GROWTH AND YIELD OF GROUNDNUT VARIETIES AS INFLUENCED BY SEED SIZE

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CERTIFICATE

This is to certify that the thesis entitled **"GROWTH AND YIELD OF GROUNDNUT VARIETIES AS INFLUENCED BY SEED SIZE"** submitted to the Department of Agronomy, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTERS OF SCIENCE (MS)** in **AGRONOMY**, embodies the result of a piece of bona fide research work carried out by **JANNATUL SIDDIQUA**, Registration No. 14-05840 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

June, 2021

Dhaka, Bangladesh

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Dedicated to
My
Beloved Parents

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GROWTH AND YIELD OF GROUNDNUT VARIETIES AS INFLUENCED BY SEED SIZE

ABSTRACT

A field experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2019 to April 2020 to study the growth and yield of groundnut varieties as influenced by seed size. The experiment was carried out in split plot design considering three varieties i.e., V_1 = BARI Chinabadam-8, V_2 = Binacheenabadam-4, V_3 = Binacheenabadam-6 in the main plot and four levels of seed size *viz*. S_1 =Unsorted, S_2 = Small, S_3 = Medium, S_4 = Large in the sub plot replicated three times. BARI Chinabadam-8 (V_1) gave the highest pod yield (1917 kg ha^{-1}) which was 29.44% and 16.04% higher than Binacheenabadam-4 (V_2) and Binacheenabadam-6 (V_3), respectively. Among the seed size, large seed (S_4) scored the highest pod yield (2110 kg ha^{-1}), whereas small seed (S_2) showed the lowest pod yield (1161 kg ha^{-1}), which was 44.97% lower than S_4. BARI Chinabadam-8 (V_1) in combination with large seed (S_4) produced the highest pod yield (2473 kg ha^{-1}), whereas Binacheenabadam-4 (V_2) in combination with small seed (S_2) produced the lowest pod yield (1040 kg ha^{-1}), which was 57.95% lower than treatment combination of V_1S_4. The higher pod yield was due to maximum pods $plant^{-1}$ followed by seeds pod^{-1}, pod length, fresh weight of pods $plant^{-1}$ and 100-seed weight. Results revealed that large seed (S_4) could be the best for groundnut production irrespective of varietal difference.

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
et al.	=	And others
e.g.	=	exempli gratia (L), for example
etc.	=	Etcetera
FAO	=	Food and Agriculture Organization
g	=	Gram (s)
i.e.	=	id est (L), that is
kg	=	Kilogram (s)
LSD	=	Least Significant Difference
m^2	=	Meter squares
ml	=	Millilitre
M.S.	=	Master of Science
No.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
var.	=	Variety
^oC	=	Degree Celsius
%	=	Percentage
NaOH	=	Sodium hydroxide
mg	=	Milligram
P	=	Phosphorus
K	=	Potassium
Ca	=	Calcium
L	=	Litre
µg	=	Microgram
USA	=	United States of America
WHO	=	World Health Organization

CHAPTER I

INTRODUCTION

The Groundnut (*Arachis hypogaea* L.) is a valuable food and oilseed crop. It is commonly called as the king of vegetable oilseeds crops or poor man's nut. It belongs to family Fabaceae. Groundnut appeared to have originated in South America. At the global level 50% of the groundnut produced is used for oil extraction, 37% for confectionary use and 12% for seed purpose (Shendage *et al*., 2018).

Groundnut is one of the principal economic crops of the world that ranks 13thamong the food crops (Mouri *et al*., 2018). Groundnut is also known as earthnuts, peanuts, goobers, goober peas, pindas, jack nuts, pinders, manila nuts, g-nuts and monkey nuts; the last of these is often used to mean the entire pod (Annadurai and Palaniappan, 2009). In Bangladesh, it is popularly known as ''cheenabadam''. Besides its food value, groundnut is a major oil seed crop. In Bangladesh, groundnut is grown in an area of 30791 hectare with a production of 55108 metric tons in Rabi and Kharif season (BBS, 2020).

