POSITIONAL EFFECT OF MICROPYLE ON SEEDLING GROWTH AND YIELD OF KHARIF MUNGBEAN AND BLACKGRAM

BY

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CERTIFICATE

This is to certify that the thesis entitled, **"POSITIONAL EFFECT OF MICROPYLE ON SEEDLING GROWTH AND YIELD OF KHARIF MUNGBEAN AND BLACKGRAM"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN AGRONOMY**, embodies the result of a piece of bona fide research work carried out by **Lima Rifat**, Registration No.**27448/00809** under my supervision and my guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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Dedicated To
My
Beloved Parents

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POSITIONAL EFFECT OF MICROPYLE ON SEEDLING GROWTH AND YIELD OF KHARIF MUNGBEAN AND BLACKGRAM

ABSTRACT

A field experiment was carried out at the experimental farm of Sher-e-Bangla Agricultural University (SAU), Dhaka, to investigate the influence of varying micropyle position, on growth and yield of mungbean and blackgram during 27th March to 25th June 2007. The trial comprised of two crops and four micropyle position treatments such as C_1= Mungbean, C_2= Blackgram, P_1= Upward micropyle position, P_2= Downward micropyle position, P_3= Lateral micropyle position, P_4= Haphazard micropyle position. The experiment was laid out in a split-plot design with three replications having two crops in the main plots and four micropyle positions in the sub-plots. Emergence percentage, plant height, root and shoot ratio, dry matter partitioning, number of branches plant^{-1}, number of pods plant^{-1}, length of pod, number of seeds pod^{-1}, 1000 seeds weight, shelling percentage, seed yield, stover yield and harvest index were tested for different treatments. Results revealed that there was no significant difference observed between mungbean and blackgram for plant height, root and shoot ratio, total dry matter production, 1000 seed weight, seed yield and stover yield. But mungbean performed better in producing the highest yield which might be attributed to the earlier emergence percentage of mungbean which was eventually supported the plant to produce more number of seeds pod^{-1} and length of pod compared to the blackgram. Number of branches plant^{-1}, number of pods plant^{-1}, shelling percentage was higher in blackgram than mungbean. The earlier emergence percentage of downward micropyle position showed the best performance and haphazard micropyle position showed numerically the maximum seed yield (0.82 t ha^{-1}). But statistically there was no significant difference among the treatments. Among the interaction treatments, the highest pod length, number of seeds pod^{-1} and 1000 seed weight were found in mungbean with haphazard micropyle position. But numerically the maximum seed yield (0.89 t ha^{-1}) was obtained from blackgram with haphazard micropyle position. Significantly the highest number of branches plant^{-1}, number of pods plant^{-1} and shelling percentage were found in blackgram with other treatments.

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LIST OF ACRONYMS

AEZ	Agro-Ecological Zone
AVRDC	Asian Vegetable Research and Development Center
Ag	Agriculture
BAU	Bangladesh Agricultural University
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
CDP	Crop Diversification Programme
cm	centi-meter
CV %	Percent Coefficient of Variance
cv.	Cultivar (s)
DF	Degrees of freedom
DAS	Days After Sowing
et al.	And others
e.g.	*exempli gratia* (L), for example
etc.	Etcetera
FAO	Food and Agriculture Organization
g	Gram (s)
HI	Harvest Index
HYV	High Yielding Variety
i.e.	*id est* (L), that is
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
J.	Journal
Kg	Kilogram (s)
LSD	Least Significant Difference
m^2	meter squares
m	meter
m ton	metric ton
mm	millimeter
M.S.	Master of Science
meq	miliequivalent
No.	Number
NS	Non significant
ppm	parts per million
p^H	(-)ve logarisom of hydrozen ion concentration
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resource and Development Institute
t ha^{-1}	ton per hectare
UN	United Nations
WHO	World Health Organization
°C	Degree Centigrade
%	Percentage

Chapter 1
Introduction

CHAPTER 1

INTRODUCTION

Pulses or grain legumes occupy an important position in world Agriculture by virtue of their high vegetable protein content. Pulses are considered poor men's meat since they are the source of protein for the underprivileged people who can not afford animal protein. Pulses contain remarkably higher amount of protein than the cereal crops (Gowda and Kaul, 1982).

Pulses or grain legumes which are a vital source of protein, easily digestible dietary pulses contain a remarkable amount of minerals, vitamins, fats and carbohydrates. Not only in respect of protein, pulses are also superior in containing amino acids, especially those are termed essential. Pulses effectively supplement cereal proteins since they are rich in lysine, which is not generally found in cereals (Kharkwal *et al.*, 1986). However, methionine and cystine are the limiting amino acids in pulses. Pulse can also provide all the B vitamins which are lost in polished rice. FAO (1999) recommends a minimum pulse intake of 80 g per head per day whereas; it is only 14.19 g in Bangladesh (BBS, 2006). This is because of the fact that production of the pulses is not adequate to meet the national demand .The crop is potentially useful in improving cropping system which can be grown as a cash crop due to its rapid growth with easily maturing characteristics. Moreover, adding of legume in cereal based cropping system can improve soil structure, nutrient exchange and maintain healthy sustainable soil system (Becker *et al.,* 1995).Besides this pulse is considered as soil building crop which has the remarkable quality of helping the symbiotic root rhizobia to fix atmospheric nitrogen. Grain legumes are believed to add 20-60 kg N ha^{-1} to the succeeding crop (Kumar *et al.,* 1998).

Soil organic matter is an important factor to be considered in improving crop productivity. Because of the tropical climate, organic matter decomposition in Bangladesh soil is high. Most soils of Bangladesh contain very low amount of organic matter, usually less than 2% (Panaullah *et al.,* 1999; Bhuiyan, 1999; Jahiruddin *et al.*, 2000).

The proper soil organic matter management needs due attention in view of the low organic matter status of our soil (Ali *et al.*, 1997). Inclusion of a legume crop in between cereals may contribute to maintain or increase in soil organic matter.

In Bangladesh, pulse production is very low as compared to others cereal production which is due to the fact that less area of our land is under pulse cultivation. During 1993-94, the area under pulse cultivation was 709311.74 hectare, but at present this has been decreased to 383400.8 hectares. That is from 1993-94 to 2004-05, 40% of the pulse area has been replaced by other crops (BBS, 2007).

Both the acreage and production of the pulses are decreasing in Bangladesh day by day due to the inception of wheat and boro rice in our cropping system with irrigation facilities. To meet up the demand of pulses, intercropping is the good technique where farmer may produce pulses with other crops (maize, rice, wheat etc.) simultaneously.

Among the pulse crops, mungbean and blackgram are important world food crops for providing an inexpensive source of vegetable protein. Mungbean and blackgram are sub-tropical, kharif crops, well adapted to semi-arid and sub-humid zones with annual rainfall between 600-1000 mm requiring an optimum mean temperature of 30^{0}c. It grows successfully on sandy loam to clay loam soil. Among the environmental factors, excess rain at the time of reproductive period causes enormous loss of both seed yield and seed quality of mungbean (Williams *et al.*, 1995).

Mungbean ranks fifth both in acreage (0.108 million ha) and production (0.03 million tones) ranks fourth among the pulses with an area of about 82000 ha (BBS, 2006). Among the pulses, mungbean is one of the best in nutritional value, having 51% carbohydrate, 26% protein, 4% mineral and 3% vitamins and blackgram is also contains 59% carbohydrate, 24% protein, 10% moisture, 4% mineral and 3% vitamins (Khan *et al.*, 1982; Kaul, 1982).

Kharif mungbean and blackgram are rainfed crop in Bangladesh, grown either during the wet season or on the residual soil moisture. They responses favorably to added water resulting in higher yields, especially when irrigation is given at the time of flowering (Lawn, 1978; Miah and Carangal, 1981). In summer cultivation when the temperature is high, relative humidity is low and evapo-transpiration is greater, then 3-4 irrigations may be needed to obtain higher yields of mungbean and blackgram (Sing and Sing, 1979 and Lal and Yadav, 1981). On the other hand, the environmental factors, excess rainfall at the time of reproductive period causes heavy loss of both seed yield and seed quality of mungbean and blackgram (Williams *et al.,* 1995). So, the seed may be damaged in the plant itself during the rainy season due to excess rainfall, if harvesting is delayed. If pre-sowing is done, we have to ensure the highest yield of mungbean and blackgram and easily overcome this environmental hazard and obtained maximum yield compared to other cereal crops.

One important factor of successfully growing of mungbean and blackgram is the good availability of its seed. The effective germination of seeds depends upon many factors of which seed position is important.

Ghosh and Das (1997) reported that *Vigna mungo cv.* T9 seeds were placed in sand with the micropyle at different orientations. The position of the micropyle did not affect seed germination or shoot length of seedlings up to 10 days after sowing. However, when the micropyle was placed in the down ward position, root length and total seedling length were increased. It is suggested that sowing *Vigna mungo* with the micropyle down would give the best early seedling growth.

Research work on different micropyle position of mungbean and blackgram seed under Bangladesh condition is limited. Moreover, some promising varieties have been released during the last decades which are mostly grown in summer. Most frequently, problem of its seed establishment has been reported. This situation should be overcome through optimum sowing time of seeds at the suitable micropyle position. Such effort may play a remarkable role for the improvement of germination and emergence that may also result in the increased yield of mungbean and blackgram.

Objectives:

i) to examine the effect of micropyle position on growth and yield of kharif mungbean and blackgram.

ii) to determine the seedling growth and yield of mungbean and blackgram.

iii) to find out the interaction effect between micropyle positions and variety on the growth and yield of mungbean and blackgram.

Chapter 2
Review of Literature

CHAPTER 2

REVIEW OF LITERATURE

Many researches on pulses carried out worldwide for its improvement. But still the acreage and production of pulses are in declining trend due to various reasons. The mungbean and blackgram can grow throughout the year in Bangladesh though timely sowing is very important for ensuring optimum production and higher yield. Micropyle position is important considering the germination and growth as well as yield of these crops. But no such reviews were possible to collect and hence only the acreage, production and importance of mungbean and blackgram have been reviewed in this chapter.

2.1 Acreage and Production

BBS (2007) reported that in comparison to cereal production, pulses production in Bangladesh is very low which is due to less area of our land is under pulse cultivation. During 1993-94, the area under pulse cultivation was 709311.74 hectare, but at present this has been decreased to 383400.8 hectares. That is, from 1993-94 to 2004-05, 40% of the pulse area has been replaced by other crops.

It showed that mungbean ranks second both in acreage (0.108 million ha) and production (0.03 million tonne) (BBS, 2005) and blackgram ranks fourth among the pulses with an area of about 82000 ha (BBS, 2006). It also reported that the total production of mungbean from the year 2001-2002 to 2005-2006 was 31, 30, 30, 18, and 17 thousand tons respectively. In these years the total production of mungbean decreased by 3% to 40%.

BBS (2005) stated that the total cultivable land of Bangladesh is 14.08 million hectares out of which 0.73 million hectares is used for cultivation of pulses. This area constituted only 5.3% of the total cultivable land. The present production of pulse is about 0.32 million tons, which can provide only 10 g per capita per day.

BBS (2004) reported that in Bangladesh, per capita daily availability for consumption of pulses is only 10.29 g per day, while the world health organization (WHO) of United Nations (UN) suggests 45 g per day per capita for a balance diet. Intake of per capita pulses in Bangladesh is far below than the WHO recommendation. To maintain the supply of this level, the government of Bangladesh has to spend a huge amount of foreign currency every year. Annually import of pulses in Bangladesh is approximately 108,000 m tons [BBS (Ag), 2004].

Weinberger *et al.* (2003) while conducting an experiment on mungbean reported that between 1972 and 2002, average annual yield increase in mungbean were only 0.1%, compared to yield increase in pulses as a whole at 0.5% and paddy at 2.4%. The profitability of mungbean production ranges from 7,700 Taka ha^{-1} to 12,856 Taka ha^{-1}. In comparison, the profitability of boro rice was only 6,424 Taka.

Weinberger (2003) reported that in Bangladesh mungbean production increased with an annual average growth rate of 6.7% between 1972 and 2002 compared with the average 3.5% for all pulses. During the period, area under mungbean has doubled, from 5.3% to 11.5%. In 2002, a total of 45,600 ha were under production and average yield levels were 680 kg ha^{-1}, higher than the neighboring India, but lower than other countries such as Thailand and Myanmar.

A field experiment was carried out by Ramakrishna *et al.* (2000) on pulse and it was found that productivity of legumes is generally very low compared to cereals. Yield of pulses in farmer's fields is usually less than 1 t ha^{-1} against the potential yield of 2 to 4 t ha^{-1} indicating a large yield gap. However, in spite of decreasing area under pulses, the productivity has been slightly increased

BBS (2000) reported that blackgram was an important crop which ranked fourth among the pulses cultivated in Bangladesh. It was also rich in plant protein and as a leguminous crop, it improves soil productivity.

Pulse is a common item in the daily diet of the people of Bangladesh. Many of the pulse seeds are consumed as raw when they are in green stage. Generally there is no complete dish without "dhal" in Bangladesh. Results showed that adding of legume in cereal based cropping system can improve soil structure, nutrient exchange and maintain healthy sustainable soil system (Becker *et al.* 1995).

Ahmed *et al.* (1985) reported that pulses are vital source of protein, calories, minerals and some vitamins of human diet. Pulses occupy an area of about 0.3 million ha (2.34% of the total cropped area) and contribute about 1.07% of the total grain production of the country.

Sarker *et al.* (1982) described that mungbean was one of the leading pulse crop of Bangladesh. It holds the first position in price, third in protein content and fourth in both acreage and production in Bangladesh.

It had been reported that the average yield of mungbean in this country is 550 kg ha^{-1} (BBS, 1980) which was much lower than in India (1320 kg ha^{-1}) and some other countries. It is partly due to low yielding potentiality and partly due to lack of appropriate agronomic practices (Daisy, 1979).

2.2 Nutrition

Saha *et al.* (2002) stated that low yields of grain legumes, including mungbean make the crop less competitive with cereals and high value crops.

AVRDC (1998) described that mungbean was very rich in protein and it complements the staple rice in Asian diets. The main reason behind decreasing the popularity of the crop was the low yield potentials. The shortfall makes the crop less competitive with cereals and other high valued crops. To increase production, it was imperative that productivity of mungbean needed to be increased.

Fernandez and Shanmugasundaram (1988) studied the capacity of biological nitrogen fixation and high seed protein content of mungbean made it a high value crop in terms of sustainable agricultural production in the tropics. Mungbean was an excellent source of easily digestible protein of low flatulence. It complements the staple rice diet in Asia.

Kharkwal *et al.* (1986) reported that not only in respect of protein, pulses are also superior in containing amino acids, especially those are termed essential. Pulses effectively supplement cereal proteins since they are rich in lysine, which is not generally found in cereals.

Gomez and Gomez (1983) stated that mungbean was an ancient and widely distributed leguminous crop of central, southern, and eastern Asia. It was a short duration crop with low nutrient demand.

In another study, it observed that pulses or grain legumes occupy an important position in world agriculture by virtue of their high vegetable protein content. They are considered as poor man's meat since they are the cheapest source of protein for the under privileged people who cannot afford animal proteins. Pulses contain remarkably higher amount of protein than the cereal crops. It was also studied methionine and cystine are the limiting amino acids in pulses. Pulses are rich in vitamin A and D (Gowda and Kaul, 1982).

Khan *et al.* (1982) and Kaul (1982) carried out an experiment on mungbean and blackgram and found that among the pulses, mungbean was the one of the best in nutritional value with 51% carbohydrate, 26% protein, 4% mineral and 3% vitamins and blackgram is also contains 59% carbohydrate, 24% protein, 10% moisture, 4% mineral and 3% vitamins. It was an excellent source of digestible protein and well digestibility and flavor.

It had been reported that pulses play an important role to meet the protein demand of human dietary. It is a part and parcel, particularly for the poor people of Bangladesh. Pulses are considered as the poor men's meat as it is the cheapest source of protein (Mian, 1976).

2.3 Growing season

Rahman (1994) reported that in Bangladesh, mungbean grown in the rabi, kharif-I and kharif- II season. Only 5 % of the total mungbean were grown in kharif-I season (March/ April), whereas 30% in kharif- II season (Aug/Sept) and 65% were grown in late rabi (January/February).

Ardeshna *et al.* (1993) stated that mungbean and blackgram are important world food crops for providing an inexpensive source of vegetable protein. They are sub-tropical, kharif crops, well adapted to semi arid and sub-humid zones with annual rainfall between 600-1000 mm requiring an optimum mean temperature of 30^0c. It grows successfully on sandy loam to clay loam soil. Usually grown on low to medium elevations in the tropics as a rain-feed crop.

Sarker *et al.* (1980) reported that mungbean was usually cultivated during rabi season, but because of poor yield and marginal profit as compared to cereal crops, farmers prefer to grow wheat to mungbean during rabi season. During the last decades, the release of high yielding cultivers of cereals have made it's cultivation less remunerative. Recently some photo-insensitive kharif cultivers have been introduced which have already received attention to the farmers.

Sing and Sing (1979) and Lal and Yadav (1981) reported that in summer cultivation when temperature is high, relative humidity is low and evapo-transpiration is greater, then 3-4 irrigations might be needed to obtain higher yields of mungbean .

Lawn (1978) and Miah and Carangal (1981) while conducting an experiment on mungbean and blackgram reported that in Bangladesh kharif –I mungbean was a rain-fed crop which grows on residual soil moisture. Mungbean and blackgram responses favorably to added water resulting in higher yields, especially when irrigation was given at the time of flowering.

Williams *et al.* (1995) stated that among the environmental factors, excess rainfall at the time of reproductive period caused heavy loss of both seed yield and seed quality of mungbean.

BBS (1991) reported that mungbean had good digestibility, flavor, and high protein content. It was cultivated with minimum land preparation and without fertilizer application and insect, diseases, or weed control. All these factors were responsible for low yield of mungbean. Average yield of mungbean was 514 kg ha^{-1} in Bangladesh.

From the result of a study, Wahhab *and Bhandari* (1981) reported that the green plants could also be used as animal feed and its residues had manual value. Blackgram is potentially useful in improving cropping pattern. The yield of blackgram was very poor as compared to many other legume crops.

The yield of blackgram such an important crop however very low in comparison to many other leguminous crops. There are many factors influence in the yield formation of blackgram of which environmental variation is important one. Lawn (1978) observed a wide range of blackgram yield (400 to 2000 kg ha^{-1}) in different environmental conditions in Australia.

2.4 Yield and other crop characters

2.4.1 Growth parameter

Ghosh (2007) reported that plant height of mungbean was significantly influenced by variety. The tallest plant was obtained from BARI mung6 compared to the Sona mung at 15, 30 and 45 DAS. Plant height of BARI mung6 increased over Sona mung was 52.82%, 44.32% and 13.83% at 15, 30 and 45 DAS respectively. But at harvest 18.51% increased plant height of Sona mung was observed over BARI mung6.

Ratna (2007) stated that plant height of mungbean and blackgram were significantly influenced by different cop varieties at 15, 30 and 45 DAS, but it was in significant at harvest. In the initial stage of growth, the increase of plant height was very slow. And then the crop remind in vegetative stage. The rapid increase of plant height was observed from 15 to 45 DAS. After reaching the maximum vegetative stage, the growth of plant become very slow. From the result of another study, Thakuria and Shaharia (1990) who found similar plant height of mungbean varieties.

Aguliar and Villarea (1989) observed that plant height of mungbean was significantly influenced by variety. Pagasa had the highest plant height and it was significantly taller than that of M.79-9-82 and M.79-13-60. The varieties EG 2, ML 9-9-82 and M 79-13-60 each produce significantly heavier seeds than did pagasa and M 350.

2.4.2 Yield attributes

In an experiment under Bangladesh condition (Ghosh, 2007) with two varieties of mungbean reported the highest number of branches plant^{-1} was observed in Sona mung and the lowest number of branches plant^{-1} was observed in BARI mung6.

Islam (2003) reported that qualitative parameters of seeds are although genetically controlled yet season, technology and location of seeds in the plants also determine the seed quality. As blackgram is in terminate crop, pod originating from early flowering start seed formation earlier than pods of late flowering. Consequently, early and late set seeds located in different positions of blackgram encounter different environmental conditions during the pod development.

Including 32 accessions of mungbean, Farghali and Hossain (1995) concluded that the accessions V6017 and UTI had significant higher plant height, number of seeds pod^{-1}, pod length and number of pods plant^{-1} than that of other accessions.

Adams *et al.* (1989) found that better quality seeds located at the top position of soybean. But such information related to rate and duration of seed growth in different plant position of blackgram cultivars is almost lacking.

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

Islam (1983) who observed significant variation of branches number plant^{-1} in different studied varieties of mungbean and the highest number of branches plant^{-1} was in the variety Faridpur 1 followed by Mubarik, BM-7715 and BM-7704.On the other hand, the maximum seed yield and stover yield were produced by BARI mung6 followed by sona mung.

Hedly and Ambrose (1980) worked to understand the necessary of the rate and duration of seed filling as well as factors associated with the formation and development of blackgram seeds. Such understanding could help to overcome the constrains to seed growth and would aid higher seed yield and better quality of blackgram seeds.

Egli and Legget (1976) and Gupta (1992) described that the higher yield of blackgram might be only obtained by selecting an appropriate cultivar with better understanding of pattern of seed growth. Growth characteristics of seeds like rate and duration of seed filling were important for yield formation in grain legumes.

2.5 Micropyle position

Ghosh and Das (1997) reported that *Vigna mungo cv.* T9 seeds were placed in sand with the micropyle at different orientations. The position of the micropyle did not affect seed germination or shoot length of seedlings up to 10 days after sowing. However, when the micropyle was placed in the down ward position, root length and total seedling length were increased. It is suggested that sowing of *Vigna mungo* with the micropyle position with down ward would give the best early seedling growth.

Yadava (1991) reported that wrong placements of setts delays germination, when setts are planted horizontally by the side of the furrow bottom, the buds should be sidewards and not upward and not upward and underneath. Though the upper position of buds is slightly better than side position, the underneath placement of buds gives delayed and poor emergence of the lower buds. In vertical planting or upper bud position the upper buds germinate first and better, but the horizontal planting gives much vigorous sett-root development.

