13.709	2.939	6.188
Seed rate (B)	4	11.865**	14.453**	22.432**	42.140*	61.604**
Interaction (A×B)	4	7.448*	41.285**	37.295**	34.707*	67.020**
Error	16	2.025	2.730	2.652	10.409	6.427

** Significant at 0.01 level of probability, * Significant at 0.05 level of probability

Appendix V. Analysis of variance of the data on number of leaves per plant as influenced by different seed rates of mungbean and blackgram

Source of variation	Degrees of freedom	Mean square				
		Number of leaves per plant at				
		20 DAS	30 DAS	40 DAS	50 DAS	At harvest
Replication	2	0.100	0.024	0.287	0.033	0.536
Crop (A)	1	13.615*	23.548**	3.421**	185.456**	201.709*
Error	2	0.475	0.249	0.018	0.004	3.607
Seed rate (B)	4	3.090**	10.758**	5.840**	19.585**	82.508**
Interaction (A×B)	4	1.899**	0.708**	1.360*	4.895*	9.829*
Error	16	0.154	0.258	0.328	1.323	2.723

** Significant at 0.01 level of probability, * Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data on number of flowers per plant, number of pods per plant, pod length and number of seeds per pod as influenced by different seed rates of mungbean and blackgram

Source of variation	Degrees of freedom	Mean square			
		Number of plant population/m²	Number of pods per plant	Pod length (cm)	Number of seeds per pod
Replication	2	2.512	1.[illegible]39	0.204	0.036
Crop (A)	1	247.394*	34.583*	5.043*	2.302*
Error	2	7.799	0.567	0.133	0.051
Seed rate (B)	4	117.737**	11.425**	0.828**	0.637**
Interaction (A×B)	4	140.481**	21.556**	0.537**	1.208**
Error	16	1.646	0.738	0.056	0.088

** Significant at 0.01 level of probability, * Significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data on 1000-seed weight, seed yield, harvest index and number of nodule per plant as influenced by different seed rates of mungbean and blackgram

Source of variation	Degrees of freedom	Mean square				
		1000-seed weight (g)	Seed yield (kg/plot)	Seed yield (t/ha)	Harvest index (%)	Number of nodule per plant
Replication	2	4.882	0.006	0.004	0.325	1.232
Crop (A)	1	27.342*	0.112*	0.166**	0.028	2.234*
Error	2	0.724	0.003	0.001	0.350	0.237
Seed rate (B)	4	14.455**	0.063**	0.111**	0.196	12.341**
Interaction (A×B)	4	5.255**	0.060**	0.102**	0.634	5.872**
Error	16	0.583	0.004	0.005	5.234	1.376

** Significant at 0.01 level of probability, * Significant at 0.05 level of probability