The importance of groundnut in the world's economy is increasing rapidly due to its demand as oil for making margarine, cooking oil, soaps and many other domestic uses (Vessey and Buss, 2002). It is very useful in crop rotation as it has the ability to fix atmospheric nitrogen into the soil, hence enriching the fertility of the soil for greater benefit of subsequent crops on the same farm land (Oranekwulu, 1995). On an average, seed contains about 38-50% oil, 26% protein, 11.5% carbohydrate, 2.3% ash, 2.5% minerals and 6% water (Oyewole *et al*., 2020). It is also rich in calcium, potassium, phosphorus, magnesium and vitamin B and E (Oyewole *et al*., 2020; Mouri *et al*., 2018).

Groundnut is a major crop in the char lands of Bangladesh, but because of poor yields, farmers derive a limited income from the crop. It is a photo insensitive crop and allows cultivation throughout the year. Despite its insensitivity, it is grown mainly in Rabi season in 'charlands' due to high land scarcity in Rabi season (FAOSTAT, 2013).

The productivity of groundnut depends on proper selection of variety, agronomic practices such as land preparation, seed size and fertilizer management, environmental factors, metal contents in soil and other management practices (Uddin *et al*., 2016). Variation in any of the weather parameter causes reduction in the pod yield. Thus, it is necessary to improve the genotype, which can withstand weather aberrations. Rao (1992) and Raagavalli *et al*. (2019) revealed that improved genotypes contribute 25 to 28 percent to the yield increase, while improved management practices contributed 30 to 32 percent. However, it is important to note that the average yield of common groundnut varieties is much lower than the average potential yield for improved groundnut varieties (Alessi *et al*., 1977; Gabisa *et al*., 2017). In Bangladesh, average yield of groundnut (1.60 t ha^{-1}) is very low (FAOSTAT, 2013) compared to average yields obtained in Mozambique, Israel and USA (Agasimani *et al*., 1986; Oyewole *et al*., 2020; Mouri *et al*., 2018). This poor yield is attributed to a wide variety of factors. Non-availability of suitable high yielding varieties and lack of proper management practices are most important factors for low pod yield. Productivity of groundnut can be raised manifold through both improved varieties and management practices (Reddy and Kaul, 1986).

Use of good quality seed is an essential factor for yield increment. It is reported that seeds in a seed lot may differ by size, weight and density due to production environment and cultivation practices (Ambika *et al*., 2014). According to Adebisi (2004) and Adebisi *et al*. (2011) seed size is one of the components of seed quality in further affecting crop performance. Therefore, size is a widely accepted

measure of seed quality and large seeds have high seedling survival growth and establishment (Jerlin and Vadivelu, 2004).

The effect of seed size on crop performance has been found to differ among crops. Vishvanath *et al*. (2006) observed significantly higher seed quality parameters *viz*., 100 seeds weight, field emergence, seedling length, vigour index with the increase in seed size in french bean. In contrast, in tropical soybean lots with small seed size had maximum seed germination and emergence while those with large seed size produced the highest pods per plant and seeds per pod (Adebisi *et al*., 2013). In groundnut, vigour of seedling grown from shrivelled and small seeds was less than that from large seeds (Sulochanamma and Reddy, 2007). Growth characteristics and yield components of groundnut were higher in plants from relatively larger seeds while plants grown from large seed reached their 50% flowering 3 to 5 days earlier than plants grown from medium and small seed sizes (Olayinka *et al*., 2016).

It is apparent that growth and yield of groundnut respond to varietal difference and size of seeds in different ways. The aim of the present study was to see how seed size affects biological productivity of groundnut varieties and to provide information on how this factor affects seed yield. With these considerations in view, the present investigation on groundnut, was therefore, planned with the following objectives:

1. To study the varietal performance on growth and yield of groundnut.
2. To know the effect of seed size on growth and pod yield of groundnut.
3. To find out the effect of different groundnut variety in combination with different seed size on growth and pod yield of groundnut.

CHAPTER II

REVIEW OF LITERATURE

The yield of groundnut may be increased through appropriate combination of seed size and variety. Though groundnut is cultivated in many parts of Bangladesh, very little research work has so far been conducted on the appropriate seed size with suitable variety especially with BARI chinabadam-8, Binacheenabadam-4 and Binacheenabadam-6. With the above background, some of the pertinent works have been reviewed in this chapter.

