STUDY ON GROWTH AND DRY MATTER PARTITIONING IN GROUNDNUT GENOTYPES

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CERTIFICATE

This is to certify that the thesis entitled, **"STUDY ON GROWTH AND DRY MATTER PARTITIONING IN GROUNDNUT GENOTYPE"** 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 (MS)** in **AGRICULTURAL BOTANY** embodies the result of a piece of bona fide research work carried out by **MD. SHARIFUZZAMAN**, Registration No. **03-01099** under my supervision and 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 been duly acknowledged.

Dated: June 25, 2008
Mymensingh, Bangladesh

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Dedicated

To

My Beloved Parents

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The author **SAU, Dhaka**

ABSTRACT

The experiment was carried out at the field laboratory of Bangladesh Institute of Nuclear Agriculture, Mymensingh, to investigate the growth, some morphological features, dry matter production and its partitioning in four groundnut genotypes *viz*., GM-16, GM-35, GM-45 and Dhaka-1 during the period from December 2007 to May 2008. The experiment was laid out in a randomized complete block design with three replications. Significant variations in morpho-physiological features, yield attributes and dry matter production and its partitioning into different plant parts were found among the four groundnut genotypes. High yielding genotypes had shorter plant height, greater branch number than the low yielder, Dhaka-1. The plant height, leaf area, leaf area index, total dry matter and absolute growth rate (at early growth stage) were superior in Dhaka-1 over its growth period followed by GM-35 but Dhaka-1 produced the lowest pod yield due to unfavorable DM distribution to the economic yield. In contrast, GM-45 performed inferiority in above studied parameters. GM-35 produced the highest pod yield (22.2 g plant^{-1} and 3.04 t ha^{-1}) due to the production of bolder and higher number of pods plant^{-1} while Dhaka-1 showed the lowest pod yield although it had the highest number of pods plant^{-1} due to production of smaller pods. Total dry matter production and its partitioning into pod (economic yield) were significantly greater in three genotypes than the cultivar, Dhaka-1 with being the highest in GM-35.

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ACRONYMS

%	=	Percent
AEZ	=	Agro Ecological Zone
AGR	=	Absolute Growth Rate
ANOVA	=	Analysis of Variance
BARI	=	Bangladesh Agricultural Research Institute
BAU	=	Bangladesh Agricultural University
BBS	=	Bangladesh Bureau of Statistics
BINA	=	Bangladesh Institute of Nuclear Agriculture
CGR	=	Crop Growth Rate
cm	=	Centimeter
cv	=	Cultivar(s)
CV%	=	Percentage of Co-efficient of Variance
DAS	=	Days After Sowing
df	=	Degrees of Freedom
DM	=	Dry Matter
DMRT	=	Duncan's Multiple Range Test
FAO	=	Food And Agricultural Organization
g	=	Gram
GM	=	Groundnut Mutant
HI	=	Harvest index
Kg	=	Kilogram
LAI	=	Leaf Area Index
LSD	=	Least Square Design
MP	=	Muriate of Potash
NAR	=	Net Assimilation Rate
RGR	=	Relative Growth Rate
SAU	=	Sher-e-Bangla Agricultural University
SLA	=	Specific Leaf Area
t/ha	=	Tones Per Hectare
TDM	=	Total Dry Matter
TSP	=	Triple Super Phosphate

Chapter 1
Introduction

CHAPTER I

INTRODUCTION

Groundnut is an annual leguminous oil crop. There are three botanical types of cultivated groundnut in the world: Virginia, Spanish and Valencia. Spanish type is mostly grown in Bangladesh. There are many oil crops grown in Bangladesh. Of them, groundnut stands third in terms of acreage but ranks second in terms of production, with mustard being the first and sesame the third, respectively. Nevertheless, the scope of extending total acreage is becoming more apparent with ever increasing shoals for continued shortfall of annual precipitation and water tables (Sarker, 2007). Being a legume crop, it fixes atmospheric nitrogen in the soil through its nodule bacteria which enriches the soil with nitrogen (49-297 kg N ha^{-1} $season^{-1}$, Hoque, 1989) and reduces the uses of synthetic fertilizer and keeps the environment more friendly.

The principal constraint of groundnut production is its low yield potential because of undesirable plant type. From 60 to 95% of groundnut flowers do not develop into mature pods (Sinha, 1977, Mondal, 1997) indicating that potential fruit number is usually much larger than the number actually produced by the plant community. The number of fruits with developing seeds inc reases after growth stage R_1 (Flower initiation stage) and reaches to a maximum after growth stage R_5 (pod and grain growth stages) (Sinha, 1977) but during this period the plant still grows vegetatively. Therefore, developing reproductive sinks are competing for assimilates with vegetative sinks. Increasing canopy photosynthesis during this period with elevated CO_2 level increased the number of fruits or seeds per unit area (Egli *et al.*, 1990).

These results suggest that seeds per unit area are related to canopy photosynthesis during flowering and a plant with optimum LAI and NAR may produce higher biological yield. The capacity of efficient partitioning between the vegetative and reproductive parts may produce high economic yield (Thakare *et al.,* 1981). For optimum yield in groundnut, the LAI should be ranged from 3.0 to 4.0 (Mondal, 1997). Any reduction of leaf area or the amount/intensity of light may have an adverse effect on yield (Dutta *et al.,* 1998). The dry matter accumulation may be the highest if the LAI attains its maximum value within the shortest possible time (Pawar and Bhatia, 1980).

The pod development and yield in groundnut is complex, and it depends on various components such as flowers formed plant^{-1}, the per cent pod set, the number of pods plant^{-1}, seeds pod^{-1} and seed size. Different physiological pathways influence the per cent pod set, the number of pods plant^{-1}, seeds pod^{-1} and seed size component characters, resulting the final yield of the crop. Moreover, the number of pods and their sizes depend on the photo-assimilates before and after anthesis, which again mostly depend on partitioning among the vegetative and reproductive sinks. Again, dry matter partitioning into reproductive organ is largely determined by the degree of competition for assimilates between vegetative and reproductive sink (Mondal, 2007). Therefore, there are needs to study the dry matter partitioning pattern in plant parts. Literature on growth, dry matter partitioning of groundnut and their inter-relationships are few and scanty. Recently, BINA has developed three promising groundnut genotypes (GM-16, GM-35 and GM-45) of high yield potentials. These three genotypes need to be assessed for their physiological growth and dry matter production and its partitioning into different parts compared to the existing popular cultivar.

Keeping all these in mind, the present investigation was under taken with the following objectives:

Objectives:

i. to evaluate some canopy characteristics and growth parameters in groundnut genotypes; and

ii. to investigate relative dry matter production ability and their patterns of distribution to different plant parts in groundnut.

Chapter 2
Review of literature

CHAPTER II

REVIEW OF LITERATURE

In this review, an attempt has been made to present relevant literature on morpho-physiological characters, dry matter production and partitioning and yield attributes in groundnut and other leguminous crops.

