INFLUENCE OF HARVESTING TIME ON GROWTH AND YIELD OF MUNGBEAN VARIETIES

BY

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REGISTRATION NO. 00932

A Thesis

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

MASTER OF SCIENCE

IN

AGRONOMY

SEMESTER: JULY-DECEMBER, 2007

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CERTIFICATE

This is to certify that the thesis entitled, "**INFLUENCE OF HARVESTING TIME ON GROWTH AND YIELD OF MUNGBEAN VARIETIES**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE IN AGRONOMY,** embodies the result of a piece of bona fide research work carried out by **Sumit Ghosh**, Registration No. 00932 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 ADORED PARENTS

LISI OF ABBREVIATIONS

Abbreviated form	Full Meaning
%	Percent
^{0}C	Degree Celsius
BARI	Bangladesh Agricultural Research Institute
BINA	Bangladesh Institute of Nuclear Agriculture
cm	Centimeter
cv.	Cultivar
CV	Coefficient of Variance
DAA	Days After Anthesis
DAS	Days After Sowing
et al.	And others
g	Gram
ha	Hectare
HI	Harvest Index
LAI	Leaf Area Index
LSD	Least Significance Difference
m^2	Square Meter
Max.	Maximum
Min.	Minimum
mm	millimeter
No.	Number
NS	Non Significant
t	Ton(s)
Temp.	Temperature

ACKNOWLEDGEMENT

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

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

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

The author would like to express his heartiest appreciation, ever indebtedness and deep sense of gratitude to his co-supervisor Professor ***Dr. Prasanta C. Bhowmik,*** *Department of Plant, Soil, and Insect Sciences, University of Massachusetts, Amherst, USA, for his utmost cooperation, constructive suggestion to conduct the research work as well as preparation of the manuscript of the thesis.*

The author wishes to express his sincere respect and profound appreciation to the departmental Chairman Professor ***Dr. Parimal Kanti Biswas and other teachers*** *for their valuable teaching and providing the facilities to conduct the experiment and sympathetic consideration in connection with the study.*

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

The author feels proud to express his deepest and endless gratitude to all of his course mates specially Tomal, Sumona, Kanok and Samrat to cooperate and help him during taking data from the field and to take care of his experimental plot time to time. Very special thanks to Iqbal to ascending his thesis paper properly and to allow him to use his computer during the critical situation. The author also thanks Shuvo to help me to prepare the manuscript of the thesis.

Finally, the author is very much grateful to his beloved father Mr. Haripada Ghosh and mother Mrs. Shila Rani Ghosh for their sacrifice, inspiration, encouragement, endless love and continuous blessing for educating him to the postgraduate level.

May God protect them all.

December, 2007

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INFLUENCE OF HARVESTING TIME ON GROWTH AND YIELD OF MUNGBEAN VARIETIES

ABSTRACT

An experiment was conducted at the Agronomy Field, Sher-e-Bangla Agricultural University, Dhaka from March 2007 to July 2007 to observe the influence of harvesting time on growth and yield of mungbean varieties. The treatments were five harvesting times viz. 15, 20, 25, 30 and 35 days after anthesis (DAA) and two mungbean (*Vigna radiata*) varieties viz. BARI mung 6 and Sona mung. The purpose of this experiment was to determine appropriate planting time of summer mungbean in the cropping pattern after identifying the best harvesting time. The varieties behaved differently at different harvesting dates. Delayed harvesting increased the yield of BARI mung 6 but reduced the yield of Sona mung. The highest seed yield (1.66 t ha^{-1}) was obtained from BARI mung 6 harvested at 35 DAA that was similar at 30 DAA (1.63 t ha^{-1}), 20 DAA (1.42 t ha^{-1}) and 25 DAA (1.41 t ha^{-1}) of the same variety. The lowest seed yield (0.57 t ha^{-1}) was obtained from Sona mung harvested at 15 DAA and 35 DAA. The higher yield might be due to better yield contributing character of the two varieties harvested at above mentioned maturity period.

CHAPTER 1

INTRODUCTION

Pulse is a common item in the daily diet of the people of Bangladesh. Pulses have been considered poor men's meat since they are the source of protein for the underprivileged people who can not afford animal protein. It is taken mostly in the form of soup. 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. 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). Grain legumes are believed to add 20-60 kg N ha^{-1} to the succeeding crop (Kumar *et al.*, 1998).

The major cropping pattern in Bangladesh consists of two major crops of rice (i.e. winter rice-fellow-summer rice) covering 1.8 million ha (Hamid *et al.*, 2003). In Bangladesh, more than 75% of the total cropping area is occupied by rice where pulse crop covers only 2.8% of the total cropping area. Mungbean (*Vigna radiata* L. Wilezck) is one of the important pulse crops of Bangladesh. Among the pulse crops the largest area is covered by lentil (40.17%) and mungbean is grown in only 6.34% area. The area under mungbean cultivation is gradually decreasing. In the year 2002-2003 the area under mungbean cultivation was 109 thousand acres that declined to 60 thousand acres in the year 2004-2005 (BBS, 2005). The total production of mungbean in Bangladesh from the year 2001-2002 to 2005-2006 was 31, 30, 30, 18 and 17 thousand tones respectively. In these years the total production of mungbean in this country decreased by 3% to 40% (BBS, 2006). In Bangladesh most of the mungbean area (~65%) is located in the southern part of the country where mungbean is fitted in T.aman rice – mungbean - fallow or Aus rice - T.aman rice – mungbean cropping system (Haque *et al.*, 2002). Pulses contribute about 2% to the total food grain production in Bangladesh.

Summer pulses are not widely grown in Bangladesh. In the level arable land, wheat and Boro rice crops do not leave much scope for the expansion of pulses, particularly where irrigation is possible. This leaves only the Aus season (spring rice crop) as a possibility for incorporating the pulses and thus making a breakthrough in their acreage and production. There is a definite gap in the Aus season which can be filled with summer pulses, mungbean and blackgram. In order to explore the potentials and possibilities of expansion in the acreage and production of mungbean, it is essential to know the performance of mungbean related cropping patterns. Mungbean is a short duration crop. A large area remains fallow in the Fallow - T. Aus / T. Aman – Rabi cropping pattern in the south – western region. The fallow period can be utilized by short duration improved mungbean varieties without disturbing the existing cropping pattern. Advantages will be increased income for farmers and enhancing soil fertility. Mungbean production in Asia has increased substantially in the past 20 years. In Bangladesh 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 same period, area under mungbean has doubled, from 5.3% (in all pulses) 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 (Weinberger, 2003). However, despite the impressive growth of overall production, increase in productivity has actually been rather low. Between 1972 and 2002, average annual yield increases 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 to 12,856 Taka/ha. In comparison, the profitability of Boro rice was only 6,424 Taka (1991 data) (Weinberger *et al.*, 2003)

It is recognized that pulses offer the most practical means of solving protein malnutrition in Bangladesh but there is an acute shortage of grain legumes in relation to its requirements, because the yield of legumes in farmer's field is usually less than 1 t ha^{-1} against the potential yield of 2 to 4 t ha^{-1} (Ramakrishna *et al.*, 2000). Low yields of grain legumes, including mungbean make the crop less competitive with cereals and high value crops (Saha *et al.*, 2002). To enhance the yield, Bangladesh Agricultural Research Institute (BARI), Bangladesh Institute of Nuclear Agriculture (BINA), Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) developed 14 mungbean varieties with high yield potentials in recent years. These varieties are resistant to both yellow mosaic virus (YMV) and *Cercospora* leaf spot (CLS) diseases, and can produce 35 to 60% higher yield than local varieties (Afzal *et al.*, 1998).

There are two major types of mungbean: 1. *aureus*, the yellow or golden gram (Sona mung), which has pale foliage, reflexed pods and yellow seed, is low in seed production, pods have a tendency to shatter; 2. *typica*, the green gram, which has green seeds, bearing is excellent, uniform in maturity, has low tendency to shatter and is grown mostly for grain. Among the pulses, mungbean is the best in nutritional value having 51% carbohydrate, 26% protein, 4% mineral and 3% vitamins (Gowda and Kaul, 1982). It is an excellent source of digestible protein.

Mungbean is a short duration crop, maturing in 55 to 70 days. Since it is short duration crop, it can fit well in a wide range of cropping pattern. Hence, the time of harvest of the preceding crop has a large bearing on the planting time of mungbean (Hamid *et al.*, 2003). Among the environmental factors, excess rainfall at the time of reproductive period causes heavy loss of both seed yield and seed quality of mungbean (Williams *et al.*, 1995). In Bangladesh, mungbean is generally sown from mid August to mid September and harvested between mid November to mid December (BBS, 2005). So, it can be introduced in the north western high lands as a new crop by replacing the fallow land preceding autumn rice. It is also possible to plant summer pulses without any tillage. Thus summer season offers a good scope of producing mungbean in fallow lands as sole crop or as mix crop with millet at any time after mid February.

The existing summer mungbean cultivars are predominately of asynchronous type in which flowering continues for a period of several weeks even when the plants are green and healthy and the plants contain flowers, immature pods and mature pods at the same time. Pod setting continues for some period and as a result all pods do not mature at a time. So the pods and thereby the seeds differ in their degree of maturity at harvest. The pod maturity extends over a long period of time and the pods have a tendency to shatter when these remain in the plant for a long time after maturity. The seed may be damaged in the plant itself during the rainy season due to high humidity, if harvesting is delayed.

There are two ways to harvest mungbean. In the synchronous type all the pods mature around the same time, harvesting is done when most of the pods have turned black. The plants are pulled out or cut at the ground level with a sickle. Generally two to three times of hand picking are done in harvesting asynchronous type of mungbean. In some areas pod picking is done once or twice and the remaining green plants are either grazed by cattle or cut for fodder or hay.

Asynchrony in pod maturity is a great problem in mungbean cultivation. The method of pod harvesting being practiced by the farmers vary from locality to locality. The harvesting method plays a significant role in yield of the crop as well as quality of the seed. Therefore, it is a necessity to examine the effect of different harvesting time on the yield and quality of mungbeen seed. With this aim in view, an experiment was conducted with the objectives as-

i. to determine the effect of different harvesting time on the yield of mungbean

ii. to identify the best harvesting time for the synchronous and non synchronous mungbean varieties

iii. to evaluate yield variations between the local and modern variety cv. Sona mung and BARI mung 6

iv. to establish an appropriate planting time of summer mungbean in the cropping pattern after identifying the best harvesting time.

CHAPTER 2

REVIEW OF LITERATURE

Mungbean is an important pulse crop of global economic importance. Extensive research work on this crop has been done in several countries, especially in the South East Asia for the improvement of its yield and quality. In Bangladesh, little attention has so far been given for the improvement of mungbean. Recently, Bangladesh Agricultural Research Institute, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) and Bangladesh Institute of Nuclear Agriculture have started research on variety development and various agronomic management practices on the crop.

Limited information is available regarding method and time of mungbean harvesting for optimum seed yield and quality. In this chapter, an attempt has been made to review some available literature related to present study under two headings: influence of the time and method of harvesting and influence of variety on the yield of mungbean.

2.1 Influence of time and method of harvesting

Debnath (1998) in an experiment on yield and seed quality of summer mungbean with different harvesting methods observed that the crop characters like the number of pods/plant, pods/m^2, fertile pods/m^2, seeds/pod, 1000 seed weight, seed yield, harvest index and all the quality attributes i.e. germination percentage, seedling dry weight, vigor index, nitrogen and protein content were significantly affected by harvesting methods. In general, harvesting individual pods when turned black was found to be better in respect of quality as compared to the harvesting individual pods when turned brown. Harvesting of mature black pods showed better percentage of germination, seedling dry weight and vigor index, but harvesting of moderately immature pods (harvesting the bunch when at least one pod turned brown, harvesting plants when 50% pods turned black, harvesting when 50% bunches from top and 50% pods turned black, harvesting when 50% bunches from bottom and 50% pods turned black) gave higher percentage of nitrogen and protein contents.

Dharmalingam and Basu (1988) noticed that mungbean seed harvested at physiological maturity (25 days after flowering) had higher germination percentage than those harvested at pre-mature stage (20 days after flowering) or post physiological maturity (30 days after flowering) stages. They also reported that the seeds developed in the distal end (7^{th} to 12^{th} seed) were better in quality than those developed in the proximal end (1^{st} to 5^{th} seed) of the pedicel in respect of 100-seed weight, germination, field emergence and dry matter content. The proximal end of the pod contained hard seeds compared to distal end.

Dharmalingam and Basu (1989a) reported 1% hard seeds at 15 DAA and 22% beyond 25 DAA in mungbean cultivar CO-3. In another experiment, Dharmalingam and Basu (1989b) obtained the maximum fresh weight and dry weight of mungbean seed from the harvested pods when their color changed from green to greenish yellow at a seed moisture content of about 19%. They also reported that seed development continues up to 15 days after anthesis. The highest percentage of seed germination was noticed at the stage when the seeds attained the maximum fresh weight and dry weight.

Gowda and Kaul (1982) mentioned that many local cultivars were non synchronous, pod maturity extends over long periods; pods had a tendency to shatter when left on the plant for a long time. So two to three hand picking were required (sometimes up to 6 picking) to achieve maximum yield.

According to Harrington (1972), the seeds reached physiological maturity when their dry matter content attained maximum value.

Islam (1995) in an experiment on planting date and harvesting method of mungbean observed that picking ripe pod method gave all through higher seed yields than stem cutting and the difference was much higher in the early date of planting.

Islam (2004) in an experiment on seed size and harvesting method of mungbean observed that the highest seed yield was obtained from individual mature pod collection which was found to be better in respect of quality. He also noticed that BINA moog-5 with individual pod collection gave the highest seed yield and BARI moog-2 with stalk cutting method gave the lowest yield.

The assessment of the potential for increasing mungbean yield and seed quality by management practices should essentially involve harvesting method. Lassim *et al.* (1984) observed that field weathering caused reduction in seed yield and quality. Yield loss was caused due to reduction in seed weight and threshing percentage. They reported that the seed dry weight was 54, 53, 49 and 40 mg/seed from four harvesting time at weekly intervals starting from 58 days after sowing and the germination ability was 98, 94, 85 and 79 percent, respectively. Over ripe pods become detached from the plant. The yield and quality of seed decreased significantly with the successive delay in harvesting intervals. The pods, when over ripe got detached from the plants.

Synchrony in maturity was a significant problem for harvesting of mungbean seeds. Generally flowering of mungbean continues for a period of several weeks when the plants remain healthy. Mungbean plant may contain flowers, green pods and mature pods at the same time and hence, it required several pickings to complete harvest (Poehlman, 1991).

Saha (1987) observed that the physiological maturity of *Vigna mungo* seeds was attained 9 days after anthesis that was well ahead of full maturity of pods. Again 13 days after anthesis 100% seed germination occur when starch accumulation was initiated in the seeds. The results indicated that the storage reserves accumulated in the cotyledons were not essential for growth and development of the embryo rather it could supply nutrition to the embryo during germination.

Saha *et al.*, (2002) reported that irrespective of cultivars, mungbean seeds harvested in Kharif I was qualitatively better than Kharif II seed. More sunny hours prevailed during the reproductive phase because of low rainfall in the Kharif I season. Cultivar differences in seed growth indicated that BUmung 2 had faster growth rate than that of BARI mung 2 in both the seasons. Seed quality depended not only on the pattern of dry matter accumulation in seeds but also on the time of seed harvest. Development of maximum seed dry weight of BUmug 2 and BARI mung 2 at 17 DAA in Kharif I and 19 DAA in Kharif II indicated their physiological maturity. The germination of BUmung 2 was 100% in seed harvested between 13 to 17 DAA in Kharif I and 15 to 19 DAA in Kharif II season whereas in BARI mung 2, it was 19 DAA in Kharif I and 17 to 19 DAA in Kharif II season. Germination percentage was significantly higher in seeds harvested from the first flush of pods than those harvested at later dates. Seed germination percentage decreased progressively over the successive harvest. Irrespective of varieties, seeds harvested from the first flush of pods gave significantly higher vigor index that declined in successive harvest.

Sing and Sing (1979) reported that the yardbean and mungbean grown during kharif or summer season should be harvested at a stage when 90% of the pods become matured and dry. The same author also reported that slight delay in harvesting at shattering varieties of mungbean might cause complete crop failure. The pods of the shattering varieties of mangbean should be picked up immediately after the pod become black. As the pods of the summer and spring beans mature at a time when plants are still green, it should be better to pick up the mature pods at that time rather than harvesting by cutting the plant.

Sriwattanapongse *et al.* (1987) in their experiment with four harvesting methods of mungbean observed that picking of mature pod was a better method than harvesting by cutting the whole plant on different dates after full bloom stage both in case of yield and seed quality. However, the yield differences were observed to be small when the crop had more than 90% mature pods. Harvesting by cutting the whole plant thus seemed to be an alternative method for the farmers where there is a scarcity of labour.

Suryavanshi and Patil (1995) observed that some mungbean cultivars attained physiological maturity within 25 to 30 days after anthesis (DAA). The developing seeds of mungbean were capable for germination 10 DAA (mean 27% germination), at that time the seed contained maximum moisture and thereafter it was reduced progressively as the period of seed development advanced from anthesis. Hard seeds appeared 15 to 20 DAA and the hard seeds (%) increased gradually with the period of retention of seed on mother plant.

Thanomsub *et al.* (1986a) in an experiment on harvesting methods with stem cutting on 55, 65 and 75 days after planting and picking ripe pods of mungbean once on 55 day, twice on 55 and 65 days and thrice on 55, 65 and 75 days after planting. They observed that stem cutting gave low cost and higher yield than picking ripe pods. They also found that the method of picking ripe pods gave higher germination percentage and vigour index of seeds than those of stem cutting.

Thanomsub *et al.* (1986b) in another experiment with different harvesting time viz. 2, 4, 6, 8, 10, 12, 14, 16 and 18 days after flowering observed that moisture contents of mungbean pods on 14 days and onwards after flowering was lower

(30%) and seed germination at 10 to 18 days after flowering was higher (90%). Seed vigour of the pod was the highest when harvested on 14 days after flowering. The pod color changed from green to yellow and yellow to black in 11 and 14 days after flowering, respectively.

Thanomsub *et al.* (1987) did not find any significant difference in yield or seed germination colleted from harvesting the first pods after ripening on 17 and 24 days. The data, however, indicated that seedling vigour was higher at early harvest than at last harvest of the ripened pods.

In an experiment on harvesting time of mungbean starting from 15 to 39 days after peak flowering at 4 days interval Wachasataya (1990), observed that the highest yield was obtained from harvesting 39 days after peak flowering. He also noted that delay in harvest declined the seed vigour. The highest seed quality was obtained from the harvest 15 to 19 days after peak flowering.