Panje *et al.*, (1963) demonstrated that top 7 or 8 buds on a horizontally placed setts germinated vigorously and formed fairly large shoots, the average fresh weight per shoot declined steeply thereafter up to the 14^{th} bud. From their below the average weight of shoots remained more or less at the same level up to the 21^{st} bud at the bottom of the stalk. As against this, the germination vigor of vertically placed sett was almost uniform. The top buds of the top portions were less vigorous than those of the corresponding horizontally placed setts. For normal planting therefore buds should be placed horizontally.

Sprouted seeds of bottle gourd, sweet gourd, cucumber, bitter gourd, ridge gourd, water melon, musk melon and bean can be sown in prepared basin at 4-5 cm depth giving micropyle position in downward direction and gave better results (Chakraborty, 1982).

Chapter 3
Materials and Methods

CHAPTER 3
MATERIALS AND METHODS

The details of methodology followed to find out the effect of two levels of crop and four micropyle positions of seed on growth and yield of mungbean and blackgram have been presented in this chapter.

3.1 Site description

3.1.1 Geographical location

The experimental area was situated at 23°77′ N latitude and 90°33′ E longitude at an altitude of 8.6 meter above the sea level (Anon., 2004).

3.1.2 Agro-Ecological Zone

The experimental field belongs to the Agro-ecological zone of "The Modhupur Tract", AEZ-28 (Anon.,1988a). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur tract leaving small hillocks of red soils as 'islands' surrounded by floodplain (Anon.,1988b). The experimental site was shown in the map of AEZ of Bangladesh in Appendix I.

3.1.3 Soil

The soil of experimental site belongs to the general soil type, Shallow Red Brown Terrace soils under Tejgaon series. Soil pH 7.1 and had organic matter 1.08%. The experimental area was flat having available irrigation and drainage system and above flood level. Soil samples from 0-15 cm depths were collected from experimental field. The analyses were done by Soil Resource and Development Institute (SRDI), Dhaka. The chemical properties of the soil are presented in Appendix-II.

3.2 Source of seed

The seeds of mungbean variety BARI mung6 and blackgram variety BARI mash1 were collected from Bangladesh Agricultural Research Institute, Joydebpur, Gazipur.

3.3 Treatments

Two sets of treatment were included in the experiment as follows:

A. Main Plot (Crop): 2

I. BARI mung6 - C_1

II. BARI mash1 - C_2

B. Sub Plot (Micropyle position): 4

I. Up-ward micropyle position - p_1

II. Down-ward micropyle position - P_2

III. Lateral micropyle position - P_3

IV. Haphazard micropyle position - P_4

The experiment comprised of 24 plots with 8 treatment combinations and 3 replications.

3.4 Experimental design and lay out

The experiment was conducted following split-plot design with 3 replications. The size of each plot was 3 m x 2 m. Block to block distance was 1 m and plot to plot distance was 0.5 m (Appendix III).

3.5 Land preparation

The land was first ploughed by a tractor drawn disc plough and subsequently cross ploughed four times with power tiller and ladder. The corners of the land were spaded. It was then harrowed to bring the soil in a good tilth condition. The final land preparation was done by disc harrow. The land was then thoroughly leveled by a ladder. Weeds and stubbles were removed from the field. All the clods were broken into small pieces. The unit plots were also prepared smoothly with spade before sowing.

3.6 Fertilizer dose

During final land preparation, fertilizer were applied at the rate of 21- 46 - 33 kg of N, P_2O_5 and K_2O hectare, respectively. The sources of N, P & K were Urea, TSP and MP respectively.

3.7 Method of fertilizer application

Whole amount of Urea, TSP and MP fertilizer's were applied as basal dose during final land preparation.

3.8 Sowing of seeds

The seeds were sown on 27 March, 2007 by hand. Mungbean and Blackgram seeds were sown in line maintaining line to line distance of 30 cm and plant to plant 5 cm. Seeds were sown in furrows and the micropyle position maintained as per treatments. The uniform depth of the furrows was maintained by using a measuring scale. In each furrow, the seeds were placed in solid line as per treatment and were then covered properly with soil.

3.9 Micropyle

A tiny hole which is present in the testa (it refers the outer covering of a seed) of a seed coat is called micropyle. When the seed is ready to germinate, water is taken in through the micropyle. The micropyle opening allows the pollen tube to enter the ovule for fertilization. In gymnosperms (e.g. conifers), the pollen itself is drawn into the ovule and the micropyle opening closes after pollination. During germination, the seedlings redicle emerges through the micropyle.

3.10 Thinning

The thinning was done 15 days after sowing maintaining plant to plant distance of 10 cm.

3.11 Intercultural operations

3.11.1 Weeding

The experimental crops were found to be infested with weeds of different kinds which were controlled manually by nirani. Weeding was done two times; 15 and 25 days after sowing (DAS).

3.11.2 Application of insecticides

The mungbean and blackgram plants were infested at seedling stage by cutworm and at vegetative stage by hairy caterpillars. They were controlled by spraying Nogos and Savin 85 SP respectively, as per recommendation. Irrigation was given as per necessity of the crop.

3.12 Harvesting

Mungbean pods were harvested on 25 May, 2007. Ten plants from each plot were selected at random before harvesting and were uprooted for data recording. The harvested pods were dried in sun for consecutive three days. Inner 4 lines of each plot were harvested for seed yield and stover yield.

3.13 Threshing

The pods were then threshed by a bamboo stick and seeds were separated from the plants.

3.14 Drying

The separated seeds were then dried in sun for consecutive three days.

3.15 Cleaning and weighing

The threshed and dried seeds were then cleaned by using a winnower.

3.16 General observations

The crop was frequently monitored to note any change in plant characters. The crop looked promising since the initial stage and it maintained a satisfactory growth till harvest.

3.17 Determination of maturity

At the time when 80% of the pods turned brown in color, the crop was assessed to attain maturity.

3.18 Recording of data

Different growth and yield data were recorded from the experiment.

A. Growth characters

i. Percentage of emergence
ii. Plant height at different growth stages (cm)
iii. Root and shoot ratio
iv. Root dry matter (g)
v. Shoot dry matter (g)
vi. Leaf dry matter (g)
vii. Pod dry matter (g)
viii. Total dry matter (g)
ix. Number of branches plant^{-1}

B. Yield and other crop characters

i. Number of pods plant^{-1}
ii. Pod length (cm)
iii. Number of seeds pod^{-1}
iv. Weight of 1000 seeds (g)
v. Seed yield (t ha^{-1})
vi. Stover yield (t ha^{-1})
vii. Shelling percentage
viii. Harvest index

3.19 Procedure of recording data

The detailed outline of data collection procedure is given below:

3.19.1 Seedling emergence

Emergence percentage and different growth attributes were monitored in field. As no seedlings were observed to emerge before 7^{th} days after sowing, the emergences were monitored from 7^{th} to 15^{th} DAS. The seedlings of which cotyledons emerged on the soil surface were considered as emerged. For the measurement of root, shoot, leaf and stem weight, 5 plants of each plot was uprooted carefully in each time and their respective weight were finally averaged.

3.19.2 Plant height (cm)

The height of pre-selected ten plants per plot were measured from the ground level to tip of the plants and then averaged. It was taken at 15, 30, 45 DAS and at harvest from selected plants.

3.19.3 Number of branches plant^{-1}

Total number of branches were counted from ten plants of each plot was counted and then averaged. It was taken at different DAS separately.

3.19.4 Dry weight plant^{-1}(g)

Ten plants were collected randomly from each plot at 30, 45 and 60 days after sowing. Those were then segmented into leaf, stem and root. At 45 and 60 days after sowing, inflorescences were also separated from the plants. Leaflets contained petioles with them.

The sampled plants were oven dried for 24 hours at 70^0 C and dry weight plant^{-1} was determined by using the formula:

$$\text{Dry weight plant}^{-1}\text{ (g)} = \frac{\text{Dry weight (g)}}{\text{Number of plants}}$$

The dry weight of each segment was measured individually. The total weight was calculated by summing up the weight of all the segments at all the growth stages.

3.19.5 Number of Pods plant^{-1}

The total numbers of pods of each selected 10 plants were counted and the mean value was calculated.

3.19.6 Number of Seeds pod^{-1}

Pods from each of ten plants were separated at harvest from which ten pods were selected randomly. The number of seeds pod^{-1} was counted and average number of seeds pod^{-1} was determined.

3.19.7 Weight of thousand seeds (g)

One thousand seeds were randomly taken from the harvest sample of each plot. The seeds were then sun dried for seven days and weighted with a sensitive electrical balance. The 1000 seed weight was recorded at 12% moisture level.

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

The pods from the central four lines were harvested plot wise as per experimental treatments and threshed. Seeds were cleaned and properly sun dried for seven days. Then seed yield plant^{-1} was recorded at 12% moisture level and converted into t ha^{-1}.

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

Stover yield was determined from the central 4 lines of each plot. After separation of seeds, the sub-samples were oven dried to a constant weight and finally converted to t ha^{-1} basis.

3.19.10 Shelling percentage

The pods of the sampled plants were taken. The seeds were separated from the pods. The chaff weight was also taken. The chaff weight was divided by the pod weight and the result was then multiplied by 100 as per following formula:

$$\text{Shelling percentage} = \frac{\text{Chaff dry weight (g)}}{\text{Pod dry weight (g)}} \times 100$$

3.19.11 Harvest index (%)

The harvest index was calculated by using the following the formula.

$$HI(\%) = \frac{\text{Grain yield (g plant}^{-1}\text{)}}{\text{Stover yield (g plant}^{-1}\text{)} + \text{grain yield (g plant}^{-1}\text{)}} \times 100$$

3.20 Statistical analysis

The collected data on different parameters were statistically analyzed using the IRRISTAT for windows software. Least Significant Difference (LSD) technique at 5% level of significance was used to compare the mean differences among the treatments (Gomez and Gomez, 1984).

Chapter 4
Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Seedling emergence

4.1.1 Effect of crops

The emergence of seedling was recorded from 4 DAS where mungbean seeds were germinated faster compared to blackgram. However, the trend of emergence for the two crops was similar (Figure 1). The seedling emerged rapidly up to 12 DAS and thereafter the emergence almost ceased.

The two crops showed significant variation in emergence of seedling. At 4 DAS mungbean showed significantly higher emergence percentage (65.85) compared to that of blackgram (4.73). The higher emergence percentage of mungbean was continued up to 7 DAS. But the variation was gradually reduced and at 8 DAS to onwards there was no statistically significant variation was found between the two crops.

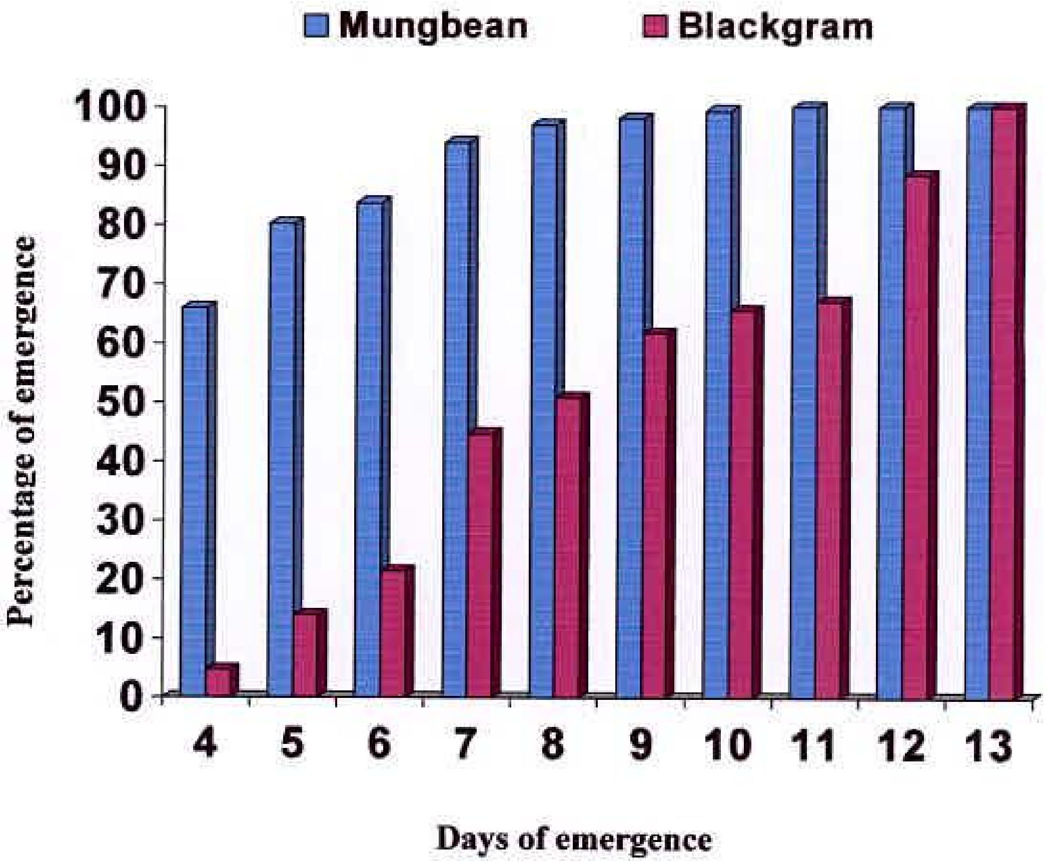
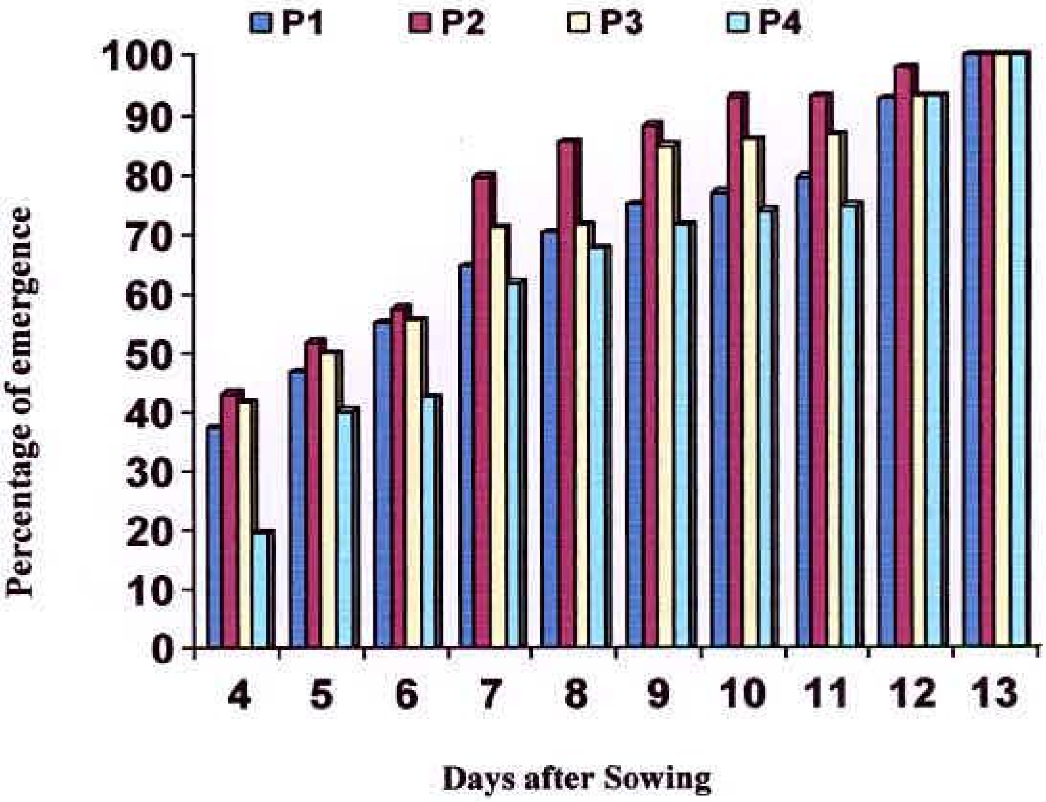


Fig. 1 Seedling emergence of mungbean and blackgram at different days after sowing ($LSD_{0.05}$ = 23.69, 45.45, 58.41, 69.01% at 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 DAS, respectively)

4.1.2 Effect of micropyle positions

Variation of micropyle positions significantly affect seedling emergence from very beginning (Figure 2).Unlike with micropyle position seedlings from two crops were found to start emerging from 4 DAS. At 4 DAS the higher percentage of emergence (43.03) was found in P_2 (downward micropyle position) that was statistically similar to P_1 i.e., upward micropyle position (41.49) and P_3 i.e., lateral micropyle position (37.23). But the lowest emergence percentage (19.40) was shown by P_4 (haphazard micropyle position). Almost similar trend of highest seed emergence was also recorded up to 8 DAS after sowing. But at 5 DAS, the percentage of lowest emergence was shown by P_1 and P_4. And at 6 DAS, the lowest emergence was found in P_4.

Thereafter at 7 and 8 DAS, the lowest percentage of emergence was shown by P_4 (61.73 and 67.68, respectively) that was statistically similar to P_1 (64.57 and 70.27, respectively) and P_3 (71.1 and 71.59, respectively). At 7 and 8 DAS, the highest percentage of emergence was shown by P_2 (79.57 and 85.42, respectively) that was statistically similar to P_1 (64.57 and 70.27, respectively) and P_3 (71.1 and 71.59, respectively). But at 9 DAS after sowing to onwards there was no significant variation of emergence observed among the variation of micropyle position (Figure 2).



P_1 = Upward micropyle position, P_2 = Downward micropyle position,

P_3 = Lateral micropyle position, P_4 = Haphazard micropyle position

Fig.2 Percentage of emergence as influenced by micropyle position ($LSD_{0.05}$ = 8.659, 7.289, 10.89, 15.559, 16.724 %, NS, NS, NS, NS and NS at 4 , 5 , 6 , 7 , 8 , 9, 10 , 11 , 12 and 13 days, respectively)

4.1.3 Interaction effect of crops and micropyle positions

The interaction of crops and micropyle positions had significant effect on emergence of seedling (Table 1).

At 4 DAS, the interaction of C_1P_2 showed the higher emergence percentage (81.95) that was statistically similar to C_1P_3 (77.59). The third highest emergence was observed in C_1P_1 (66.89). The next highest emergence was in C_1P_4 (36.95). Irrespective of micropyle position, blackgram showed significantly lowest emergence percentage for all the studied periods except at 13 DAS where all the treatments showed similar emergence percentage.

At 5 DAS, C_1P_2 showed the highest emergence of seedling (89.42) which was statistically similar to C_1P_3. The C_1P_3 (83.42) was similar to C_1P_1 (76.98). The next highest percentage of emergence was found in C_1P_4 (70.77) and C_2P_4 showed the lowest (9.26) emergence of seedling which was not significantly differ to C_2P_1, C_2P_2 and C_2P_3.

At 6 DAS, the percentage of highest emergence of seedling (91.58) was found in C_1P_2 that was statistically similar to C_1P_3 and C_1P_1. The second highest emergence of seedling (82.08) was showed in C_1P_1 which was statistically similar to C_1P_4 (72.75). The third highest emergence was in C_2P_1 (27.98) but statistically similar to C_2P_2 and C_2P_3. The C_2P_4 showed the lowest (12.04) emergence percentage of seedling which, however, was significantly similar to C_2P_2 and C_2P_3 interaction (Table 1).

At 7 DAS, C_1P_2 showed the highest emergence of seedling (97.81) which was not significantly differ to C_1P_3, C_1P_4 and C_1P_1 interaction. The next highest emergence was observed in C_2P_2 (61.33) which were statistically similar to C_2P_3 and C_2P_1 treatments. C_2P_4 showed the lowest (31.51) emergence of seedling that was similar to C_2P_1 treatments.

At 8 DAS, C_1P_2 showed the highest emergence of seeding (98.52) which was statistically similar to C_1P_3, C_1P_4 and C_1P_1 interactions. The C_2P_4 interaction showed the lowest (39.08) emergence percentage of seedling which was statistically similar to C_2P_1 and C_2P_3 interactions.

At 9 DAS, the highest emergence percentage of seedling was found in C_1P_3 (100.00) and C_1P_4 (100.00) that were statistically similar to C_1P_2 and C_1P_1 treatments. The second highest emergence was in (96.30) C_1P_2 which was not significantly differ to C_1P_1, C_2P_2 and C_2P_3 interaction. The seedling emergence percentage (79.91) of C_2P_2 was similar to C_2P_3 and C_2P_1 interaction. The C_2P_4 treatment occurred the lowest percentage of seedling emergence (42.88) than other treatments but similar to C_2P_1 and C_2P_3 interaction.

At 10 DAS, C_1P_2, C_1P_3 and C_1P_4 interaction showed the highest emergence of seedling (100.00) which was statistically similar to C_1P_1. The C_1P_1 (97.18) that was not significantly differ to C_2P_2 and C_2P_3 treatment. The lowest (47.88) emergence of seedling was found in C_2P_4 that was also similar to C_2P_1 and C_2P_3 interaction.

At 11 and 12 DAS, irrespective of micropyle position, the mungbean seeds showed the hundred percent emergences of seedling (100.00) and at 11 DAS and which was statistically similar to C_2P_2 and C_2P_3 interaction. At 12 DAS, it was similar to C_2P_2 treatment. The C_2P_4 showed the lowest (49.45) emergence of seedling, which was similar to C_2P_1 and C_2P_3 at 11 DAS. At 12 DAS, the lowest emergence of seedling was (85.64) found in C_2P_1 which was statistically similar to C_2P_4, C_2P_3 and C_2P_2. It was exception that all the stages, C_2P_4 shown the lowest emergence percentage but at 12 DAS, C_2P_1 showed the lowest seedling emergence though no significant variations were observed among blackgram seeds. But at 13 DAS, there was no significant variation of emergence observed for the variation of crop and micropyle position interaction.