2.1 Morphological characters

2.1.1 Plant height

Plant height is a measure of longitudinal distribution of plant and it varies with the genotypes concerned. Mondal (1997) evaluated variability among 30 accessions for plant height and observed high variability in plant height ranging from 33.5 to 50.2 cm. Azad and Hamid (2000) conducted experiment with 40 mutants/cultivars of groundnut and reported that there had wide variability in case of plant height, branch number and leaf area among the studied mutants. Similar results were also reported by Dewan (2005) in groundnut. Rahman (2003) studied comparative performance in respect of growth and yield in four groundnut genotypes and reported that high yielding genotypes had shorter plant height than in the low yielding ones. Similar result was also reported by Rahman (2001) after studying the comparative performances of 39 groundnut genotypes.

2.1.2 Branch number

The number of branches plant^{-1} is an important morphological character that influence canopy and leaf display (Wilson and Teare, 1972). Several workers reported that seed yield was significantly and positively correlated with number of primary branches per plant (Dhopte and Kudupley, 1986; Mondal, 1997, Chowdhury *et al*., 1998). A positive association of number of branches was observed with pods per plant (Kalita *et al.,* 2003). Further, Rahman (2001) stated that high yielding genotypes had greater branch number per plant than low yielding ones in groundnut. Similar result was reported by BINA (2002) in groundnut.

2.1.3 Leaf area

Leaf is the most important part of any crop. It is directly related with photosynthesis, which influences other morpho-physiological traits. Khan (1981) stated that leaf area index, a measure of leafiness and photosynthetic surface area of a crop; depend on the leaf growth, number of leaves, mode of branching and leaf senescence. Significant differences in leaf area were observed in groundnut genotypes ranging from 1260 to 2600 cm^2 (Sharma and Singh, 1994). Similar result was also observed by Mondal (1997) in groundnut. Further, most of the researchers reported that seed yield and TDM production were significantly and positively correlated with leaf area in groundnut (Hoque *et al.,* 1993; Deshmukh *et al*., 1996; Tekale *et al.,* 1998; BINA, 2002; Islam, 2007).

2.2 Growth characters

2.2.1 Total dry matter

Total dry matter (TDM) production and distribution are economically useful to determine the crop yield (Evans, 1975). Total dry matter of a crop depends on the size of leaves, its activity as well as the duration of its growth period during which photosynthesis continues. Dutta (2001) stated that total dry matter production was largely dependent on the solar radiation interception over the growing season and also indicated that total grain yield was influenced by photosynthesis and the distribution of photosynthesis within the plant.

Hamid *et al*. (1990) reported that total dry matter production was positively correlated with the amount of foliage displayed in the upper 50% of canopy in legume crops. It seems that the foliage developed in the lower part of the canopy has little or negative contribution to dry matter production in legume.

Groundnut either in winter or summer always had steady increase in dry matter before flowering (Mondal, 1997). In a legume, the initial growth was very slow during the early vegetative phase and relatively smaller amount of total dry matter was produced before flower initiation (Osumi *et al*., 1998) and a maximum dry matter was produced around physiological maturity (Prodhan, 2004). Many researchers reported that grain yield was positively and significantly correlated with total dry matter production (Varman and Raveendran, 1999; Azad and Hamid, 2000, Rahman, 2001, Rahman, 2003; Islam, 2007).

2.2.2 Leaf area index

Leaf area index (LAI) is a ratio of total surface area of leaves to a unit area of land and it is the functional size of the standing crop on unit land area (Hunt, 1978). LAI measures photosynthetic surface area of a crop and it depends on the leaf growth, number of leaf, plant density and leaf senescence (Khan, 1981).

LAI is a better parameter of crop growth than net assimilation rate and the higher productivity depends on the persistence of a high leaf area index over a greater part of its vegetative phase. The rate of photosynthesis depends on the LAI and structure of the canopy (Evans, 1975).

Percent solar radiation interception and rate of dry matter production increased with leaf area development and approached to a maximum at similar leaf area indices (Hamid *et al.*, 1990). Rapid early growth and maintenance of reasonably high LAI with higher net assimilation rate during pod formation and pod filling stage have great influence on grain yield (Desmukh and Bhapker, 1979). However, most of the researchers stated that seed yield was positive and significantly correlated with LAI (Mondal, 1997, Rahman, 2001, Rahman, 2003; Khatun, 2006; Mondal, 2007).

2.2.3 Crop growth rate

The crop growth rate (CGR) in a unit area of canopy cover at any instant time is defined as the increase of plant material per unit of time (Hunt, 1978). It is the rate of dry matter production per unit area of land per unit time (Hunt, 1978). CGR is a simple and important index of agricultural productivity.

CGR is strongly correlated with LAI and net assimilation rate and it increases with LAI (Rahman, 2005). In groundnut, blackgram, lentil and mungbean, the CGR became minimum during early vegetative phase and reached to a maximum with the onset of the reproductive phase (Pandey *et al.*, 1978; Rahman, 2003; Prodhan, 2004; Maola, 2005). The CGR was maximum at the stage of grain filling and pod maturity possibly for increased sink strength (Rahman, 2003). Kim (1985) described that CGR rate was positively correlated with RGR, NAR, LAR and SLA in rice. Several workers reported the same opinion in relation to growth analysis in different leguminous crops (Tomar *et al.*, 1995; Prodhan, 2004; Maola, 2005; Rahman, 2005).

2.3 Dry matter production and partitioning

Grain yield may be considered as a function of biomass accumulation and its partitioning to grain (Muchow *et al*., 1993). High dry matter production and its partitioning to sink are prime determinants of productivity (Dutta, 2001). Hamid *et al*. (1990) reported that total dry matter production was positively correlated with amount of foliage displayed in the upper 50% of the canopy. It seems likely that the foliage developed in the lower part of the canopy had little contribution to dry matter production. In a trial with cowpea, Medina *et al*. (1996) observed that weight of leaf, stem, branch, flower and pod was affected by genotype. Watanabe and Terao (1998) examined total dry matter, seed yield and other phenological traits of cowpea and observed that reduction in seed yield under drought condition due to reduction of TDM.

Patel *et al*. (2005) studied accumulation and partitioning of total dry matter and their relationship with seed yield of 10 groundnut genotypes and reported that high yielding genotype had a significant and overriding influence on the pattern of dry matter accumulation, partitioning, seed yield and yield attributes. The author further reported that greater seed yield was achieved through the contribution of higher total dry matter. Similar results were also reported by Karanjikar *et al.* (2005) in groundnut.

Further, Azad and Hamid (2000) studied path coefficient analysis in groundnut and observed that biological yield plant^{-1} had the maximum positive direct effect on pod yield. Almost all the yield contributing characters had higher positive indirect effect via biological yield plant^{-1}. Hoque *et al.* (1993) reported that all yield contributing characters were positively correlated with total biological yield in groundnut. They further reported that most of the genotypes with higher biomass also produced higher seed yield in groundnut.