Bochniarz *et al.* (1987) from a field experiment of fababean cv. Nadwislarsv with four harvesting dates when 5 to 10, 40 to 50, 80 to 85 or 95 to 100% of pods become black, obtained the average seed yields of 3.54 to 3.57, 3.83 to 3.96, 3.79 to 3.92 and 3.74 t/ha., respectively. They also reported that the seeds attained full germination capacity even at the early harvesting stage when 5 to 10% pods become black.

Chuntarachurd *et al.* (1984) in an investigation on the yield and quality in yardlong bean seed during 1980 at 2 days intervals from 12 to 20 days after pollination observed that seed quality in respect of germination percentage (93 to 98%) at each development stage did not significantly differ during the period but seed harvested at 16 days after pollination produced the highest seed quality. However, the seed yield was not found to differ significantly during the periods from 12 to 20 days after pollination.

Demir *et al.* (1996), for finding out the relationship between reduction in seed moisture content during maturation and changes in seed quality in snapbean (*Phaseolus vulgaris*) cv. 4F-89, observed that the seed quality parameters like germination and emergence rates, seedling length and seed dry matter attained the maximum value when seed moisture content was about 45 to 50% although a stage of seed moisture content of about 14% was found to be the optimum time for harvesting of seeds. Any delay after that result in deterioration of physiological ageing and seed loss through shedding.

Gorecki (1986) reported that in various legumes the vigor of seed increased until the end of ripening. The seed vigor was also dependent on harvesting method. He observed that seeds from middle and lower nodes generally showed more vigour and greater viability than those from upper nodes. High density seeds were the most vigorous and were less affected by storage condition than low density seeds.

Kalavathi and Ramaswamy (1988), in an experiment of harvesting of soybean cv. Co. 1, observed that the crop harvested at 55 days after 50% flowering gave the highest values for the number of pods, seeds/plant, seed yield/plant and shelling percentage than the crop harvested on other dates of 5 day intervals which was started 40 to 60 days from 50% flowering.

Kashyap and Punia (1995) reported in a field trial that the physiological maturity in pegion pea was attained during 50 days after flowering when seed moisture content was the lowest, seed dry matter content was the highest and seed germination was 92.3%.

In a pod and seed development study with three cowpea genotypes cv.C-152, S-488 and Tox-183690E, Ramaiah *et al.* (1994) observed that the number of days to 50% flowering and to physiological maturity was the lowest in S-488 and that in other two cultivars was similar but higher. They also reported that the seed germination and vigour index were highest at 31 days after anthesis in S-488.

Tu *et al.* (1988) observed that the seed quality in navybean was dependent on the weathering elements. The early maturing cultivars usually gave better quality seed but excessive rainfall deteriorated the seed quality of bean due to fungal infestation. They found that selection of proper variety along with harvesting at right time were the main factors for obtaining better quality seed with higher productivity.

Zade *et al.* (1993) reported that the seed development of *Vigna umbellata* cv. RBL-1 during Kharif season continued up to 19 days after anthesis. The physiological maturity was attained by 22 days after anthesis when seed weight, germination percentage and seed vigour were high. At physiological maturity stage the leaves and pods turned yellow, while seeds became whitish yellow in colour.

2.2 Varietal performance for yield and seed quality

Aguliar and Villarea (1989) observed that plant height, 1000-seed weight and harvest index of mungbean were 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 produced significantly heavier seeds than did Pagasa and M 350. The variety M 350 exhibited the height harvest index which was significantly higher than all other entries.

BARI (1982) reported that strain 7706 gave significantly higher yield than 7704. BINA (1998) reported that MC-18 (BINA moog-5) produced higher seed yield over BINA mung-2. Field duration of BINA mung -5 was about 78 days and 82 days for BINA mung -2.

Dhillon and Nainautee (1989) studied five varieties of mungbean viz. H-70-16, K-851, MH-309, T-44 and 12-333 for their total protein contents. The protein ranged from 22.0 to 26.6 % among studied varieties. The polyacrylamide gel electrophrosis of total protein showed that cv. K-851 differed from others, showing the absence of a few proteins of high molecular weight.

Farrag (1995) reported from a field trial with 23 mungbean accession the seed yield, number of pods plant^{-1}, number of seeds pod^{-1} and 1000-seed weight varied among the tested accessions. He also observed that some cultivars like VC 2711 A, KPSI and UTT performed well under late sown condition. Varital differences in yield do exist under similar field condition. This indicates that all varieties do not perform equally under similar condition.

Including 32 accessions of mungbean with three sowing dates, Farghali and Hossain (1995) concluded that V6017 had the highest seed yield. They also recorded that the accessions V6017 and UTI had significantly higher plant height, number of seeds pod^{-1}, pod length and number of pods plant^{-1} than that of other accessions.

Gupta and Kapoor (1980) working with high yielding varieties of *Vigna radiata* observed that there were some differences in the protein content among varieties of the same species.

Haque *et al*. (2002) reported that there was significant positive correlation between the number of pods per plant and yield per plant.

Cultivars played a key role in increasing yield since the response to management practices was mainly decided by the genetic potential. The yields of mungbean cultivars Mubarik, Kanti and Binamoog-1 ranged from 0.8 to 1.0, 1.0 to 1.2 and 0.8 to 1.0 t/ha, respectively (ICRISAT, 1991).

In an experiment under Bangladesh condition with four varieties of mungbean Islam (1983) reported the highest number of branches/plants given by the variety Faridpur-1 followed by Mubarik, BM-7715 and BM-7704. The maximum number of pod/plant was produced by Mubarik followed by BM-7704, BM-7715 and Faridpur-1. He identified that pods per plant were a useful agronomic character contributing to higher yield in mungbean.

Jain *et al.* (1988) reported from an experiment with four mungbean varieties that 'ML 131' produced the highest seed yield as compared with other varieties. In another study Katial and Shah (1998) studied 19 cultivars of *Vigna radiata* and found that 1000 seed weight was highest in Gajaral-2 (39g) and lowest in ML 131 (24g). Seed weight was highest in PIMS-1 (0.89 t/ha) and lowest in 11/99 (0.52 t/ha). Similar yield variation of different mungbean varieties were also reported by Masood and Meena (1986) and Pahlwan and Hossain (1983).

Patil *et al.* (2003) studied genetic diversity among 36 genotypes of mungbean, consisting of both released varieties and advance lines pre selected for tolerance to different stress conditions. The genotypes were grown in three distinct environments with recommended dose of fertilizer + plant protection measures (E_1), only recommended dose of fertilizers (E_2), and fertilizer- and pesticide- free conditions (E_3) in Dharwad, Karnataka, India. Observations were recorded for plant height, branches plant^{-1}, cluster plant^{-1}, pods plant^{-1}, seeds pod^{-1}, 100- seed weight, biological yield, harvest index, days of first flowering, days to 50% flowering, days to initiation of pod maturity, days to 75% pod maturity, powdery mildew at 45 days, and mungbean yellow mosaic virus. The simultaneous test for significance for pooled effect of all the characters in all the test environments showed significant differences among the genotypes, indicating the presence of considerable genetic variability for different characters. Among the genotypes, K 851, LM 608 and LM 5-12 were the most genetically diverse in all the 3 environments.

Pookpakdi *et al.* (1980) working with five cultivars of mungbean viz. CES 87, CES 14, Pagasa, Hong 1 and local Thai variety with 32 plants/m^2 reported that the highest yield of CES 14 was due to highest number of seeds pod^{-1} and the low yield of local variety resulted from the lowest number of pods $plant^{-1}$. Among the varieties, Pagasa produced the lowest amount of total dry weight because the variety gave the lowest shoot dry weight.

Rajat *et al.* (1978) found that the highest grain yield was produced by 'PS 7' followed by 'PS 16' and 'PS 10'. The higher yield was due to the results of higher number of pods $plants^{-1}$ and 1000- grain weight.

Result obtained by Rosario *et al.* (1980) revealed high protein content in the proximate composition of 18 mungbean varieties. The minor difference observed by them could be attributed to varietal influence. The range of variation for the different nutrients computed on a 14% moisture basis was from 22.9 to 25.0 % of protein.

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 that of the two other cultivars.

The experimental evidence presented above revealed that asynchronous type of mungbean and other legume crops continued flowering over a period of several weeks, plants contains mature pods, green pods and flower at the same time and the yield of mungbean was also influenced by variety. Any delayed in harvesting of mature pods from the optimum stage of maturity leads to shattering of seeds. Moreover, excessive rainfall at maturity period also reduced the seed quality. Therefore, it was necessary to pick up the pods at a suitable time for obtaining better yield and quality of seed with minimum cost. It was thus important to examine the effect of different harvesting time on the yield and yield attributes as well as on seed quality attributes of mungbean.

CHAPTER 3

MATERIALS AND METHODS

The experiment was conducted to study the effect of harvesting time on the yield and seed quality of summer mungbean. The materials and methodology followed in the investigation have been presented in details in this chapter.

3.1 Site

The experiment was conducted at the Agronomy Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from last week of March to mid June 2007. The experimental area was situated at 23°41′ N latitude and 90°22′ E longitude at an altitude of 8.5 meter above the sea level.

3.2 Soil

The experimental land was medium high belonging to the "The Modhupur Tract", AEZ-28. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH ranged from 5.4-5.6 and had organic carbon 0.82%. The experimental area was flat having available irrigation and drainage system and above flood level. The prevailing weather data during the period of the study on precipitation and temperature have been presented in the Appendex-I.

3.3 Materials

The seeds of BARI mung 6, a modern mungbean variety and Sona mung, a local variety were used as experimental material. BARI mung 6 was developed by Bangladesh Agricultural Research Institute (Hussain *et al.*, 2006) characterized as of 40-45 cm in height, life cycle lasts for 55-58 days and synchronous type. The plants are erect, stiff and less branched. Each plant contains 15-20 pods. Each pod is approximately 10 cm. long and contains 8-10 seeds. Seeds are green in colour and drum shaped. On the other hand, the plants of the local variety are 70-80 cm. in height, life cycle lasts for 75-80 days and asynchronous type. The plants are erect and branched. Each plants contains 25-30 pods and the pods are around 6-7 cm. long. Each pod contains 10-12 seeds. The seeds are small and light green in colour. The seed yield of BARI mung 6 ranges from 1.5 t ha^{-1}, while the local variety gives yield around 1 t ha^{-1}.

3.4 Treatments

The aim of this experiment was to increase the yield and improve seed quality of summer mungbean by using several harvesting time based on stages of maturity of the crop. As such, two sets of treatments were included in the experiment which were as follows:

A. Main Plot (Variety): 2

I.BARI *mung* 6 (MV)- V_1

II.Sona mung (Local)- V_2

B. Sub Plot (Harvesting time): 5

I. *Picking of pods at 15* DAA - H_1

II. Picking of pods at 20 DAA - H_2

III. Picking of pods at 25 DAA - H_3

IV. Picking of pods at 30 DAA- H_4

V. Picking of pods at 35 DAA - H_5

The experiment comprised of 30 plots with 10 treatments and 3 replications.

3.5 Experimental design

The experiment was laid out in a split-plot design with three replications where variety is assigned as the main plot and harvesting time as the sub plot. The unit plot size was 4.0m x 2.4m. The blocks and unit plots were separated by 1m and 0.5m spacing respectively.

3.6 Land preparation

The land was opened with a disc harrow on 20 March 2007 and then ploughed with a rotary plough twice followed by laddering to achieve a medium tilth that required for the crop under consideration.

3.7 Manuring

During final land preparation, each unit plot was manured with 45, 100 and 55 kg/ha of Urea, TSP and MP respectively.

3.8 Seed sowing

The seeds (BARI mung 6 and Sona mung having 80% and 100% germination respectively) were sown by hand in 30 cm apart lines continuously at about 3 cm depth at the rate of 58 g/plot (BARI mung 6) and 50 g/plot (Sona mung) on March 27, 2007.

3.9 Intercultural operations

The plots were weeded twice on 15 and 30 days after sowing and thinning was done simultaneously to maintain a uniform plant stand. The fungicide Cupravit 50 WP (Copper oxychloride) was sprayed @ 80g/5 decimal during the later stage of crop to control fungal diseases.

3.10 Harvesting

The crop was harvested as per experimental specification. The first harvesting of BARI mung 6 was done on 16 May and the others on 21 May, 26 May, 31 May and 5 May respectively. The harvesting of Sona mung was started on 24 May and the following harvesting was done on 29 May, 3 June, 8 June and 13 June respectively. The harvesting was done by picking pods from central 4 rows for avoiding the boarder effects. The collected pods were sun dried, threshed and weighed to a control moisture level. The seed weight of two harvesting per plot was added and converted per hectare basis.

3.11 Data collection

At harvest ten sample plants were collected for recoding data on plant parameters. The seed and straw yield were taken from central four rows of each plot. After threshing, cleaning and drying the seeds were weighed. Data were collected on:

A. Growth data

1. Plant height at 15 days interval
2. Leaf area plant^{-1} at 15 days interval
3. Dry weigh meter^{-2} at 15 days interval
4. Days to first flowering

B. Yield and other crop characters data-

1. Number of primary branches plants^{-1}
2. Number of pods branch^{-1}
3. Length of pod (cm)
4. Number of seeds pod^{-1}
5. Weight of 1000 seeds (g)

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

7. Straw yield (t ha^{-1})

8. Harvest index (%)

9. Shelling percentage

C. Post harvest data

1. Germination percentage
2. Vigority

The detailed outline of data collection procedure is given below:

3.11.1 Plant height (cm)

The height of ten randomly pre-selected plants from each plot was measured from the ground level to the tip of the leaf of the main shoot at 15 days interval till harvest.

3.11.2 Dry weight (g m^{-2})

Five plants were randomly selected at 15 DAS to harvest and different plant parts were separated. After that the separated plant parts were oven dried and weighed.

3.11.3 Branches $plant^{-1}$ (No.)

Total number of primary branches from ten plants of each plot was counted and the mean value was determined.

3.11.4 Pods $plant^{-1}$ (No.)

The total numbers of pods of ten selected plants per plot at harvest were counted and the average values were recorded.

3.11.5 Seeds pod^{-1} (No.)

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

3.11.6 1000-seed weight (g)

A sub sample of seeds was taken from each plot from which 1000 seeds were counted manually. One thousand seeds thus counted were weighed at 12% moisture level in a digital balance to obtain 1000-seed weight (g).

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

The pods from harvested area were harvested as per experimental treatments and were threshed. Seeds were cleaned and properly dried under sun. Then seed yield plot^{-1} was recorded at 12% moisture level and converted into t ha^{-1}.

3.11.8 Shelling percentage

The shells of the harvested pods from each plot were collected and dried under the sun. After that the weight of the shells were recorded from which shelling percentage was calculated as –

$$\text{Shelling percentage} = \frac{\text{Weight of shell}}{\text{Weight of grain} + \text{Weight of shell}} \times 100$$

3.11.9 Harvest index was determined as follows

$$\text{Harvest index (\%)} = \frac{\text{Seed yield (t ha}^{-1}\text{)}}{\text{Biological yield (t ha}^{-1}\text{)}} \times 100$$

Where, Biological yield = Grain yield + Straw yield

= Crop dry weight.

3.12 Seed quality

The post harvest performances of the seeds collected from each plot were studied for germination and vigor index.

3.12.1 Germination

The 25 seeds from each treatment were randomly selected and placed on a wet blotting paper in Petri dish with three replications. The germination was counted from starting 24 hour to 72 hour after placement. The germination percentage was calculated using the following formula (Agrawal, 1982).

$$\text{Germination (\%)} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds set for germination}} \times 100$$

3.12.2 Vigor index

The daily record of seed germination was kept starting from 24 hours up to 72 hours after placement of seeds for germination. Vigor index was calculated by the following formula (Agrawal, 1991).

$$\text{Vigor index} = \frac{\text{No. of seeds germinated at first count}}{\text{Days required to first count}} + \frac{\text{No. of seeds germinated at last count}}{\text{Days required to last count}}$$

3.13 Statistical analysis

The collected data were statistically analyzed following the IRRISTAT for windows software and the means values were adjudged by least significant difference (LSD) test at 5% level of significance.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Crop growth characters

4.1.1 Plant height at different days after sowing

4.1.1.1 Effect of variety

Plant height of mungbean was significantly influenced by variety at 15, 30, and 45 days after sowing (DAS) and at harvest (Appendix II and Table 1).

At 15 DAS, the tallest plant (11.14 cm) was obtained from BARI mung 6 (V_1) and the shortest plant (6.97 cm) from Sona mung (V_2). The tallest plant height (31.52 cm) was recorded at 30 DAS from BARI mung 6 followed by Sona mung. Similar trend of plant height was observed at 45 DAS. But at harvest, the tallest plant (78.11 cm) was obtained from Sona mung and the shortest height (65.91 cm) was obtained from BARI mung 6. Plant height of BARI mung 6 increase over Sona mung was 52.82, 44.32 and 13.83% at 15, 30 and 45 DAS, respectively. At harvest 18.51% increased plant height of Sona mung was observed over BARI mung 6. These results were in agreement with the findings of Aguilar and Villarea (1989) and Thakuria and Saharia (1990) who reported that varieties differ significantly in respect of plant height, 1000 seed weight and seed yield of mungbean.

4.1.1.2 Effect of harvesting time

Harvesting time had no significant effect on plant height at 15, 30 and 45 DAS (Appendix II and Table 1). At harvest the tallest plant (73.86 cm) was obtained from 35 DAA, which was statistically similar to plants 25 DAA (73.33 cm) and 30 DAA (73.25 cm). The shortest plant (68.31 cm) was obtained from 20 DAA which was statistically similar to plant 15 DAA. Debnath (1998) reported that the number of plants/m^2, plant height, number of branches/plant, number of sterile pods/m^2 and crop dry weight of mungbean were not affected due to harvesting method.