2.1 Varietal performance

The significant variances among different genotypes were credited to the different response of the genotypes to the environmental circumstances like variation in temperature and rainfall prevailing during the crop period. Genetic formations of genotypes of different origin and environmental factors during crop period might be responsible for variation of genotypes for this trait (Manaf *et al*., 2017). Despite estimated yearly increases in total acreage cultivated, there has not been a corresponding increase in the total annual production, because of the generally low average yields on farmers' fields (Tsigbey *et al*., 2003; FAO, 2010). On the average, yields on farmers' fields are estimated to be about 900 kg ha^{-1} compared with the potential yields of 1800-2800 kg/ha for the improved cultivars recommended for production by farmers (Adu-Dapaah *et al*., 2007).

Mulumba *et al*. (2021) carried out this study to determine the performance of selected landraces and improved groundnut varieties. 23 groundnut lines with varying degrees of tolerance to a range of stresses were evaluated at two sites. Results showed significant ($P \leq 0.05$ to $P \leq 0.001$) differences among genotypes for yield. Significant ($P \leq 0.05$ to $P \leq 0.001$) varietal differences were also observed between landraces and improved varieties for growth and physiological traits but

not for pest and disease reaction. Clustering was not evident on the basis of either landraces or improved cultivars for pests and diseases incidences. However, associations of a mix of both groundnut classes of with particular diseases and/or pests were observed. Varieties such as India, Serenut 10, Kabonge, and DOK Tan associated with diseases such as rosette virus disease and its vector pest, the aphids. The results reported in this study shall be useful for driving the development of new cultivars owing to their good adaptability and acceptance thus the need to conserve and ensure sustainable use of these germplasm.

Aliyu (2020) evaluated the growth and yield of groundnut (*Arachis hypogaea* L.) as affected by varieties in dry land farm. The aim of the study is to evaluate the effects of variety on growth and growth components as well as yield and yield components of groundnut. The treatments comprised of six (6) varieties of groundnut. Four are improved varieties (Samnut23, Samnut24, Samnut25 and Samnut26) and two local varieties (Bahausa and Yarmadani). Data on growth and yield parameters such as stand count, plant height, canopy spread, 50% flowering, Days to maturity, pod yield, grain yield, 100-seed weight, harvest index and haulm yield were taken. Results of the analysis indicated that varieties differed significantly on growth and yield except for stand count at 3WAS. Samnut24 recorded the highest mean stand count before harvest and highest mean pod yield while Samnut25 recorded the highest canopy spread, least days to maturity and highest grain yield. Bahausa recorded the highest mean haulm yield and thus, the study concluded that Bahausa has the highest haulm yield per hectare with yield of 2166.7kg/ha and Samnut25 possess highest grain yield of 117.80 kg/ha. It is therefore recommended that appropriate variety should be sown in the study area based on the interest of the farmer whether for grain or for haulm. Keywords: Groundnut varieties, Semi-arid, growth, yield.

Parwada *et al*. (2020) conducted a field experiment on the performance of three newly released short-seasoned (Nsinjiro, Chitala and JL11) against old (Nyanda,

Illanda and Tern) groundnuts varieties under same agronomic practices. Varieties were evaluated for days to 50% emergence, 50% flowering, days to physiological maturity, pod and seed yield, and shelling percentage. There was no significant difference in the days to 50% emergence among all varieties but significant difference ($p<0.05$) was observed on days to 50% flowering. JL11 and Tern took shortest (90 days) and longest (120 days) time to physiological maturity respectively. Chitala had highest (3.804 t/ha) and Tern had lowest (3.020 t/ ha) seed yield. Jl11 had highest (83%) and Nyanda least (68%) shelling percentage. Results showed that the new varieties out-performed the old varieties in all measured parameters. Therefore, resource constrained farmers may safely opt for the new short-seasoned varieties over the old ones.

Yousif and Hussain (2019) conducted a research to evaluate the effects of 17 genotypes and three plant densities (57142, 71429 and 95238 plant ha^{-1}) on growth and yield characteristics of peanut (*Arachis hypogaea* L.). The results showed that the planting of recent released peanut cultivar have a larger seed size with further resistance to common fungal diseases known in the target area. Significant differences were noticed for plant densities, plant genotypes and their interactions for pant height, pod weight and seed oil percentage. The significant difference effects of plant genotypes for branches $plant^{-1}$, pods $plant^{-1}$, seed pod^{-1}, 100 seed weight and seed yield reveal that GN-IS-5 gave the lowest plant height and GN-IS-2 the highest branches $plant^{-1}$ (17.07) and seed oil percentage (51.9%). Greater pod weight (17.5g) was noticed with IND-IS-14. Result indicates the wide range of pods plant-1 (38.8 - 89.3) with wide genetic base and may reflect the utilization of exploitation IDN-IS-15 in improving pods $plant^{-1}$ and 100 seed weight for the current released varieties by hybridization. Whereas, GN-IS-4 gave the highest seed pod^{-1}(1.4) and IND-IS-16 exceeded significantly on all other genotypes except the released variety (IND1IS-14) and gave more than 4 ton ha^{-1}.