A field experiment was conducted by Laxmi (2003) to determine the dry matter distribution and seed yield in 10 lentil cultivars under soil moisture stress and reported that seed yield was mainly dependent on the rate of dry matter partitioning per day of seed filling period and dry matter accumulation. On the other hand, Whitehead *et al.* (2000) studied with 112 accession of lentil and reported that low yielding genotypes produced meager biomass (average 0.72 t ha^{-1}) and poor harvest index (19%) and productive genotypes had substantially higher biomass (3.52 t ha^{-1}) and improved HI (34%).

Harvest index is a measure of the efficiency of conversion of photosynthate into economic yield of a crop plant (Gautom and Sharma, 1987). Increase HI results in increase crop yield, probably because of improved partitioning of dry matter to reproductive parts (Dutta, 2001). Grain yield is positively correlated with harvest index in groundnut (Reddy and Gupta, 1992), in lentil (Rajput and Sarwar, 1989) and chickpea (Mishra *et al.*, 1988).

2.4 Yield contributing characters

2.4.1 Number of pods

The number of pods plant^{-1}, the prime yield attribute, is an important criterion for the visual selection of high yielding genotypes (Dutta, 2001). Rahman (2001) reported that seed yield in groundnut was dependent on pod number, seeds pod^{-1} and seed size. Dutta (2001) further recommended that pods plant^{-1}, plant height and number of productive branches were important for selection of high yielding genotypes. Similar result was also reported by Mondal (1997) in groundnut and Dutta and Mondal (1998) in lentil who observed that high yielding genotypes had high number of pods plant^{-1}. BINA (2002) further observed a wide variation in case of pod plant^{-1} in groundnut. However, most of the researchers reported that seed yield was strongly dependent on pod number plant^{-1} (Deshmukh *et al.,* 1986; Mondal and Hamid, 1998; Azad and Hamid, 2000).

2.4.2 Pod length

Rahman (2001) studied 39 groundnut mutants for flowering pattern and yield contributing characters and found that there was a high variation in pod length. Rahman (2003) conducted an experiment on groundnut cultivars *viz.*, Binachinabadam-1, Binachinabadam-2, Binachinabadam-3 and Dhaka-1 and found that pod length was the highest in Binachinabadam-3. A wide range of variation in pod length was observed by Patil and Bhapkar (1987).

2.4.3 Hundred pod and seed weight

Rahman (2003) conducted an experiment on groundnut cultivars *viz.*, Binachinabadam-1, Binachinabadam-2, Binachinabadam-3 and Dhaka-1 and found that 100-pod and-seed weight varied significantly among the tested cultivars and 100-pod and-seed weight were the highest in Binachinabadam-3. Similar result was also reported by Chauhan and Shukla (1985) in groundnut and they reported that there had a wide range of variability in 100-pod and-seed weight among the studied genotypes. Pathak *et al.* (1993) reported that seed yield was positively correlated with 100-pod and-seed weight in groundnut. Similar results were also reported by many workers in groundnut (Patil and Bhapker, 1987; Mondal and Hamid, 1998; Azad and Hamid, 2000; Islam, 2007).

2.5 Varietal performance

Many workers have studied yield performance of groundnut across the world. Rahman (2001) studied 39 mutants of groundnut and found that there was a wide range of pod yield ranging from 12.4 to 25.2 g $plant^{-1}$. Mondal (1997) reported that there was significant variation in pods $plant^{-1}$ and seed yield in 30 groundnut mutants and the yield range was 5.35-11.9 g $plant^{-1}$. Youngkeun *et al.* (2002) observed that plant height, branch number, pod number and 100-seed weight were significantly influenced by variety. In an experiment with 30 mutants in groundnut, the highest seed yield was obtained in D1/36-2 (BINA, 2002). Rahman (2003) working with modern varieties of groundnut and observed that there were significant differences in all plant characters among the varieties of the same species.

Chapter 3
Materials and Methods

CHAPTER III
MATERIALS AND METHODS

The details of different materials used and methodology followed during the experimental period are presented under the following heads:

3.1 Experimental site

The experiment was carried out at the experimental farm of the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, during the period from 2 December 2007 to 20 May 2008. Geographically the experimental area is located at $24^0 75'$ N latitude and $90^0 50'$ E longitudes at the elevation of 18 m above the sea level (FAO, 1988). The experimental field was medium high land belonging to the Sonatola Soil Series of Grey Floodplain soil under the agro-ecological zone of Old Brahmaputra Floodplain (AEZ-9). The soil was silty loam. Fertility status is sown in the Appendix I.

3.2 Climate and weather

The experimental field was under sub-tropical climates characterized by heavy rainfall during the month of April to September and scanty rainfall during October to March. The monthly mean maximum, mean minimum and mean air temperatures, relative humidity and total rainfall received at the experimental site during the period from November 2007 to May 2008 are presented in the Appendix II.

3.3 Treatment of the experiment

Three promising high yielding groundnut mutants, namely GM-16, GM-35 and GM-45 along with a popular variety, Dhaka-1 were used.

3.4 Land preparation

The land of the experimental site was first opened in 2nd week of November 2007 with power tiller. Later, the land was ploughed and cross-ploughed three times followed by laddering to obtain the desired tilth. The corners of the land were spaded and large clods were broken into smaller pieces after ploughing and laddering. All the stubbles and uprooted weeds were removed and the land was made ready.

3.5 Experimental design

The experiment was laid out in a Randomized Complete Block Design with three replications.

3.6 Fertilizers

Urea, triple super phosphate (TSP), muriate of potash (MP) and gypsum were used as source of nitrogen, phosphorus, potassium and sulphur, respectively. Total amount of urea, TSP, MP and gypsum were applied at basal doses during final land preparation. The doses of fertilizers were: urea 40, TSP 80, MP 60 and gypsum 40 kg ha^{-1}.

3.7 Plot preparation, sowing of seeds and thinning

The size of the unit plot was 3 m x 2 m. Distances between block to block and plot to plot were 0.5 meter. Plant to plant and row to row distances were maintained at 15 cm and 30 cm, respectively. The seeds of groundnut were hand sown in rows on 2 December, 2007. Seeds were placed at about 3-4 cm depth from the soil surface.

3.8 Weeding

Weeding was done twice at 25 and 55 days after sowing (DAS) before flowering starts.

3.9 Protection against pests

At flowering, few plants were affected by aphid. To control it, Malathion 57 EC was sprayed @ 0.25% at afternoon by using a sprayer.

3.10 Crop sampling

Some morpho-physiological, yield attributes and yield data were collected at five harvests. The first crop sampling was done at 100 DAS and continued at an interval of 15 days up to 160 DAS. From each plot, five plants were randomly selected and uprooted for obtaining data of necessary parameters. The plants were separated into leaves, stems, roots, matured and immatured pods, and the corresponding dry weights were recorded after oven drying at 80 ± 2^0 C for 72 hours.