Table 1. Influence of variety, harvesting time and their interaction on plant height (cm) of mung bean

Treatments	Days after sowing (DAS)			
	15	**30**	**45**	**At harvest**
Variety				
V_1	11.14	31.52	58.66	65.91
V_2	6.97	21.84	51.53	78.11
$LSD_{0.05}$	0.687	1.900	2.690	3.100
Harvesting time				
H_1	8.70	26.28	54.97	71.28
H_2	9.08	26.24	52.62	68.31
H_3	9.06	26.44	55.42	73.33
H_4	8.84	27.13	56.04	73.25
H_5	9.61	27.33	56.44	73.86
$LSD_{0.05}$	NS	NS	NS	4.910
Interaction of variety and harvesting time				
V_1H_1	10.52	31.61	58.17	64.43
V_1H_2	11.28	30.5	52.52	62.95
V_1H_3	11.56	32.08	58.37	68.93
V_1H_4	10.88	31.15	61.42	66.37
V_1H_5	11.48	32.28	62.81	66.87
V_2H_1	6.89	20.96	51.76	78.13
V_2H_2	6.88	21.98	52.72	73.67
V_2H_3	6.56	20.8	52.47	77.73
V_2H_4	6.79	23.11	50.65	80.13
V_2H_5	7.73	22.38	50.07	80.87
$LSD_{0.05}$	1.520	4.250	6.020	6.940
CV (%)	9.80	9.20	6.31	5.57

V_1= BARI mung 6, V_2= Sona mung, H_1= Picking of pods at 15 days after anthesis (DAA), H_2= Picking of pods at 20 DAA, H_3= Picking of pods at 25 DAA, H_4= Picking of pods at 30 DAA, H_5= Picking of pods at 35 DAA.
NS= Not significant

4.1.1.3 Interaction effect of variety and harvesting time

There was significant variation in plant height observed due to interaction of variety and harvesting time at 15, 30, and 45 DAS, and at harvest (Appendix II and Table 1).

At 15 DAS, the tollest plant (11.56 cm) was found from treatment V_1H_3 (BARI mung 6 harvesting at 25 DAA) followed by treatment V_1H_5, V_1H_2, V_1H_4 and V_1H_1 (BARI mung 6 harvesting at 35, 20, 30 and 15 DAA respectively) which were statistically similar. The shortest plant (6.56 cm) was recorded in treatment V_2H_3 which was statistically similar with treatment V_2H_1, V_2H_2, V_2H_4 and V_2H_5 (Sona mung harvesting at 15, 20, 30 and 35 DAA respectively). Similar trend of plant height was observed at 30 DAS. At 45 DAS the tallest plant (62.81 cm) was recorded in treatment V_1H_5 (BARI mung-6 harvesting at 35 DAA) followed by the treatment V_1H_4, V_1H_3 and V_1H_1. The shortest plant height (50.07 cm) was obtained from the treatment V_2H_5 (Sona mung harvesting at 35 DAA) followed by other harvesting date of Sona mung. At harvest, the tallest plant (80.87 cm) was recorded in treatment V_2H_5 (Sona mung harvesting at 35 DAA). Similar plant height was obtained from the same variety when harvested at 30, 25 and 15 DAA. The shortest plant height (62.95 cm) was recorded from treatment V_1H_2 (BARI mung 6 harvesting at 20 DAA) followed the treatment V_1H_1, V_1H_4, V_1H_5 and V_1H_3. From the findings of the experimental results it observed that irrespective of harvesting time BARI mung 6 plants were taller from 15 DAS to 45 DAS but Sona mung showed significantly highest plant height at harvest.

4.1.2 Leaf area index (LAI) at different days after sowing

The leaf area of the plant is one of the major determinants of its growth. The net dry matter production by a plant in an interval time is more dependent on the size of its total assimilating system than on the photosynthetic rate of a single leaf which is just one of the parameters determining the total photosynthetic production of the crop.

4.1.2.1 Effect of variety

Leaf area index (LAI) of mungbean was significantly influenced by the treatment of variety at 15 DAS and 30 DAS but it was found non-significant at 45 DAS (Appendix III).

At 15 DAS, significantly higher (0.23) LAI was recorded in BARI mung 6 and lower (0.16) in Sona mung. Significantly maximum (3.91) and minimum (2.12) LAI at 30 DAS was observed from BARI mung-6 and Sona mung, respectively. No significant difference was found in LAI at 45 DAS in both varieties though the higher (6.16) LAI was recorded in Sona mung followed by BARI mung 6 which was statistically similar (Figure1).

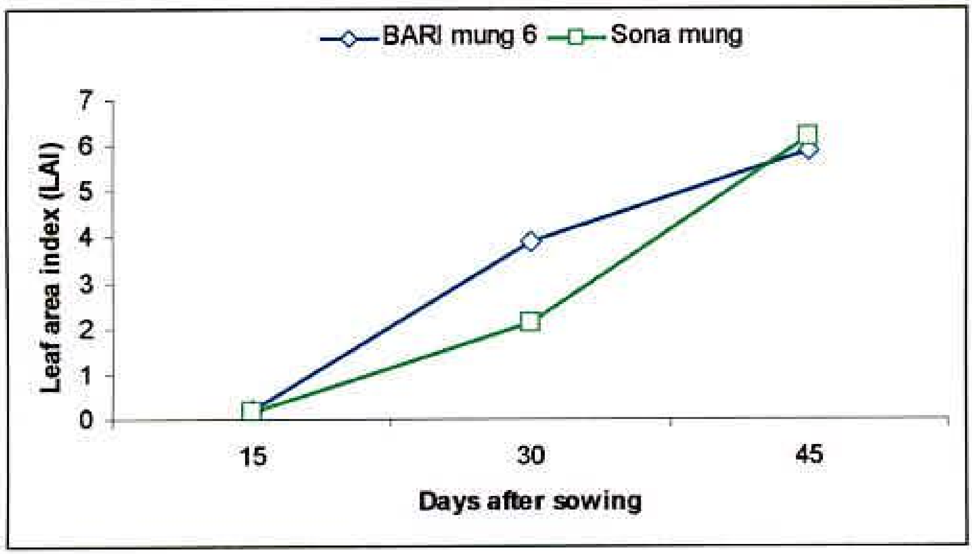


Figure 1. Influence of variety on leaf area index of mungbean at different DAS ($LSD_{0.05}$ at 15 and 30 DAS=0.043 and 0.477 respectively)

4.1.2.2 Effect of harvesting time

Leaf area index was not significantly influenced by harvesting time at 15, 30 and 45 DAS (Appendix III).

The diagrammatic representation of the data on leaf area index is presented in Figure 2. At 15 DAS the maximum LAI (0.21) was obtained from the harvest 20 DAA followed by harvesting 15 DAA, harvesting 25 DAA, harvesting 30 DAA and harvesting 35 DAA. There were no significant differences. AT 30 DAS, maximum LAI was recorded in treatment H_5 (harvesting 35 DAA) followed by H_1 (harvesting 15 DAA), H_2 (harvesting 20 DAA), H_3 (harvesting 25 DAA) and H_4 (harvesting 30 DAA) which were statistically similar. Similar trend of increased LAI was observed at 45 DAS.

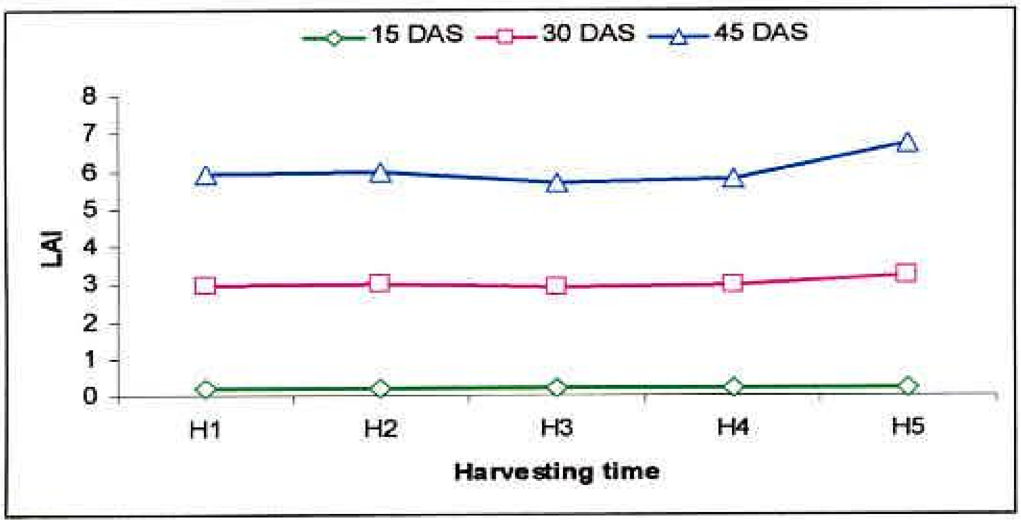


Figure 2. Influence of harvesting time on leaf area index (LAI) at different harvesting time ($LSD_{0.05}$ at 15 and 30 DAS=0.043 and 0.477 respectively)

4.1.2.3 Interaction effect of variety and harvesting time on leaf area index (LAI)

Leaf area index of mungbean was significantly influenced by the interaction between variety and harvesting time at 15 DAS and 30 DAS but not different at 45 DAS (Appendix III and Table 2).

At 15 DAS, maximum LAI (0.25) was obtained in treatment V_1H_5 and V_1H_3 (BARI mung 6 harvesting at 35 and 25 DAA) followed by treatment V_1H_2 (BARI mung 6 harvesting at 20 DAA), V_1H_1 (BARI mung 6 harvesting at 15 DAA), V_1H_4 (BARI mung 6 harvesting at 30DAA) and V_2H_4 (Sona mung harvesting at 30 DAA), V_2H_2 (Sona mung harvesting at 20 DAA),V_2H_1(Sona mung harvesting at 15 DAA) and V_2H_5(Sona mung harvesting at 35 DAA) which were statistically similar. The minimum LAI (0.10) was recorded in treatment V_2H_3 (Sona mung harvesting at 25 DAA). Irrespective of harvesting time, the higher LAI was observed in BARI mung 6 compared to Sona mung at 30 DAS. At 45 DAS, the trend of LAI was some what changed in which no significant differences were observed among the treatments. The maximum LAI was produced by the treatment V_1H_5 (BARI mung 6 harvesting at 35 DAA) at this stage. At later stages of growth, the local variety (Sona mung) showed severe susceptibility to Mungbean yellow mosaic. In contrast, BARI mung 6 showed excellent tolerance against this disease. The results agreed with the findings of Patil *et al.* (2003) who found significant variations among genotypes in disease susceptibility at different environment.

Table 2. Interaction effect of variety and harvesting time on leaf area index of mungbean at different days after sowing

Treatments	Days after sowing (DAS)		
	15	**30**	**45**
V_1H_1	0.21	4.00	5.81
V_1H_2	0.24	3.77	5.80
V_1H_3	0.25	3.97	5.82
V_1H_4	0.21	3.62	5.08
V_1H_5	0.25	4.18	6.91
V_2H_1	0.16	1.94	6.03
V_2H_2	0.18	2.27	6.11
V_2H_3	0.10	1.86	5.58
V_2H_4	0.21	2.29	6.51
V_2H_5	0.16	2.23	6.57
$LSD_{0.05}$	0.095	1.070	NS
CV (%)	37.21	14.34	14.38

V_1= BARI mung 6, V_2= Sona mung, H_1= Picking of pods at 15 days after anthesis (DAA), H_2= Picking of pods at 20 DAA, H_3= Picking of pods at 25 DAA, H_4= Picking of pods at 30 DAA, H_5= Picking of pods at 35 DAA.
NS= Not significant

4.1.3 Dry matter production

4.1.3.1 Effect of variety

The total dry weight of plant was significantly influenced by variety from 15 DAS to harvest (Appendix IV and Table 3)

At 15 DAS, maximum dry weight (4.61 g m^{-2}) was recorded in BARI mung 6 and minimum dry weight (2.16 g m^{-2}) was recorded in Sona mung. Similar trend of dry matter production was observed at 30 DAS, 45 DAS and at harvest (Table 3).

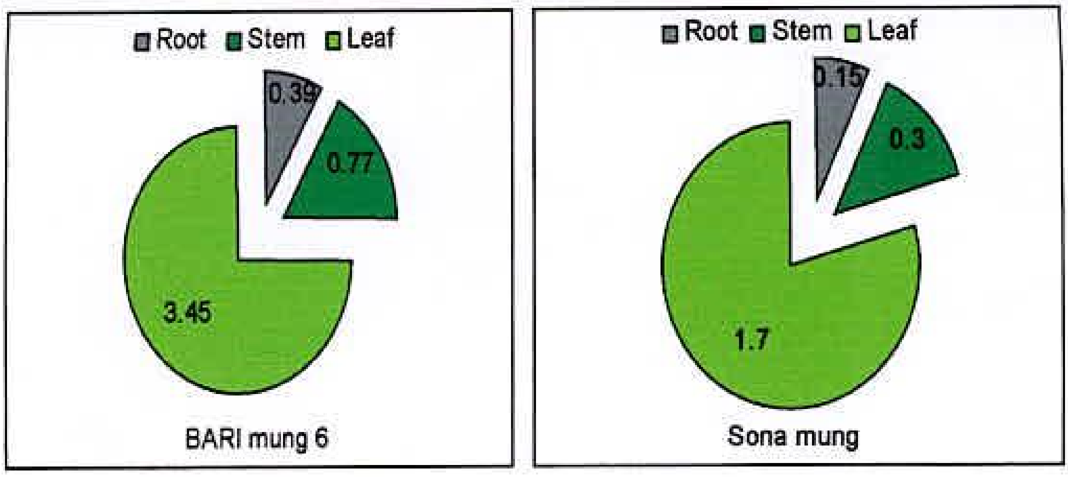
The dry matter production of different plant parts from 15 DAS to harvest was recorded in which dry weights of leaf, stem, root and pod and flowers were statistically influenced by variety [Appendix V and Fig 3(a-d)].

At 15 DAS, maximum leaf dry weight (3.45 g m^{-2}) was recorded in BARI mung 6 and the lowest was recorded in Sona mung (1.7 g m^{-2}). In case of stem dry weight the maximum weight (0.77 g m^{-2}) was obtained from BARI mung 6, followed by Sona mung (0.3 g m^{-2}) which was statistically not different (Figure 3a). At 30 DAS, the maximum dry weight in leaf (48.81 g m^{-2}), stem (7.23 g m^{-2}), and root (8.94 g m^{-2}) was recorded in BARI mung 6 while the minimum dry weight of leaf (22.5 g m^{-2}), stem (1.91 g m^{-2}) and root (3.14 g m^{-2}) was recorded in Sona mung (Figure 3b). Similar trend of dry matter production was recorded in 45 DAS (Figure 3c). At harvest the maximum dry weight in leaf (290.97 g m^{-2}) was recorded in BARI mung 6 and the minimum (180.87 g m^{-2}) in Sona mung. In case of stem dry weight the highest weight (181.75 g m^{-2}) was recorded in Sona mung and the lowest weight (163.46 g m^{-2}) was recorded in BARI mung 6. Sona mung also produced the higher root dry weight (37.88 g m^{-2}) as compared to BARI mung 6 (37.61 g m^{-2}) which was not statistically different. The maximum dry weight (217.97 g m^{-2}) of pod and flower was recorded in BARI mung 6 and the minimum dry weight (124.12 g m^{-2}) of pod and flower was recorded in Sona mung (Figure 3d). These findings agree with Pookpakdi *et al.* (1980) who stated that total dry weight and dry matter production in different plant parts vary according to variety.

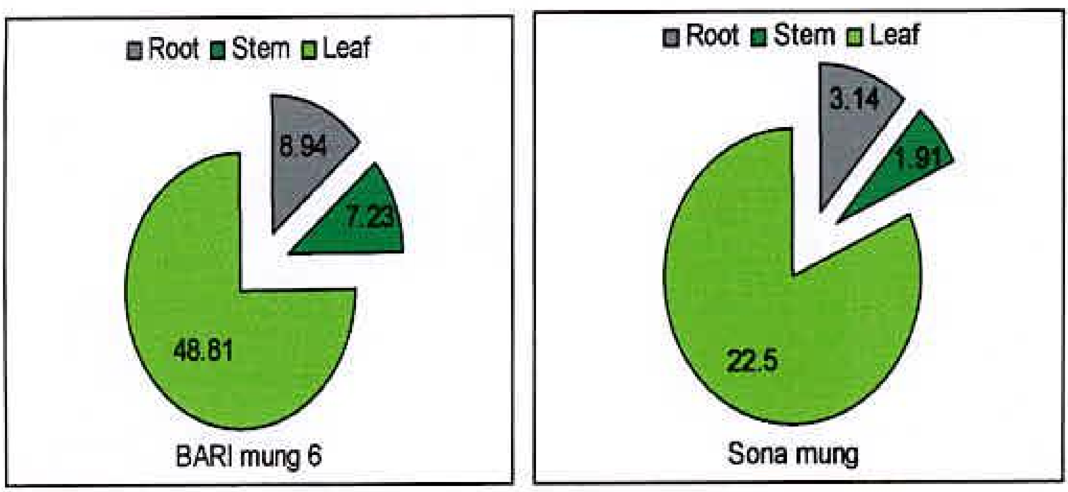
Table 3. Total dry matter weight of mungbean as influenced by variety, harvesting time and their interaction

Treatments	Total dry weight, g m^{-2}			
	15 DAS	**30 DAS**	**45 DAS**	**At harvest**
Variety				
V_1	4.61	64.98	379.02	709.62
V_2	2.16	27.55	237.63	524.59
$LSD_{0.05}$	0.368	9.480	41.570	82.300
Harvesting time				
H_1	3.65	43.11	307.99	641.57
H_2	3.24	51.62	302.5	591.13
H_3	3.25	38.93	304.59	535.10
H_4	3.15	53.76	335.73	712.86
H_5	3.64	43.9	290.80	604.87
$LSD_{0.05}$	NS	NS	NS	130.120
Interaction of variety and harvesting time				
V_1H_1	4.68	51.1	317.17	690.02
V_1H_2	4.51	73.39	411.04	590.10
V_1H_3	4.42	55.5	321.75	670.67
V_1H_4	4.57	78.95	466.55	784.00
V_1H_5	4.88	65.93	378.57	813.33
V_2H_1	2.61	35.11	298.82	593.13
V_2H_2	1.97	29.84	193.95	592.16
V_2H_3	2.09	22.35	287.43	399.53
V_2H_4	1.73	28.6	204.91	641.72
V_2H_5	2.39	21.87	203.03	396.40
$LSD_{0.05}$	0.823	21.200	92.970	184.020
CV (%)	14.02	26.47	17.42	17.23

V_1= BARI mung 6, V_2= Sona mung, H_1= Picking of pods at 15 days after anthesis (DAA), H_2= Picking of pods at 20 DAA, H_3= Picking of pods at 25 DAA, H_4= Picking of pods at 30 DAA, H_5= Picking of pods at 35 DAA.
NS= Not significant