Table 1 Interaction effect of crops and micropyle positions on the percent emergence of mungbean and blackgram at different days after sowing

Treatments	Percentage of emergence at different dates after sowing									
	4	5	6	7	8	9	10	11	12	13
Interaction (C X P)										
C_1P_1	66.89	76.98	82.08	89.26	95.07	95.59	97.18	100	100	100
C_1P_2	81.95	89.42	91.58	97.81	98.52	96.30	100	100	100	100
C_1P_3	77.59	83.42	88.24	96.51	97.48	100	100	100	100	100
C_1P_4	36.95	70.77	72.75	91.94	96.27	100	100	100	100	100
C_2P_1	7.58	16.67	27.98	39.88	45.47	54.36	56.58	58.80	85.64	100
C_2P_2	4.11	13.86	23.15	61.33	72.31	79.91	86.07	86.52	95.65	100
C_2P_3	5.38	16.13	22.45	45.696	45.70	69.52	71.48	73.44	86.27	100
C_2P_4	1.85	9.26	12.04	31.51	39.08	42.88	47.88	49.45	86.16	100
LSD $_{(0.05)}$	12.246	10.309	15.40	22.003	23.65	29.445	28.411	26.566	11.514	0.00
CV (%)	3.974	3.35	5.00	7.14	7.68	9.56	9.22	8.62	3.74	0.00

C_1 = BARI mung 6, C_2 = BARI mash 1, P_1 = Upward micropyle position, P_2 = Downward micropyle position, P_3 = Lateral micropyle position, P_4 = Haphazard micropyle position

4.2 Plant height

Results of plant height at different growth stages have been presented in Figure 3, Figure 4 and Table 2. Irrespective of treatment differences, plant height of mungbean and blackgram ranged from 8.23-16.90 cm, 28.03-46.27 cm, 47.53-57.64 cm, 58.90-70.47cm at 15, 30, 45 DAS and at harvest, respectively.

4.2.1. Effect of crops

The results revealed that at 15 DAS, the crop mungbean produced the taller plant (15.55 cm.) and the blackgram gave the shorter plant height (9.91 cm) and the same trend of plant height was also observed at 30 DAS. At 45 DAS, no significant variation of plant height was observed between the two crops, through numerically the taller plant height (66.36 cm) was found in mungbean and short plant height (66.21 cm) was found in blackgram. There was no significant difference in plant height due to different crop was observed at harvest. In the initial stage of growth, the increase of plant height was very slow and then the crop remained in vegetative stage. The rapid increase of plant height was observed from 15 to 45 DAS. After reaching the maximum vegetative stage, the growth of plant became very slow. Taller plant height of mungbean to blackgram was observed at 15, 30 and 45 DAS. But mungbean was at equal height at harvest compared to blackgram. These results were in agreement with the findings of Ratna and Ghosh, (2007) who found similar plant height of mungbean varieties.

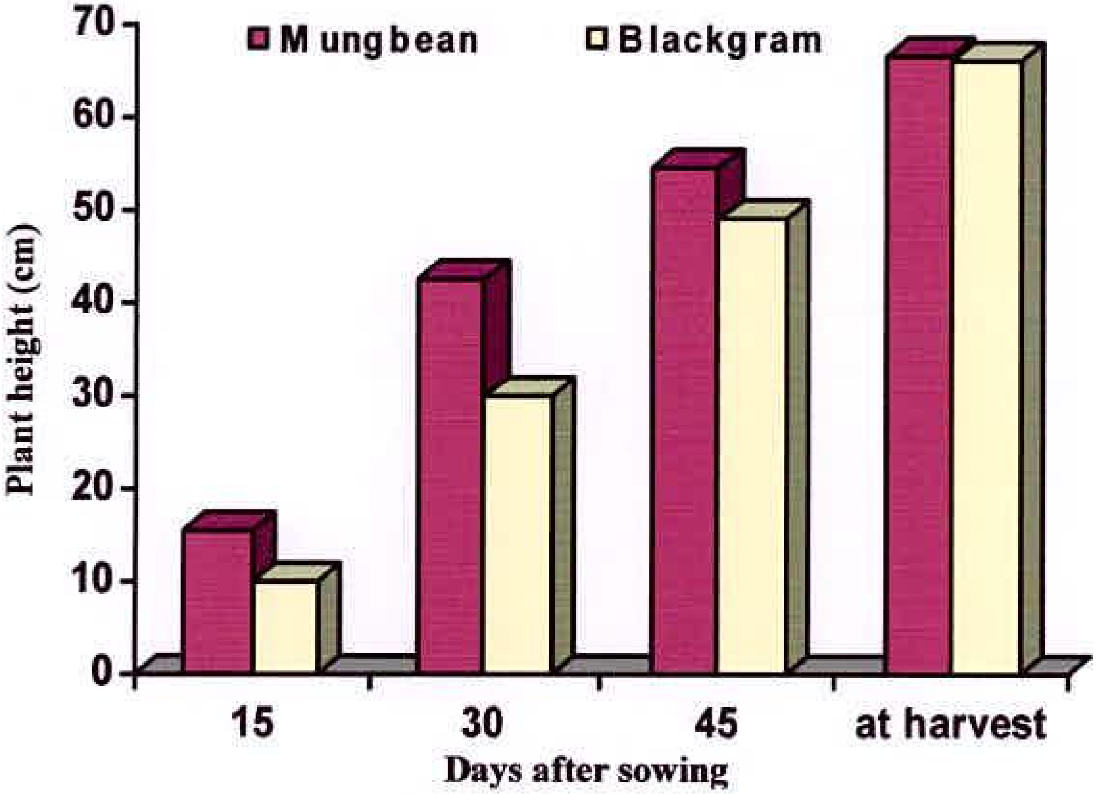
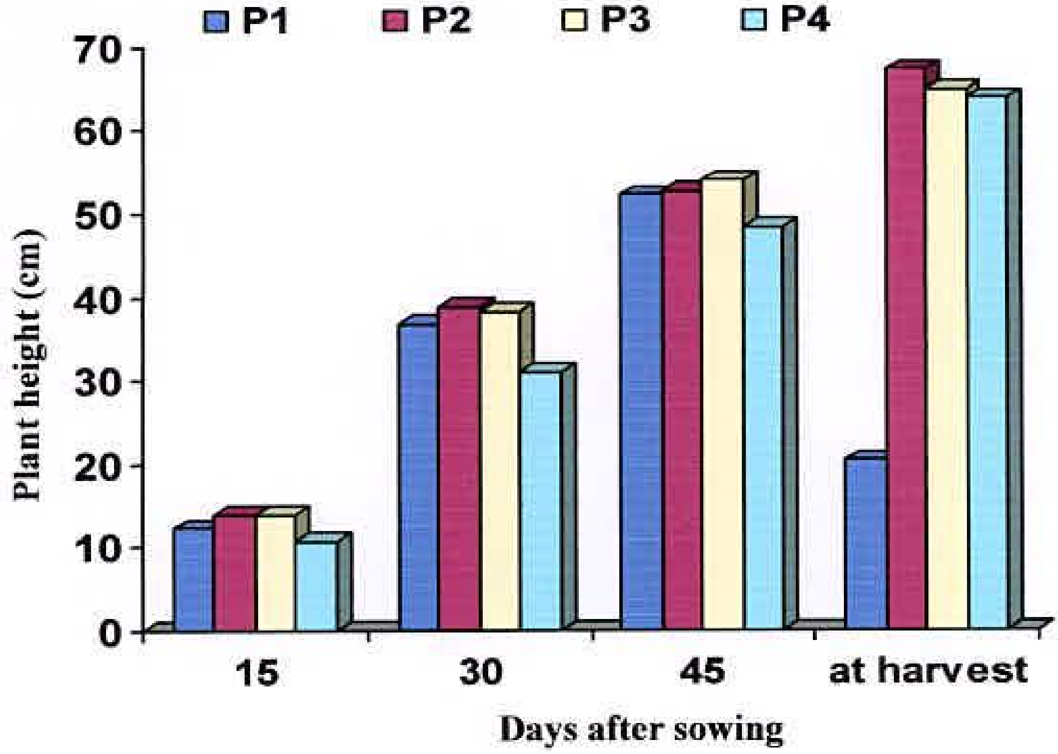


Fig. 3 Plant height of mungbean and blackgram at different growth durations ($LSD_{0.05}$ = 2.663, 9.579 cm, NS and NS at 15, 30, 45 and at harvest, respectively)

4.2.2 Effect of micropyle positions

At 15 DAS, the tallest plant height (13.99 cm) was obtained in downward micropyle position which was statistically similar to lateral (13.84 cm) and upward (12.34 cm) micropyle position. The shortest plant height (10.74) was obtained from haphazard micropyle position (Fig. 4). Thereafter, at 30 DAS to harvest, no significant variation of plant height observed among the micropyle positions through numerically the maximum plant height (69.37 cm) was found in upward micropyle position, at harvest. The same trend of plant height was shown at 30 DAS and 45 DAS. At harvest numerically the minimum plant height (63.72 cm) was found in haphazard micropyle position.



P_1 = Upward micropyle position, P_2 = Downward micropyle position, P_3 = Lateral micropyle position, P_4 = Haphazard micropyle position

Fig. 4 Plant height of mungbean and blackgram as influenced by micropyle position ($LSD_{0.05}$ = 2.582, NS, NS and NS at 15, 30, 45 and at harvest, respectively)

4.2.3 Interaction effect of crops and micropyle positions

Significant interaction effect between the crops and micropyle positions was observed at 15, 30 and 45 DAS.

At 15 DAS, C_1P_2 showed the highest plant height (16.90 cm). However there was no significant difference observed among the plant height of C_1P_3, C_1P_1 and C_1P_4. The second highest plant height was in C_1P_4 (13.25 cm) that was statistically similar to C_2P_3 and C_2P_2 treatments. The C_2P_4 showed the lowest plant height (8.23 cm) which, however, was not statistically differ to that of C_2P_1, C_2P_2 and C_2P_3.

At 30 DAS, C_1P_2 showed the highest plant height (46.27 cm). There was no significant difference of height observed among the plants of C_1P_2 with those of C_1P_3 and C_1P_1. The C_2P_1 showed the lowest plant height (28.03 cm) which was statistically similar to C_2P_4, C_2P_2, C_2P_3 and C_1P_4 interactions.

At 45 DAS, C_1P_2 showed the highest plant height (57.64 cm). That was statistically similar to C_1P_3, C_1P_1, C_2P_3 and C_2P_1 interaction treatments. The upward and lateral micropyle position was shown same result between mungbean and blackgram treatments at 45 DAS. The C_2P_2 showed the lowest plant height (47.53 cm) which however was statistically similar to C_1P_4 (47.94 cm). The other interaction treatments did not show any significant difference among themselves.

At harvest, there was no significant variation of plant height observed among the variation of crops and micropyle positions. But numerically the maximum plant height was found in C_1P_2 (70.47 cm) and the minimum one was at C_1P_4 (58.9 cm).

Table 2 Interaction effect of crops and micropyle positions on plant height of mungbean and blackgram at different growth stages

Treatments	Plant height (cm) at different days after sowing			
	15	30	45	At harvest
C_1P_1	15.78	45.02	55.64	68.97
C_1P_2	16.90	46.27	57.64	70.47
C_1P_3	16.27	45.15	56.00	67.10
C_1P_4	13.25	32.77	47.94	58.90
C_2P_1	8.89	28.03	48.73	69.77
C_2P_2	11.08	31.16	47.53	63.95
C_2P_3	11.42	31.17	51.92	62.60
C_2P_4	8.23	29.03	48.65	68.53
$LSD_{(0.05)}$	3.651	11.251	9.545	NS
CV (%)	1.185	3.651	3.098	3.990

C_1 = BARI mung 6, C_2 = BARI mash 1, P_1 = Upward micropyle position, P_2 = Downward micropyle position, P_3 = Lateral micropyle position, P_4 = Haphazard micropyle position

4.3 Root and shoot ratio

Results of root and shoot ratio at different growth stages have been presented in Figure 5, Figure 6 and Table 3. Irrespective of treatment differences, root and shoot ratio of mungbean and blackgram ranged from 3.35-4.95, 4.08-7.06, 3.51-6.12, at 30 and 45 DAS and at harvest, respectively. The root and shoot ratio of mungbean and blackgram were significantly differed at 30, 45 DAS and at harvest.

4.3.1 Effect of crops

At 30 DAS, mungbean produced the highest ratio (4.54) than the blackgram ratio (3.66) and the same trend of root and shoot ratio was observed up to harvest. The maximum root and shoot ratio of mungbean (6.59) was revealed at 45 DAS compared to blackgram (4.76). At harvest the highest root and shoot ratio (5.15) was found in mungbean crop compared to the blackgram which produced the lowest root and shoot ratio (3.96).

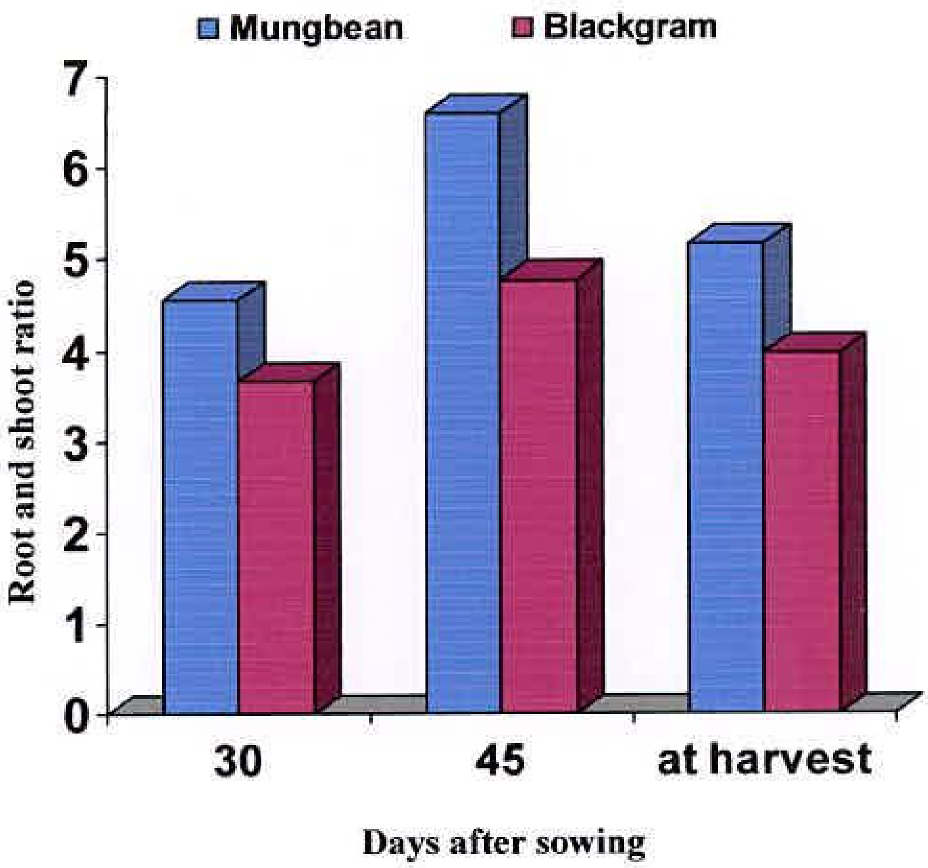
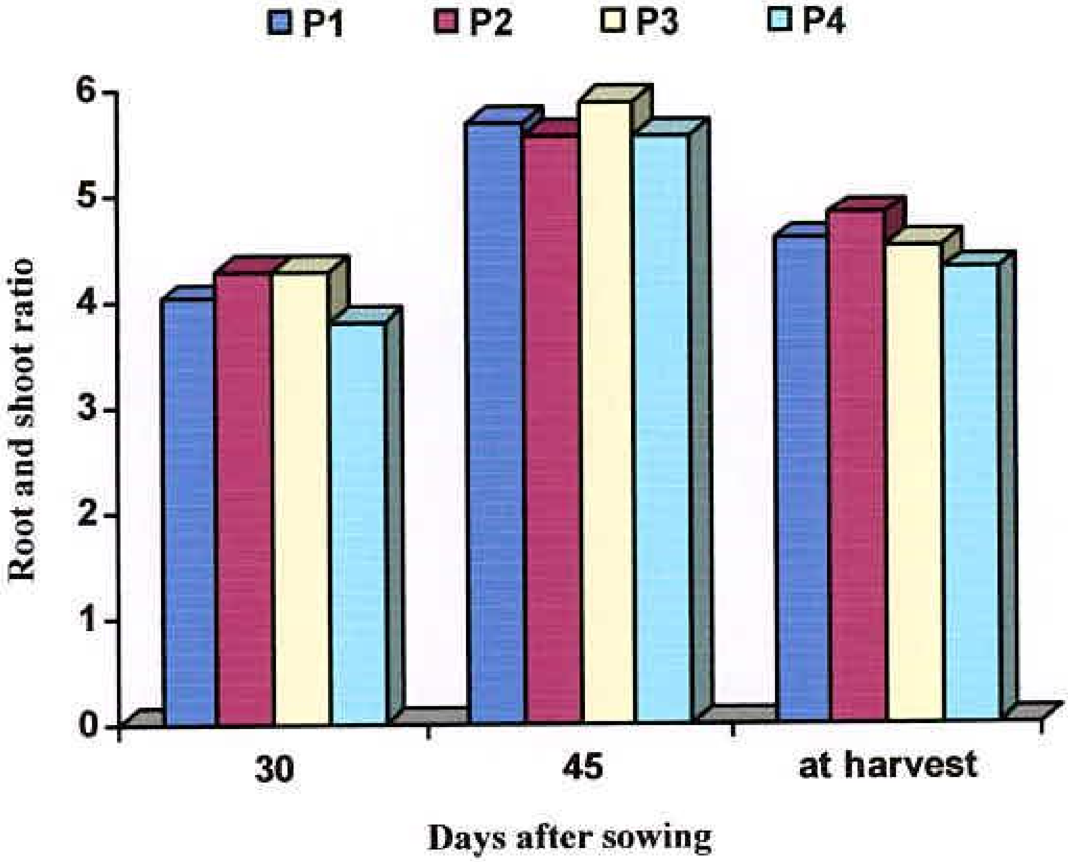


Fig. 5 Root and shoot ratio of mungbean and blackgram at different growth durations ($LSD_{0.05}$ = 0.648, 0.366 and 1.066 at 30, 45 DAS and at harvest, respectively)

4.3.2 Effect of micropyle positions

At 30 DAS, the variation of micropyle positions had significant effect on seedling root and shoot ratio. The highest seedling root and shoot ratio (4.29) was obtained from P_2 which was statistically similar to P_3 and P_1. The lowest seedling root and shoot ratio (3.81) was obtained from P_4 which was significantly lower than P_1 and P_3. After that at 45 DAS and at harvest there was no significant difference of root and shoot ratio observed among the variation of micropyle positions though numerically the maximum root and shoot ratio was shown at 45 DAS.



P_1 = Upward micropyle position, P_2 = Downward micropyle position,

P_3 = Lateral micropyle position, P_4 = Haphazard micropyle position

Fig. 6 Root and shoot ratio of mungbean and blackgram seedlings as influenced by micropyle position ($LSD_{0.05}$ = 0.470 , NS and NS at 30, 45 and at harvest respectively)

4.3.3 Interaction effect of crops and micropyle positions

Significant interaction effect between the crops and micropyle positions were observed at all the growth stages on root and shoot ratio (Table 3).

At 30 DAS, the highest root and shoot ratio was obtained from the mungbean with lateral micropyle position (4.95) which was statistically similar to the interaction of mungbean with downward and upward micropyle position. The next highest root and shoot ratio was in C_1P_1 (4.69) interaction which was similar to C_2P_4 . There was no significant variation of root and shoot ratio was observed among C_2P_4, C_2P_2, C_2P_3 and C_1P_4 interactions. The lowest seedling root and shoot ratio was found in C_2P_1 (3.35) and the interaction of C_2P_3, C_2P_2 and C_2P_4 was shown statistically similar root and shoot ratio.

At 45 DAS, the highest root and shoot ratio was obtained from the mungbean with downward micropyle position (7.06) which was statistically similar to the C_1P_1, C_1P_3 and C_1P_4 interactions. The second highest root and shoot ratio was in C_1P_3 (6.53) that was significantly similar to the C_1P_4 and C_2P_3. The next highest root and shoot ratio was in C_1P_4 (5.96) which was similar to C_2P_3 and C_2P_4. But the lowest root and shoot ratio was in C_2P_2 (4.08) compared to the C_2P_1, C_2P_4 and C_2P_3 treatments though no significant variations was observed among themselves. At harvest, C_1P_2 showed the highest root and shoot ratio (6.12) which was statistically similar to C_1P_1. The second highest root and shoot ratio was found in C_1P_1 (5.26) that was similar to the C_1P_3, C_1P_4, C_2P_3 and C_2P_4. The lowest value of root and shoot ratio was found in C_2P_2 (3.51) that was statistically similar to the C_2P_1, C_2P_4, C_2P_3, C_1P_4 and C_1P_3.

Table 3 Interaction effect of crops and micropyle positions on root and shoot ratio at different growth stages

Treatments	Root and shoot ratio at different days after sowing		
	30	45	At harvest
C_1P_1	4.69	6.82	5.26
C_1P_2	4.94	7.06	6.12
C_1P_3	4.95	6.53	4.72
C_1P_4	3.58	5.96	4.51
C_2P_1	3.35	4.57	3.92
C_2P_2	3.63	4.08	3.51
C_2P_3	3.62	5.27	4.31
C_2P_4	4.04	5.19	4.00
LSD (0.05)	0.665	1.318	1.202
CV (%)	0.216	0.428	0.390

C_1 = BARI mung 6, C_2 = BARI mash 1, P_1 = Upward micropyle position,
P_2 = Downward micropyle position, P_3 = Lateral micropyle position,
P_4 = Haphazard micropyle position

4.4 Root dry weight

Results of root dry weight of mungbean and blackgram have been presented in Figure 7, Figure 8 and Table 4. The dry weight of root increased gradually from 30 DAS to harvest. Irrespective of treatment differences, root dry weight of mungbean and blackgram ranged from 0.20-0.40, 0.35-0.52 and 1.02-2.15g plant^{-1} at 30, 45 DAS and at harvest, respectively.

4.4.1 Effect of crops

At all the growth stages, root dry weight was numerically higher in mungbean crop seedlings compared to the blackgram crop. The maximum dry weight was obtained with mungbean (0.30g) and minimum from blackgram seedling (0.26 g) at 30 DAS. There was no significant differences were observed between mungbean and blackgram crop for root dry weight at all the growth stages studied.