3.11 Data collection: The following data were recorded:

3.11.1 Morphological parameters

i) Plant height

ii) Number of branches plant^{-1}

iii) Leaf area

3.11.2 Growth parameters

i) Total dry matter

ii) Leaf area index

iii) Absolute growth rate

3.11.3 Dry matter (DM) partitioning plant^{-1}

i) Root DM

ii) Stem DM

iii) Leaf DM

iv) Seed DM

v) Husk DM

vi) Total DM

3.11.4 Yield and related traits

i) Pod yield plant^{-1}

ii) Number of pods plant^{-1}

iii) Pod length

iv) Single pod weight

v) 100-seed weight

vi) Harvest index (%)

Description of the collected data

Morpho-physiological parameters

i) **Plant height:** Plant height was taken to be the length between the base of the plant to the tip of the main stem.

ii) **Number of branches plant^{-1}:** Number of branches was counted from randomly selected 10 plants of each plot at each harvest and average branches plant^{-1} was calculated.

iii) **Leaf area plant^{-1}:** Leaf area per plant was measured by automatic leaf area meter.

iv) **Harvest index:** Harvest index was calculated by dividing economic yield with biological yield of plant and multiplying the result with 100 and expressed in percentage

$$\textbf{Harvest index (\%)} = \frac{\textbf{Economic yield}\ \text{(seed yield, kg plot}^{-1}\text{)}}{\textbf{Biological yield}\ \text{(kg plot}^{-1}\text{)}} \times \mathbf{100}$$

Growth parameters

i) **Total dry matter plant^{-1}:** The total dry matter was calculated from summation of oven dried ($80^0C \pm 2$) leaves, stem, root and pod dry weight per plant.

ii) **Leaf area index**: It was calculated by leaf area ÷ land area of a unit area.

iii) **Absolute growth rate (AGR):** Rate of dry matter production per unit of time per plant.

$$\text{i.e. } \mathbf{AGR} = \frac{\mathbf{W_2 - W_1}}{\mathbf{(T_2 - T_1)}} \quad \text{g plant}^{-1}\text{ day}^{-1}$$

Where, W_2 and W_1 are the DM at time T_2 and T_1, respectively.

Yield and yield contributing characters

i) **Number of pods plant^{-1}:** Pods of randomly selected 10 plants of each replication were counted and then the average number of pods for each plant was determined.

ii) **Single pod weight:** Fifty randomly selected pods from each of the plot were weighed and then divided by fifty to get single pod weight.

iii) **100-seed weight:** One hundred clean sun dried seeds were counted from the seed stock obtained from the sample plants and weighed by using electronic balance.

iv) **Seed yield plant^{-1}:** The seeds were separated from pod of 10 plants manually. Seeds were then sun dried and weighed and seed weight plant^{-1} was calculated.

v) **Seed yield (t ha^{-1}):** Seed yield per plot was recorded and then converted into tons hectare^{-1}.

3.12 Statistical analysis

The collected data were analyzed statistically following the analysis of variance (ANOVA) technique and the mean differences were adjudged with Duncan's Multiple Range Test (DMRT) using the statistical computer package program, MSTAT-C (Russell, 1986).

Chapter 4

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The results of the study on the effects of groundnut genotypes on morpho-physiological, yield and yield related traits have been presented and possible interpretations have been made and discussed in this chapter.

4.1 Morphological features in four groundnut genotypes

4.1.1 Plant height

The plant height at different growth stages of four groundnut genotypes is presented in Fig.1 (Appendix-III). The increment of plant height varied significantly due to genotype very ability at all growth stages. The results revealed that plant height increased rapidly until 130 days after sowing (DAS) followed by plant height that increased slowly till maturity (160 DAS). The cultivar, Dhaka-1 showed the tallest plant at all growth stages and the shortest was recorded in GM-45 which was statistically similar to GM-16 and GM-35. These results are in agreement with the result of Mondal (1997) who stated that plant height differed significantly among the studied genotypes in groundnut. The author further reported that high yielding genotypes showed shorter plant than in low yielding one. Similar result was also observed in the present investigation.

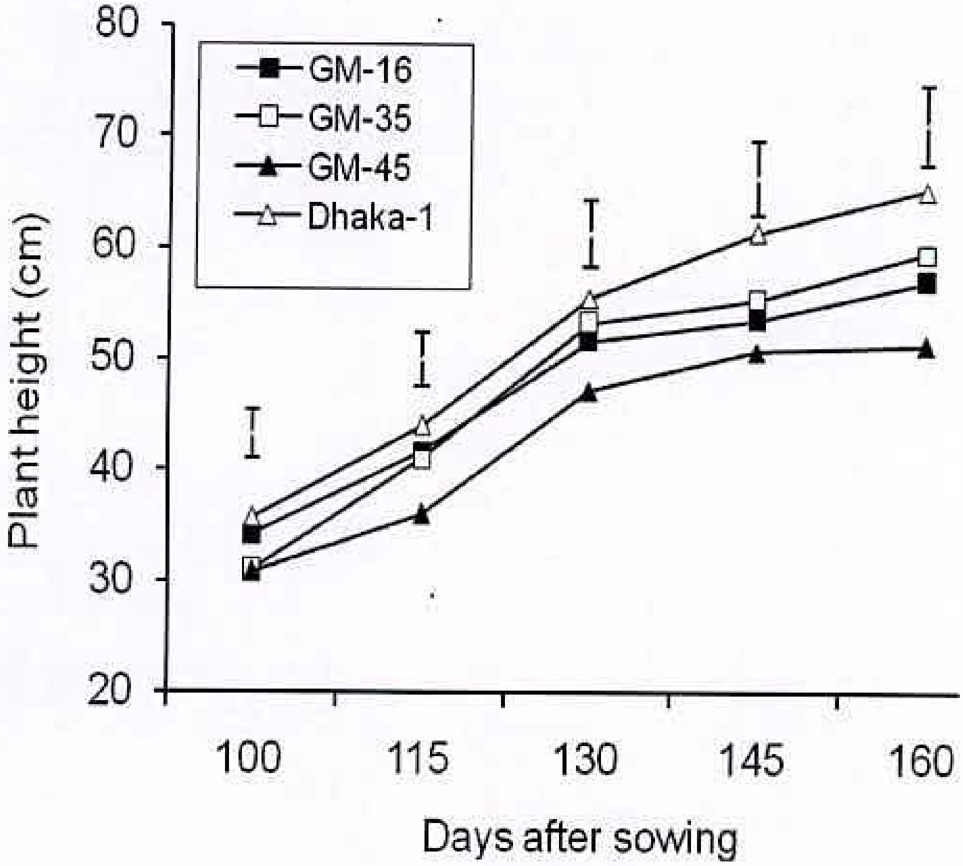

Fig. 1. Plant height at different growth stages in four groundnut genotypes. Vertical bars represent LSD $_{(0.05)}$.