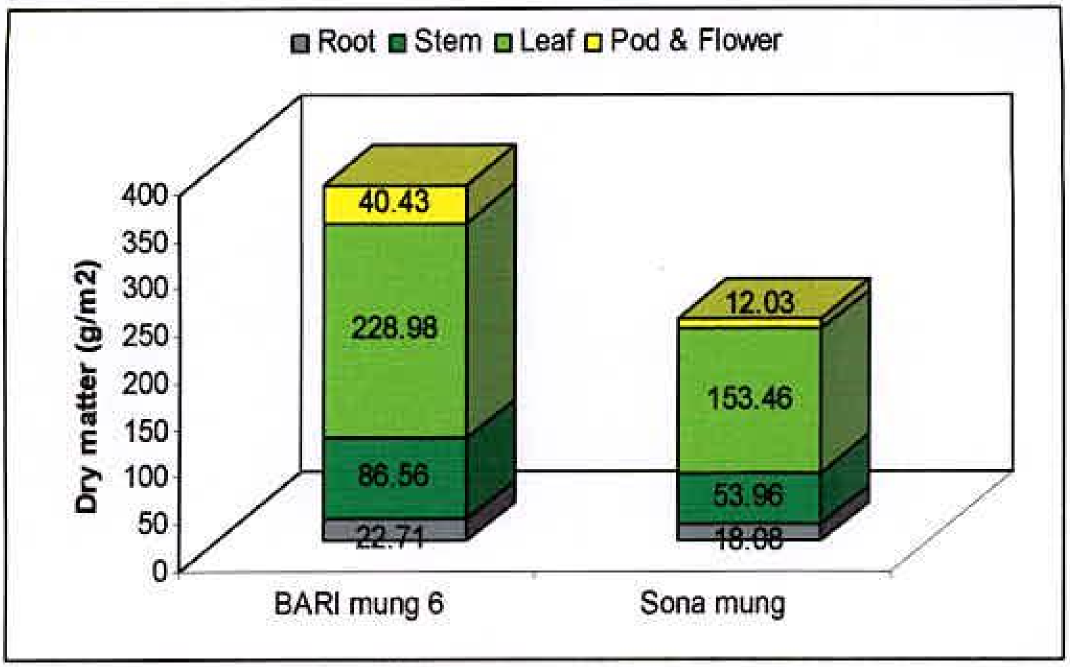


3a. 15 DAS

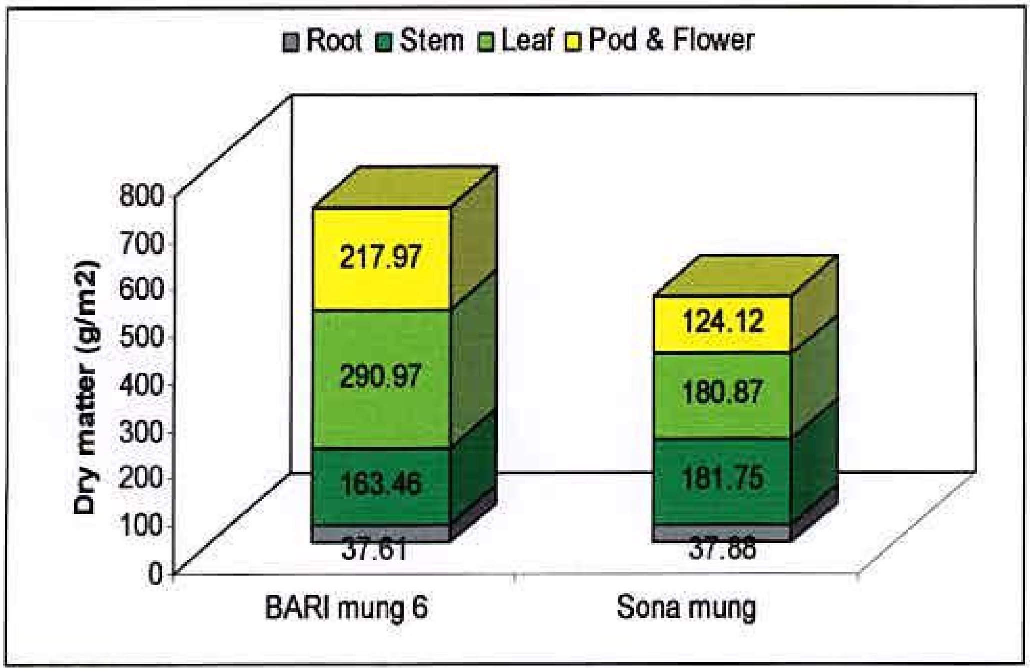


3b. 30 DAS

Figure 3(a-b). Dry matter partitioning of varieties from 15 to 30 days after sowing (DAS)



3c. 45 DAS



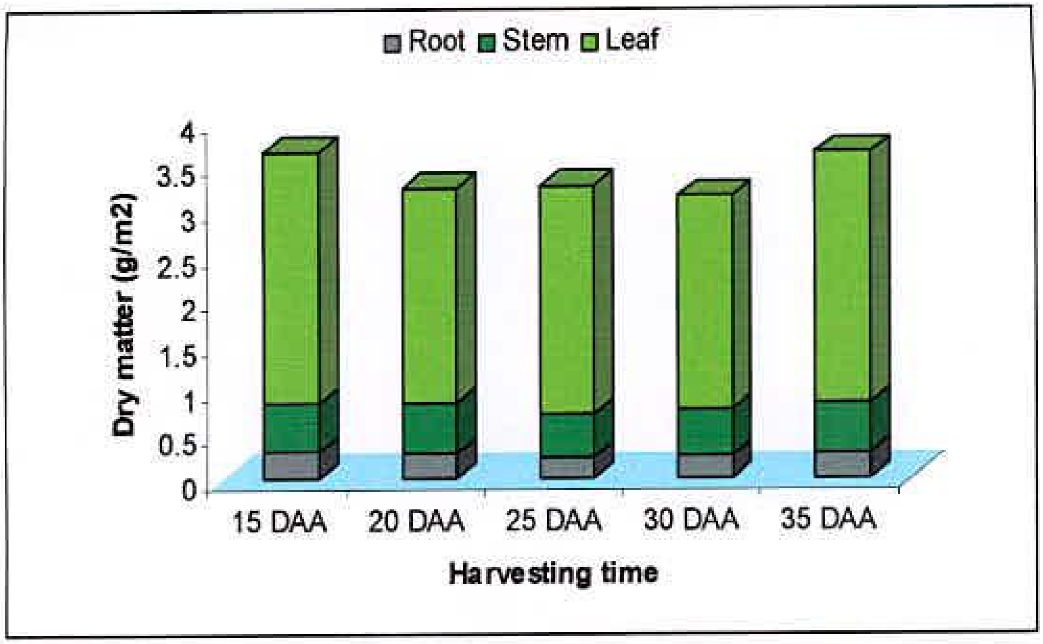
3d.At harvest

Figure 3(c-d). Dry matter partitioning of varieties from 45 days after sowing (DAS) to harvest

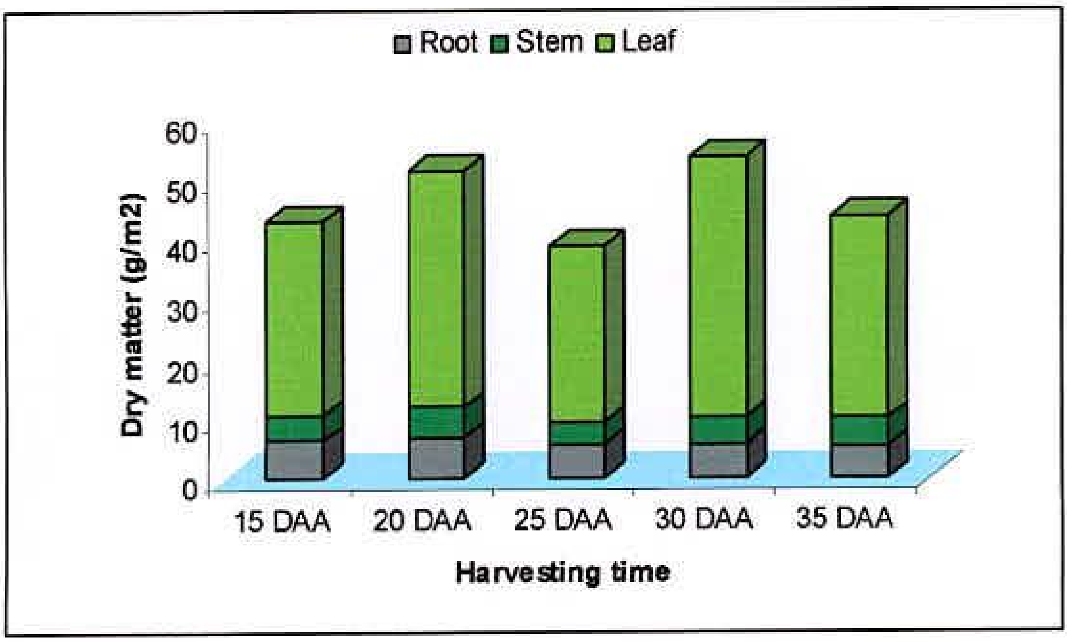
4.1.3.2 Effect of harvesting time

Total dry matter production was not affected by different harvesting time at 15, 30 and 45 DAS but it significantly different at harvest (Appendix IV and Table 3).

At harvest, the maximum dry weight (712.86 g m^{-2}) was recorded in 30 DAA followed by 15, 20 and 35 DAA which were statistically not different. The minimum dry weight (535.10 g m^{-2}) was recorded in 25 DAA. Dry matter partitioning of leaf, stem, root and pod and flower of mungbean showed no differences at 15 and 45 DAS, but at 30 DAS the highest leaf dry weight (43.28 g m^{-2}) was recorded in treatment H_4 (harvesting 30 DAA) followed by H_1, H_2 and H_5 (harvesting 15, 20 and 35 DAA respectively).The lowest leaf dry weight (29.38 g m^{-2}) was recorded in treatment H_3 (harvesting 25 DAA), while no differences were found with stem and root dry weights at that stage. At harvest, the highest leaf dry weight (292.91 g m^{-2}) was recorded in 15 DAA followed by 20 and 30 DAA. The lowest leaf dry weight (196.95 g m^{-2}) was recorded in 35 DAA followed by 25 DAA. The highest stem dry weight (205.2 g m^{-2}) was recorded in 30 DAA followed by 35 DAA and the lowest stem dry weight (142.89 g m^{-2}) was recorded in 25 DAA. Similarly the highest dry weight of root (48.25 g m^{-2}) was recorded in 30 DAA and the lowest root dry weight (31.09 g m^{-2}) was recorded in 20 DAA followed by 25 DAA, where no differences were found. In case of pod and flower dry weight the highest dry weight (234.36 g m^{-2}) was recorded in 30 DAA while the lowest dry weight (144.68 g m^{-2}) was recorded in 25 DAA flowed by 20, 15 and 35 DAA, which were statistically similar. Thus results revealed that dry matter production in the leaf, stem, root and pod and flower was highest at 30 DAA, while the dry matter production of these parts was lowest at 25 DAA [Appendix V and Figure 4(a-d)].

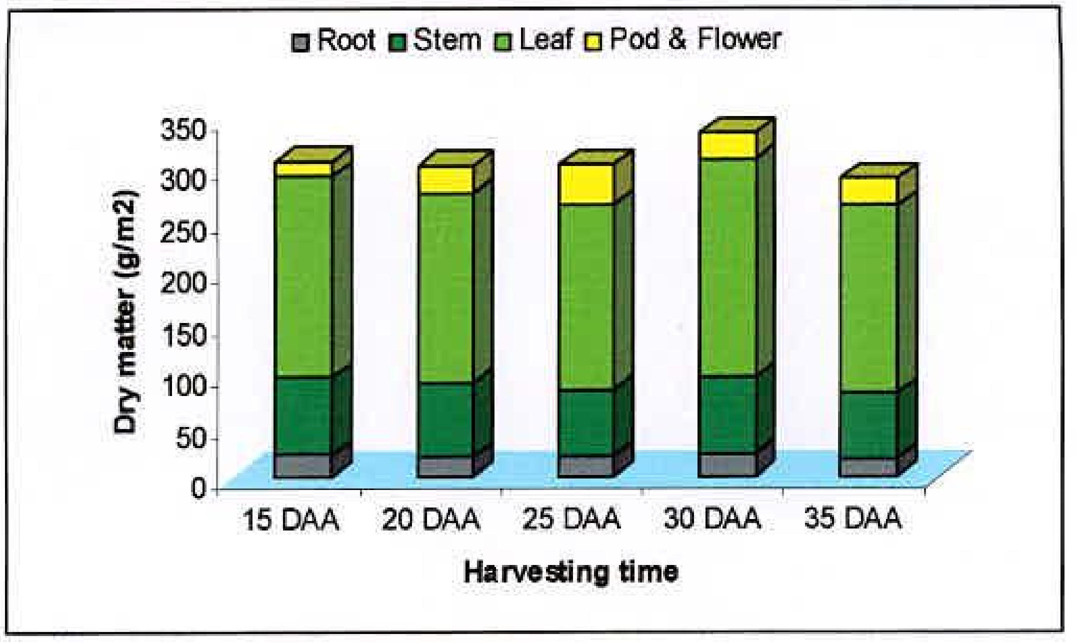


4a. 15 DAS

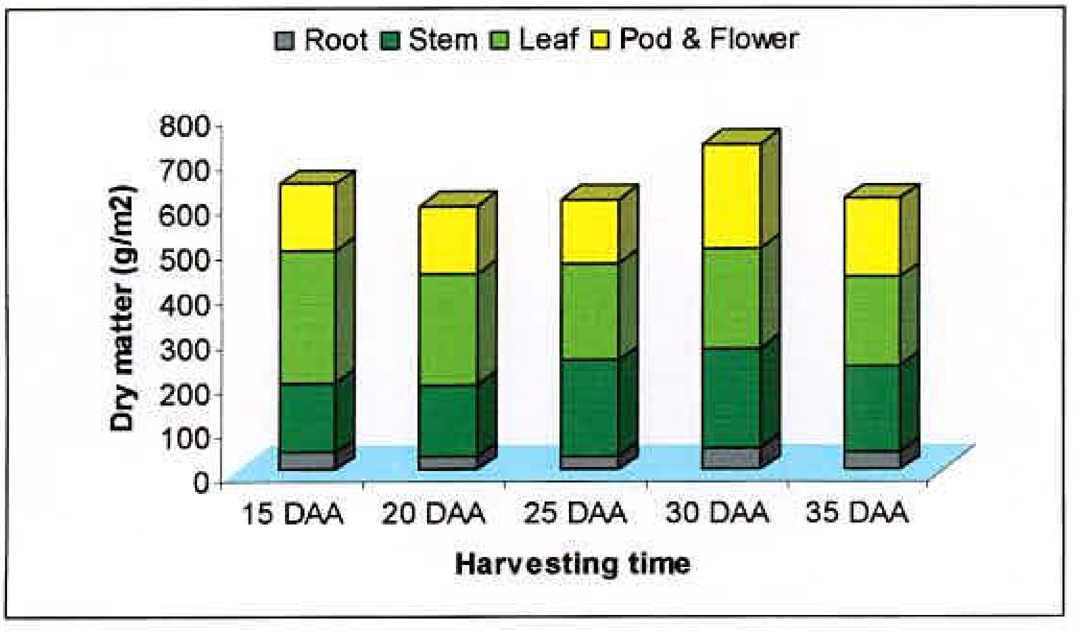


4b. 30 DAS

Figure 4 (a-b). Dry matter partitioning from 15 to 30 days after sowing (DAS) as affected by harvesting time



4c. 45 DAS



4d.At harvest

Figure 4 (c-d). Dry matter partitioning from 45 days after sowing (DAS) to harvest as affected by harvesting time

4.1.3.3 Interaction effect of variety and harvesting time

The total dry weight of mungbean was significantly influenced by variety and harvesting time from 15 DAS to harvest (Appendix IV and Table 3).

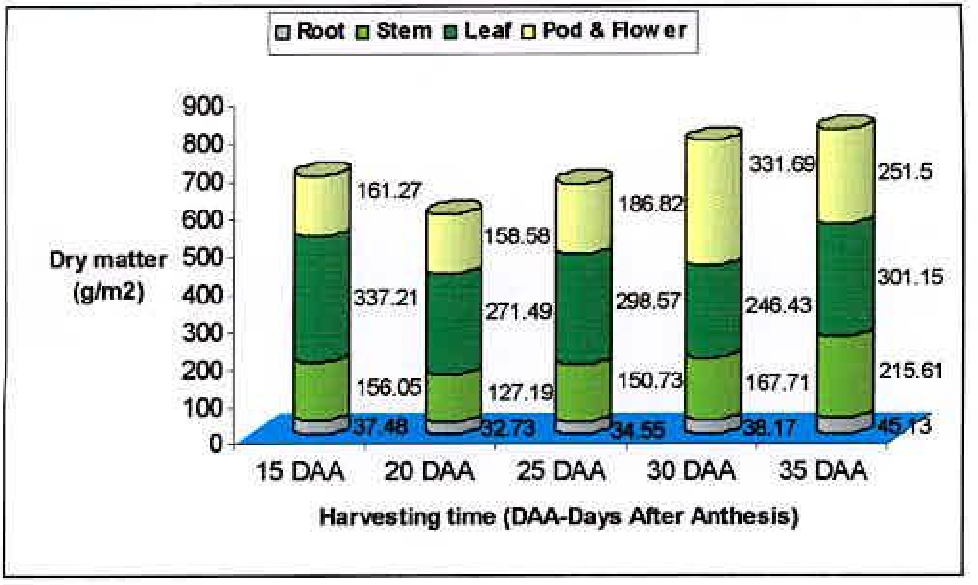
At 15 DAS, the highest total dry weight (4.88 g m^{-2}) was recorded in treatment V_1H_5 (BARI mung 6 harvested at 35 DAA) followed by the treatment V_1H_1, V_1H_4, V_1H_2 and V_1H_3 (BARI mung 6 harvested at 15, 30, 20 and 25 DAA respectively) where no differences were found, while the lowest total dry weight (1.73 g m^{-2}) was recorded in V_2H_4 (Sona mung harvested at 30 DAA). At 30 DAS, the highest total dry weight (78.95 g m^{-2}) was recorded in treatment V_1H_4 (BARI mung 6 harvested at 30 DAA) and the lowest total dry weight (21.87 g m^{-2}) was recorded in treatment V_2H_5 (Sona mung harvested at 35 DAA) followed by V_2H_3, V_2H_4 and V_2H_2 (Sona mung harvested at 25, 30 and 20 DAA respectively) which were statistically similar. At 45 DAS, the maximum total dry weight (466.55 g m^{-2}) was obtained from V_1H_4 (BARI mung 6 harvested at 30 DAA) while the minimum total dry weight (193.95 g m^{-2}) was recorded in treatment V_2H_2 (Sona mung harvested at 20 DAA). At harvest the maximum total dry weight (813.33 g m^{-2}) was recorded in BARI mung 6 harvested at 35 DAA that was statistically similar with all other time of the same variety except V_1H_2. The minimum total dry weight (396.40 g m^{-2}) was obtained from Sona mung when harvested at 35 DAA that was not different with the same variety harvested at 25 DAA (Table 3).