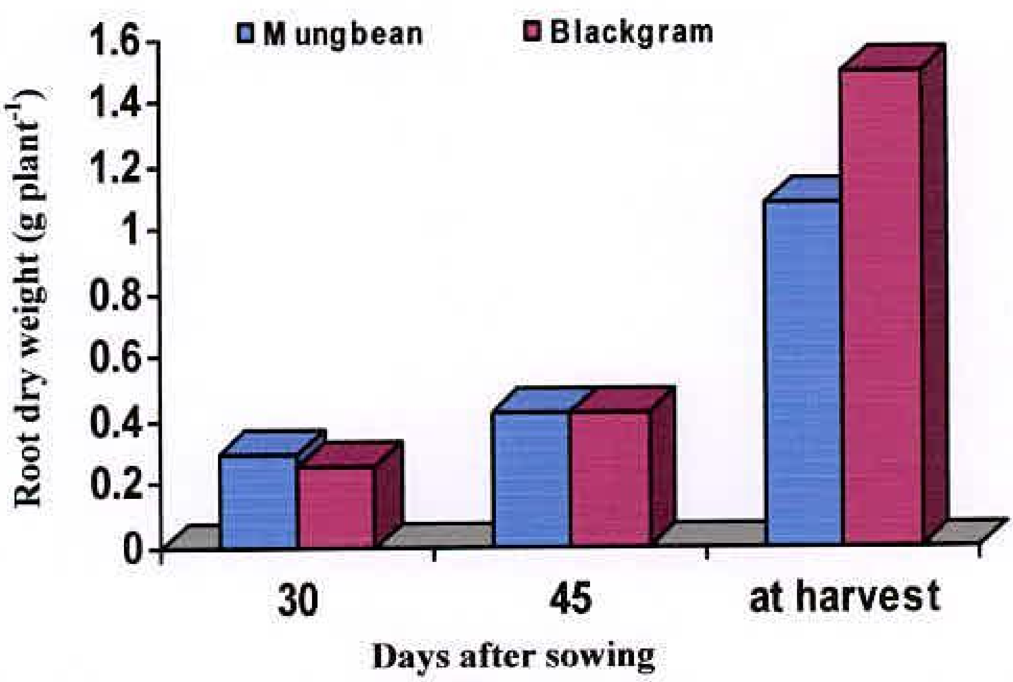
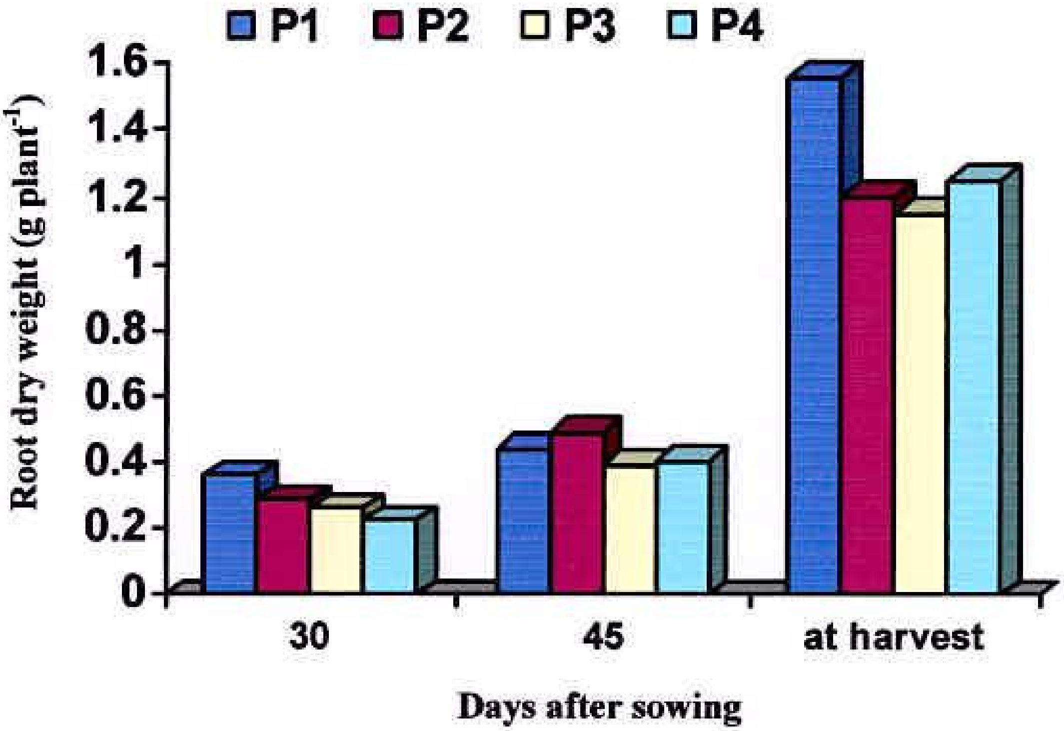


Fig. 7 Root dry weight of mungbean and blackgram seedlings at different growth durations

4.4.2 Effect of micropyle positions

The micropyle position had significant effect on dry weight of root at 30 DAS and at harvest except 45 DAS. When there was no significant differences observed among the variation of micropyle positions.

At 30 DAS, and at harvest, significantly the highest dry weight of root was shown by P_1 (0.36 g plant^{-1}and 1.56 g plant^{-1}) respectively that was statistically similar to P_2, P_3 and P_4, P_2 respectively. The P_4 showed the minimum (0.22 g plant^{-1}) dry weight that was statistically similar as P_3 and P_2 at harvest, the lowest dry weight was found in P_3 (1.15 g plant^{-1}) which was statistically similar to P_2 and P_4 .



P_1 = Upward micropyle position, P_2 = Downward micropyle position,

P_3 = Lateral micropyle position, P_4 = Haphazard micropyle position

Fig. 8 Root dry weight of mungbean and blackgram seedlings as influenced by micropyle position at different growth durations ($LSD_{0.05}$ = 0.119, NS and 0.398 at 30, 45 DAS and at harvest respectively)

4.4.3 Interaction effect of crops and micropyle positions

The interaction of crops and micropyle positions had significant effect on dry weight of root at all the studied period except at 45 DAS (Table 4). At 45DAS, there was no significant difference among all the treatment of interaction and C_1P_1 showed numerically the highest dry weight (0.48 g plant^{-1}) and the lowest dry weight (0.35 g plant^{-1}) in C_1P_4 and C_2P_3.

At 30 DAS, C_1P_1 showed the highest dry weight (0.4 g $plant^{-1}$) and the lowest dry weight was in C_2P_4 (0.2 g $plant^{-1}$). All other interaction treatments showed root dry weight values which were in between the both of the highest and lowest values.

At 45 DAS, there was no significant difference observed among the treatments and C_1P_1 showed numerically the maximum dry weight (0.48 g $plant^{-1}$) and the minimum dry weight (0.35 g $plant^{-1}$) in C_1P_4 and C_2P_3.

At harvest, C_2P_1 showed the highest root dry weight (2.15 g $plant^{-1}$). The C_1P_1 showed the lowest root dry weight (0.97 g $plant^{-1}$) which, however, was statistically similar but lower than that most of the other interaction treatments.

Table 4 Interaction effect of crops and micropyle positions on root dry weight of mungbean and blackgram at different growth stages

	Root dry weight (g $plant^{-1}$) at different days after sowing		
Treatments	**30**	**45**	**At harvest**
C_1P_1	0.40	0.48	0.97
C_1P_2	0.32	0.46	1.27
C_1P_3	0.26	0.44	1.02
C_1P_4	0.23	0.35	1.05
C_2P_1	0.32	0.40	2.15
C_2P_2	0.25	0.52	1.14
C_2P_3	0.26	0.35	1.28
C_2P_4	0.20	0.46	1.44
LSD (0.05)	0.169	0.331	0.563
CV (%)	0.055	0.108	0.183

C_1 = BARI mung 6, C_2 = BARI mash 1, P_1 = Upward micropyle position, P_2 = Downward micropyle position, P_3 = Lateral micropyle position, P_4 = Haphazard micropyle position

4.5 Shoot dry weight

Results of dry weight of shoot of mungbean and blackgram were presented in Figure 9, Figure 10 and Table 5. Irrespective of treatment differences, shoot dry matter partitioning of mungbean and blackgram ranged from 0.22-0.9, 0.50-1.84, and 3.88-9.95 g plant^{-1} at 30 and 45 DAS and at harvest, respectively. The dry weight of shoot increased gradually up to the harvest.

4.5.1 Effect of crops

The crop had a significant effect on dry weight of shoot (Figure 9). At 30 and 45 DAS, numerically the higher shoot dry weight was obtained in mungbean compared to blackgram. Thereafter at harvest blackgram showed the highest dry weight of shoot. Significantly higher dry weight was obtained from mungbean seedling (1.53 g plant^{-1}) and lower dry weight from blackgram (0.68 g plant^{-1}) at 45 DAS. At 30 DAS and at harvest there was no a significant difference or shoot dry weight observed between mungbean and blackgram seedlings.

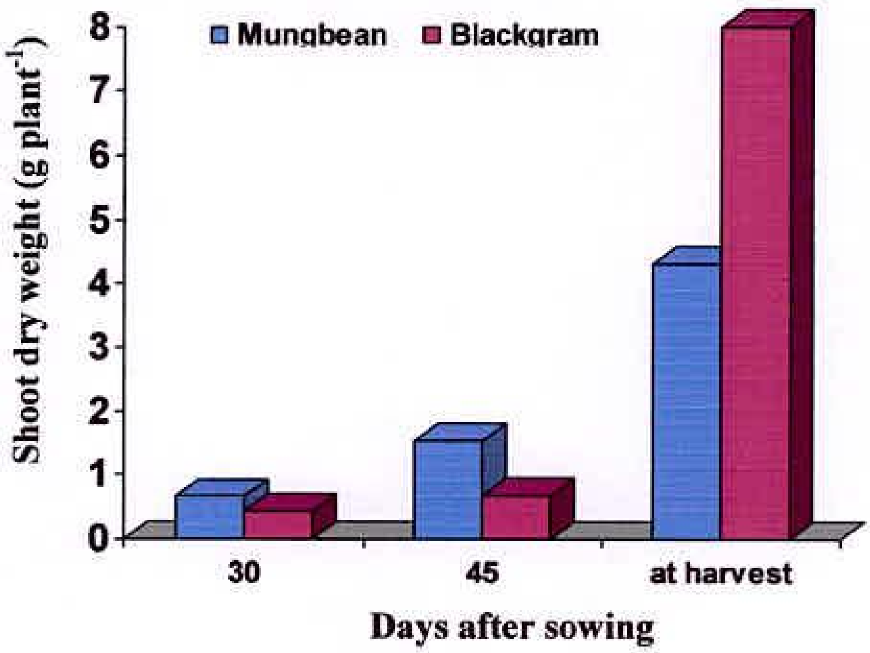
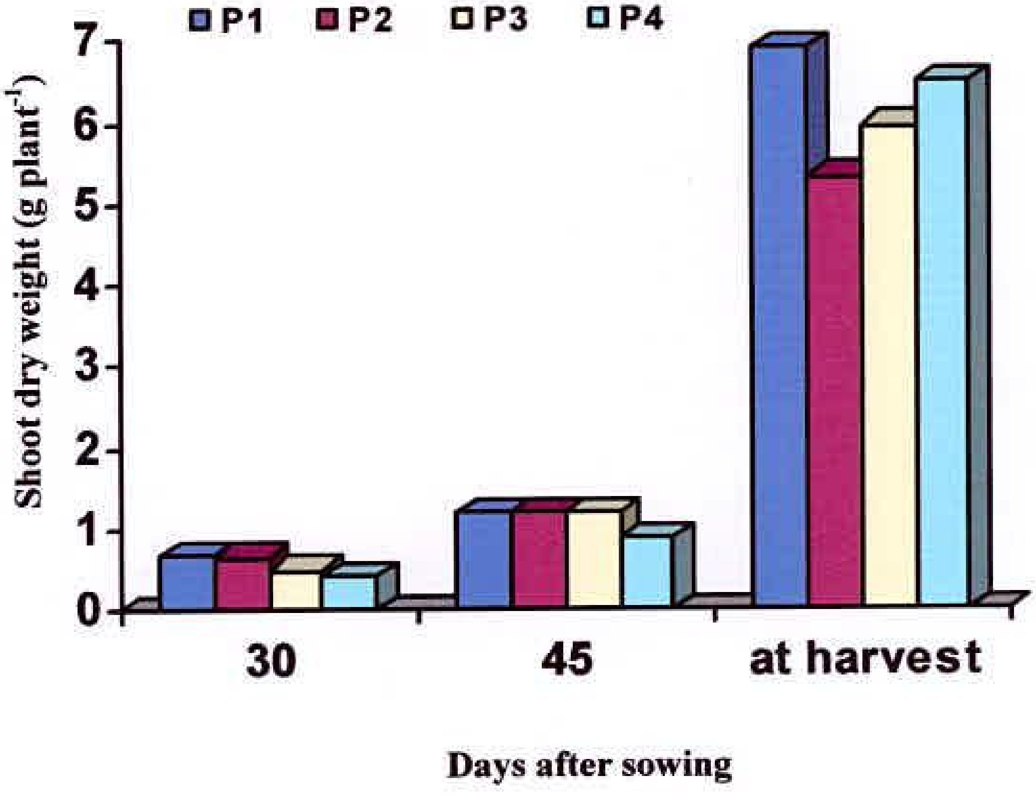


Fig. 9 Shoot dry weight of mungbean and blackgram seedlings at different growth durations ($LSD_{0.05}$ = NS, 0.172 and NS at 30, 45 DAS and at harvest, respectively)

4.5.2 Effect of micropyle positions

The micropyle position had no significant effect on dry weight of shoot (Figure 10). At 30 DAS and at harvest, the numerically maximum dry weight observed in upward micropyle position and the minimum shoot dry weight was found when the seeds were sown in haphazard position at 30 and 45 DAS and in downward micropyle position at harvest.



P_1 = Upward micropyle position, P_2 = Downward micropyle position,
P_3 = Lateral micropyle position, P_4 = Haphazard micropyle position

Fig. 10 Shoot dry weight of mungbean and blackgram seedling as influenced by micropyle position.

4.5.3 Interaction effect of crops and micropyle positions

The interaction treatment had significant effect on shoot dry weight at all the growth stages.

At 30 DAS, C_1P_1 showed the highest shoot dry weight (0.90 g plant^{-1}). However there was no significant difference observed among the dry weight of C_1P_2, C_2P_3, C_1P_4 and C_2P_2. The C_2P_4 showed the lowest shoot dry weight (0.22 g plant^{-1}) which, however, was statistically similar but lower than that of all other interaction treatments except C_1P_1 and C_1P_2. Most of the other interaction treatments did not show significant difference among them.

At 45 DAS, C_1P_1 showed the highest shoot dry weight (1.84 g plant^{-1}). However, there was no significant difference observed among the interaction of C_1P_2 and C_1P_3. The second highest dry weight was found in C_1P_2 (1.68 g plant^{-1}) and it was statistically similar to C_1P_3 and C_1P_4. The third highest weight was C_1P_3 (1.47 g plant^{-1}) and it was similar to C_1P_4 and C_2P_3. The lowest shoot dry weight was C_2P_1 (0.50 g plant^{-1}) which was statistically similar to all blackgram interactions and the mungbean interactions with haphazard micropyle position.

At harvest, C_2P_1 showed the highest dry weight of shoot (9.95 g plant^{-1}) that was similar to C_2P_4. The C_1P_1 showed the lowest shoot dry weight that was statistically similar to all other mungbean interactions and downward micropyle position with blackgram treatment.

Table 5 Interaction effect of crops and micropyle positions on shoot dry matter of mungbean and blackgram at different growth stages

	Shoot dry weight (g plant^{-1}) at different growth duration		
Treatments	30	45	At harvest
C_1P_1	0.90	1.84	3.88
C_1P_2	0.80	1.68	4.83
C_1P_3	0.39	1.47	4.50
C_1P_4	0.55	1.11	4.06
C_2P_1	0.46	0.50	9.95
C_2P_2	0.48	0.68	5.80
C_2P_3	0.60	0.86	7.39
C_2P_4	0.22	0.67	8.87
LSD (0.05)	0.428	0.665	2.403
CV (%)	0.139	0.216	0.7798

C_1 = BARI mung 6, C_2 = BARI mash 1, P_1 = Upward micropyle position, P_2 = Downward micropyle position, P_3 = Lateral micropyle position, P_4 = Haphazard micropyle position

4.6 Leaf dry weight

Results of dry weight of leaf have been presented in Figure 11, Figure 12 and Table 6. Irrespective of treatment differences, leaf dry matter of mungbean and blackgram ranged from 0.91-2.14, 1.89-3.11 and 4.50-16.92 g plant^{-1} at 30 and 45 DAS and at harvest, respectively.

4.6.1 Effect of crops

The crop had no significant effect on dry weight of leaf (Figure 11). At harvest, numerically the maximum dry weight of leaf was shown by blackgram compared to the mungbean.

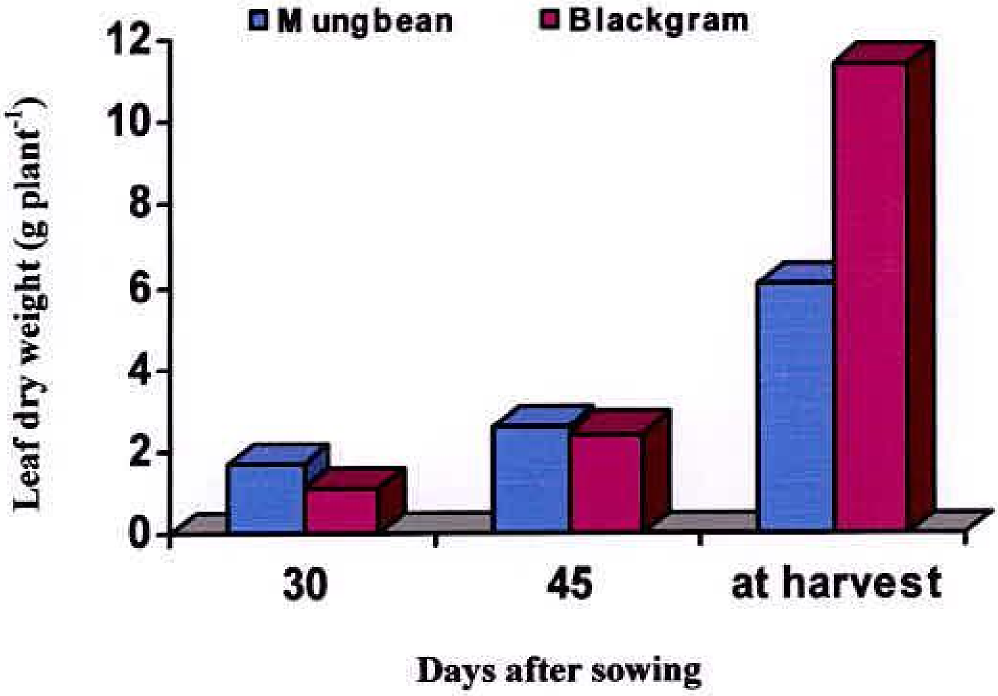
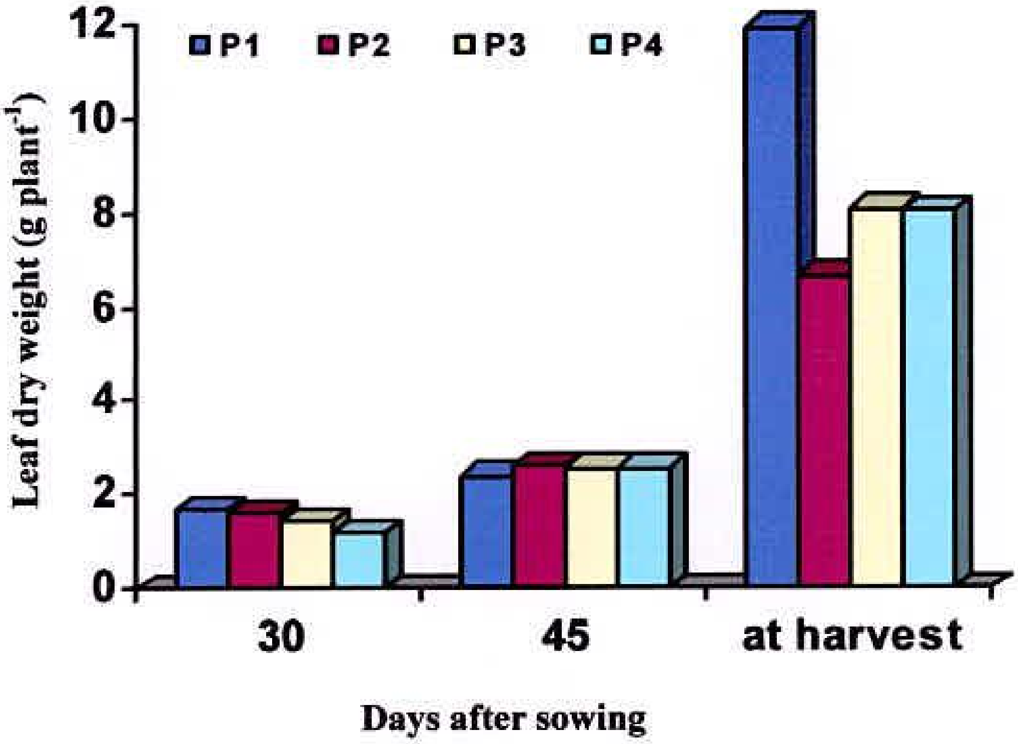


Fig. 11 Leaf dry weight of mungbean and blackgram seedlings at different growth durations

4.6.2 Effect of micropyle positions

The micropyle position had no significant difference on leaf dry weight at 30 and 45 DAS except at harvest.

At harvest, upward micropyle position showed the highest (11.98 gm) leaf dry weight which was statistically similar to lateral micropyle position. The lowest dry weight of leaf (6.67 gm) was in downward micropyle positions which were lower than other different treatments.



P_1 = Upward micropyle position, P_2 = Downward micropyle position,

P_3 = Lateral micropyle position, P_4 = Haphazard micropyle position

Fig. 12 Leaf dry matter partitioning of mungbean and blackgram seedling as influenced by micropyle position ($LSD_{0.05}$ = NS , NS and 3.907 at 30, 45 DAS and at harvest respectively).

4.6.3 Interaction effect of crops and micropyle positions

The interaction had significant effect on dry weight of leaf (Table 6) for all the studied durations.

At 30 DAS, C_1P_1 showed the highest dry weight (2.14 gm), however, there was no significant difference observed among the dry weight of C_1P_2, C_1P_3, C_1P_4 and C_2P_3. The C_2P_4 showed the lowest dry weight (0.91 g plant^{-1}) which, however, was not significantly different but lower than that of C_1P_3, C_1P_4 and all the blackgram interactions. Most of the other interaction treatments showed leaf dry weight values which were in between the values of the highest and lowest and did not show any significant difference among themselves.