4.1.2 Number of branches plant^{-1}

The effect of genotypes on branch number was significant at all growth stages (Fig. 2) (Appendix-IV). The results revealed that the number of branches increased with time up to 115 DAS followed by a decline till maturity (160 DAS) due to some new branches died. The three genotypes, GM-16, GM-35 and GM-45 were higher yielder than Dhaka-1 always maintained the greater number of branches over Dhaka-1 at all growth stages. It means yield is positively correlated with branches. GM-16 maintained the highest number of branches plant^{-1} over its growth period except 160 DAS followed by GM-35 with same statistical rank. Branch is a unique character to groundnut for production. With the decrease of branches (both primary and secondary) the yield will be decreased considerably (Rahman, 2003). Similar trend of result was also observed in the present study.

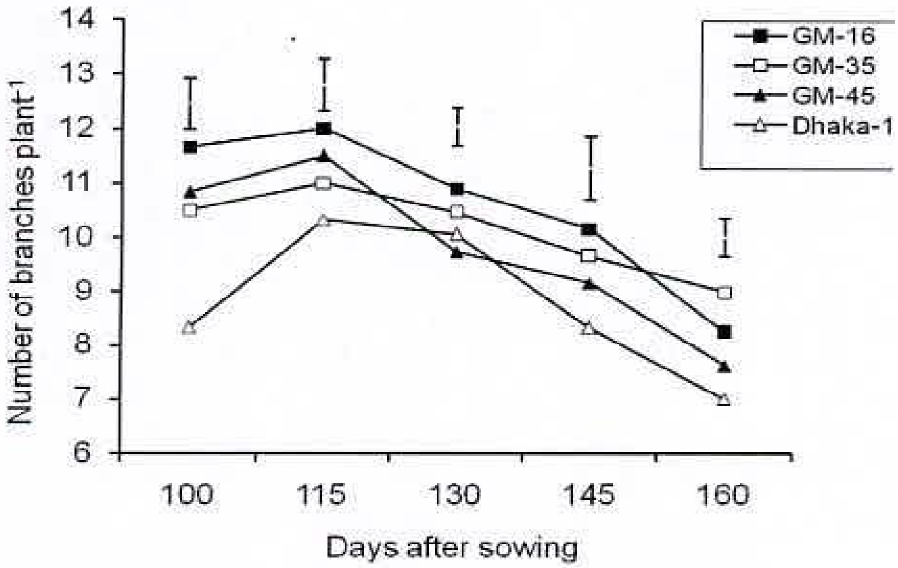

Fig. 2. Branch number at different growth stages in four groundnut genotypes. Vertical bars represent LSD $_{(0.05)}$.

4.1.3 Leaf area plant^{-1}

The development of leaf area (LA) over time in groundnut genotypes is presented in Fig. 3 (Appendix-V). The results revealed that LA increased till 115 DAS followed by a decline because of leaf shedding. Leaf area varied significantly due to genotype at all growth stages except 100 days after sowing (DAS). The LA production by Dhaka-1 was significantly higher than other three genotypes at all growth stages except 100 DAS. In contrast, GM-16 and GM-45 always produced the lowest leaf area at all growth stages and GM-35 maintained intermediate leaf area. The variation in leaf area might have occurred due to the variation in number of leaves and the expansion of leaf. The results obtained from the present study is consistent with the results of Dewan (2005) in groundnut who stated that variation in LA could be attributed to the changes in number of leaves. The results are also supported by the result of Kalita *et al.* (2003) in groundnut. The results are also supported by the result of Pathak *et al.*(1993) in groundnut.

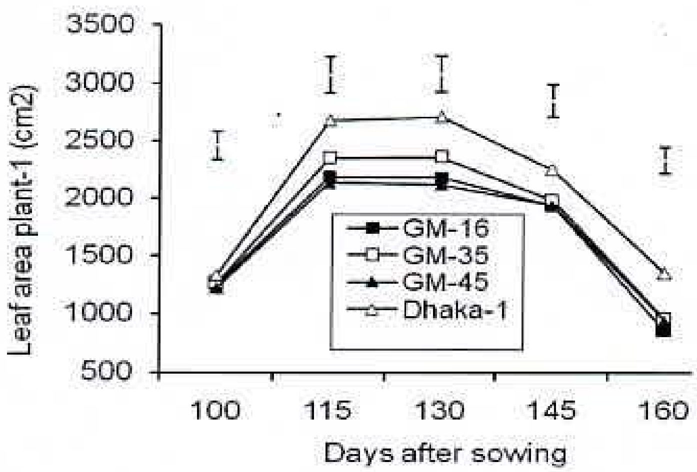

Fig. 3. Leaf area development at different growth stages in four groundnut genotypes. Vertical bars represent LSD $_{(0.05)}$.

4.1.4 Leaf area index

Significant differences in leaf area index (LAI) of groundnut genotypes were observed at all growth stages except 100 DAS (Fig. 4) (Appendix-VI). The LAI continued to increase till 115 DAS followed by a decline up to maturity (160 DAS). Dhaka-1 showed the highest LAI at all growth stages followed by GM-35. In contrast, GM-45 showed the lowest LAI over its growth period followed by GM-16 with same statistical rank. The variation in LAI might have occurred due to the variation in number of leaves and the expansion of leaf. The results obtained from the present study are consistent with the result of Rahman (2003) who stated that the variation in LAI could be attributed to the changes in the number of leaves and rate of leaf expansion and abscission. The results are also supported by the findings of Mondal (1997).

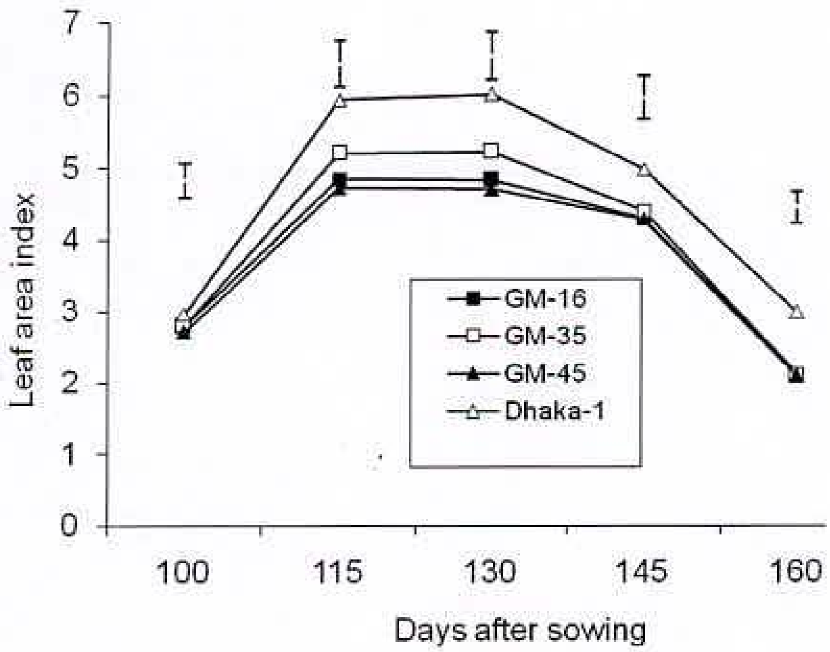

Fig. 4. Changes in leaf area index at different growth stages of four groundnut genotypes. Vertical bars represents LSD $_{(0.05)}$.