In case of dry matter partitioning treatment V_1H_4 (BARI mung 6 harvested at 30 DAA) produced higher amount of dry matter in leaf, stem, root and even in pod and flower from 15 DAS to 45 DAS. At harvest, the highest amount of dry matter in leaf (337.21 g m^{-2}) and in pod and flower (331.69 g m^{-2}) was recorded in BARI mung 6 at 15 and 30 DAA, respectively. Dry matter accumulation in stem (242.69 g m^{-2}) and root (58.32 g m^{-2}) was grater in Sona mung at 30 DAA. The lowest amount of dry matter in leaf (92.75 g m^{-2}) as well as in pod and flower (100.22 g m^{-2}) was recorded in Sona mung at 35DAA (Figure 5a and 5b). Treatment V_2H_5 (Sona mung harvested at 35 DAA) produced significantly the lowest amount of dry matter in leaf, stem, root and even in pod and flower at 15 DAS to 45 DAS (Table 4). From this result it can be be noted that, at 15 DAS to harvest dry matter partitioning in different plant parts showed statistically highest values in treatment V_1H_4 (BARI mung 6 harvested at 30 DAA) while it was recorded lowest in treatment V_2H_5 (Sona mung harvested at 35 DAA).

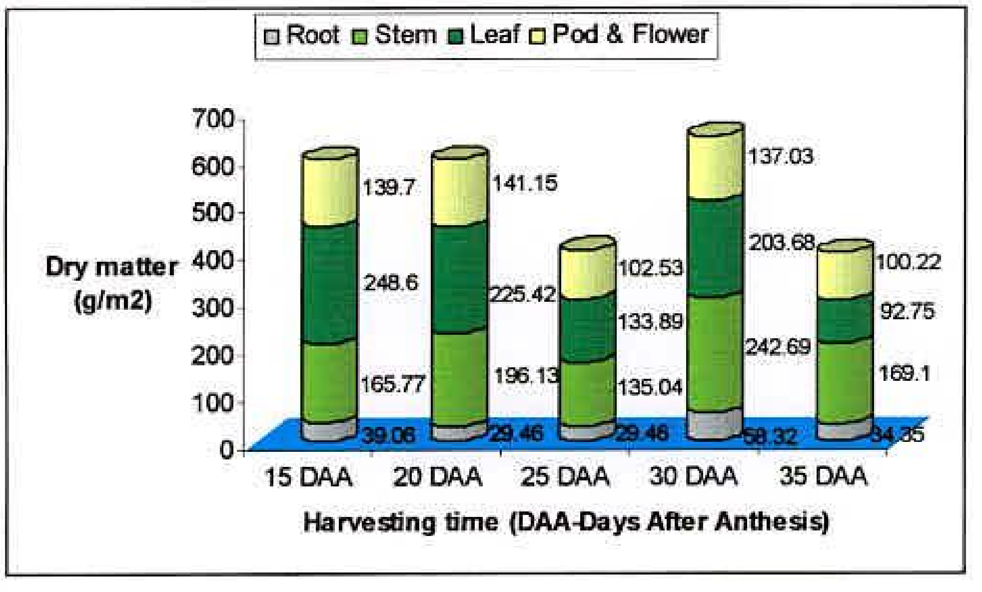
Table 4. Interaction effect of variety and harvesting time on dry matter partitioning (g m^{-2}) at different growth stages

Treatments	At 15th day			At 30th day			At 45th day			
	Leaf	stem	root	Leaf	Stem	Root	leaf	Stem	root	Flower and pod
V_1H_1	3.49	0.75	0.43	36.58	5.87	8.64	197.23	81.68	19.82	18.41
V_1H_2	3.3	0.81	0.39	54.18	8.58	10.62	243.34	98.71	24.26	44.72
V_1H_3	3.41	0.65	0.35	41.62	5.63	8.25	184.49	68.28	18.76	48.62
V_1H_4	3.39	0.81	0.37	62.7	8.03	8.22	294.07	101.46	28.57	42.43
V_1H_5	3.67	0.81	0.39	48.95	8.03	8.95	225.78	82.67	22.13	47.98
V_2H_1	2.11	0.33	0.17	28.09	2.84	4.17	194.67	69.05	23.07	11.42
V_2H_2	1.49	0.32	0.15	24.9	1.84	3.09	127.62	45.63	13.90	6.93
V_2H_3	1.67	0.28	0.13	17.13	1.91	3.3	174.12	62.67	21.42	29.19
V_2H_4	1.36	0.24	0.13	23.87	1.6	3.12	131.40	49.03	17.05	7.41
V_2H_5	1.89	0.33	0.17	18.52	1.34	1.99	139.48	43.40	14.94	5.21
$LSD_{0.05}$	0.677	0.156	0.118	17.96	2.4	2.48	58.41	24.67	8.29	25.39
CV (%)	15.16	16.78	26.38	19.1	20.32	23.76	17.65	20.28	23.51	25.92

V_1= BARI mung 6, V_2= Sona mung, H_1= Picking of pods at 15 days after anthesis (DAA), H_2= Picking of pods at 20 DAA, H_3= Picking of pods at 25 DAA, H_4= Picking of pods at 30 DAA, H_5= Picking of pods at 35 DAA.



5a. BARI mung 6



5b. Sona mung

Figure 5 (a-b). Interaction effect of variety and harvesting time on dry matter production at harvest

4.1.4 Days to first flowering

4.1.4.1 Effect of Variety

Time required for flowering was significantly influenced by variety (Appendix VI). Flowering was earlier (33.26 days) in BARI mung 6, whereas Sona mung required maximum time (36.8o days) (Table 5). The results agreed with Gowda and Kaul (1983) and Poehlman (1991) who reported that local of mungbean cultivars were non synchronous and flowering continues for a period of several weeks as long as the plants remain healthy.

4.1.4.2 Effect of harvesting time

Time required for first flowering was not affected by harvesting time (Appendix VI). The days required to produce flower in treatment H_1 (15 DAA), H_2 (20 DAA), H_3 (25 DAA), H_4 (30 DAA) and H_5 (35 DAA) was 35.00, 34.83, 35.33, 35.00 and 35.00, respectively.

Table 5. Duration of first flowering of mungbean as affected by variety and harvesting time

Treatments	Days required for flowering
Variety	
V_1	33.26
V_2	36.80
$LSD_{0.05}$	0.847
Harvesting time	
H_1	35.00
H_2	34.83
H_3	35.33
H_4	35.00
H_5	35.00
$LSD_{0.05}$	NS
CV (%)	3.12

V_1= BARI mung 6, V_2= Sona mung, H_1= Picking of pods at 15 days after anthesis (DAA), H_2= Picking of pods at 20 DAA, H_3= Picking of pods at 25 DAA, H_4= Picking of pods at 30 DAA, H_5= Picking of pods at 35 DAA.
NS= Not significant

4.1.4.3 Interaction effect of variety and harvesting time

Interaction effects of variety and harvesting time on first flowering were significant (Appendix VI). Longer duration of flowering (38 days) was observed with treatment V_2H_3 (Sona mung harvested at 25 DAA) followed by the treatment V_2H_4 (37 days) and V_2H_2 (37 DAS) which were statistically not different. In BARI mung 6, the duration needed for flowering was shorter and it was within treatment V_1H_1 (34 days), V_1H_2 (32.66 days), V_1H_3 (32.66 days), V_1H_4 (33 days) and V_1H_5 (34 days) which were statistically similar (Fig. 6). Early flowering and synchronous maturity in BARI mung 6 was probably due to its genetical characteristics. The results agreed with Tu *et al.* (1998) who reported that early maturing cultivars usually gave better quality seeds but excessive rainfall would deteriorates the seed quality of bean due to fungal infestations.

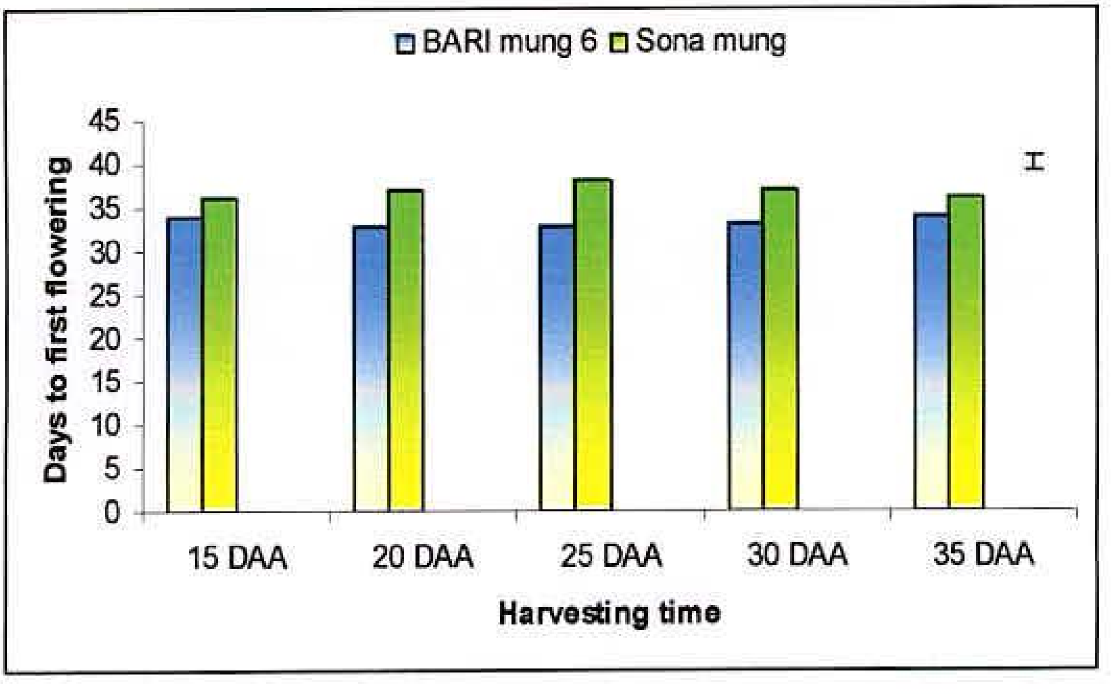


Figure 6. Duration of first flowering as influenced by variety and harvesting time (Vertical bar indicates LSD value at 5% level of significance)

4.2 Yield and other crop characters

4.2.1 Number of primary branches plant $^{-1}$

4.2.1.1 Effect of variety

The number of primary branches plant^{-1} was significantly different with the variety (Appendix VII). The highest number of primary branches plant^{-1} was observed in Sona mung (2.2) and the lowest number (1.01) was observed in BARI mung 6 (Table 6). The results agreed with Islam (1983) who observed significant variation of branch number plant^{-1} was in different varieties of mungbean and the highest number of branches plant^{-1} was found in variety Faridpur 1 followed by Mubarik, BM-7715 and BM-7704.

4.2.1.2 Effect of harvesting time

Harvesting time did not significantly affect the number of primary branches plant^{-1} (Appendix VII and Table 6). The highest number of primary branches plant^{-1} (1.83) was recorded in treatment H_2 (harvested at 20 DAA) which was followed by other treatments.

Table 6. Influence of variety and harvesting time on yield and other crop characters of mungbean

Treatments	Primary branches plant^{-1} (No.)	Pods plant^{-1} (No.)		Pod length (cm)	Seeds pod^{-1} (No.)	Wt. of 1000 seeds (g)
		Main stem	Total			
Variety						
V_1	1.01	16.48	21.41	9.45	10.53	48.38
V_2	2.2	20.81	31.61	6.25	11.48	16.93
$LSD_{0.05}$	0.444	4.780	6.190	0.400	NS	2.690
Harvesting time						
H_1	1.63	17.4	23.8	7.97	10.35	30.63
H_2	1.83	22.1	34.93	8.04	10.80	37.79
H_3	1.43	19.7	27.4	8.22	11.75	32.43
H_4	1.7	16.87	23.47	7.12	10.62	30.08
H_5	1.43	17.17	22.97	7.91	11.5	32.36
$LSD_{0.05}$	NS	7.56	9.78	0.63	NS	4.25
CV (%)	35.57	33.13	30.14	6.5	11.73	10.62

V_1= BARI mung 6, V_2= Sona mung, H_1= Picking of pods at 15 days after anthesis (DAA), H_2= Picking of pods at 20 DAA, H_3= Picking of pods at 25 DAA, H_4= Picking of pods at 30 DAA, H_5= Picking of pods at 35 DAA.
NS= Not significant

4.2.1.3 Interaction effect of variety and harvesting time

The number of primary branches plant^{-1} was significantly affected by variety and harvesting time (Appendix VII). The highest number of primary branches plant^{-1} (2.40) was observed in Sona mung harvested at 30 DAA that was statistically not different with the other harvesting times of the same variety. The lowest number of primary branches plant^{-1} (0.80) was recorded in BARI mung 6 harvested at 25 and 35 DAA followed by the same variety harvested at 30 DAA (1.00), 15 DAA (1.07) and 20 DAA (1.40). Irrespective of harvesting time, the variety Sona mung had the highest number of branches plant^{-1} as compared to BARI mung 6 (Figure 7).

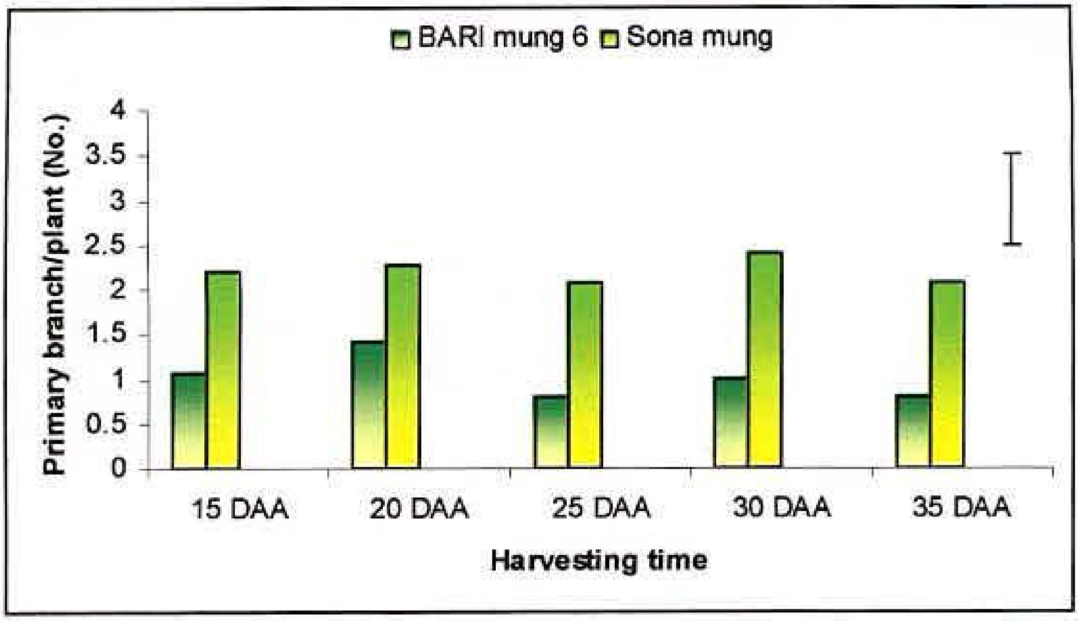


Figure 7. Number of primary branches plant^{-1} as influenced by interaction of variety and harvesting time (Vertical bar indicates LSD value at 5% level of significance)

4.2.2 Number of pods plant^{-1}

4.2.2.1 Effect of variety

The total number of pods plant^{-1} differed significantly due to varietal characteristis (Appendix VII). The maximum number of pods plant^{-1} (31.61) was recorded in Sona mung and the minimum number (21.41) was recorded in BARI mung 6 (Table 6). In case of number of pods in the main stem, Sona mung produced significantly the higher number (20.81) and BARI mung 6 produced the lower number of pods (16.48) (Table 6). The main stem of BARI mung 6 produced 77% pods, while it was 66% in Sona mung. Sona mung produced 47.64 percent higher number of pods than BARI mung 6.The results agreed with Pahlwan and Hossain (1983) who observed highest number of pods plant^{-1} from variety Mubarik. However, our results disagreed with Pookpadi *et al.* (1980) who found the lowest number of pods plant^{-1} in local variety. Masood and Meena (1986) reported that number of pods plant^{-1} varied significantly with genotypes. Islam (1983), Haque *et al.* (2002) also opined pods plant^{-1} as an useful agronomic character contributing to higher yield of mungbean and there was a significant positive correlation between the number of pods plant^{-1} and yield plant^{-1}.

4.2.2.2 Effect of harvesting time

The total number of pods plant^{-1} differed significantly with different harvesting times (Appendix VII). The highest (34.93) and the lowest (22.97) number of total pods plant^{-1} was obtained from harvesting at 20 DAA and 35 DAA, respectively followed by harvesting at 15 DAA and 30 DAA which were not different (Table 6). The results agreed with the findings of Debnath (1998) who observed that number of pods plucked varied considerably among the harvesting dates and harvesting methods.

4.2.2.3 Interaction effect of variety and harvesting time

Interaction effects of variety and harvesting time in respect of total number of pods plant^{-1} was significant (Appendix VII and Figure 8). The highest number of total pods plant^{-1} (42.60) was recorded in Sona mung harvested at 20 DAA followed by the same variety harvested at 25 DAA (37.53) and 15 DAA (34.27) which did not differ significantly. The lowest number of total pods plant^{-1} (13.33) was recorded in BARI mung 6 harvested at 15 DAA. Number of pods produced in the main stem was highest (27.20) in Sona mung harvested at 20 DAA that followed by the same variety harvested at 25 DAA (26.13) which were statistically not different. The lowest number of pods (11.67) in the main stem was recorded in BARI mung 6 harvested at 15 DAA. Similar reports were published by Kalavathi and Ramaswamy (1988) who found highest number of pods in Soybean cultivar Co.1 harvested at 55 days after 50% flowering.