At 45 DAS, numerically C_1P_2 showed the highest leaf dry weight (3.11 g plant^{-1}) though there was no significant difference of leaf dry weight observed for the variation of micropyle position between two crops.

At harvest, C_2P_1 showed the highest leaf dry weight (16.92 g plant^{-1}) which was statistically similar to C_2P_3. The C_1P_3 showed the lowest dry weight (4.5 g plant^{-1}) of leaf which was statistically lowers than that of other treatments.

Table 6 Interaction effect of crops and micropyle positions on leaf dry weight of mungbean and blackgram at different growth stages

Treatments	Leaf dry weight (g plant^{-1}) at different growth duration		
	30	45	At harvest
C_1P_1	2.14	2.89	7.04
C_1P_2	1.92	3.11	7.28
C_1P_3	1.43	2.35	4.50
C_1P_4	1.41	1.99	5.21
C_2P_1	1.18	1.89	16.92
C_2P_2	1.21	2.14	6.05
C_2P_3	1.36	2.72	11.69
C_2P_4	0.91	3.09	10.86
LSD (0.05)	0.86	NS	5.526
CV (%)	0.28	0.62	1.79

C_1 = BARI mung 6, C_2 = BARI mash 1, P_1 = Upward micropyle position, P_2 = Downward micropyle position, P_3 = Lateral micropyle position, P_4 = Haphazard micropyle position

4.7 Pod dry weight

Results of dry matter weight of pod have been presented in Figur.13, Figure 14 and Table 7. Irrespective of treatment differences, pod dry matter of mungbean and blackgram ranged from 0.23-1.10 and 11.91-19.27 g plant^{-1} at 45 DAS and at harvest, respectively. The dry weight of pod increased gradually from 45 DAS to harvest.

4.7.1 Effect of crops

Irrespective of treatment differences, dry weight of pod of mungbean showed higher value (0.81 g plant^{-1}) compared to blackgram (0.29 g plant^{-1}) at 45 DAS and thereafter blackgram showed maximum (17.13 g plant^{-1}) pod dry weight compared to mungbean.

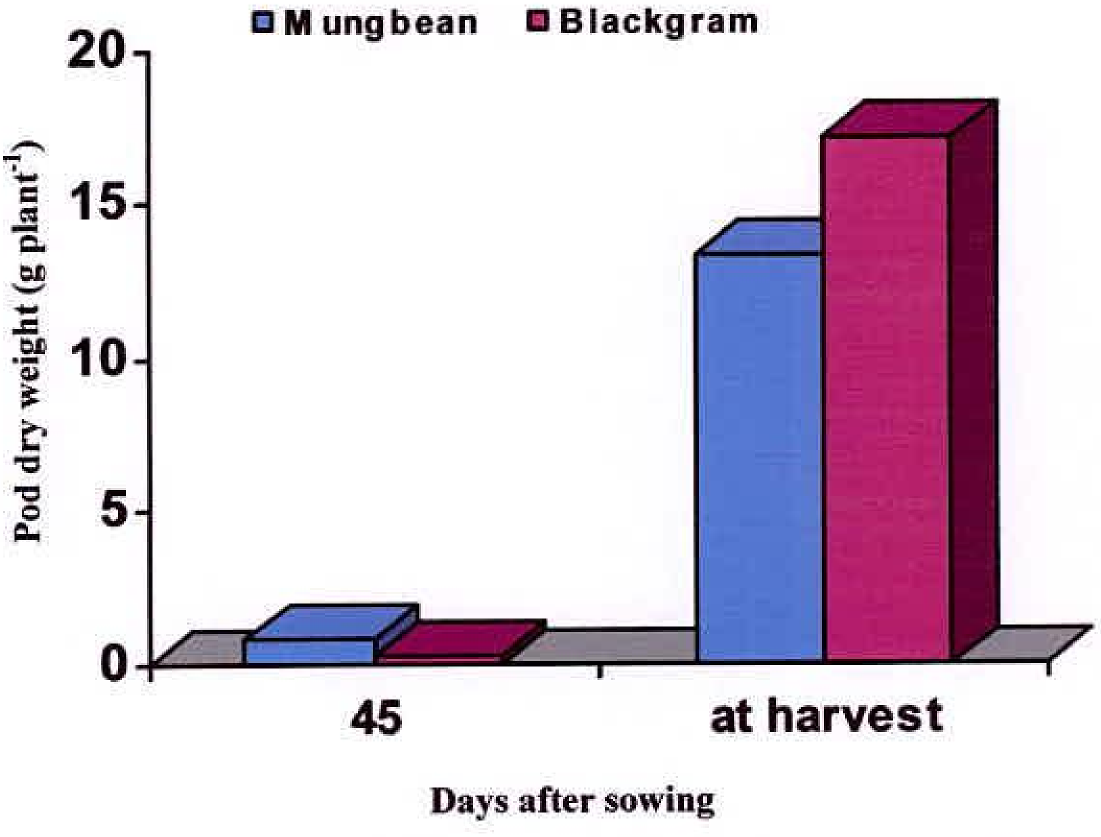
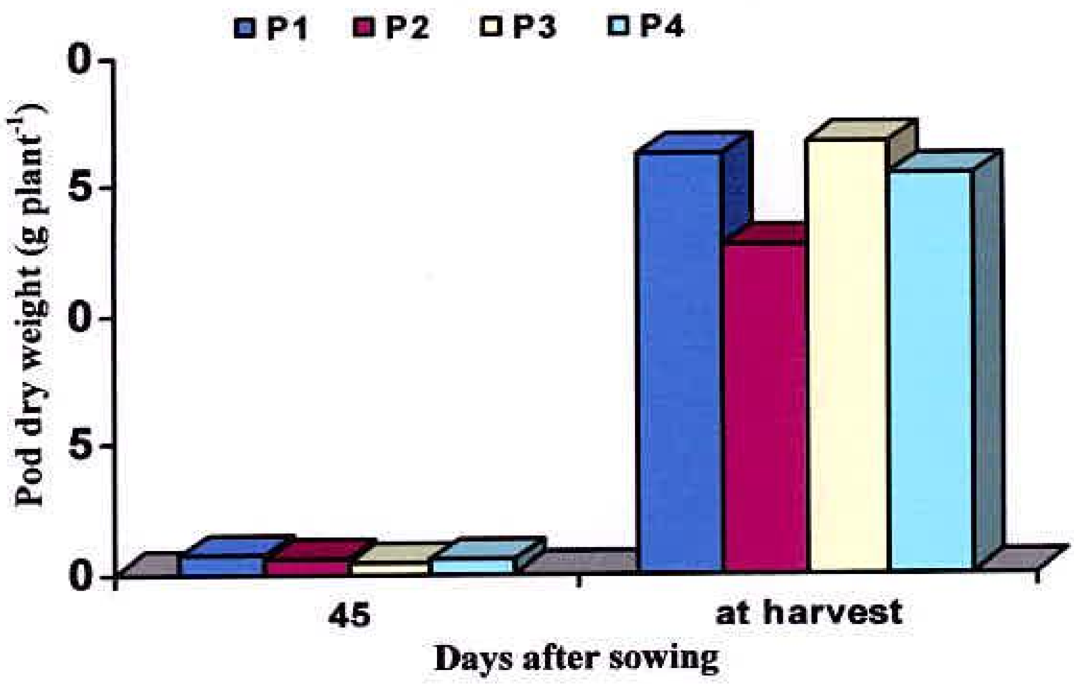


Fig. 13 Pod dry weight of mungbean and blackgram seedlings at different growth durations ($LSD_{0.05}$ = 0.335 and NS at 45 DAS and at harvest, respectively)

4.7.2 Effect of micropyle positions

The micropyle position had significant effect on the pod dry weight (Figure 14) at 45 DAS where the highest dry weight (0.66 g plant^{-1}) was obtained from P_1 seeds that was similar to P_2 and P_4 and the lowest dry weight (0.41 g plant^{-1}) was obtained from the P_3 which was statistically similar to P_2 and P_4. At harvest there was no significant difference observed among the variation of micropyle position.



P_1 = Upward micropyle position, P_2 = Downward micropyle position,

P_3 = Lateral micropyle position, P_4 = Haphazard micropyle position

Fig. 14 Pod dry weight of mungbean and blackgram seedling as influenced by micropyle position at different growth durations ($LSD_{0.05}$ = 0.20, NS at 45 DAS and at harvest, respectively)

4.7.3 Interaction effect of crops and micropyle positions

The interaction had no significant effect on dry weight of pod at harvest (Table 7).At 45 DAS, C_1P_1 showed the highest dry weight (1.10 g plant^{-1}) of pod which was statistically similar to C_1P_4 (0.84 g plant^{-1}) that was similar to C_1P_2 and C_1P_3. The third highest dry weight of pod (0.57 g $plant^{-1}$) was in C_1P_3. The C_2P_1 showed the lowest dry weight (0.23 g $plant^{-1}$) of pod which was lower than that of other treatments.

Table 7 Interaction effect of crops and micropyle positions on pod dry weight of mungbean and blackgram at different growth stages

Treatments	Leaf dry weight (g $plant^{-1}$) at different growth duration	
	45	At harvest
C_1P_1	1.10	13.36
C_1P_2	0.76	13.45
C_1P_3	0.57	14.15
C_1P_4	0.84	12.76
C_2P_1	0.23	19.17
C_2P_2	0.33	11.91
C_2P_3	0.26	19.27
C_2P_4	0.35	18.17
LSD (0.05)	0.28	NS
CV (%)	0.092	2.661

C_1 = BARI mung 6, C_2 = BARI mash 1, P_1 = Upward micropyle position, P_2 = Downward micropyle position, P_3 = Lateral micropyle position, P_4 = Haphazard micropyle position

4.8 Total dry weight

Results of total dry weight were presented in Figure 15, Figure 16 and Table 8. Irrespective of treatment differences, total dry matter weight of mungbean and blackgram ranged from 0.077-0.35, 1.36-3.72, 3.01-6.25 and 23.08-48.19 g $plant^{-1}$ at 15, 30 and 45 DAS and at harvest, respectively.

4.8.1 Effect of crops

The mungbean and blackgram showed significant variation in total dry weight at 15 and 45 DAS. But 30 DAS and at harvest, there was no significant variation of total dry matter observed between two crops.

At 15 DAS, the mungbean produced higher dry weight (0.29 g plant^{-1}) as compared to the blackgram (0.11 g plant^{-1}) and same trend of total dry matter partitioning was also found up to 45 DAS, but at harvest, blackgram produced the higher total dry weight (38 g plant^{-1}) compared to the mungbean (24.83 g plant^{-1}).

The dry matter production of different plant parts at harvesting time was recorded in which all partitioned components were statistically different for each crop (Figure 15). The dry matter production of different plant parts of blackgram was numerically maximum compared to the mungbean (Figure 15).

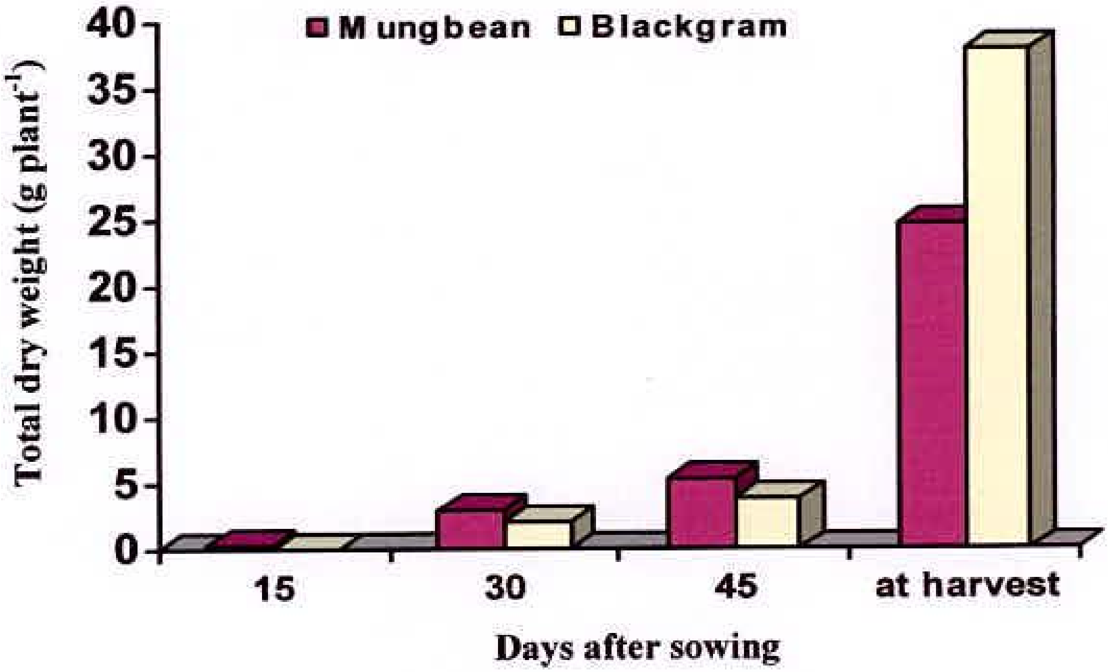


Fig. 15 Total dry weight of mungbean and blackgram seedlings at different growth stages ($LSD_{0.05}$ = 0.037, NS, 0.852 and NS at 15, 30, 45 DAS and at harvest, respectively)

4.8.2 Effect of micropyle positions

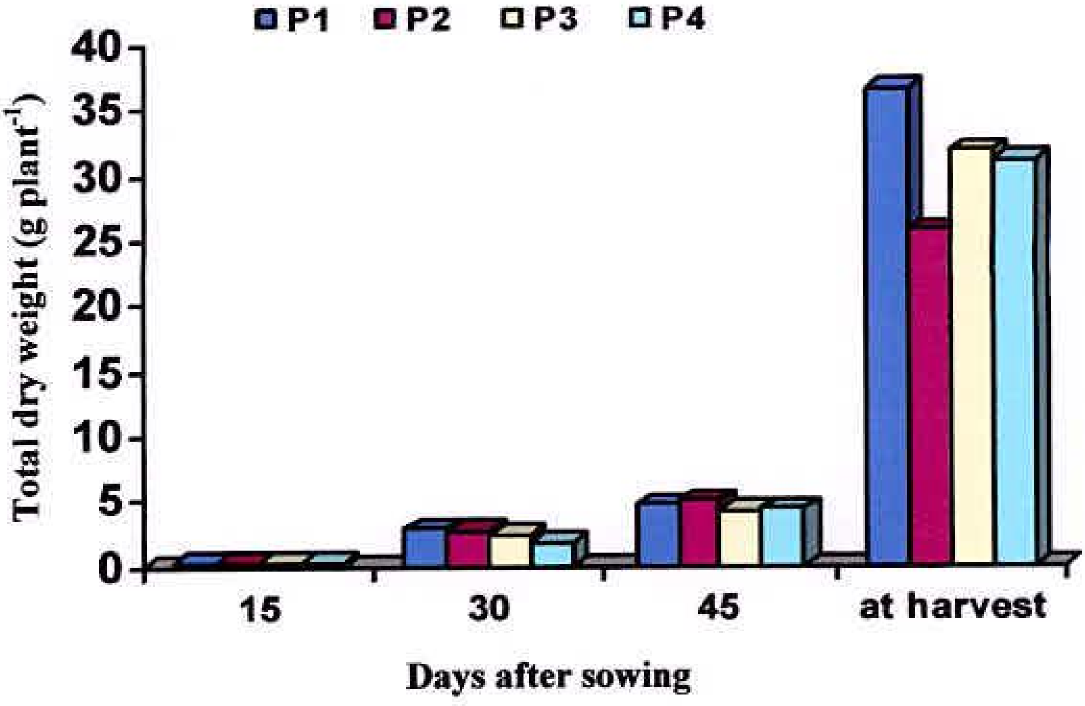
Total dry matter weight was significantly affected for the differences in micropyle position at different studied periods except 45 DAS. Where the highest dry weight was in P_2 (4.95 g plant^{-1}) and lowest dry weight was in P_3 (4.19 g plant^{-1}) which was no significant difference observed among the variation of micropyle positions.

At 15 DAS, the downward micropyle position (P_2) showed the highest total dry matter weight (0.23 g plant^{-1}) which was statistically similar to upward and lateral micropyle position. The lowest dry weight was in P_4 (0.16 g plant^{-1}) that was similar to P_1 and P_3.

At 30 DAS, the upward micropyle position (P_1) showed the highest total dry weight (2.85 g plant^{-1}) which was not significantly different from P_2 and P_3. The lowest total dry weight (1.81 g plant^{-1}) was in P_4.

At 45 DAS, the maximum dry weight was in P_2 (4.95 g plant^{-1}) and minimum dry weight was in P_3 (4.19 g plant^{-1}) where there was no significant difference observed for the variation of micropyle position.

At harvest, P_1 showed the highest dry weight (36.72 g plant^{-1}) that was statistically similar to P_3 and P_4. The lowest dry weight was observed in P_2 (25.84 g plant^{-1}) which was lower than that of the other treatments.



P_1 = Upward micropyle position, P_2 = Downward micropyle position,

P_3 = Lateral micropyle position, P_4 = Haphazard micropyle position

Fig. 16 Total dry weight of mungbean and blackgram seedlings as influenced by micropyle position ($LSD_{0.05}$ = 0.048, 0.8495, NS, 9.991 at 15, 30 and 45 DAS and at harvest, respectively).

4.8.3 Interaction effect of crops and micropyle positions

Crops and micropyle positions influenced the total dry weight of mungbean and blackgram at all the growth stages (Table 8). Interaction of mungbean treatments showed the higher total dry weight compared to blackgram up to 45 DAS. But at harvest blackgram showed higher weight and mungbean showed lowest total dry weight.

At 15 DAS, C_1P_1 showed the highest dry weight (0.35 g $plant^{-1}$) which was statistically similar to C_1P_3 and C_1P_2. The second highest dry weight was in C_1P_2 (0.29 g $plant^{-1}$) and third highest dry weight was in C_2P_2 (0.17 g $plant^{-1}$ that treatment was statistically similar to C_1P_4. The lowest total dry weight was showed in C_2P_1 (0.077 g $plant^{-1}$) compared to the most of the interaction treatments.

At 30 DAS, C_1P_1 showed the highest dry weight (3.72 g $plant^{-1}$) which did not differ with C_1P_2 treatment. The lowest total dry weight observed in C_2P_4 (1.36 g $plant^{-1}$) and it was lower than most of the treatments. The other treatments showed intermediate value which was not significantly differed among themselves.

At 45 DAS, C_1P_2 showed the highest dry weight (6.25 g $plant^{-1}$) which was similar to all treatment except C_2P_1 and C_2P_2. The lowest total dry weight was in C_2P_1 (3.01 g $plant^{-1}$). The other interactions showed intermediate value which was not significantly varied among themselves.

At harvest, the interaction of blackgram with upward micropyle position (C_2P_1) showed the highest dry weight (48.19 g $plant^{-1}$) that was statistically similar to C_2P_3 and C_2P_4. On the other hand, the interaction of mungbean with haphazard micropyle position (C_1P_4) showed the lowest (23.08 g $plant^{-1}$) dry weight that was lower than other interaction treatments. All other interaction treatments showed the total dry weight values and those were in between the values of the highest and lowest

Table 8 Interaction effect of crops and micropyle positions on total dry weight of mungbean and blackgram at different growth stages

Treatments	Total dry weight (g plant^{-1}) at different growth durations			
	15	30	45	At harvest
C_1P_2	0.29	3.19	6.25	26.83
C_1P_3	0.31	2.37	4.19	24.17
C_1P_4	0.23	2.25	4.11	23.08
C_2P_1	0.077	1.98	3.01	48.19
C_2P_2	0.17	1.99	3.66	24.84
C_2P_3	0.10	2.35	4.18	39.63
C_2P_4	0.08	1.36	4.55	39.34
LSD $_{(0.05)}$	0.068	1.20	2.751	14.130
CV (%)	0.02	0.39	0.90	4.59

C_1 = BARI mung 6, C_2 = BARI mash 1, P_1 = Upward micropyle position, P_2 = Downward micropyle position, P_3 = Lateral micropyle position, P_4 = Haphazard micropyle position

4.9 Number of branches plant^{-1}

Results of number of branches plant^{-1} have been presented in Table 9 and Figure 17. From the figures, it is seen that the number of branches plant^{-1} of mungbean and blackgram ranged from 0.17-7.23 at harvest. The number of branches plant^{-1} of mungbean and blackgram was affected by micropyle positions and their interactions.

4.9.1 Effect of crops

The crop had a significant effect on number of branches plant^{-1} (Table 9). The results showed that the blackgram produced maximum number of branches (5.48 plant^{-1}) compared to the mungbean (0.26 plant^{-1}). The variation in the production of branches plant^{-1} might be due to genetic constituents of the crops. This finding was supported by Ratna (2007) who worked on mungbean and blackgram and reported that blackgram produced maximum number of branches plant^{-1} compared to the mungbean. The results agreed with Ghosh (2007) who observed significant variation of branch number plant^{-1} in different varieties of mungbean and the lowest number of branch plant^{-1} was found in variety BARI mung 6.

4.9.2 Effect of micropyle positions

Micropyle position significantly influenced the number of branches plant^{-1} (Table 9). The highest number of branches (3.73 plant^{-1}) was obtained from the upward micropyle position (P_1) that was similar to P_3 and P_2 .The lowest number of branches plant^{-1} was obtained from the haphazard micropyle position (P_4) and it was statistically similar to P_2 and P_3.