Raagavalli *et al*. (2019) conducted a field experiment to study the influence of sowing windows on growth and yield of groundnut genotypes under rainfed conditions. Among four groundnut genotypes (GKVK-5, GPBD-4, G2-52 and TMV-2), GKVK-5 recorded significantly higher pod yield (16.73 q ha^{-1}), shelling percentage and kernel yield.

Shendage *et al*. (2018) conducted an experiment entitled, "Effect of sowing times and varieties on growth and yield of summer groundnut (*Arachis hypogaea* L.)" with the objective the optimum sowing time and varieties of groundnut under summer condition. Among four groundnut varieties, the height of plant was significantly higher in JL-501 while number of functional leaves, leaf area $plant^{-1}$, number of branches, dry matter accumulation was higher in variety JL-501 followed by TAG-24. The yield attributing characters like number of pod $plant^{-1}$ was maximum in variety JL-501 while it was minimum in JL-24. The weight of 100 kernel was higher in JL-501 (57.55 g), shelling percentage, kernel yield was also higher in variety JL-501. The dry pod yield given by JL-501 (34.84 q ha^{-1}) was maximum among the varieties JL-24 (29.26 q ha-1) JL-286 (32.21 q ha^{-1}) and TAG-24-(33.91 q ha^{-1}). The dry haulm yield was significantly higher in variety JL-501 (31.21 q ha^{-1}). Higher oil content (48.67%), protein content (24.57%) and oil yield (10.32 q ha^{-1}), protein yield (7.35 q ha^{-1}) was also recorded by JL-501 as compared to other varieties.

Mouri *et al*. (2018) carried out an experiment to evaluate the effect of variety and phosphorus on the yield and yield components of groundnut. The experiment comprising of two groundnut varieties *viz*. BARI Chinabadam-8 and Binacheenabadam-6 and four levels of phosphorus *viz*. 0, 20, 40 and 60 kg P ha^{-1}. The highest value of all the parameters e.g. leaf area index (2.02), dry matter (51.88 g $plant^{-1}$), number of primary branches plant-1 (10.70), number of secondary branches $plant^{-1}$ (13.85), number of pegs $plant^{-1}$ (64.35), number of total pods $plant^{-1}$ (44.50), weight of 100-pods (94.66 g), weight of 100-seeds (44.47 g),

shelling percentage (81.84%), seed yield (2.48 t ha^{-1}), pod yield (3.03 t ha^{-1}), stover yield (6.92 t ha^{-1}) and harvest index (30.45%) were recorded from BARI Chinabadam-8 applied with 60 kg P ha^{-1}. The lowest value of all these parameters was found in Binacheenabadam-6 and with no applied phosphorus.

Gabisa *et al*. (2017) conducted a field experiment to determine the effect of plant density on yield components and yield of groundnut varieties. There were three varieties of groundnut (Tole1, Fayo and NC-4x) and five plant densities (142847, 166666, 200000, 250000 and 333333 plants ha^{-1}). The highest above ground dry biomass (6050 kg ha^{-1}) recorded for the variety "NC-4x" at the highest plant density. The variety "Tole-1" at lowest plant density gave the highest number of pegs per plant (78.83 pegs per plant) and total pod per plant (77.33 pods per plant). Likewise, the variety "Tole-1" at lowest plant density of (142857 plants ha^{-1}) gave the highest number of matured pods per plant (73 pods per plant). The variety "Tole-1" at plant density of (250,000 plants ha^{-1}) gave the highest dry pod yield (3,831 kg ha^{-1}) and the highest seed yield (2,790 kg ha^{-1}) as well as highest harvest index (36.5%).