4.1.5 Total dry matter plant^{-1}

A significant difference on total dry matter (TDM) production at different growth stages in groundnut genotypes was observed (Fig. 5) (Appendix-VII). The results revealed that TDM production increased with time up to 145 DAS followed by a decline. The TDM decreased at 160 DAS due to heavy leaf shedding (Fig. 3). Dhaka-1 always maintained the highest TDM at all growth stages except 145 DAS. AT 145 DAS, the highest TDM was recorded in GM-35 might be due to increased pod number (Table 1). On the other hand, GM-45 maintained the lowest TDM over its growth period followed by GM-16 with same statistical rank. Increased TDM in Dhaka-1 and GM-35 was possibly due to greater leaf area (Fig. 3) and AGR (Fig. 6). The result is partially supported by the result of Sharma and Singh (1994) who reported that TDM increased with increasing plant age up to physiological maturity.

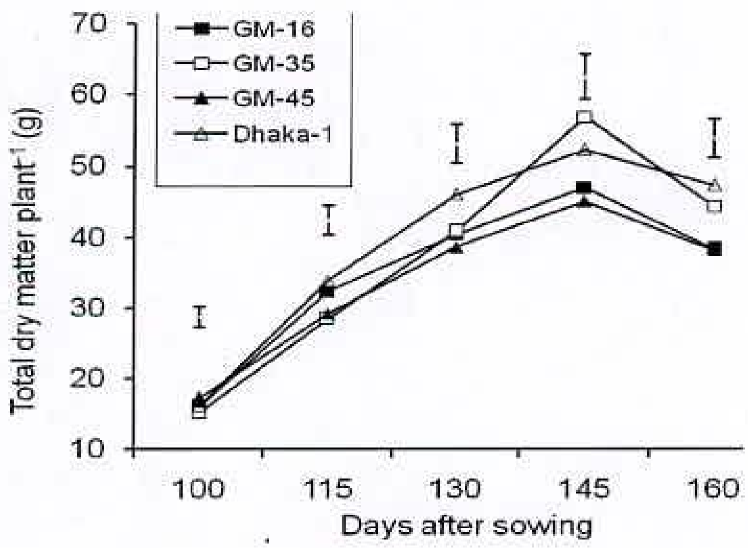

Fig. 5. Changes in total dry matter over time in four groundnut genotypes. Vertical bars represent LSD $_{(0.05)}$.

4.1.6 Absolute growth rate

The absolute growth rate (AGR) derived from four groundnut genotypes was determined from flowering stage (100 DAS) to maturity (160 DAS) and the results have been presented in Fig. 6(Appendix-VIII). It is mentionable that the AGR at 145-160 DAS was negative due to decrease in TDM at 160 DAS over 145 DAS. The results revealed that AGR in all genotypes were significantly different at all growth stages. The increment of AGR was observed till 100-115 DAS and thereafter decreased with progress to maturity except GM-35 at 130-145 DAS. In GM-35, AGR increased at 130-145 DAS due to rapid increase in TDM for increased number of matured pods. In contrast, GM-45 maintained the lowest AGR at most of the growth stages due to production of less TDM (Fig. 5). Furthermore, the maximum AGR was observed during flowering and pod development stages (100-115 DAS) of all the genotypes.

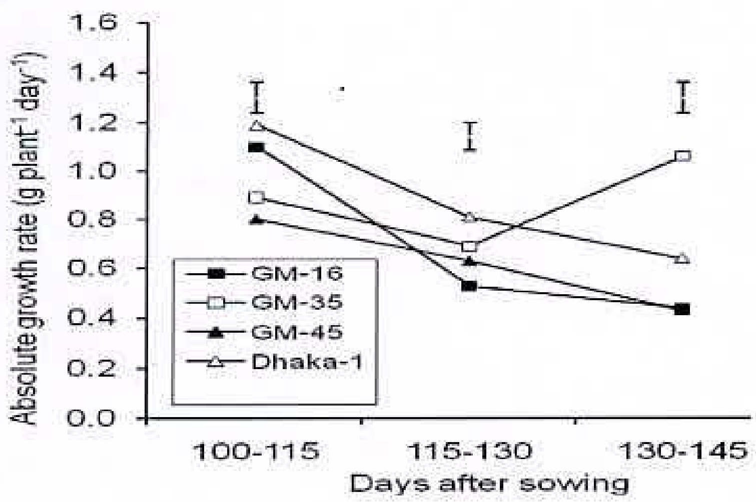

Fig. 6. Absolute growth rate at different growth stages of four groundnut genotypes. Vertical bars represent LSD $_{(0.05)}$.

CGR is positively correlated with LAI (Bhardway *et al.*, 1987). The CGR increased along with increase in LAI. The higher value of AGR at middle stage of growth was the result of higher LAI (Fig. 4). This result is in agreement with the findings of Rahman (2003). At 100-115 DAS, the AGR value was found to be maximum which means that plants expanded it's assimilate for the growth of leaf area and feeding of pods. The decline of AGR after reaching the maximum in all varieties might be the result of abscission of leaves. These results are consistent with the results of Dutta and Mondal (1998) and Maola (2005).

4.2 Yield and yield contributing characters

4.2.1 Number of matured pods plant^{-1}

Matured pod number, one of the most important yield attributes varied significantly among the genotypes of groundnut (Table 1) (Appendix-IX). The highest number of matured pods plant^{-1} was recorded in Dhaka-1 (32.7) followed by GM-35 (27.1) and these two genotypes were significantly different with each other. Interestingly, Dhaka-1 produced the highest number of pods plant^{-1} but showed the lowest yield due to smaller pod size, almost half of the others. In contrast, the lowest number of pods plant^{-1} was recorded in GM-45 (19.0) followed by GM-16 (21.6) with same statistical rank. However, GM-45 produced the lowest pod number, it showed the third highest pod yield due to its bolder pod size. This result was supported by Rahman (2001).

4.2.2 Single pod weight

Single pod weight varied significantly among the genotypes under study (Table 1) (Appendix-IX).GM-45 had the highest single pod weight (858 mg) followed by GM-16 (817 mg) and GM-35 (815 mg) with same statistical rank. In contrast, Dhaka-1 had the lowest single pod weight (473 mg). This result of variability in single pod weight agrees with the results of Islam (2007) in groundnut.

4.2.3 Hundred seed weight

Hundred -seed weight varied significantly among the genotypes (Table 1) (Appendix-IX). GM-45 showed the highest 100 -seed weight (45.7 g) with a significant difference from all other genotypes. On the other hand, Dhaka-1 had the lowest 100 -seed weight (26.9 g). This result of variability in 100-seed weight agrees with the results of Pathak *et al.* (1993) and Mondal (1997) in groundnut.