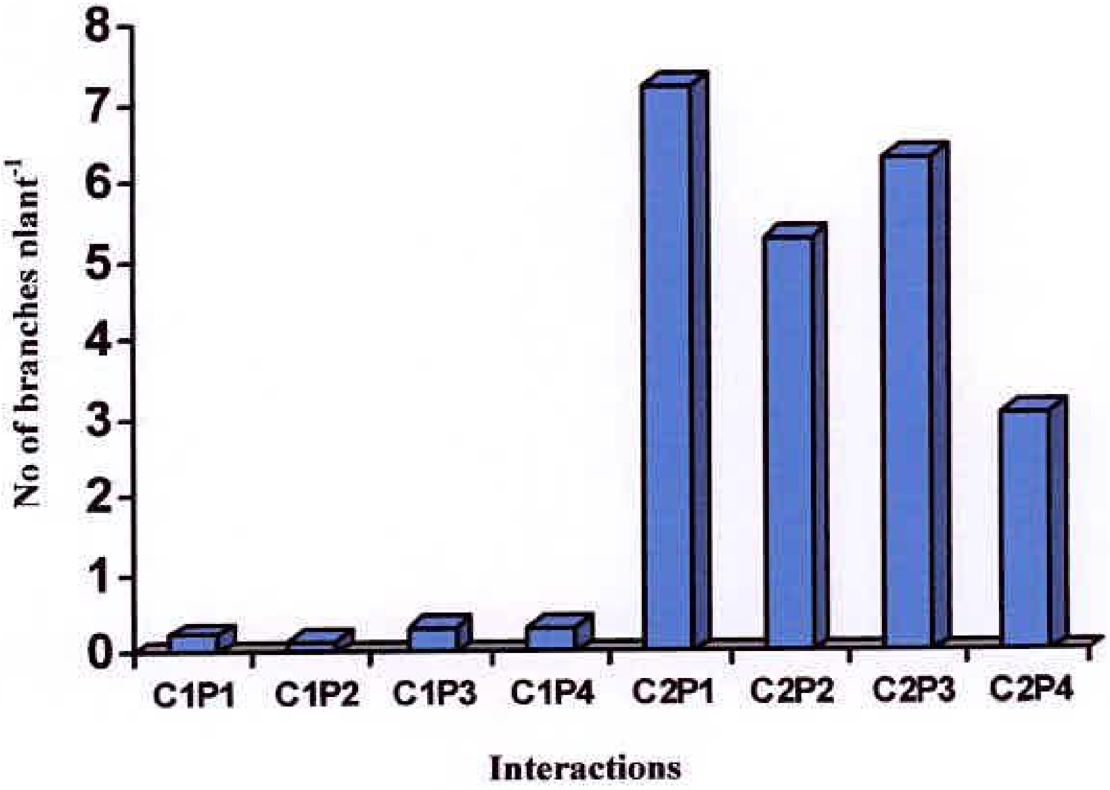
Table 9 Effect of different crops and micropyle positions on yield and other crop characters of mungbean and blackgram

Treatments	Bran-ches plant^{-1} (No.)	Pods Plant^{-1} (No.)	Pod length (cm)	Seeds pod^{-1} (No.)	1000 seed wt. (g)	Shell-ing percentage	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Har-vest inde
Crop (C)									
C_1	0.26	13.65	8.44	9.65	43.54	38.54	0.67	2.52	23.1
C_2	5.48	42.21	4.28	6.63	28.87	45.14	0.59	2.19	23.2
LSD (0.05)	1.346	6.396	0.179	1.024	17.044	4.170	NS	NS	NS
CV (%)	0.44	2.00	0.13	0.14	2.30	0.95	0.099	0.34	2.07
Micropyle position (P)									
P_1	3.73	27.93	6.33	8.17	33.25	40.31	0.50	2.80	18.0
P_2	2.72	26.43	6.14	8.05	36.12	43.42	0.61	2.22	24.6
P_3	3.32	31.45	6.38	8.12	37.51	42.10	0.58	1.67	25.5
P_4	1.70	25.90	6.60	8.23	37.94	41.52	0.82	3.46	24.4
LSD (0.05)	1.903	NS	NS	NS	NS	NS	NS	1.476	NS
CV (%)	0.618	2.816	0.184	0.197	3.248	1.344	0.140	0.479	2.92

C_1 = BARI mung 6, C_2 = BARI mash 1, P_1 = Upward micropyle position, P_2=Downward micropyle position, P_3 = Lateral micropyle position, P_4 = Haphazard micropyle position

4.9.3 Interaction effect of crops and micropyle positions

The number of branches plant^{-1} was significantly varied due to interaction of crops and micropyle positions (Figure 17). The highest number of branches was found in C_2P_1 (7.23 plant^{-1}) which was similar to C_2 P_3 and C_2P_3. The second highest number of branches plant^{-1} was found in C_2P_2 (5.27) that was similar to C_2P_4. The lowest number of branches plant^{-1} was in C_1P_2 (0.17) that was statistically similar to the all mungbean interaction treatments.



C_1 = BARI mung 6, C_2 = BARI mash 1, P_1 = Upward micropyle position, P_2 = Downward micropyle position, P_3 = Lateral micropyle position, P_4 =Haphazard micropyle position

Fig. 17 Interaction effect of crop and micropyle position on number of branches plant^{-1} of mungbean and blackgram ($LSD_{0.05}$ = 2.692).

4.10 Number of pods plant^{-1}

Results of number of pods plant^{-1} was presented in Table 9 and Figure 18. The number of pods plant^{-1} of mungbean and blackgram ranged from 12.8-48.87.

4.10.1 Effect of crops

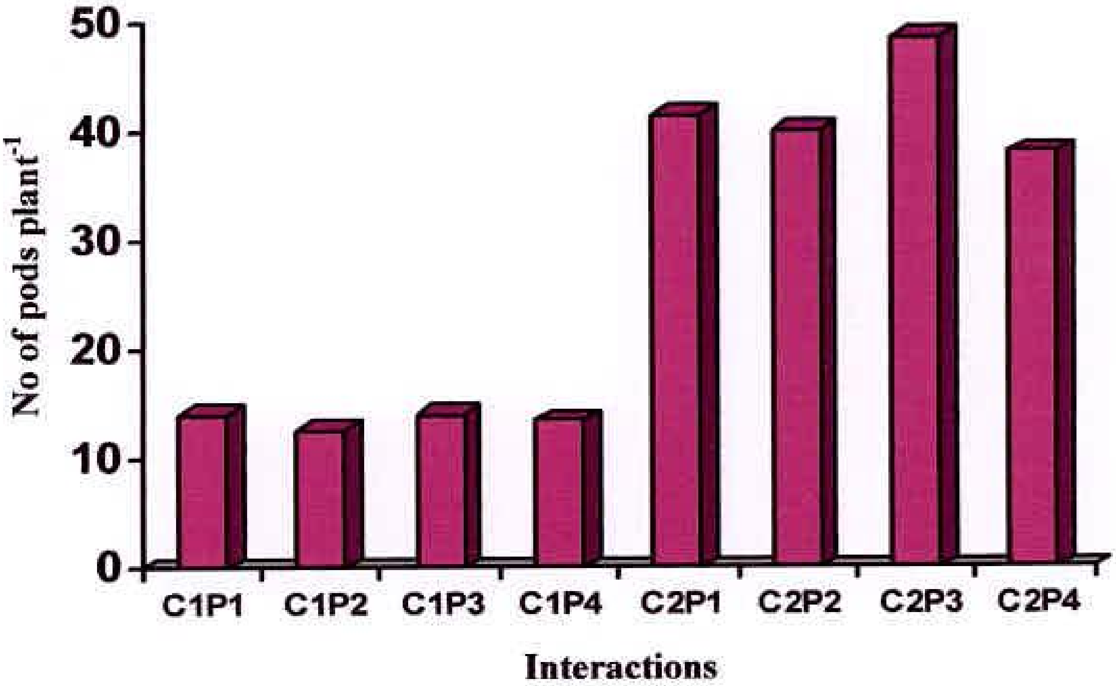
The number of pods plant^{-1} was significantly different for two crops (Table 9). Results showed that the blackgram produced maximum number of pods plant^{-1} (42.21) and the minimum was obtained from mungbean (13.65). The variation in the production of pods plant^{-1}as related to genetic constituents of the crops. Ratna (2007) reported that the number of pods plant^{-1} of blackgram was higher compared to that of mungbean. Ghosh (2007) also opined the lowest pods plant^{-1} was found in variety BARI mung6 as an useful agronomic character contributing to higher yield of blackgram and there was a significant positive correlation between the number of pods plant^{-1} and yield plant^{-1}.

4.10.2 Effect of micropyle positions

Micropyle position had no significant effect on the number of pods plant^{-1} (Table 9). The numerically maximum number of pods plant^{-1} (31.45) was obtained with P_3 and minimum number of pods plant^{-1} (25.90) was obtained from the P_4 treatment.

4.10.3. Interaction effect of crops and micropyle positions

The number of pods plant^{-1} was significantly different for two crops and micropyle positions (Figure 18). The highest number of pods plant^{-1}(48.87) was obtained from C_2P_3 which was statistically similar to all blackgram interaction treatments. The lowest number of pods plant^{-1} (12.80) was obtained from C_1P_2 which was statistically similar to all mungbean interaction treatments.



C_1 = BARI mung 6, C_2 = BARI mash 1, P_1 = Upward micropyle position,

P_2 = Downward micropyle position, P_3 = Lateral micropyle position,

P_4 =Haphazard micropyle position

Fig. 18 Interaction effect of crops and micropyle positions on number of pods plant^{-1} of mungbean and blackgram ($LSD_{0.05}$ = 12.271)

4.11 pod length

Results of pod length were presented in Table 9 and Figure 19.The pod length of mungbean and blackgram ranged from 12.8-48.87

4.11.1 Effect of crops

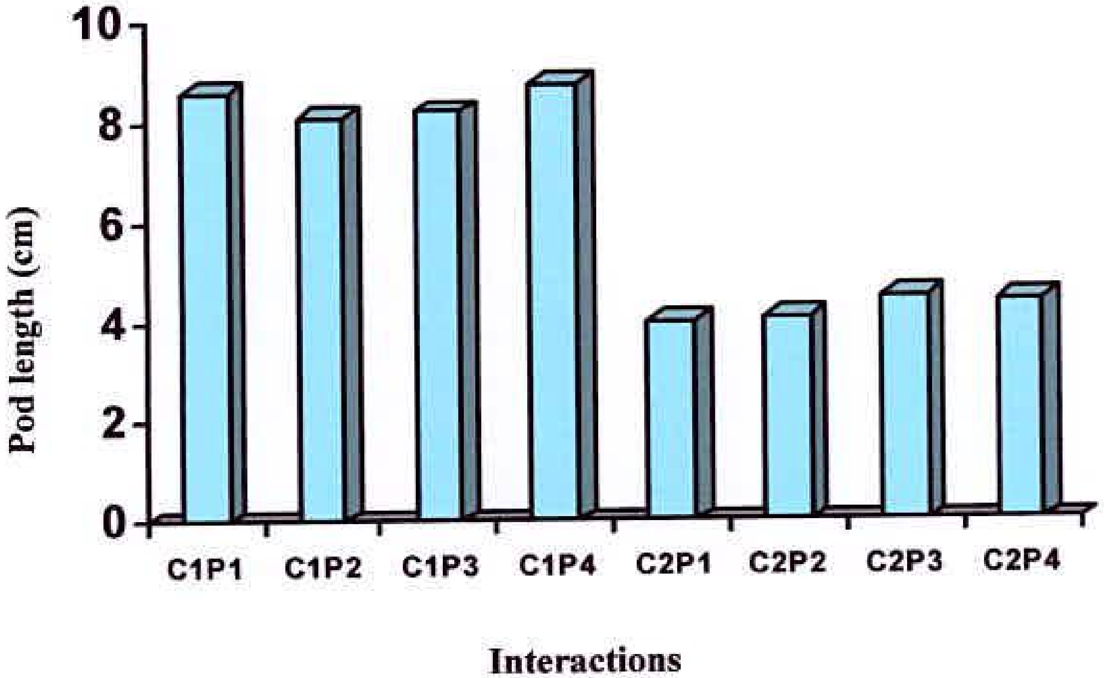
The pod length of mungbean and blackgram was significantly different (Table 9). The maximum (8.44 cm) and minimum (4.28 cm) pod length was recorded from mungbean and blackgram respectively. The similar trend was also recorded by Ratna (2007) who found that length of pods of mungbean was higher than blackgram.The results seemed to be close agreement with the findings of Ghosh (2007) who reported that the highest pod length was found in variety BARI mung 6 and it was also in agreement with the findings of Farghali and Hossain (1995) who observed that varieties differed significantly in respect of pod length.

4.11.2 Effect of micropyle positions

The micropyle position had no significant effect on the length of pod (Table 9). Numerically, the maximum pod length (6.60 cm) was in P_4 and minimum (6.14 cm) was in P_2.

4.11.3 Interaction effect of crops and micropyle positions

The length of pod was significantly influenced by the interaction effects of crops and micropyle positions (Figure 19). The highest pod length (8.77 cm) was recorded from C_1P_4 which was statistically similar to all mungbean interaction treatments. The lowest pod length (4.03 cm) was obtained from C_2P_1 which was statistically similar to all blackgram interaction treatments.



C_1 = BARI mung 6, C_2 = BARI mash 1, P_1 = Upward micropyle position,

P_2 = Downward micropyle position, P_3 = Lateral micropyle position,

P_4 =Haphazard micropyle position

Fig. 19 Interaction effect of crops and micropyle positions on pod length of mungbean and blackgram ($LSD_{0.05}$ = 0.801)

4.12 Number of seeds pod^{-1}

Results of number of seeds per pod have been presented in Table 9 and Figure 20. The number of seeds pod^{-1} of mungbean and blackgram ranged from 6.30-10.03.

4.12.1 Effect of crops

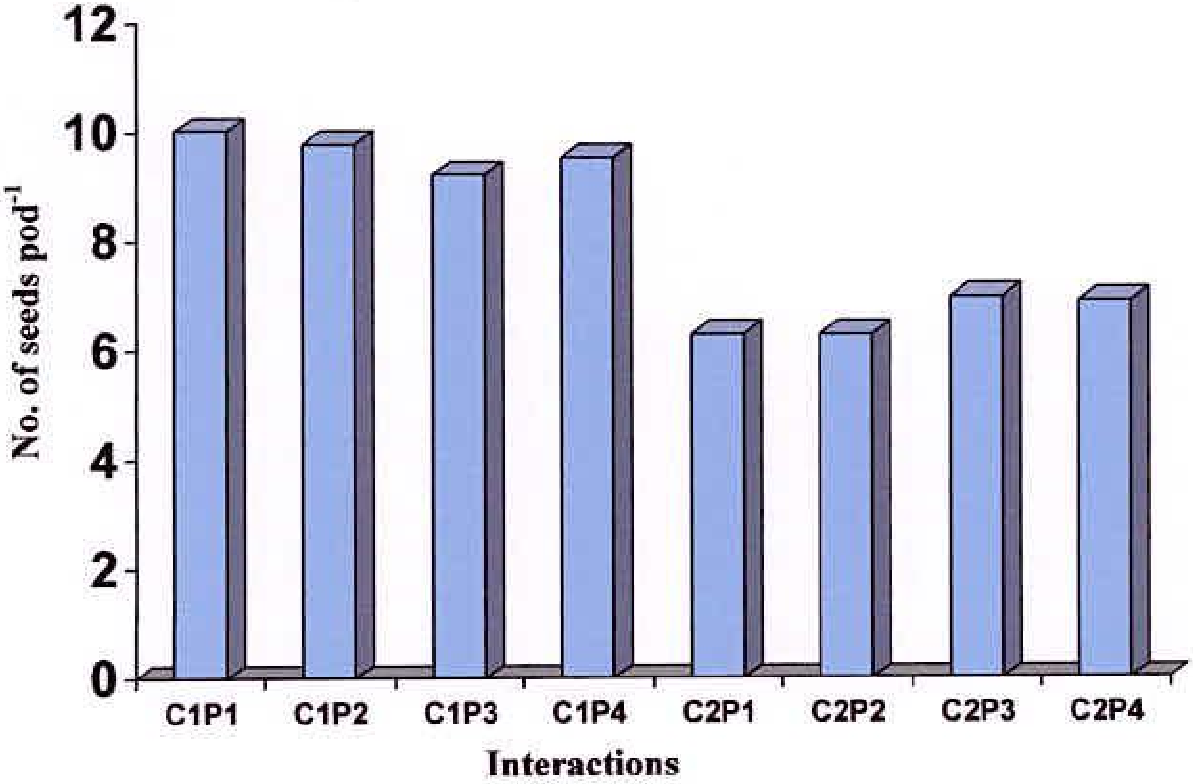
Each crop produced significantly different number of seeds pod^{-1} (Table 9). Mungbean produced the maximum number of seeds pod^{-1} (9.65). The lowest number of seeds pod^{-1} produced by blackgram (69.63). The result was in agreement with Ratna (2007) who reported that the number of seeds pod^{-1} of mungbean was higher than that of blackgram.

4.12.2 Effect of micropyle positions

Micropyle position had no significant effect on the number of seeds pod^{-1} (Table 9). Numerically the maximum (8.23) and the minimum (8.05) number of seeds pod^{-1} was obtained in P_4 and P_2 respectively.

4.12.3 Interaction effect of crops and micropyle positions

The number of seeds pod^{-1} was significantly influenced by the interaction of crops and micropyle positions (Figure 20). The highest number of seeds pod^{-1} (10.03) and lowest number of seeds pod^{-1} (6.30) was obtained from C_1P_1 and C_2P_1 respectively and C_2P_2 was statistically similar to other blackgram interaction treatments.



C_1 = BARI mung 6, C_2 = BARI mash 1, P_1 = Upward micropyle position,

P_2 = Downward micropyle position, P_3 = Lateral micropyle position,

P_4 =Haphazard micropyle position

Fig. 20 Interaction effect of crops and micropyle positions on number of seeds pod^{-1} of mungbean and blackgram ($LSD_{0.05}$ = 0.859)

4.13 Weight of 1000 seeds

Results of 1000 seed weight were presented in Table 9 and Figure 21. The 1000 seed weight of mungbean and blackgram ranged from 26.81-47.19 g.

4.13.1 Effect of crops

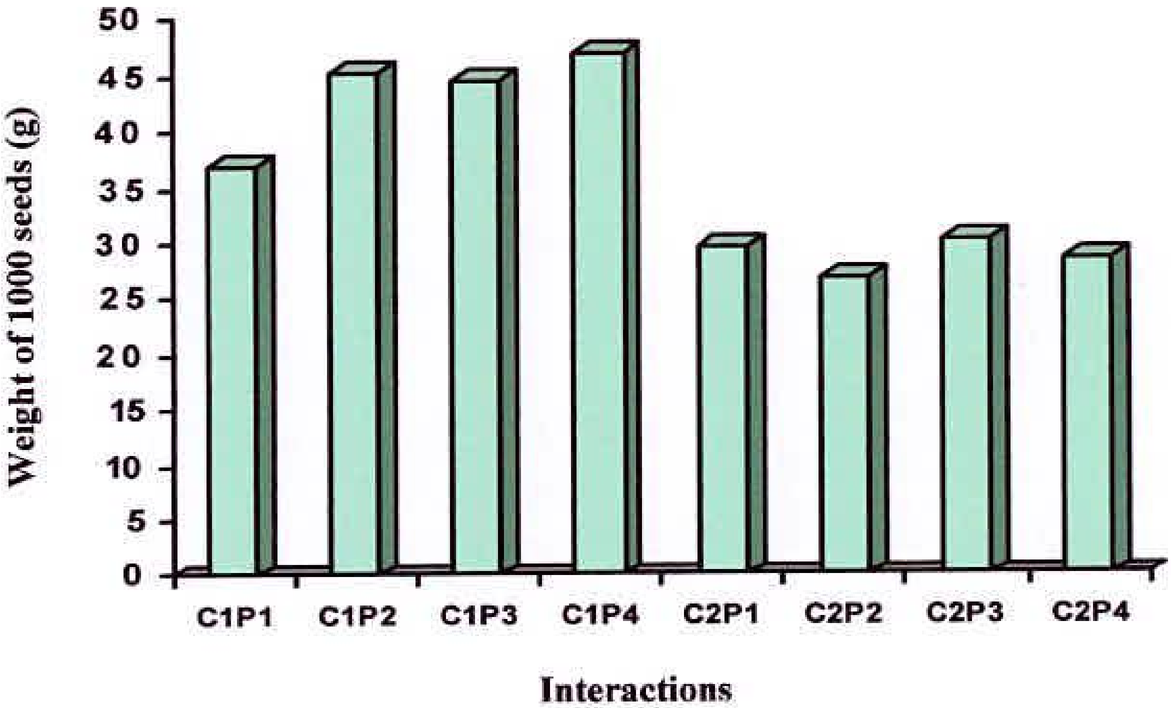
The crop had no significant effect on 1000 seed weight and numerically the 1000 seed weight of mungbean was higher (43.54 g) than the blackgram (28.87 g).

4.13.2 Effect of micropyle positions

There was no significant variation observed among the micropyle positions in respect of 1000 seeds weight (Table 9). The numerically maximum 1000 seed weight (37.94 g) was obtained with P_4 and minimum 1000 seed weight (33.25 g) was obtained from the P_1.

4.13.3 Interaction effect of crops and micropyle position

The 1000 seed weight was significantly affected due to interaction of crops and micropyle positions (Figure 21). The highest 1000 seed weight was found in C_1P_4 (47.19 g) that was similar to C_1P_1, C_1P_2 and C_1P_3 treatments. The lowest 1000 seed weight was found in C_2P_2 (26.81 g) which was statistically similar to C_2P_4, C_2P_1, C_2P_3 and C_1P_1.



C_1 = BARI mung 6, C_2 = BARI mash 1, P_1 = Upward micropyle position,

P_2 = Downward micropyle position, P_3 = Lateral micropyle position,

P_4 =Haphazard micropyle position

Fig. 21 Interaction effect of crops and micropyle positions on 1000 seed weight of mungbean and blackgram ($LSD_{0.05}$ = 14.153)

4.14 Shelling percentage

Results of shelling percentage was presented in Table 9 and Figure 22. It was seen that the shelling percentage of mungbean and blackgram ranged from 35.13-47.91 at the time of harvest.