Priya *et al*. (2016) conducted a field experiment to study the performance of groundnut cultivars *viz*., 'Abhaya', 'TAG-24', 'Dharani' and 'Kadiri-6' under different plant populations *viz*., 3.33, 4.44, 5.00 and 6.66 lakh/ha. The results revealed that the highest stature of growth parameters *viz*., plant height, LAI and DMP were higher with the groundnut cultivar 'Kadiri-6' while at their lowest with 'TAG-24.' However, the yield attributes *viz*., number of filled pods/plant, 100-pod, 100-kernel weight and pod yield were significantly higher with groundnut cultivar, 'Dharani' followed by 'TAG-24'.

Manaf *et al*. (2017) conducted a field experiment to determine the response of groundnut genotypes to sulphur sources under rainfed conditions. Experiment was comprised of four groundnut genotypes *viz*. Bari-2011, Golden, Bard-92 and PG-

1058 and three sources of sulphur (S) SSP (45 kg ha^{-1}), SOP (45 kg ha^{-1}) and gypsum (400 kg ha^{-1}) with control. Results revealed that genotype Bari-2011 gave best performance for number of plants m^{-2}, number of pegs $plant^{-1}$, number of pods $plant^{-1}$, number of seeds pod^{-1}, seed index, seed yield and harvest index.

Meena *et al*. (2014) conducted an experiment during Kharif seasons of 2009 and 2010 on groundnut (*Arachis hypogaea* L.) with four dates of sowing (April 20, May 15, June 9 and July 4) and two varieties (HNG 10 and TG 37A) combination with four fertility levels (0, 20 N: 40 P_2O_5, 30 N: 60 P_2O_5 and 40 N: 80 P_2O_5 kg/ha). Yield component of semi spreading variety 'HNG 10' i.e. pods/plant, number of kernel/pod, seed index, shelling percentage and yields i.e. pod, kernel, haulm and biological yield were statistically at par with each other from April 20 to June 9 sowing and minimum yield was observed in July 4 sowing, while days to maturity reduced significantly with delay sowing. Variety 'TG 37A' had significantly higher yield attributes and yields in delay sowing.

Dapaah *et al*. (2014) conducted a field study to determine the effects of different sowing densities on the growth and yield of three groundnut cultivars during the 2009 and 2010 seasons. Azivivi, Nkosour and Shitaochi groundnut cultivars were sown at four sowing densities (14.29 plants m^{-2}, 16.67 plants m^{-2}, 20.0 plants m^{-2} and 33.33 plants m^{-2}. Azivivi and Nkosour are improved 120-day maturing Virginia bunch types, while Shitaochi is a widely grown local 95–100-day maturing Spanish type. In 2009, Nkosour and Azivivi produced similar, but greater haulm (11-30%), pod (83-113%) and seed (71-95%) yield than the Shitaochi cultivar. In 2010, Nkosour and Shitaochi produced similar haulm and seed yields, which were 12-17% and 9-17%, respectively, higher than the yields produced by Azivivi.

Tarawali and Quee (2014) conducted a study with nine groundnut trials to evaluate the performance of two improved/groundnut varieties (Samnuts22 and 23) and one

improved local variety in the transitional rain forest and the savanna grassland agro-ecologies and to evaluate the responses of the varieties to phosphorous fertilizer. The experiments were laid out in a randomized complete block design with three replications. Grain yield by the treatment combination was significantly higher in the transitional rain forest than in the savanna grassland. The variety Samnut23 performed significantly higher in terms of grain yield than the varieties Samnut22 and Slinut1, while the variety Samnut22 produced more stover yield than Samnut23 and the improved local variety in the two agro-ecologies considered in both years, an indication that Samnut23 could be recommended for grain production while Samnut22 recommended for fodder production in both agro-ecologies. The improved local variety was an early maturing variety; Samnut23 was a medium maturing variety, while Samnut22 was a late maturing variety.

Ramadevi and Rama Rao (2005) reported that in two cultivars of groundnut JL-24 and TPT-4, the number of pods per plant and 100 seed mass were significantly higher in plants from bold seed (15.10 and 39.69) followed by medium sized seed (12.90 and 35.79). The lowest numbers of pods per plant, 100 seed mass were recorded in plants from shriveled seed (6.9 and 27.1). Among the cultivars, JL-24 recorded higher pods per plant and 100 seed mass (11.3 and 34.6 g) compared to TPT-4 (10.5 and 31.29).