4.2.4 Pod weight plant^{-1}

The effect of genotypes on pod weight was significant (Table 1) (Appendix-IX). The genotype GM-35 produced the highest pod yield plant^{-1} (22.2 g) which was significant different from the others. On the other hand, Dhaka-1 produced the lowest pod yield (15.5 g plant-1) followed by GM-45 (16.2 g plant-1) and GM-16 (17.6 g plant-1) with same statistical rank. Genotypic variation in pod weight plant^{-1} was also observed by many workers in groundnut (Dhopte and Kudupley, 1986; Dewan, 2005; Karanjikar *et al.*, 2005; Islam, 2007)

Table 1. Yield and yield attributes in four groundnut genotypes

Genotype	Pods plant^{-1} (no)	Single pod weight (mg)	100-seed weight (g)	Pod weight plant^{-1} (g)	Pod yield (t ha^{-1})
GM-16	21.6 c	817 a	40.4 b	17.6 b	2.93 a
GM-35	27.1 b	815 a	38.4 b	**22.2 a**	**3.04 a**
GM-45	19.0 c	**858 a**	**45.7 a**	16.2 b	2.54 b
Dhaka-1	**32.7 a**	473 b	26.9 c	15.5 b	2.01 c
F-test	*	**	**	**	**
CV (%)	8.88	3.86	2.32	7.06	4.92

In a column figures having the same letter (s) do not differ significantly at $P \leq 0.05$

*, ** = Significant at 5% and 1% levels of probability

4.2.5 Pod yield hectare^{-1}

Pod yield (tons ha^{-1}) varied significantly among the genotypes (Table 1) (Appendix-IX). GM-16 and GM-35 produced higher pod yield with being the highest in GM-35 (3.04 t ha^{-1}). The yield was higher in those genotypes because of the production of higher number of pods plant^{-1} and bolder pods. The lower pod yield was recorded in Dhaka-1 (2.01 t ha^{-1}) followed by GM-45 (2.54 t ha^{-1}). The yield was lower in GM-45 due to production of fewer pods plant^{-1}. On the other hand, although Dhaka-1 produced higher number of pods plant^{-1} yet showed lower yield due to production of smaller pods. This result is consistent with the result of Patil and Bhapker (1987) and Rahman (2001) in groundnut who observed that there was significant variation among the studied genotypes for pod yield.

4.3 Dry matter production and its distribution in different plant parts

The effect of genotypes on dry matter production and distribution was significant (Table 2) (Appendix-X). The results revealed that among the different plant parts, pod weight contributed the highest and root weight contributed the lowest to total DM production in all genotypes. The stem and leaf were the second and third highest contributor to the TDM, respectively. Total dry matter production and its allocation into root (1.36 g) and pod weight plant^{-1} (22.15 g) was significantly greater in GM-35 than the others. The highest stem weight (24.13 g) and leaf weight plant^{-1} (15.22 g) was recorded in Dhaka-1 followed by GM-35. In contrast, the lowest root and pod weight plant^{-1} was recorded in Dhaka-1 (0.93 and 15.45 g plant^{-1}, respectively). Again, the lowest stem (15.76 g) and leaf weight plant^{-1} (12.17 g) was recorded in GM-45.

Total dry matter production is determined by magnitude of DM partitioning into root, leaf and shoot growth. In GM-35, the high yielding genotypes, thus increased DM partitioning into root and pod growth resulted greater TDM production than the low yielders. Among the different plant parts, pod weight contributed the highest total DM production in GM-35 (39.02%) than the others which resulting the highest HI (38.0 %).

The TDM was higher in Dhaka-1 yet it showed lower pod yield due to major DM partitioned to stem and leaf development and as a result HI was lower (27.12%). This result indicates that dry matter partitioned to economic yield is more important for getting higher seed yield.

The highest harvest index (HI) was observed in GM-35 (38.0%) which was significantly greater than the other genotypes. In contrast, the lowest HI was recorded in Dhaka-1 (27.12%). HI is a measure of the efficiency of conversion of photosynthates into economic yield of a crop (Dutta and Mondal, 1998). According to Poehlman (1991), high yield is determined by physiological process leading to a high net accumulation of photosynthates and it's partitioning into plant and seed. This opinion has been reflected in the present study. In the present investigation, high yielding genotype, GM-35 maintained high HI.

Table 2. Dry matter production and distribution in different parts of canopy in four groundnut genotypes at 145 days after planting

Genotype	Root weight plant^{-1} (g)	Stem weight plant^{-1} (g)	Leaf weight plant^{-1} (g)	Pod weight plant^{-1} (g)	Total dry matter plant^{-1} (g)	Harvest index (%)
GM-16	0.96 b	16.81 c	11.78 c	17.56 b	47.11 b	34.16 b
	(2.04)	*(35.68)*	*(25.00)*	*(37.27)*		
GM-35	**1.36 a**	19.67 b	13.59 b	**22.15 a**	**56.77 a**	**38.00 a**
	(2.39)	*(34.65)*	*(23.94)*	*(39.02)*		
GM-45	0.96	15.76 c	12.17 bc	16.30 bc	45.20 b	33.27 b
	(2.15)	*(34.87)*	*(26.92)*	*(36.06)*		
Dhaka-1	*0.93*	***24.13 a***	***15.22 a***	*15.45 c*	55.73 a	27.12 c
	(1.67)	*(43.30)*	*(27.31)*	*(27.72)*		
F-test	**	**	**	**	**	**
CV (%)	6.12	3.86	5.77	4.46	5.42	6.96

In a column, figures having the same letter (s) do not differ significantly $P \leq 0.05$.

** = Significant at 1% level.of probability; Figures in parenthesis indicate per cent contribution to the total TDM

Chapter 5
Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was carried out with four groundnut genotypes with a view to evaluate their growth, morphological characters, dry matter production and its partitioning, and yield performance. The experiment was conducted at the field laboratory of Bangladesh Institute of Nuclear Agriculture, Mymensingh, during the period from December 2007 to May 2008. The experiment comprised of three advanced genotypes and one variety *viz.*, GM-16, GM-35, GM-45 and Dhaka-1. The experiment was laid out in a randomized complete block design with three replications. The collected data were statistically analyzed and the means were adjudged by DMRT at 5% level of significance.

Significant variations in morphological shoot characters were found among the four groundnut genotypes. The plant height, branch number, leaf area (LA), leaf area index (LAI) and total dry matter (TDM) plant^{-1}, and absolute growth rate (AGR) of groundnut genotypes were significantly different at most of the growth stages (Fig. 1-6). The results revealed that high yielding genotypes maintained shorter plant height, greater number of branches than the low yielding Dhaka-1. The plant height increased with age till physiological maturity whereas branch number, leaf area, leaf area index and absolute growth rate increased till 115 DAS followed by a decline.