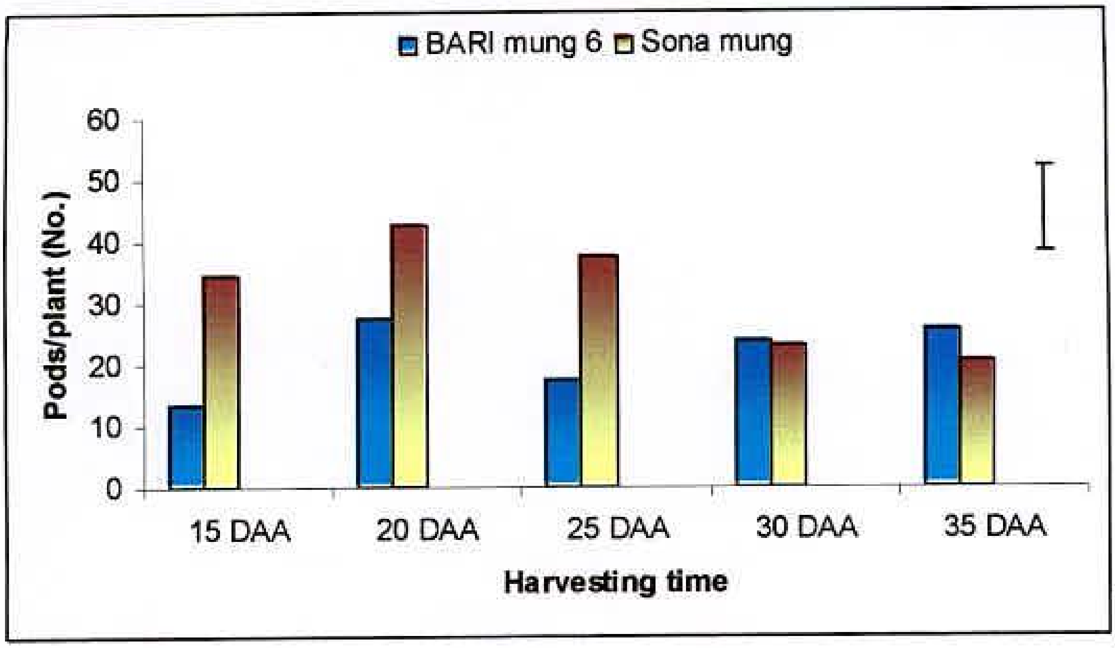


Figure 8. Number of pods plant^{-1} as influenced by interaction of variety and harvesting time (Vertical bar indicates LSD value at 5% level of significance)

4.2.3 Pod length

4.2.3.1 Effect of variety

The pod length varied significantly with the varieties (Appendix VII and Table 6). The maximum (9.45 cm) and minimum (6.25 cm) pod lengths were observed in BARI mung 6 and Sona mung, respectively (Table 6). The results agreed with the findings of Farghali and Hossain (1995) who observed that varieties differed significantly in respect to pod length.

4.2.3.2 Effect of harvesting time

Pod length was significantly affected by the harvesting time (Appendix VII). The longest pod (8.22 cm) was recorded when harvested at 25 DAA followed by harvested at 20 DAA, 15 DAA and 35 DAA which were statistically similar (Table 6). The shortest pod (7.12 cm) was recorded when harvested at 30 DAA. The reduced pod length at 30 DAA might be due to heavy rainfall during that period which reduced photosynthesis (Appendix X and XI). Saha *et al.* (2002)

also reported that irrespective of cultivars seed development was better in Kharif I than in Kharif II season due to more sunny hours and low rain fall prevailed during the reproductive phases in the Kharif I season.

4.2.3.3 Interaction effect of variety and harvesting time

Pod length was significantly affected by interaction of variety and harvesting time (Appendix VII and Figure 9). The longest pod (9.94 cm) was obtained from BARI mung 6 harvested at 25 DAA. The subsequent pod length was recorded in the same variety harvested at 35 DAA (9.61 cm), 15 DAA (9.55 cm) and 20 DAA (9.48 cm). The shortest pod (5.56 cm) was recorded in Sona mung harvested at 30 DAA. The other treatments produced intermediate pod length.

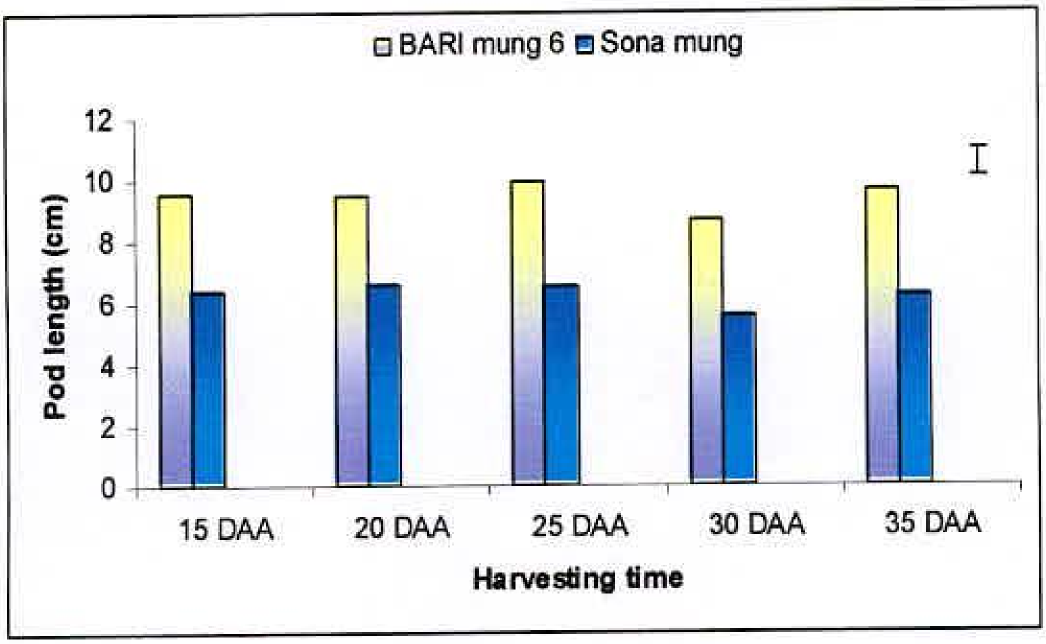


Figure 9. Pod length of mungbean as influenced by interaction of variety and harvesting time (Vertical bar indicates LSD value at 5% level of significance)

4.2.4 Number of seeds pod^{-1}

4.2.4.1 Effect of variety

The number of seeds pod^{-1} did not differ significantly between the two varieties (Appendix VII). The maximum number of seeds pod^{-1} (11.48) was found in Sona mung and the minimum (10.53) in BARI mung 6 (Table 6). The results did not support the findings of Pahlwan and Hossain (1983) and Pookpakdi *et al.* (1980) who found highest yield from two mungbean cultivars Mubarik and CES 14 with the highest number of seeds pod^{-1}.

4.2.4.2 Effect of harvesting time

Harvesting times did not significantly affect the number of seeds pod^{-1} (Appendix VII). The maximum number of seeds pod^{-1} (11.75) was observed at 25 DAA followed by 35 DAA, 20 DAA, 30 DAA and 15 DAA which were not statistically different (Table 6). These results were different from those findings of Debnath (1998) who observed that all the yield contributing characters, including seeds pod^{-1} were significantly affected by harvesting time.

4.2.4.3 Interaction effect of variety and harvesting time

Interaction effects of variety and harvesting time on seeds pod^{-1}were significant (Appendix VII and Figure 10). The highest number of seeds pod^{-1} (12.20) was obtained in Sona mung harvested at 20 DAA and it was statistically not different with 15DAA, 25 DAA, 30 DAA and 35 DAA of the same variety along with BARI mung 6 harvested at 25 DAA, 30 DAA and 35 DAA but the lowest number seeds pod^{-1} (9.40) was recorded in BARI mung 6 harvested at 20 DAA that similar to the same variety harvested at 15 DAA. The results agreed with the findings of Kalavathi and Ramaswamy (1988) who reported highest value for seeds pod^{-1}in Soybean cultivar Co.1 harvested at 55 days after 50% flowering.

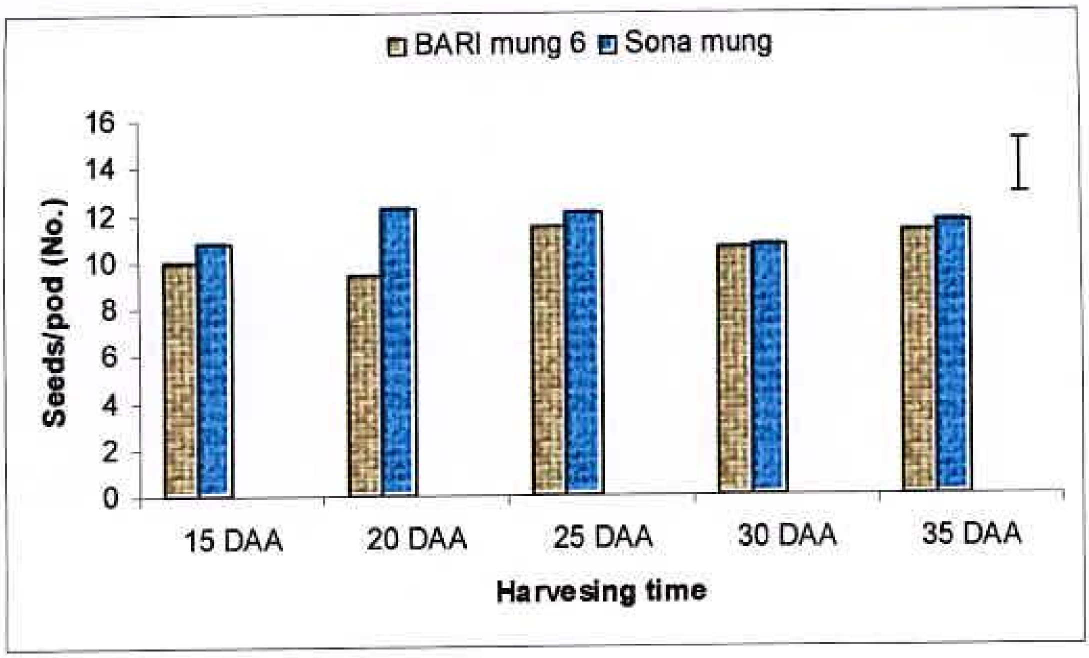


Figure 10. Number of seeds Pod^{-1} as influenced by interaction of variety and harvesting time (Vertical bar indicates LSD value at 5% level of significance)

4.2.5 Weight of 1000 seeds

4.2.5.1 Effect of variety

The weight of 1000 seeds was influenced by variety (Appendix VII and Table 6). The highest 1000 seeds weight (48.38 g) was obtained from BARI mung 6 and the lowest (16.93 g) was recorded in Sona mung. The results agreed with the findings of Aguliar and Villarea (1989); Katial and Shah (1998) who reported that 1000 seeds weight was influenced by variety.

4.2.5.2 Effect of harvesting time

Harvesting time significantly affected the weight of 1000 seeds (Appendix VII). The highest 1000 seed weight (37.79 g) was found when harvest at 20 DAA and the lowest (30.08 g) at 30 DAA which was followed by harvest at 15 DAA, 35 DAA and 25 DAA (Table 6). The finding was in agreement with Debnath (1998) who stated that 1000 seeds weight was influenced by harvesting method.

4.2.5.3 Interaction of variety and harvesting time

Interaction of variety and harvesting time was significant in respect to 1000 seeds weight (Appendix VII and Figure 11). The heaviest 1000 seeds weight (54.56 g) was recorded in BARI mung 6 harvested at 20 DAA that followed by the same variety harvested at 25 DAA and 35 DAA, which were statistically not different. The lowest 1000 seeds weight (14.17 g) was found in Sona mung harvested at 30 DAA followed by the same variety harvested at 35 DAA, 25 DAA and 15 DAA, which did not differ significantly. The probable cause of reduction in 1000 seeds weight in Sona mung at 35 DAA to 25 DAA might be due to heavy rainfall during that period (Appendix I). The results were in conformity with the findings of Saha *et al.* (2002) who reported that irrespective of cultivars seed growth was better in Kharif I than in Kharif II season due to more sunny hours which prevailed during the reproductive phases as well as low rainfall in the Kharif I season. Lassim *et al.* (1984) also observed that field weathering caused reduction in seed yield and quality.

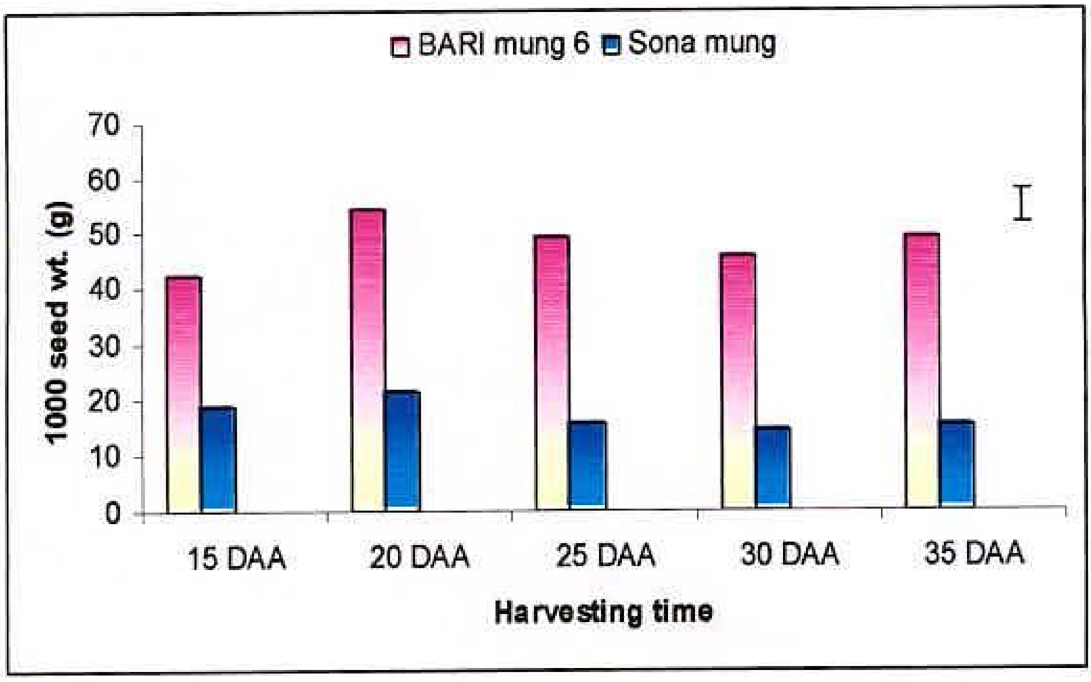


Figure 11. Weight of 1000 seeds as influenced by interaction of variety and harvesting time (Vertical bar indicates LSD value at 5% level of significance)

4.2.6 Seed yield

4.2.6.1 Effect of variety

Seed yield of mungbean was influenced by variety (Appendix VIII and Table 7). Maximum seed yield (1.42 t ha^{-1}) was obtained from BARI mung 6 and minimum (0.74 t ha^{-1}) from Sona mung. The finding was in agreement with BARI (1982), ICRISAT (1991) and Sing and Sing (1988) who reported that cultivars played a key role in increasing yield.

4.2.6.2 Effect of harvesting time

Seed yield was influence by harvesting time (Appendix VIII). The highest seed yield (1.21 t ha^{-1}) was recorded when harvested at 30 DAA followed by 25 DAA (1.16 t ha^{-1}), 20 DAA (1.13 t ha^{-1}) and 35 DAA (1.11 t ha^{-1}) which were not statistically different. The lowest seed yield (0.79 t ha^{-1}) was recorded at 15 DAA (Table 7). Findings were in agreement with Debnath (1998), Dharmalingam and Basu (1989b), Poehlman (1991) and Wachasataya (1990) who reported that seed yield of legumes was affected by harvesting method and harvesting time and the highest yield was obtained from harvesting 39 days after peak flowering.

4.2.6.3 Interaction effect of variety and harvesting time

Seed yield of mungbean was influenced by the interaction of variety and harvesting time (Appendix VIII and Figure 12). The highest seed yield (1.66 t ha^{-1}) was obtained from BARI mung 6 harvested at 35 DAA. The subsequent yield was given by the same variety harvested at 30 DAA (1.63 t ha^{-1}), 20 DAA (1.42 t ha^{-1}) and 25 DAA (1.41 t ha^{-1}). Lowest yield (1.00 t ha^{-1}) of BARI mung 6 was obtained when harvested at 15 DAA. The lowest seed yield (0.57 t ha^{-1}) was obtained from Sona mung harvested at 15 DAA and 35 DAA that was similar to 30 DAA (0.80 t ha^{-1}) and 20 DAA (0.84 t ha^{-1}). The maximum yield (0.91 t ha^{-1}) from Sona mung was obtained when harvested at 25 DAA. The higher seed yield of BARI mung 6 might be due to heavier seed weight of the variety. The finding was in agreement with Aguliar and Villarea (1989) who observed that 1000 seeds weight was influenced by variety. Rajat *et al*. (1978) found that the highest grain yield was produced by 'PS 7' followed by 'PS 16' and 'PS 10'. The higher yield was due to the results of large number of pods plants^{-1} and 1000- grain weight. The result disagreed with Pahlwan and Hossain (1983) who reported that the highest yield was obtained from the variety Mubarik due to the highest number of pods plant^{-1} and seeds plant^{-1}. Though Sona mung had more pods plant^{-1} than BARI mung 6, the probable cause of yield reduction in Sona mung might be due to heavy rainfall during harvesting time (Appendix I) as well as lower seed weight. However, the results agreed with Lassim *et al*. (1984) and Saha *et al*. (2002) who reported that weather condition caused reduction in seed yield and quality of pulses. Yield loss was caused due to the reduction in seed weight and threshing percentage. They mentioned that irrespective of cultivars seed yield was better in Kharif I season because of low rainfall during the reproductive phase in Kharif I. Maximum development of seed dry weight of BUmug 2 and BARI mung 2 at 17 DAA in Kharif I and 19 DAA in Kharif II indicated their physiological maturity. BINA (1998) reported that MC-18 (BINA moog-5) produced higher seed yield over BINA moog-2. Field duration of BINA moog-5 was about 78 days while it was 82 days for BINA moog-2.