4.14.1 Effect of crops

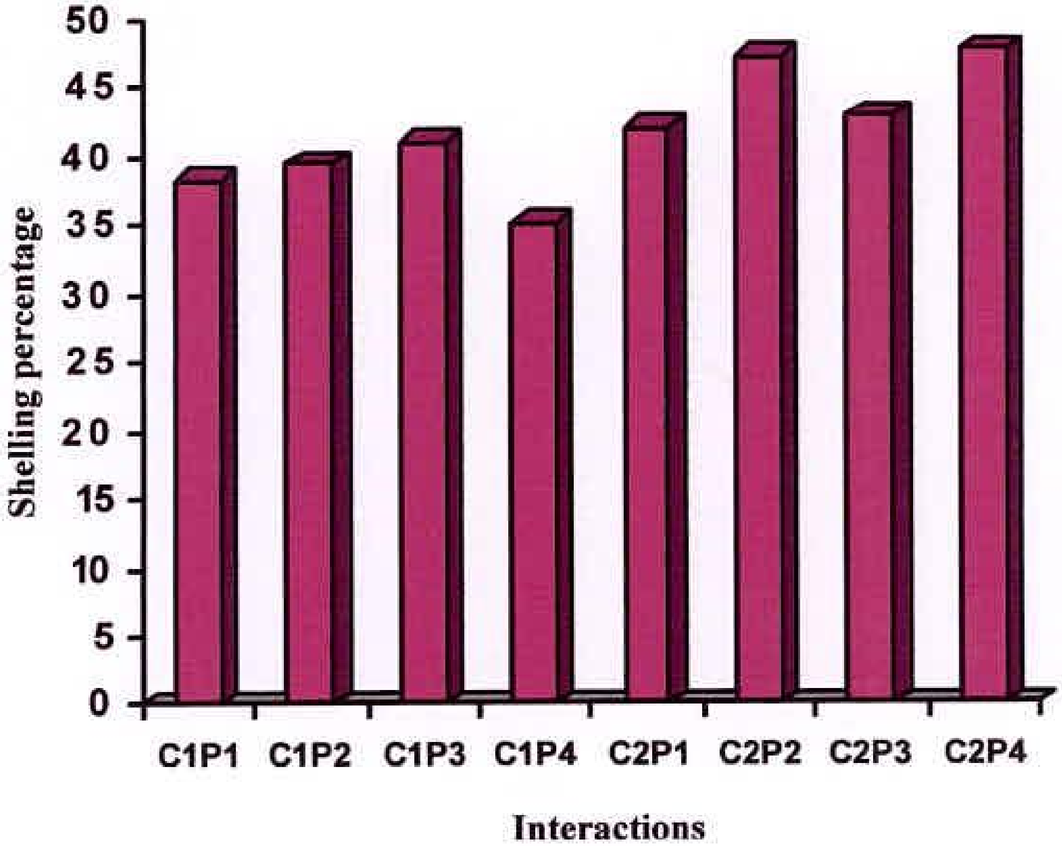
Shelling percentage was significantly affected by the crops (Table 9). The highest shelling percentage (45.14) was found in blackgram and the lowest shelling percentage (38.54) was found in mungbean. The result was similar with those of Ratna (2007) who reported the higher shelling percentage of blackgram than mungbean.

4.14.2 Effect of micropyle positions

Micropyle position had no significant effect on shelling percentage (Table 9). The numerically higher shelling percentage (43.42) and lower percentage (40.31) was found in P_2 and P_1, respectively.

4.14.3 Interaction effect of crops and micropyle positions

The difference of shelling percentage among the treatments was significant due to interaction of crops and micropyle positions (Figure 22). The highest shelling percentage (47.91) was found in C_2P_4 which was similar to C_2P_2, C_2P_3 and C_2P_1. The second highest shelling percentage (43.06) was found in C_2P_3 which was similar to C_2P_1, C_1P_3, C_1P_2 and C_1P_1. The lowest shelling percentage (35.13) was found in C_1P_4 that was not significantly different to $C_1P_1$and C_1P_2.



C_1 = BARI mung 6, C_2 = BARI mash 1, P_1 = Upward micropyle position,

P_2 = Downward micropyle position, P_3 = Lateral micropyle position,

P_4 =Haphazard micropyle position

Fig. 22 Interaction effect of crops and micropyle positions on shelling percentage of mungbean and blackgram ($LSD_{0.05}$ = 5.856)

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

Results of seed yield were presented in Table 9 and Figure 23. The seed yield of mungbean and blackgram ranged from 0.36-0.89 ton per hectare.

4.15.1 Effect of crops

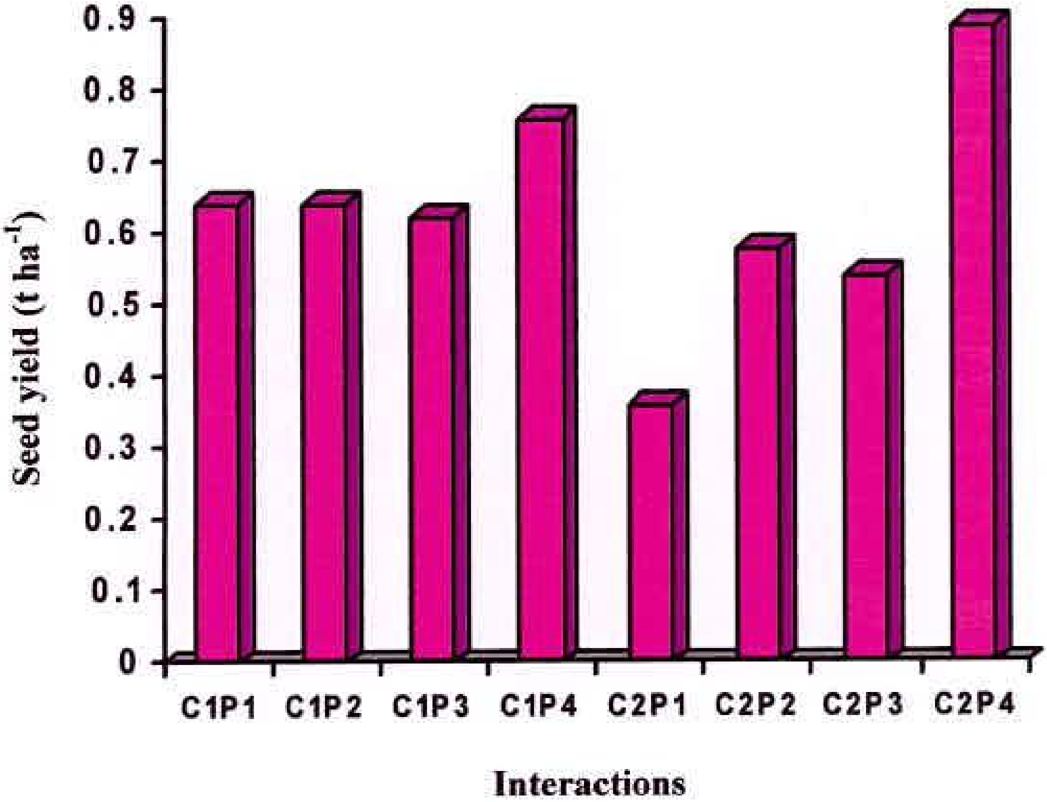
Seed yield was not significantly influenced by the crops (Table 9). Numerically, the maximum seed yield (0.67 t ha^{-1}) was obtained from the mungbean compared to the yield (0.59 t ha^{-1}) of blackgram. Similar yields of BARI mung6 and BARI mash1 was also reported by Hussain *et al,* (2006) and Ratna (2007). Ghosh (2007) reported that the maximum seed yield was obtained from BARI mung6 compared to another variety. This finding was in agreement with BARI (1982), ICRISAT (1991) and Sing and Sing (1988) who reported that cultivars played a key role in increasing the yield.

4.15.2 Effect of micropyle positions

Micropyle position had no significant effect on seed yield (Table 9). But numerically the P_4 (haphazard micropyle position) produced the highest seed yield (0.82 t ha^{-1}) and the lowest seed yield (0.50 t ha^{-1}) was obtained from P_1.

4.15.3 Interaction effect on crops and micropyle positions

The difference of seed yield among the treatments was not significant in respect of interaction of crops and micropyle positions (Figure 23). Though numerically the maximum seed yield (0.89 t ha^{-1}) was obtained from blackgram sown in haphazard micropyle position and the minimum seed yield (0.36 t ha^{-1}) was obtained from blackgram with upward micropyle position.



C_1 = BARI mung 6, C_2 = BARI mash 1, P_1 = Upward micropyle position,

P_2 = Downward micropyle position, P_3 = Lateral micropyle position,

P_4 =Haphazard micropyle position

Fig. 23 Interaction effect of crops and micropyle positions on seed yield of mungbean and blackgram

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

Results of stover yield were presented in Table 9 and Figure 24. The stover yield of mungbean and blackgram ranged from 1.22-3.83 ton per hectare.

4.16.1 Effect of crops

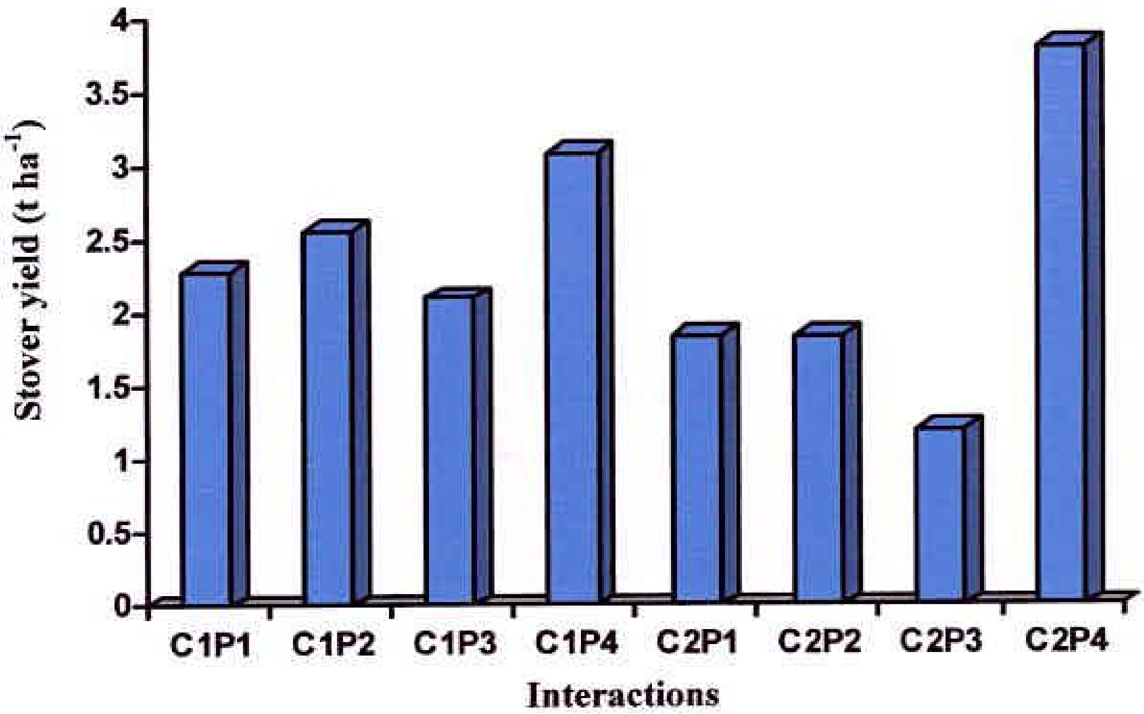
Stover yield was not significantly influenced by the mungbean and blackgram (Table 9). Numerically the maximum stover yield (2.52 t ha^{-1}) was obtained from mungbean compared to the yield of blackgram (2.19 t ha^{-1}).This result was in agreement with Ghosh (2007) who reported that the maximum stover yield was obtained from BARI mung6.

4.16.2 Effect of micropyle positions

The micropyle positions had significant effect on stover yield (Table 9). The P_4 showed the highest stover yield (3.46 t ha^{-1}) which was statistically similar to P_1 and P_2. The lowest stover yield (1.67 t ha^{-1}) was produced by P_3 which was similar to P_1 and P_2.

4.16.3 Interaction effect of crops and micropyle positions

Interaction effect of crops and micropyle positions was found significant in respect of stover yield (Figure 24). The highest stover yield (3.83 t ha^{-1}) was obtained from C_2P_4 and the lowest stover yield was found in C_2P_3 (1.22 t ha^{-1}).The other interaction treatments showed intermediate values which were in between the values of the highest and lowest and they did not show significant difference among themselves.



C_1 = BARI mung 6, C_2 = BARI mash 1, P_1 = Upward micropyle position,

P_2 = Downward micropyle position, P_3 = Lateral micropyle position,

P_4 =Haphazard micropyle position

Fig. 24 Interaction effect of crops and micropyle positions on stover yield of mungbean and blackgram ($LSD_{0.05}$ = 2.088)

4.17 Harvest index

Results of harvest index were presented in Table 9 and Figure 25. It was seen that the harvest index of mungbean and blackgram ranged from 15.90-28.38.

4.17.1 Effect of crops

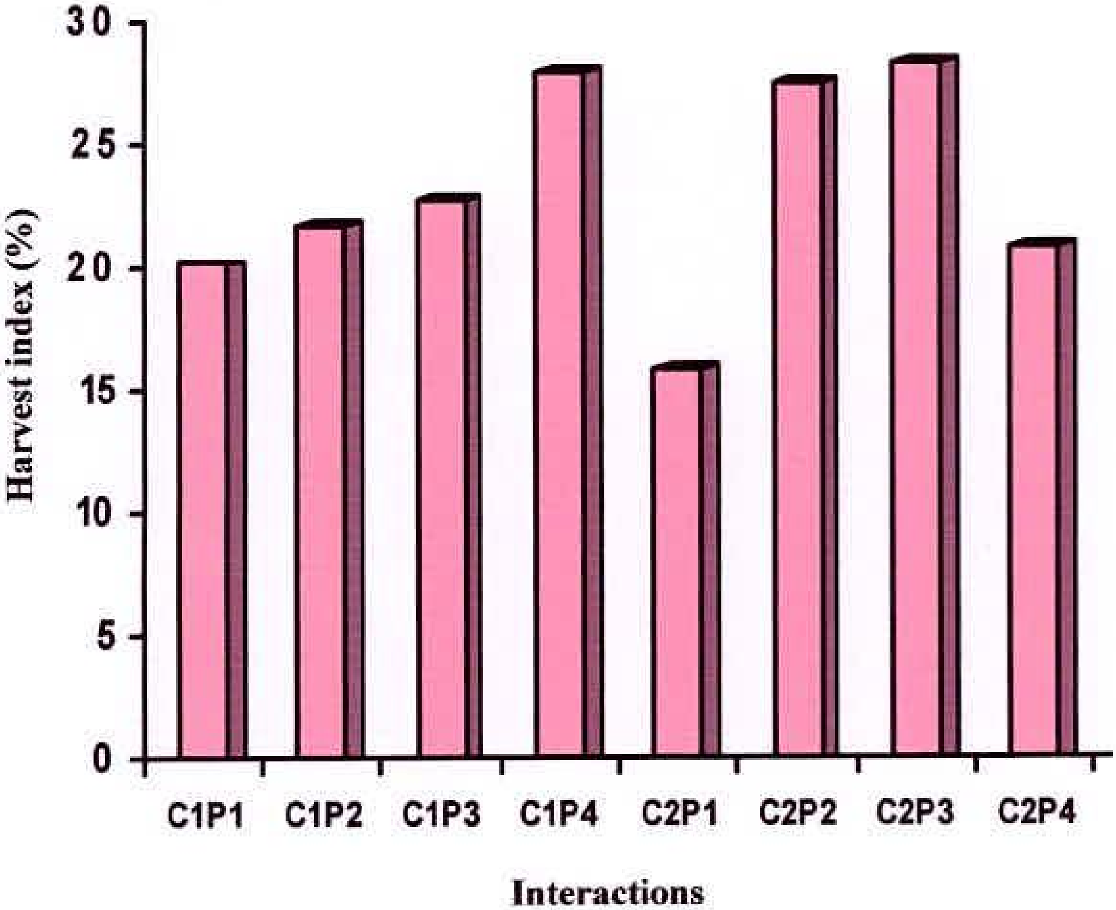
The crop had no significant effect on harvest index (Table 9). The highest harvest index (23.20) was shown by the blackgram and significantly the minimum harvest index (23.18) was shown by the mungbean that was similar to blackgram.

4.17.2 Effect of micropyle positions

The micropyle position had no significant effect on harvest index (Table 9). The maximum harvest index (25.59) was shown by the P_3. Minimum harvest index (18.04) was shown by the P_1 that was similar to the P_2 and P_4.

4.17.3 Interaction effect of crops and micropyle positions

The difference of harvest index among the treatments was not significant due to interaction of crops and micropyle positions (Figure 25). Numerically the maximum harvest index (28.38) was obtained from C_2P_4 and the minimum harvest index (15.90) was obtained from the C_2P_1. The results showed that harvest index was not significantly affected by interaction of crops and micropyle positions.



C_1 = BARI mung 6, C_2 = BARI mash 1, P_1 = Upward micropyle position,

P_2 = Downward micropyle position, P_3 = Lateral micropyle position,

P_4 =Haphazard micropyle position

Fig. 25 Interaction effect of crops and micropyle positions on harvest index of mungbean and blackgram

Chapter 5
Summary and Conclusion

CHAPTER 5

SUMMARY

An experiment was conducted at the experimental farm of Sher-e-Bangla Agricultural University (SAU), Dhaka, during 27th March 2007 to 25th June 2007 to study the performance of different micropylc positions of mungbean and blackgram in kharif season under the Modhupur Tract (AEZ-28). The experiment was consisted of two crops viz. BARI mung6 (C_1) and BARI mash1(C_2) and four micropyle positions viz. upward micropyle position (P_1), downward micropyle position (P_2), lateral micropyle position (P_3), haphazard micropyle position (P_4). The experiment was laid out in a split-plot design following the principles of randomization with three replications having crops in the main plots and micropyle positions in the sub-plots. The unit plot size was 3m x 2m. The land was fertilized with Urea, TSP and MP applied as basal at the rate of 45-100-55 N, P_2O_5 and K_2O, respectively. The seeds were sown on 27th March, 2007. Intercultural operations such as weeding, water management and pest management were done as and when necessary.

From the field experiment, data on crop growth parameters like plant height, root and shoot ratio, dry matter and number of branches plant^{-1} were recorded at different growth stages. Yield and other parameters like number of pods plant^{-1}, length of pod, number of seeds pod^{-1}, 1000 seed weight, seed yield and stover yield were recorded after harvest.

Data were analyzed using IRRISTAT computer package. The mean differences among the treatments were compared by least significant difference (LSD) test at 5% level of significance.

From the results of the percentage of emergence, it was seen that the seedlings started emerging from 4 days after sowing (DAS). Crops had significant effect on the emergence. At all the days, the emergence percentage of mungbean was significantly earlier compared to the blackgram.

Unlike with crop seedlings from all of micropyle positions were found to start emerging from 4 DAS. After the start, seedlings emerged almost faster up to 12 DAS and thereafter the emergence was ceased. From 5 DAS and onwards, the downward micropyle position (P_2) emerged significantly faster and had higher emergence values than P_1, P_3 and P_4. Similar trend was also observed up to the 8 DAS. After that, there was no significant difference observed among all other micropyle positions. At all the counts the significantly lower emergence was shown by P_4.

Interaction effect of crops and micropyle positions was found significant in respect of the seedling emergence. The C_1P_3 and C_1P_4 showed earlier emergence compared to the other treatments. The C_2P_4 showed late emergence of seedlings and that was similar to the other blackgram treatments.

Results showed that variation of crop had no significant effect on plant height, root, shoot, leaf, pod and total dry weight except root and shoot ratio and number of branches plant^{-1}. Whereas, blackgram produced maximum number of branches plant^{-1} (5.48) compared to mungbean (0.26). The higher root and shoot ratio was obtained from mungbean and the lower root and shoot ratio was obtained from blackgram.

The growth parameters were also significantly affected by the micropyle positions. At all the growth stages, significantly the highest total dry weight and number of branches plant^{-1} was shown by the upward micropyle position (P_1) whereas, the minimum total dry weight and number of branches was found in the downward micropyle position (P_4). There was no significant variations observed on plant height and root and shoot ratio at all the growth stages except 15 DAS and 30 DAS.

The interaction effect of crops and micropyle positions was also significant on different growth parameters. The highest mungbean root and shoot ratio was initially found with the downward micropyle position. But at lowest root and shoot ratio was observed in the lateral micropyle position of blackgram which was similar to the downward micropyle position of blackgram. In the later stages, the maximum root, shoot and leaf dry weight was obtained from the lateral micropyle with blackgram and minimum was obtained from the lateral micropyle with mungbean except pod dry weight. At harvest, upward micropyle position produced highest total dry weight and number of branches plant^{-1} of blackgram. The interaction effect on the rapid increase of plant height was observed in the mungbean with downward micropyle compared to the blackgram at 15, 30 and 45 DAS, but the effect was not significant at harvest.

The crop had a significant effect on different reproductive parameters such as number of pods plant^{-1}, length of pod, number of seeds pod^{-1}, shelling percentage and harvest index. Crops did not have significant effect on 1000 seed weight, seed yield (t ha^{-1}), stover yield (t ha^{-1}) and harvest index. In all the cases, the higher value was obtained from mungbean (C_1) and lower one was from blackgram (C_2) except harvest index. Blackgram produced maximum number of pods pant^{-1} and shelling percentage compared to mungbean. The higher number of seeds pod^{-1} (9.65) and length of pod (8.44) was obtained from mungbean and the lower number of seeds pod^{-1} (6.63) and pod length (4.28) was obtained from blackgram.

Micropyle position did not have significant effect on number of pods plant^{-1}, length of pod, number of seeds pod^{-1}, 1000 seed weight, shelling percentage, seed yield and harvest index except stover yield. Though numerically haphazard micropyle position (P_4) produced the highest seed yield (0.82 t ha^{-1}) and the upward micropyle position (P_1) produced the lowest seed yield (0.50 t ha^{-1}). But, statistically P_4 produced the highest stover yield (3.46 t ha^{-1}) whereas, lateral micropyle position (P_2) produced the lowest stover yield (1.67 t ha^{-1}).