On the other hand, total dry matter increased up to 145 DAS followed by a decline. Dhaka-1 always showed superiority in plant height, branch number, LA, LAI and TDM plant^{-1} at most of the growth stages compared to others. In contrast, GM-45 showed inferiority in case of above mentioned parameters followed by GM-16 with same statistical rank. In general, high yielding genotypes produced higher TDM as well as yield except Dhaka-1. Dhaka-1 produced greater TDM yet it produced the lowest seed yield because of most of assimilates transferred towards vegetative sink like stem and leaf.

Yield and yield attributes were significantly varied in four groundnut genotypes (Table 1). The highest pod number plant^{-1} was recorded in Dhaka-1 although it produced the lowest pod yield because of smaller pod size. GM-45 showed the highest single pod and 100-seed weight but gave the third highest yield due to production of fewer pods plant^{-1}. GM-35 produced the highest pod yield both per plant and per hectare followed by GM-16. In contrast, the lowest pod yield was recorded in Dhaka-1.

The effect of genotypes on dry matter production and distribution was significant in groundnut (Table 2). Total dry matter production and its allocation into root and pod weight plant^{-1} was significantly greater in GM-35 than in the others. Dhaka-1 produced the highest stem and leaf weight which consequently showed higher TDM but showed lower pod yield. This result indicates that dry matter production and its allocation is important for getting higher yield.

The maximum dry matter allocation to economic sink was recorded in GM-35 and showed the highest pod yield. The highest harvest index was recorded in GM-35 (38.0%) and the lowest was recorded in Dhaka-1 (27.1%).

From the results, it could be concluded that GM-35 performed superior among the studied genotypes with respect to growth, yield attributes, dry matter production and partitioning.

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APPENDICES

Appendix. I. Nutrient status of soil of the experimental plots

Properties of soil	Content
Soil P^H	7.1
Organic carbon	1.25%
Organic matter	2.06%
Total nitrogen	0.11%
Available phosphorus (ppm)	16.50
Available potassium (me in %)	0.13
Available sulphur (ppm)	12.10

Source: Soil Science Division, BINA, Mymensingh.

Appendix II. The monthly total rainfall, mean air temperatures and relative humidity during the experimental period between November 2007 to May 2008 at the BAU area, Mymensingh

Month	Monthly mean air temperature (^0C)			Rainfall (mm)	Average relative humidity (%)	Average daily sunshine (hrs)
	Maximum	Minimum	Average			
November	29.49	19.55	24.52	00.0	84.3	8.45
December	26.52	13.19	19.85	00.0	80.8	6.67
January	23.43	12.93	18.18	00.0	78.0	7.20
February	27.34	16.41	21.87	26.6	73.9	8.18
March	29.61	20.57	25.09	63.6	80.6	7.66
April	31.24	23.78	27.51	146.1	81.45	6.44
May	33.06	25.40	28.23	255.7	81.94	6.22

Source: Weather Yard, Department of Irrigation and Water Management, BAU, Mymensingh

Appendix III. Analysis of variance (mean square) of plant height at different growth stages in four groundnut genotypes

Source of variation	df	Plant height (cm)				
		100 DAS	115 DAS	130 DAS	145 DAS	160 DAS
Replication	2	9.00	1.00	0.25	4.00	0.25
Genotype	3	17.15 *	34.00 **	37.44 *	61.16 *	100.63 *
Error	6	3.00	3.00	7.58	7.33	12.92

*, ** indicate significant at 5% and 1% level of probability, respectively

Appendix IV. Analysis of variance (mean square) of branch number at different growth stages in four groundnut genotypes

Source of variation	df	Number of branches plant^{-1}				
		100 DAS	115 DAS	130 DAS	145 DAS	160 DAS
Replication	2	0.004	0.172	0.093	0.059	0.284
Genotype	3	7.039 **	1.527 *	1.387 **	4.572 **	2.195 **
Error	6	0.215	0.229	0.124	0.336	0.122

*, ** indicate significant at 5% and 1% level of probability, respectively

Appendix V. Analysis of variance (mean square) of leaf area development at different growth stages in four groundnut genotypes

Source of variation	df	Leaf area plant^{-1} (cm^2)				
		100 DAS	115 DAS	130 DAS	145 DAS	160 DAS
Replication	2	40.00	10000	10000	1296	342
Genotype	3	6638 ^{ns}	176864 *	210650 *	66371 *	144853 **
Error	6	4675	30000	30000	7101	5348

*, ** indicate significant at 5% and 1% level of probability, respectively
ns = Not significant

Appendix VI. Analysis of variance (mean square) of leaf area index at different growth stages in four groundnut genotypes

Source of variation	df	Leaf area index				
		100 DAS	115 DAS	130 DAS	145 DAS	160 DAS
Replication	2	0.048	0.029	0.016	0.04	0.023
Genotype	3	0.033 *	0.893 **	1.043 **	0.324 *	0.581 **
Error	6	0.004	0.039	0.056	0.062	0.003

*, ** indicate significant at 5% and 1% level of probability, respectively

Appendix VII. Analysis of variance (mean square) of total dry matter production at different growth stages in four groundnut genotypes

Source of variation	df	Total dry matter plant^{-1} (g)				
		100 DAS	115 DAS	130 DAS	145 DAS	160 DAS
Replication	2	0.016	1.00	25.00	22.33	9.00
Genotype	3	2.152^{ns}	20.29 *	36.45 **	83.80 **	56.49 **
Error	6	0.766	3.00	1.00	7.00	5.67

*, ** indicate significant at 5% and 1% level of probability, respectively
ns = Not significant

Appendix VIII. Analysis of variance (mean square) of absolute growth rate at different growth stages in four groundnut genotypes

Source of variation	df	Absolute growth rate (g plant^{-1} day^{-1})		
		100-115 DAS	115-130 DAS	130-145 DAS
Replication	2	0.002	0.001	0.001
Genotype	3	0.098 **	0.041 **	0.392 **
Error	6	0.007	0.004	0.002

** indicate significant at 1% level of probability

Appendix IX. Analysis of variance (mean square) of yield and yield attributes in four groundnut genotypes

Source of variation	df	Pods plant^{-1} (no)	Single pod weight (mg)	100-seed weight	Pod weight plant^{-1} (g)	Pod yield (t ha^{-1})
Replication	2	0.0003	961	20.25	1.32	0.202
Genotype	3	111.15 **	96765 **	188.02 **	26.74 **	0.810 **
Error	6	3.33	818	0.25	1.59	0.002

** indicate significant at 1% level of probability

Appendix X. Analysis of variance (mean square) of dry matter production and distribution in different parts of canopy in four groundnut genotypes at 145 days after planting

Source of variation	df	Root weight plant^{-1} (g)	Stem weight plant^{-1} (g)	Leaf weight plant^{-1} (g)	Pod weight plant^{-1} (g)	Total dry matter plant^{-1} (g)	Harvest index (%)
Replication	2	0.001	4.41	0.034	2.641	49.00	4.00
Genotype	3	0.125 **	42.02 **	7.31 **	26.74 **	104.3 **	61.92 *
Error	6	0.004	0.543	0.578	0.634	1.667	8.67

*, ** indicate significant at 5% and 1% level of probability, respectively

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