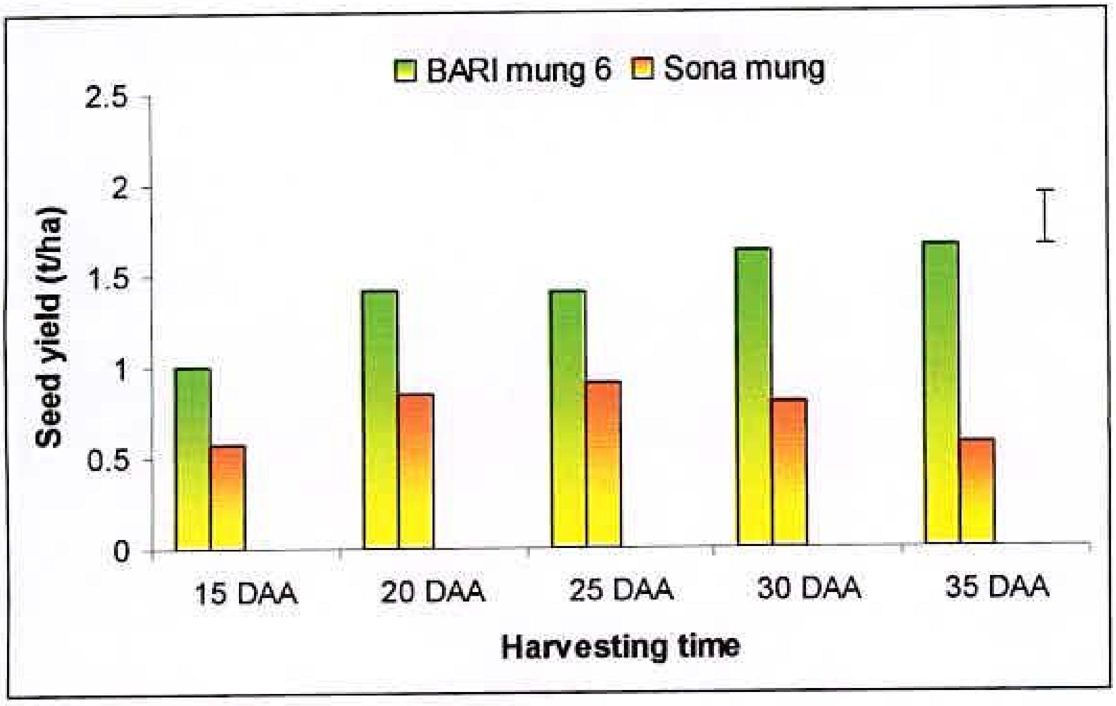


Figure 12. Seed yield as influenced by interaction of variety and harvesting time (Vertical bar indicates LSD value at 5% level of significance)

4.2.7 Straw yield

4.2.7.1 Effect of variety

Straw yield was influenced by variety (Appendix VIII). Maximum straw yield (7.09 t ha^{-1}) was obtained from BARI mung 6 and minimum (5.24 t ha^{-1}) from Sona mung (Table 7).

4.2.7.2 Effect of harvesting time

Straw yield was influenced by harvesting time (Appendix VIII and Table 7). The highest straw yield (7.12 t ha^{-1}) was recorded when harvested at 30 DAA followed by harvest at 15 DAA (6.41 t ha^{-1}), 35 DAA (6.04 t ha^{-1}) and 20 DAA (5.91 t ha^{-1}) which were statistically not different. The lowest straw yield (5.35 t ha^{-1}) was recorded when harvested at 25 DAA.

Table 7. Influence of variety and harvesting time on the yield and other parameters of mungbean

Treatments	Seed yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index	Shelling percentage
Variety				
V_1	1.42	7.09	20.22	37.30
V_2	0.74	5.24	15.47	36.57
$LSD_{0.05}$	0.130	0.823	3.380	NS
Harvesting time				
H_1	0.79	6.41	12.58	42.26
H_2	1.13	5.91	19.18	36.04
H_3	1.16	5.35	22.62	34.54
H_4	1.21	7.12	17.18	37.97
H_5	1.11	6.04	17.67	33.86
$LSD_{0.05}$	0.200	1.301	5.340	5.040
CV (%)	15.74	17.22	24.48	11.15

V_1= BARI mung 6, V_2= Sona mung, H_1= Picking of pods at 15 days after anthesis (DAA), H_2= Picking of pods at 20 DAA, H_3= Picking of pods at 25 DAA, H_4= Picking of pods at 30 DAA, H_5= Picking of pods at 35 DAA.
NS= Not significant

4.2.7.3 Interaction of variety and harvesting time

Significant variation was observed in straw yield due to the interactions of variety and harvesting time (Appendix VIII). The highest straw yield (8.13 t ha^{-1}) was observed in BARI mung 6 harvested at 35 DAA followed by the same variety harvested at 30 DAA (7.84t ha^{-1}), 15 DAA (6.89 t ha^{-1}), 25 DAA (6.71 t ha^{-1}) and Sona mung harvested at 30 DAA (6.41 t ha^{-1}) those were statistically similar. The lowest straw yield (3.99 t ha^{-1}) was observed in Sona mung harvested at 25 DAA followed by the same variety harvested at 35 DAA (3.96 t ha^{-1}) that showed no differences (Figure 13).

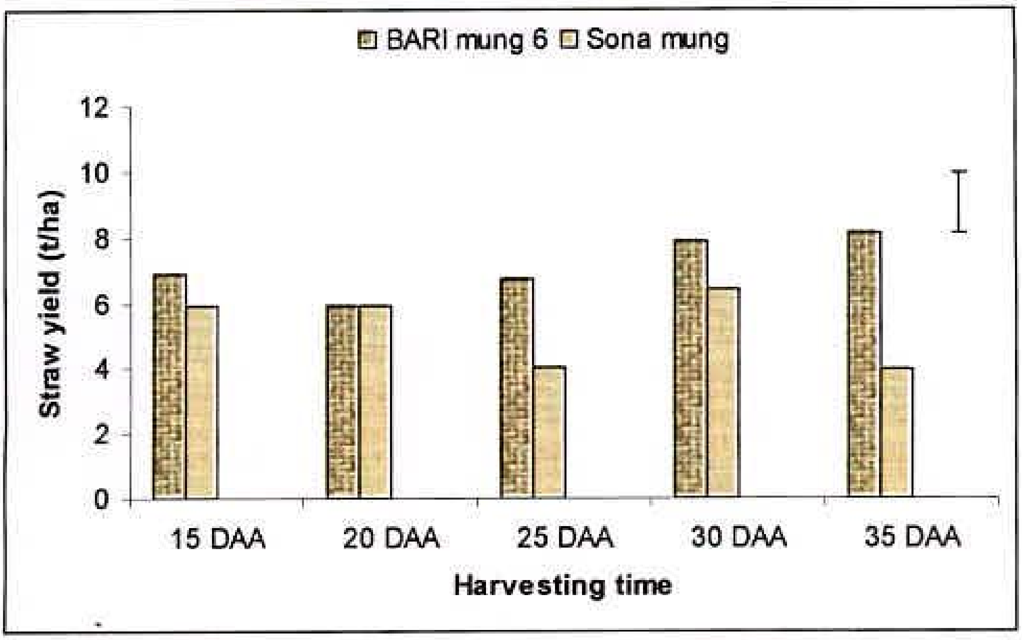


Figure 13. Straw yield as influenced by interaction of variety and harvesting time (Vertical bar indicates LSD value at 5% level of significance)

4.2.8 Harvest index

4.2.8.1 Effect of variety

The harvest index was influenced by variety (Appendix VIII and Table 7). The higher harvest index (20.22) was found in BARI mung 6 and the lowest (15.47) in Sona mung. The results agreed with the findings of Aguliar and Villarea (1989) who reported that the harvest index of mungbean was significantly influenced by the variety.

4.2.8.2 Effect of harvesting time

Harvesting time had significant effect on the harvest index (Appendix VIII and Table 7). The highest harvest index (22.62) was obtained at 25 DAA followed by 20 DAA (19.18) and 35 DAA (17.67) that did not differ significantly. The lowest harvest index (12.58) was produced at 15 DAA. This result was in agreement with Debnath (1998) who reported that the crop characters like harvest index were affected by harvesting method.

4.2.8.3 Interaction effect of variety and harvesting time

Harvest index was significantly affected by interaction of variety and harvesting time (Appendix VIII and Figure 14). The highest harvest index (24.30) was produced by Sona mung when harvested at 25 DAA followed by all the harvesting time of BARI mung 6 except 15 DAA. The lowest harvest index (10.63) was produced by Sona mung harvested at 15 DAA.

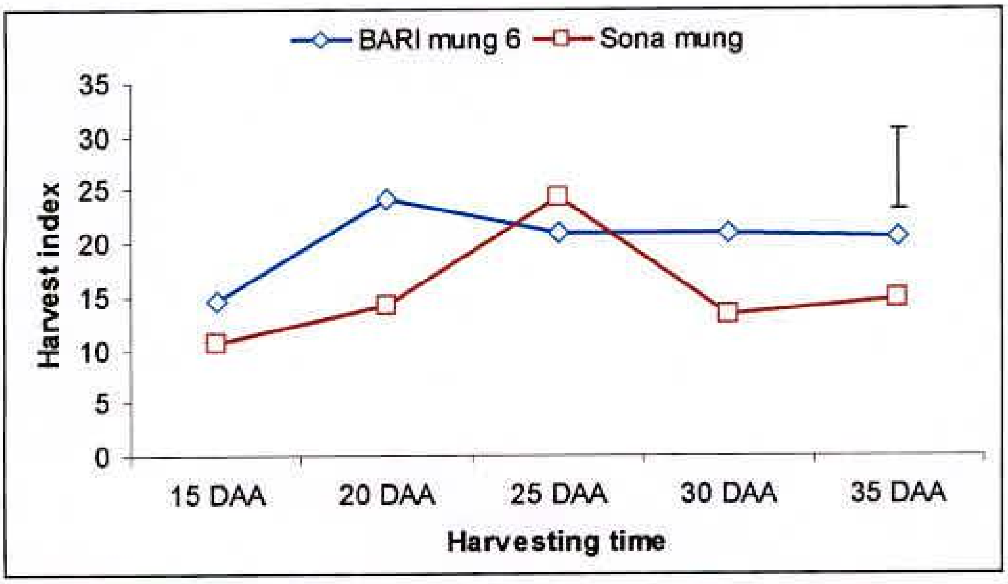


Figure 14. Harvest index as influenced by interaction of variety and harvesting time (Vertical bar indicates LSD value at 5% level of significance)

4.2.9 Shelling percentage

4.2.9.1 Effect of variety

Variety showed similar effect on shelling percentage of mung bean (Appendix VIII). Numerically maximum (37.30 %) and minimum (36.57%) shelling percentage was found in BARI mung 6 and Sona mung, respectively (Table 7).

4.2.9.2 Effect of harvesting time

Shelling percentage was influenced by different harvesting time (Appendix VIII and Table 7). The highest shelling percentage (42.26) was recorded at 15 DAA that of 30 DAA (37.97). The lowest shelling percentage (33.86) was recorded at 35 DAA followed by 25 DAA (34.54) and 20 DAA (36.04). The result agreed with the findings of Kalavathi and Ramaswamy (1988) who reported highest shelling percentage of Soybean cultivar Co.1 harvested at 55 days after 50% flowering.

4.2.9.3 Interaction effect of variety and harvesting time

Shelling percentage was influenced by interaction of variety and harvesting time (Appendix VIII and Figure 15). The highest shelling percentage (42.63) was recorded in Sona mung harvested at 15 DAA followed by the same variety harvested at 30 DAA (37.41) along with BARI mung 6 harvested at 15 DAA (41.89), 30 DAA (38.52) and 20 DAA (37.61). The lowest shelling percentage (33.37) was recorded in BARI mung 6 harvested at 35 DAA.

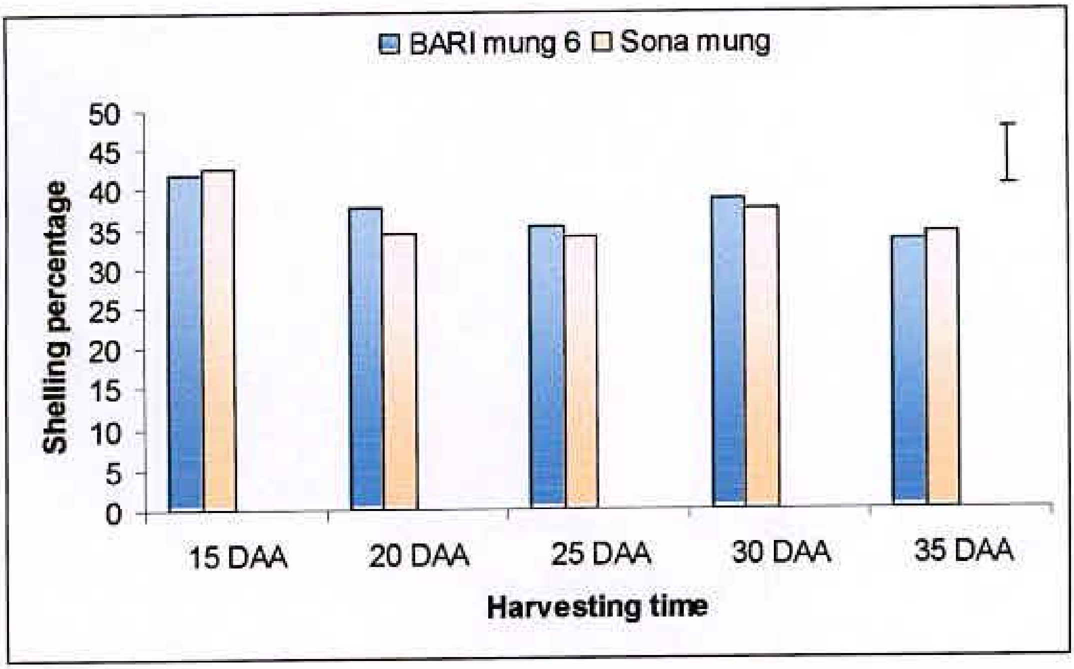


Figure 15. Shelling percentage as influenced by variety and harvesting time (Vertical bar indicate LSD value at 5% level of significance)

4.3 Post harvest study

4.3.1 Germination percentage

4.3.1.1 Effect of variety

Germination percentage of the harvested seeds was influenced by variety (Appendix IX and Table 8). The highest germination percentage (100%) was recorded in Sona mung and the lowest (94.66%) in BARI mung 6.

4.3.1.2 Effect of harvesting time

The harvesting time had significant effect on germination percentage (Appendix IX and Table 8). The highest germination percentage (100) was recorded when harvested at 15 DAA followed by 25 DAA (99.16).The lowest germination percentage was recorded at 30 DAA (95) which was similar to 20 DAA (96.66) and 35 DAA (95.83). Saha *et al.* (2002) repotted that germination percentage was higher in seeds harvested from the first flush of pods than those harvested at later dates. Seed germination percentage decreased progressively over the successive harvests. Saha (1987) observed that mungbean at 13 days after anthesis 100% seed germination occur when starch accumulation was initiated in the seeds.

Table 8. Post harvest germination and vigor of mungbean seeds as affected by variety and harvesting time

Treatments	Germination (%)	Vigor
Variety		
V_1	94.66	30.31
V_2	100	36.36
$LSD_{0.05}$	2.422	1.863
Harvesting time		
H_1	100	35.83
H_2	96.67	33.44
H_3	99.17	32.44
H_4	95.00	31.49
H_5	95.83	33.47
$LSD_{0.05}$	3.830	2.945
CV	3.21	7.22

V_1= BARI mung 6, V_2= Sona mung, H_1= Picking of pods at 15 days after anthesis (DAA), H_2= Picking of pods at 20 DAA, H_3= Picking of pods at 25 DAA, H_4= Picking of pods at 30 DAA, H_5= Picking of pods at 35 DAA.

4.3.1.3 Interaction effect of variety and harvesting time

Germination percentage was influenced by the interaction of variety and harvesting time (Appendix IX and Figure 16). The highest germination percentage (100%) was observed in Sona mung at all the harvested dates along with BARI mung 6 harvested at 15 DAA (100%) and 25 DAA (98.33%).The lowest germination percentage (90%) was recorded in BARI mung 6 harvested at 30 DAA which was similar to the same variety harvested at 20 DAA (93.33%) and 35 DAA (91.67%). The results agreed with the findings of Saha (1987) who reported that in *Vigna mungo* physiological maturity of seeds attained at 9 DAA well ahead of full maturity of pods and full germination occurred at 13 DAA. Suryavanshi and Patil (1995) reported that some mungbean cultivars reached physiological maturity within 25 to 30 DAA and developing seeds of mungbean were capable for germination on 10 DAA (mean 27% germination) and there after it was reduced progressively as the period of seed development advanced from anthesis. Thonamsub *et al.* (1986b) also reported that seed germination of mungbean at 10 to 18 days after flowering was higher (90%).

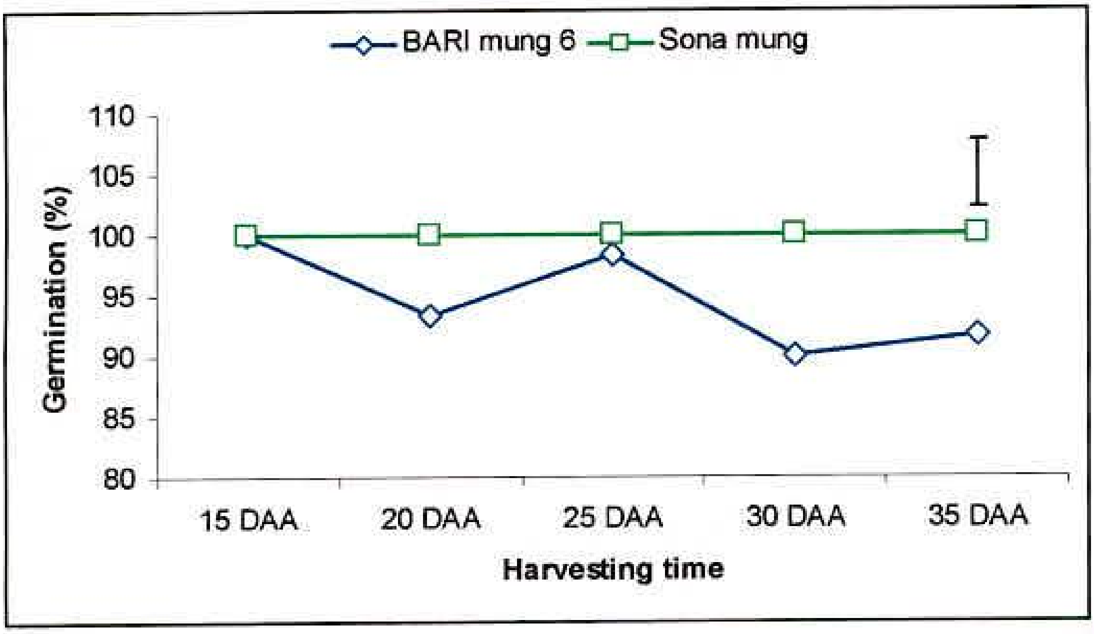


Figure 16. Germination percentage as influenced by interaction of variety and harvesting time (Vertical bar indicates LSD value at 5% level of significance)

4.3.2 Vigor

4.3.2.1 Effect of variety

Vigor of the harvested seeds was influenced by variety (Appendix IX and Table 8). The highest vigor (36.36) was recorded in Sona mung and the lowest vigor (30.31) was recorded in BARI mung 6.

4.3.2.2 Effect of harvesting time

The harvesting time had significant effect on vigor (Appendix IX and Table 8). The highest vigor (35.83) was recorded when harvested at 15 DAA followed by 35 DAA (33.47) and 20 DAA (33.44). The lowest vigor was recorded at 30

DAA (31.49) that followed by 25 DAA (32.44) that was statistically not different. Saha *et al.* (2002) reported that irrespective of varieties, seeds harvested from the first flush of pods gave higher vigor index that declined in successive harvest. Thanomsub *et al.* (1986b) reported that seed vigour of the pod was the highest when harvested 14 days after flowering.