Interaction effect of crops and micropyle positions also significantly affected the yield and yield contributing characters except seed yield and harvest index. The maximum number of pods plant^{-1} (48.87) and shelling percentage (43.06 %) was obtained from the lateral micropyle position of blackgram; however the lowest number of pods plant^{-1} (13.60) and shelling percentage (35.13 %) was obtained from the haphazard micropyle position of mungbean. The highest pod length (8.77), weight of 1000 seeds (47.19 g) were obtained from the haphazard micropyle position of mungbean and the lowest pod length (4.14) and weight of 1000 seeds (26.8 g) was obtained from the downward micropyle position of blackgram, which was similar to the other micropyle positions of the same crop. The higher number of seeds pod^{-1} (10.03) was obtained from upward micropyle position of mungbean and the lower number of seeds pod^{-1} (6.30) was obtained from the upward micropyle position of blackgram. Among the treatments, numerically the maximum seed yield (0.89 t ha^{-1}) was observed with blackgram in haphazard micropyle position and the minimum yield (0.36 t ha^{-1}) was obtained in upward micropyle position with blackgram. The highest stover yield (3.83 t ha^{-1}) was recorded in the haphazard micropyle position with blackgram and the lowest stover yield (1.22 t ha^{-1}) was found in the lateral micropyle position with blackgram. Both the crop and micropyle position had no significant effect on harvest index.

CONCLUSION

Based on the results of the above summary the following conclusions may be drawn-

Mungbean (C_1) showed significantly the higher percentage of emergence, root and shoot ratio, number of seeds pod^{-1} and length of pod. Significantly higher number of branches plant^{-1}, number of pods plant^{-1}, shelling percentage was obtained with blackgram (C_2).

The percentage of emergence was significantly highest at P_2 and the significantly highest total dry weight and number of branches plant^{-1} were observed with P_1. It was seen that significantly the highest number of pods plant^{-1} and shelling percentage were observed in P_3 while P_4 showed the maximum stover yield and numerically better performance in respect of seed yield.

Results of interaction effect of crops and micropyle positions showed the highest emergence percentage with C_1P_3 and C_1P_4. The interaction treatment of C_2P_1 showed significantly the highest value of root dry weight, shoot dry weight, leaf dry weight, total dry weight and number of branches plant^{-1}. Significantly highest root and shoot ratio was obtained with C_1P_2. The interaction of C_1P_4 showed significantly higher pod length and 1000 seed weight. The highest number of seeds pod^{-1} and stover yield was observed with the interaction effect of C_1P_1 and C_2P_4, respectively. However, to reach a specific conclusion, more research work on micropyle positions of some other crops should be done in different soil conditions that will help to develop some device to place the seed in its desired position for better emergence.

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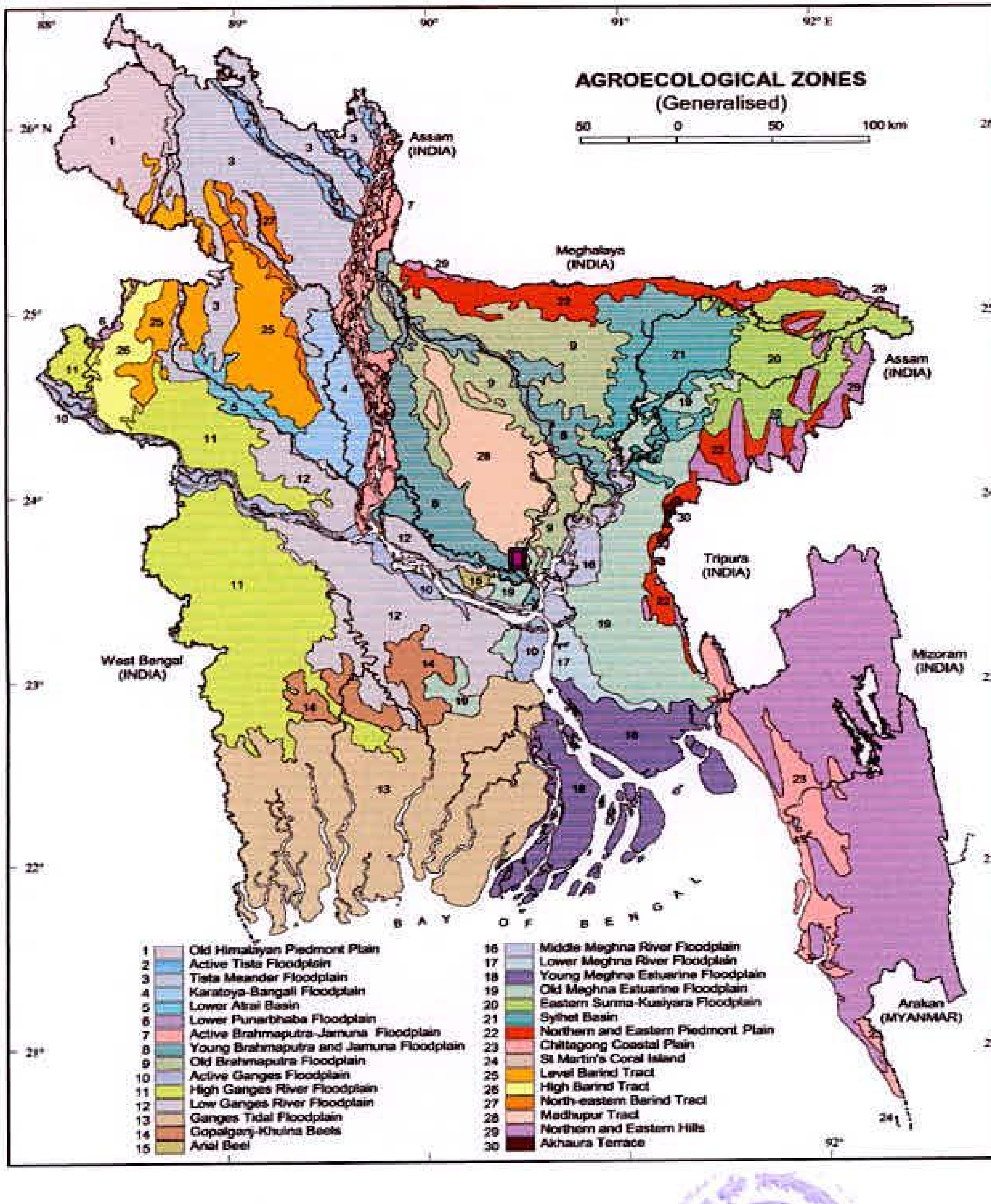
APPENDICES

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 experimentation (0 - 15 cm depth).

Mechanical composition:

Particle size constitution

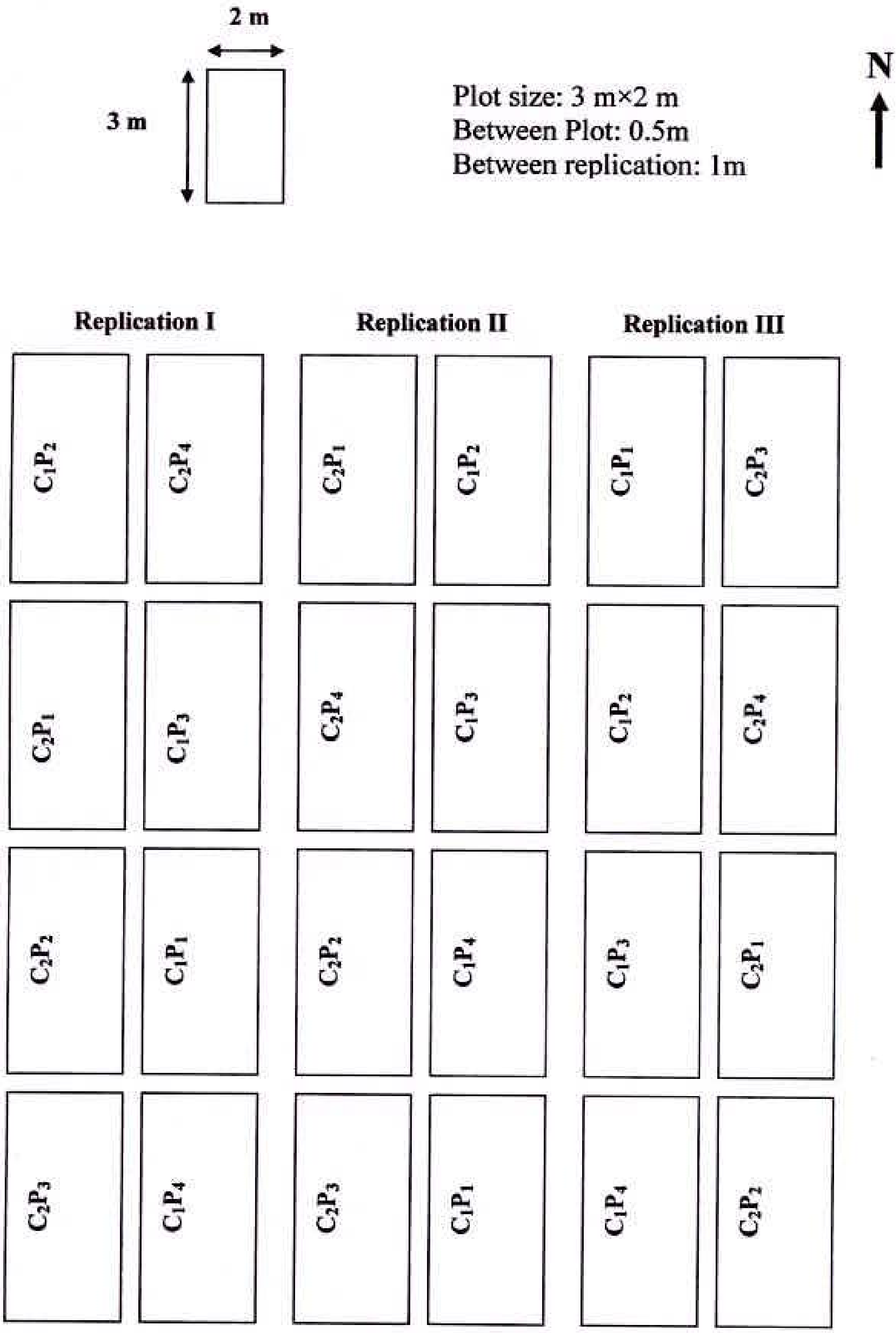
Sand	:	26%
Silt	:	45%
Clay	:	29%
Texture	:	Silty clay

Chemical composition:

Soil characters	Value
pH	7.1
Organic matter	1.08%
Total Nitrogen	0.054 %
Potassium	0.27 meq/100 g soil
Calcium	3.5 meq/100 g soil
Magnesium	0.46 meq/100 g soil
Phosphorus	10.46 ppm
Sulphur	18 ppm
Boron	0.4 ppm
Copper	1.6 ppm
Iron	14 ppm
Manganese	36.8 ppm
Zinc	1.84 ppm

Source: Fatima (2007) SAU, Dhaka- 1207

Appendix III. Layout of Experimental field



Appendix IV : Analysis of variance on emergence of mungbean and blackgram

Sources of variation	DF	Mean square									
		Emergence									
		4 day	5 day	6 day	7 day	8 day	9 day	10 day	11 day	12 day	13 day
Replication	2	93.550	821.331	1406.45	2557.77	2365.69	1901.20	2110.64	2099.42	362.364	0.000
Factor A (crop)	1	22411.5 **	26270.1 **	23256.6 **	14569.1 **	12803.4 **	7907.95 **	6851.26 **	6512.90 **	803.074 **	0.000^{NS}
Error 1	2	333.083	1225.50	2024.57	2825.74	2738.54	2469.32	2145.24	2099.42	362.364	0.000
Factor B (micropyle position)	3	708.884 **	155.976 *	280.485 **	376.899^{NS}	329.495^{NS}	373.453^{NS}	452.452^{NS}	398.884^{NS}	34.890^{NS}	0.000^{NS}
Interaction A*B	3	541.505 **	72.733^{NS}	59.776^{NS}	145.305^{NS}	281.502^{NS}	444.142^{NS}	402.088^{NS}	398.884^{NS}	34.890^{NS}	0.000^{NS}
Error 11	12	47.384	33.582	74.946	152.973	176.754	273.945	255.052	222.994	41.890	0.000
Total	23										

** = Significant at 1 % level; * = Significant at 5 % level; NS = Not Significant

DF =Degrees of freedom

Appendix V : Analysis of variance on plant height of mungbean and blackgram

Sources of variation	DF	Mean square			
		Plant height (cm)			
		15DAS	30DAS	45DAS	At harvest
Replication	2	36.607	183.848	146.590	200.840
Factor A (crop)	1	191.140 **	931.136 **	155.805 *	0.1276^{NS}
Error 1	2	4.206	54.442	31.528	6.851
Factor B (micropyle position)	3	13.872 *	76.597^{NS}	35.444^{NS}	38.010^{NS}
Interaction A*B	3	1.307^{NS}	52.903^{NS}	31.580^{NS}	78.037^{NS}
Error 11	12	4.206	39.994	28.785	47.765
Total	23				

** = Significant at 1 % level; * = Significant at 5 % level; NS = Not Significant

DF =Degrees of freedom

Appendix VI: Analysis of variance on root and shoot ratio of mungbean and blackgram

Sources of variation	DF	Mean square root and shoot ratio		
		30 DAS	45 DAS	At harvest
Replication	2	1.675	0.603	1.718
Factor A (crop)	2	4.638 **	19.765 **	8.544 **
Error 1	1	0.249	0.080	0.674
Factor B (micropyle position)	3	0.319^{NS}	0.142^{NS}	0.268^{NS}
Interaction A*B	3	1.190 **	1.473^{NS}	1.611 *
Error 11	12	0.140	0.549	0.457
Total	23			

** = Significant at 1 % level; * = Significant at 5 % level; NS = Not Significant
DF =Degrees of freedom

Appendix VII: Analysis of variance on root dry weight of mungbean and blackgram

Sources of variation	DF	Mean square Root dry matter (gm)		
		30 DAS	45 DAS	At harvest
Replication	2	0.0148	0.0053	0.4435
Factor A (crop)	1	0.0122^{NS}	0.0000^{NS}	1.088 **
Error 1	2	0.0284	0.0191	0.758
Factor B (micropyle position)	3	0.0224^{NS}	0.0112^{NS}	0.2032^{NS}
Interaction A*B	3	0.0018^{NS}	0.0154^{NS}	0.458 *
Error 11	12	0.0090	0.0346	0.1003
Total	23			

** = Significant at 1 % level; * = Significant at 5 % level; NS = Not Significant
DF =Degrees of freedom

Appendix VIII: Analysis of variance on shoot dry weight of mungbean and blackgram

Sources of variation	DF	Mean square Shoot dry matter (gm)		
		30 DAS	45 DAS	At harvest
Replication	2	0.4074	0.4107	14.4065
Factor A (crop)	1	0.2993 *	4.3011 **	81.5491 **
Error 1	2	0.1390	0.0176	15.1370
Factor B (micropyle position)	3	0.1110 ^{NS}	0.1198 ^{NS}	2.8360 ^{NS}
Interaction A*B	3	0.1317 ^{NS}	0.2463 ^{NS}	7.4647 *
Error 11	12	0.0579	0.1398	1.8247
Total	23			

** = Significant at 1 % level; * = Significant at 5 % level; NS = Not Significant
DF =Degrees of freedom

Appendix XI: Analysis of variance on leaf dry weight of mungbean and blackgram

Sources of variation	DF	Mean square Leaf dry matter (gm)		
		30 DAS	45 DAS	At harvest
Replication	2	1.1359	1.3163	12.5603
Factor A (crop)	1	1.8816 ^{NS}	0.0963 ^{NS}	173.183 **
Error 1	2	0.3932	0.1655	39.5448
Factor B (micropyle position)	3	0.2899 ^{NS}	0.0567 ^{NS}	31.4334 *
Interaction A*B	3	0.2133 ^{NS}	1.6067 ^{NS}	33.5804 *
Error 11	12	0.2347	1.1438	9.6471
Total	23			

** = Significant at 1 % level; * = Significant at 5 % level; NS = Not Significant
DF =Degrees of freedom

Appendix X: Analysis of variance on pod dry weight of mungbean and blackgram

Sources of variation	DF	Mean square	
		Pod dry matter (gm)	
		45 DAS	At harvest
Replication	2	22.8763	2.6243
Factor A (crop)	1	12.7313 NS	82.251 NS
Error 1	2	26.064	105.336
Factor B (micropyle position)	3	25.3183 NS	19.6175 NS
Interaction A*B	3	20.8652 NS	18.4449 NS
Error 11	12	23.2969	21.2406
Total	23		

** = Significant at 1 % level; * = Significant at 5 % level; NS = Not Significant
DF =Degrees of freedom

Appendix XI: Analysis of variance on total dry weight of mungbean and blackgram

Sources of variation	DF	Mean square			
		Total dry matter (gm)			
		15DAS	30DAS	45DAS	At harvest
Replication	2	0.00445	2.0713	4.0908	50.721
Factor A (crop)	1	0.2072 **	5.5584 **	10.733 *	1041.09 **
Error 1	2	0.0008	0.6082	0.4311	426.445
Factor B (micropyle position)	3	0.0057 *	1.1790 NS	0.6884 NS	119.079 NS
Interaction A*B	3	0.0066 *	0.7733 NS	5.0087 NS	170.042 NS
Error 11	12	0.0015	0.4561	2.3914	63.0814
Total	23				

** = Significant at 1 % level; * = Significant at 5 % level; NS = Not Significant
DF =Degrees of freedom

Appendix XII: Analysis of variance on yield attributes of mungbean and blackgram

Sources of variation	DF	Mean square								
		Yield and other crop characters								
		No. of branc-hes plant^{-1}	No. of pods plant^{-1}	Pod length (cm)	No. of seeds pod^{-1}	1000 seed weight (g)	Shell ing per-ce ntage	Seed yield (tons ha^{-1})	Stov er yield (tons ha^{-1})	Har -vest index (%)
Replication	2	165.203	101.682	0.252	0.262	25.422	30.545	0.448	2.797	42.152
Factor A (crop)	1	602.002 *	4893.47 **	103.958 **	54.602 **	1292.43^{NS}	261.360 **	0.0323^{NS}	0.631 ^{NS}	0.0020^{NS}
Error 1	2	161.033	24.272	0.01905	0.622	172.356	10.317	0.128	1.006	328.894
Factor B (micropyle position)	3	160.194^{NS}	37.503^{NS}	0.222^{NS}	0.036^{NS}	26.841^{NS}	9.982^{NS}	0.113^{NS}	3.590 ^{NS}	72.130^{NS}
Interaction A*B	3	158.934^{NS}	28.882^{NS}	0.226^{NS}	0.767 *	42.234^{NS}	34.756^{NS}	0.041^{NS}	0.802 ^{NS}	66.508^{NS}
Error 11	12	133.250	47.579	0.203	0.233	63.291	10.834	0.117	1.377	51.1726
Total	23									

** = Significant at 1 % level; * = Significant at 5 % level; NS = Not Significant
DF =Degrees of freedom

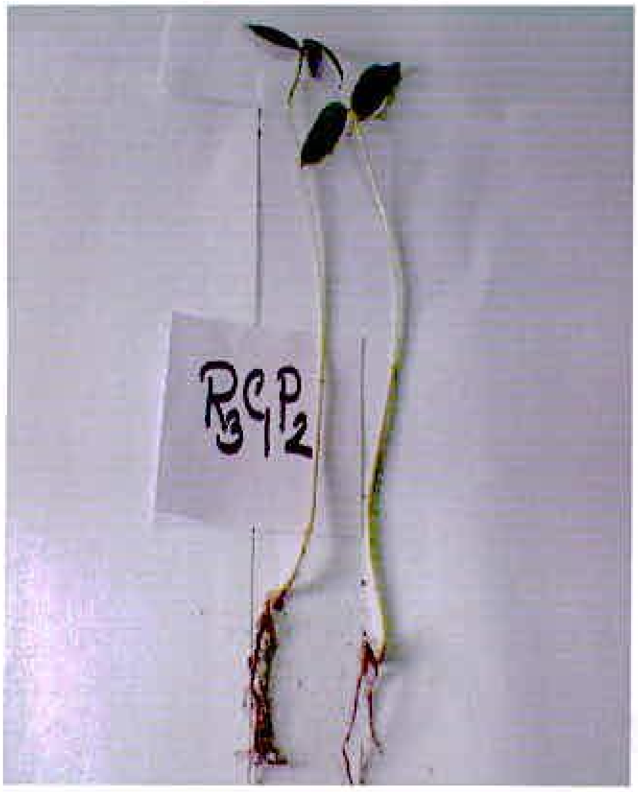
PLATES

Plate 1. The placing of seeds as per micropyle position

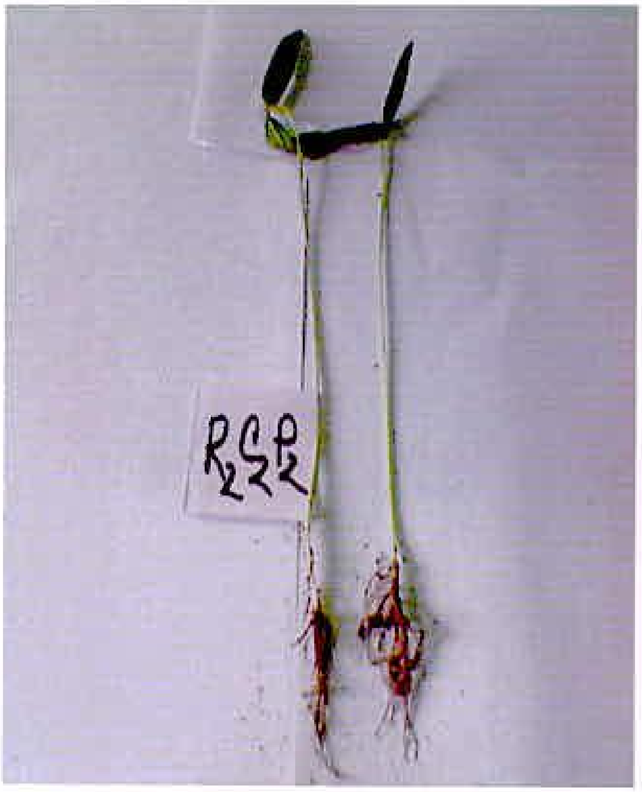
Plate 2. Field view of the experiment at a glance

Mungbean(C_1 P_1)

Blackgram(C_2P_1)



Mungbean (C_1 P_2)



Blackgram (C_2P_2)

Plate 3. Comparison of mungbean and blackgram seedlings at 15 DAS with different micropyle position

Mungbean(C_1 P_3)

Blackgram(C_2P_3)

Mungbean (C_1 P_4)

Blackgram (C_2P_4)

Plate 3. Continued

Plate 4. Mungbean seedlings growth with different micropyle position at 45 DAS

Plate 5. Blackgram seedlings growth with different micropyle position at 45 DAS