4.3.2.3 Interaction effect of variety and harvesting time

Vigor was influenced by the interaction of variety and harvesting time (Appendix IX and Figure 17). The highest Vigor (36.66) was observed in Sona mung when harvested at 15 DAA, 25 DAA and 35 DAA followed by 20 DAA (35.99) and 30 DAA (35.83) along with BARI mung 6 harvested at 15 DAA (34.99). The lowest Vigor (27.16) was recorded in BARI mung 6 harvested at 30 DAA which was similar to the same variety harvested at 20 DAA (30.88), 35 DAA (30.27) and 25 DAA (28.22).

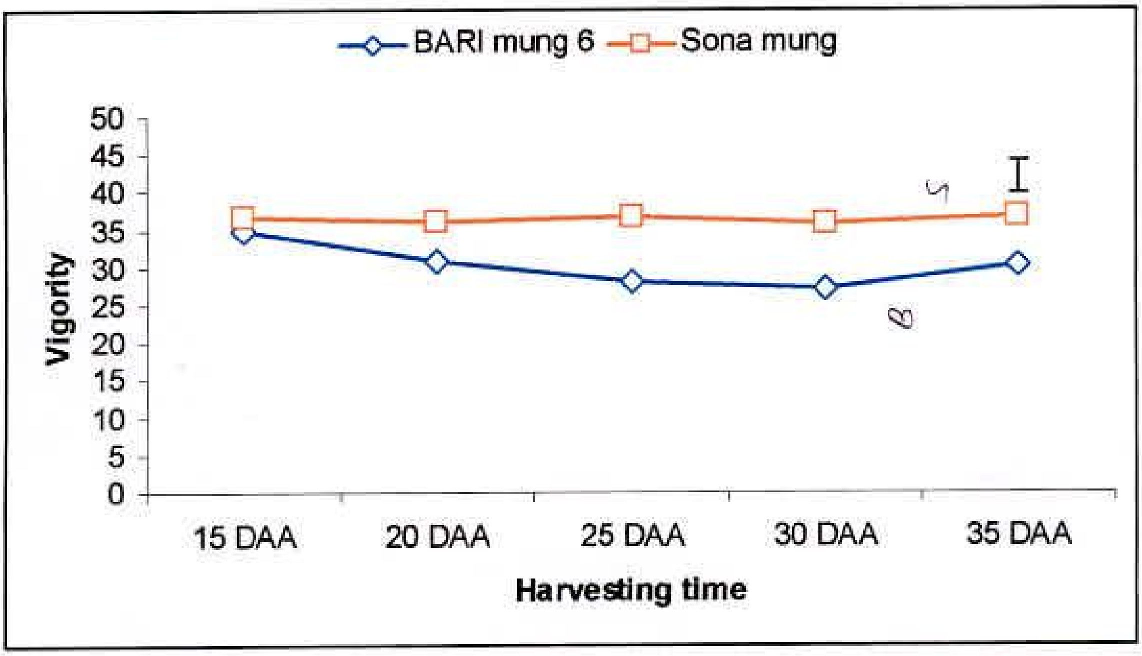


Figure 17. Vigority as influenced by interaction of variety and harvesting time (Vertical bar indicates LSD value at 5% level of significance)

CHAPTER 5

SUMMARY AND CONCLUSION

The present study was conducted at the Agronomy Field, Sher-e-Bangla Agricultural University, Dhaka from March, 2007 to June, 2007 to find out the influence of harvesting time on growth and yield of two mungbean varieties. The treatment consisted of five harvesting time viz. 15, 20, 25, 30 and 35 days after anthesis (DAA) and two varieties viz. BARI mung 6 and Sona mung. The experiment was laid out in split-plot design with four replications. The sowing date was March 27, 2007.

Ten plants were randomly selected from each plot for taking observations on plant height and LAI with 15 days interval at 15, 30 and 45 days and number of primary branches plant^{-1}, number of pods plant^{-1}, pod length, number of seeds pod^{-1}. Dry weigh m^{-1} was determined from 15 days after sowing to harvest. Central four rows from each pot were harvested for seed yield, straw yield, harvest index (%), shelling percentage and than converted into t ha^{-1}. Thousand seed weight, post harvest germination and vigor were determined from sample seed.

Among the growth parameters LAI from 15 to 30 DAS and dry matter m^{-2} was higher in BARI mung 6. Among the growth parameters pod length, weight of 1000 seeds, seed yield, straw yield, harvest index were higher in BARI mung 6. Number of primary branches plant^{-1}, number of pods plant^{-1}, post harvest germination and Vigor were higher in Sona mung. Plant height was highest in Sona mung at harvest.

Our data showed that harvesting time influenced number of pods plant^{-1}, pod length, thousand seed weight, seed yield, straw yield, harvest index (%), shelling percentage, post harvest germination and vigor. Maximum number of pods plant^{-1} was found from harvesting the crop at 20 DAA and the minimum was found from harvesting the crop at 35 DAA. The highest pod length was found from harvesting the crop at 25 DAA and the lowest was found from harvesting at 30 DAA. Weight of thousand seeds was highest at early harvesting on 20 DAA and lowest was from harvesting the crop at 30 DAA. Maximum seed yield was recorded from harvesting the crop at 30 DAA and the minimum was found from early harvesting at 15 DAA. Straw yield was found highest for harvesting the crop at 30 DAA and it was found lowest harvesting the crop at 25 DAA. The highest harvest index was recorded from harvesting the crop at 25 DAA and it was recorded lowest when the crop was harvested at 15 DAA. Shelling percentage was found highest at early harvesting and minimum from delayed harvesting. Post harvest germination and vigor was higher from the early harvested seeds.

The interaction of variety and harvesting time was found significant with plant height, dry matter m^{-2}, days to first flowering, number of primary branches plant^{-1}, number of pods plant^{-1}, pod length, number of seeds pod^{-1}, weight of 1000 seeds, seed yield (t ha^{-1}), straw yield (t ha^{-1}), harvest index, selling percentage, post harvest germination and vigor. Maximum seed yield of BARI mung 6 was recorded when harvested at 35 DAA. Weight of thousand seed and pod length was also found higher in BARI mung 6 for harvesting the crop at 20 and 25 DAA, respectively. Shelling percentage, pods plnat^{-1} and primary branches plant^{-1} was highest in Sona mung for harvesting at 15, 20 and 30 DAA, respectively. The highest harvest index was recorded also from Sona mung for harvesting at 25 DAA. The seeds of Sona mung showed highest post harvest germination percentage and vigor at all the harvesting dates. Number of branches and plant height was found highest in Sona mung for harvesting at 30 and 35 DAA.

Late harvesting enhanced seed yield, straw yield and harvest index. Early harvest enhances number of pods, thousand seed weight and shelling percentage. So, harvesting the crop at 20 DAA was optimum for seed yield, harvest index, thousand seed weight, number of pods plant^{-1} and pod length.

Based on the results of the present study the conclusion may be drawn as noted in the following paragraph.

Highest seed yield was found from BARI mung 6 when harvested at 35 DAA. Sona mung showed higher yield when harvested at 25 DAA. So, harvesting the crop at 25 DAA was optimum for Sona mung. Harvesting the crop at 35 DAA was optimum for BARI mung 6 because this variety showed highest result with late harvesting. However, to reach a specific conclusion and recommendation, more research work on wider range of harvesting time of mungbean varieties should be done over different Agro-ecological zones of Bangladesh.

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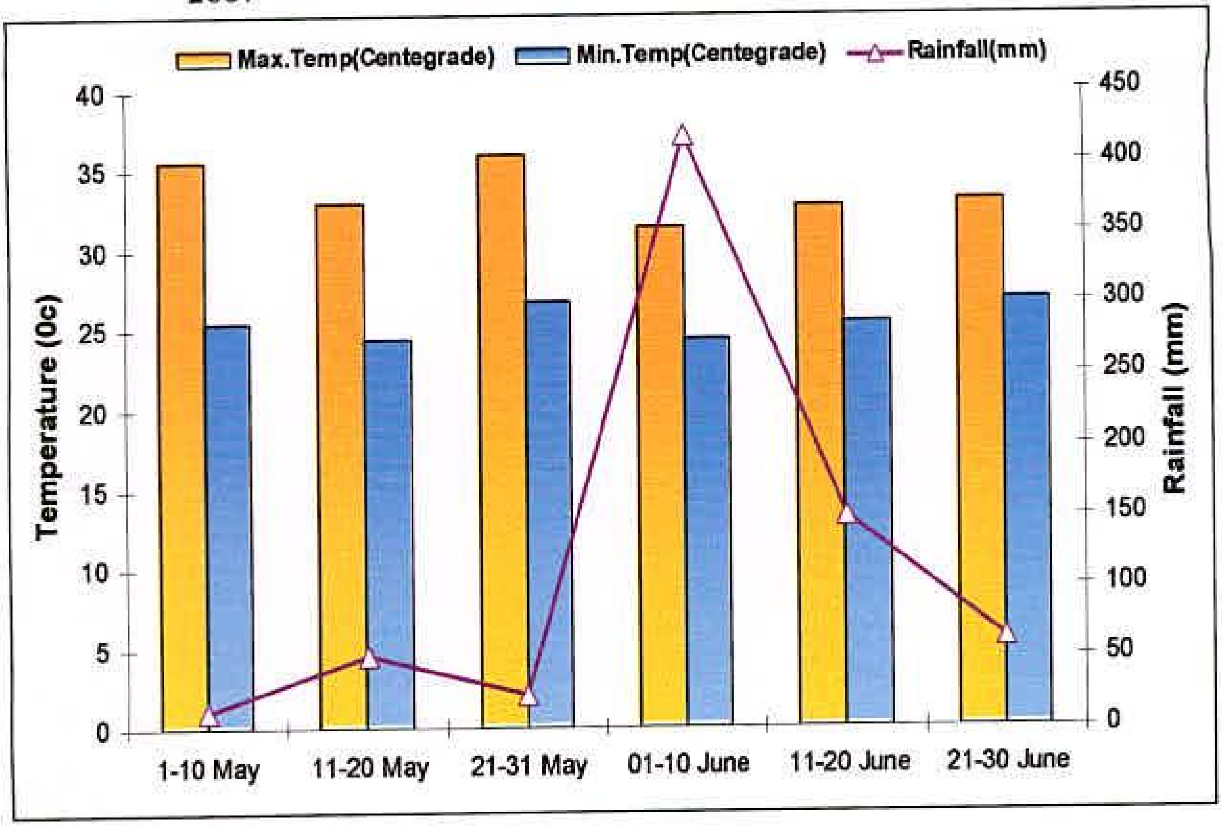
APPENDICES

Appendix I. Average temperature and rainfall (1o days interval) of the experimental site during the period from May 2007 to June 2007



Appendix II. Means square values for plant height of mungbean at different days after sowing

Sources of variation	Degrees of freedom	Means square values 15 DAS	30 DAS	45 DAS	At harvest
Replication	2	0.84	3.49	63.34	12.33
Variety (V)	1	130.79**	702.67**	381.06**	1115.81**
Error (a)	2	1.52	1.81	53.69	13.80
Harvesting time (H)	4	0.72	1.55	13.44	31.46*
V X H	4	0.45*	2.84*	37.7*	8.13*
Error (b)	16	0.79	6.02	12.10	16.08
CV (%)		9.80	9.20	6.31	7.72

* Significant at 5% level

** Significant at 1% level

Appendix III. Means square values for LAI of mungbean at different days after sowing

Sources of variation	Degrees of freedom	Means square values		
		15 DAS	30 DAS	45 DAS
Replication	2	0.006	1.22	5.49
Variety (V)	1	0.038**	24.04**	0.57
Error (a)	2	0.004	0.043	4.23
Harvesting time (H)	4	0.001	0.078	1.03
V X H	4	0.004*	0.18*	0.75
Error (b)	16	0.003	0.38	1.67
CV (%)		37.21	14.34	14.38

* Significant at 5% level

** Significant at 1% level

Appendix IV. Means square values of total dry matter weight of mungbean at different days after sowing

Sources of variation	Degrees of freedom	Means square values			
		15 DAS	30 DAS	45 DAS	At harvest
Replication	2	1.52	28.54	8471.83	16303.7
Variety (V)	1	45.06**	10504.2**	149929**	256786**
Error (a)	2	2.18	215.86	19384.7	3820.98
Harvesting time (H)	4	0.33	231.71	1659.09	25976.0*
V X H	4	0.12*	272.38*	17985.6*	39671.6 *
Error (b)	16	0.22	150.01	2884.71	11303.3
CV (%)		14.02	26.47	17.42	17.23

* Significant at 5% level

** Significant at 1% level

Appendix V. Means square values of dry matter partitioning of mungbean at harvest

Sources of variation	Degrees of freedom	Means square values			
		Leaf	Stem	Root	Pod & flower
Replication	2	3308.09	2566.00	123.272	716.06
Variety (V)	1	90916.2**	2508.93*	0.533*	66054.0**
Error (a)	2	819.658	2073.88	5.60	649.895
Harvesting time (H)	4	8143.46*	3888.24*	298.99*	8397.72*
V X H	4	8143.46*	4202.53*	215.81*	9232.00*
Error (b)	16	3352.50	1608.77	74.83	2178.19
CV (%)		24.54	23.23	22.92	27.28

* Significant at 5% level

** Significant at 1% level

Appendix VI. Means square values for days of first flowering

Sources of variation	Degrees of freedom	Means square values
Replication	2	1.03
Variety (V)	1	93.63**
Error (a)	2	2.03
Harvesting time (H)	4	0.20
V X H	4	3.30*
Error (b)	16	1.20
CV (%)		3.12

* Significant at 5% level

** Significant at 1% level

Appendix VII. Means square values different crop characters of mungbean

Source of variation	Degree of freedom	Means square values					
		Primary branches plant^{-1} (No.)	Pods plant^{-1} (No.) Main stem	Pods plant^{-1} (No.) Total	Pod length	Seeds pod^{-1} (No.)	Weight of 1000 seeds (g)
Replication	2	0.769	19.13	50.72	0.123	0.362	2.76
Variety (V)	1	10.56*	140.83*	780.30**	76.86**	6.81	7417.95**
Error (a)	2	0.457	7.48	33.19	0.327	1.31	32.75
Harvesting time (H)	4	0.181	29.92	151.35*	1.07*	2.13	55.87**
V X H	4	0.061*	146.24*	220.49*	0.076*	1.71*	29.66*
Error (b)	16	0.328	38.19	63.86	0.265	1.66	12.05
CV (%)		35.57	33.15	30.14	6.55	11.7	10.62

* Significant at 5% level

** Significant at 1% level

Appendix VIII. Means square values for Seed yield, straw yield, harvest index and shelling percentage of mungbean

Source of variation	Degree of freedom	Means square values			
		Seed yield	Straw yield	Harvest index	Shelling percentage
Replication	2	0.009	1.63	10.89	36.76
Variety (V)	1	3.52**	25.7**	169.21**	4.00
Error (a)	2	0.022	0.384	15.86	6.67
Harvesting time (H)	4	0.169**	2.59*	79.14*	68.13*
V X H	4	0.11*	3.97*	37.87*	4.18*
Error (b)	16	0.027	1.13	19.07	16.97
CV (%)		15.21	17.22	24.47	11.15

* Significant at 5% level

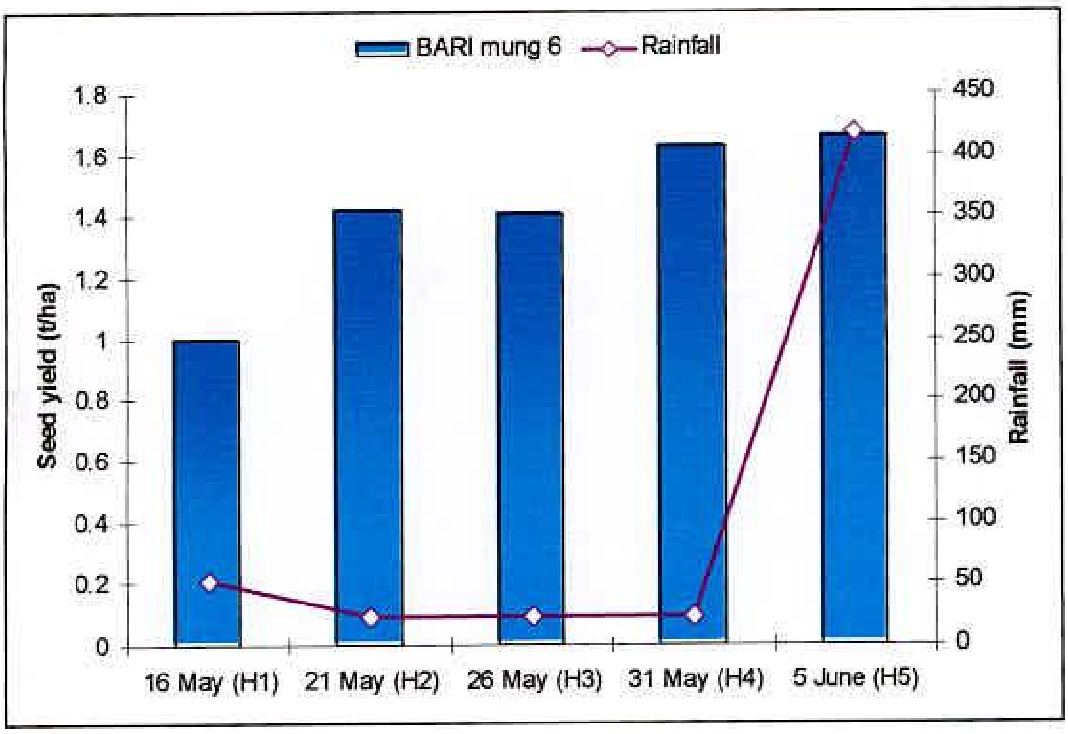
** Significant at 1% level

Appendix IX. Means square values for post harvest germination and vigority

Sources of variation	Degrees of freedom	Means square values	
		Germination	Vigority
Replication	2	10.83	5.85
Variety (V)	1	213.33**	274.82**
Error (a)	2	10.83	3.05
Harvesting time (H)	4	27.91*	15.95*
V X H	4	27.91*	11.98*
Error (b)	16	9.79	5.79
CV (%)		3.21	7.22

* Significant at 5% level
** Significant at 1% level

Appendix X. Amount of rainfall at different harvesting time of BARI mung 6.



Appendix XI. Amount of rainfall at different harvesting time of Sona mung.