2.2 Effect of seed size

Seed size is a significant physical indicator of seed quality that influences the vegetative growth and is frequently related to yield, market grade factors and harvest efficiency. Genetic variation is the cause for variation in seed size between varieties (Ambika *et al*., 2014). Based on size, the seeds are classified as large, medium and small. This variation is due to flow of nutrients into the seed coat and embryonic axis is the first to develop in a seed within a pod and accumulation of

food reserve follows as they reported. Seed lot may differ by size, weight and density due to production environment and cultivation practices (Karkannavar *et al*., 1991).

2.2.1 Effect of seed size on growth and yield of groundnut

Oyewole *et al*. (2020) conducted pot experiments to evaluate the influence of seed size on plant performance with reference to seedling emergence, seedling growth, development and yield components and yield of groundnut (*Arachis hypogaea*). The treatment consisted of three different seed sizes: small, medium and large seeds. The seeds were initially graded into small, medium and large seeds based on visual assessment for length and diameter and from each group 100-seed weight was determined thus 100-seed weight became the parameter for measuring seed size as used in this experiment. The analyzed data showed no significant effect of seed size on groundnut canopy height, leaf number, leaf area, stem girth, days to first flower, number of pods/plant, pod weight, and shelling percentage, but significantly influenced mean days to seedling emergence, days to 50 percent flowering, 100-seed weight and taproot length. The significant effect of seed size on days to seedling emergence, days to 50 percent flowering, 100-seed weight and taproot length could significantly influence farmers' opinion in the choice of seeds used in planting a field; as this could determine crop maturity, grain yield/ha while length of tap root could affect depth of root forage for nutrients and water, thus crop survival. Despite the non-significant effect of the treatment (seed size) on most parameters investigated, generally crop performance increased with seed size and vice versa, thus sowing of larger seeds is recommended for better groundnut performance.

Olayinka *et al*. (2016) conducted a field experiment to evaluate the effect of seed size on seedling emergence, biological yield and proximate composition of groundnut (*Arachis hypogaea* L.). Matured seeds were graded into three different

seed sizes with respect to length. The large seeds were 1.3 to 1.5 cm, medium seeds 1.1 to 1.25 cm and small seeds were equal to or less than 0.83 cm in length. At 10 days after planting, large and medium seed sizes had higher percentage emergence, 54 and 42%, respectively, when compared with small size seeds with 10% emergence. Growth characteristics such as plant height and number of leaves were higher in plants from relatively larger seeds at various crop stages. Groundnut plants grown from large seed reached their 50% flowering 3 to 5 days earlier than plants grown from medium and small seed sizes. The results of yield components (seed yield and harvest index) followed a similar pattern to that of growth characters. Seeds of plants grown from seeds with small size had significantly higher protein (30.11%) and fat (49.10%) when compared to seeds harvested from plants grown from medium and large seeds. The results of this study revealed that large seed size is associated with improved growth and seed yield with higher contents of ash, fibre and carbohydrates.

Ankaiah (2013) conducted field and lab experiments to study the effect of seed size on seedling vigour in groundnut. The results revealed that seedlings established from large seed had uniform germination and vigorous in terms of shoot length, seedling length, seedling vigour index I and vigour index II as compared to medium, small, shriveled and ungraded seeds. Seed quality characters like oil content was also higher in large seed than other seed sizes. However, the performance of ungraded seed in respect of seedling characters such as root length was on par with the large seed. In the present investigation, large seed had better initial vigour, seedling establishment than medium, small, shriveled and ungraded seeds.

Studies of the relationship between seed size and early growth have been reported (Willenborg *et al*., 2005). Seed size is an important physical indicator of seed quality that affects growth and is frequently related to yield, market grade factors and harvest efficiency. Seed size is one of the most important characteristics of

seeds that can affect the seed development duration (Willenborg *et al*., 2005). The main purpose of seed grading is to understand the better physiological quality of the seed lot (Dar *et al*., 2002).

2.2.1 Effect of seed size on growth and yield of other crops

There was positive relationship between seed size and seedling emergence rate was found in some crops (Gholami *et al*., 2009) whereas contradictory results have been reported for soybean and groundnut (Ahmed *et al*., 2010; Marison and Xue, 2007).

Hojjat (2011) reported that large seeds of lentil genotypes showed early germination compared with smaller seed size. Similar trend was reported in tree crops where larger seeds were said to give faster emergence and produce larger seedlings (Gunaga *et al*., 2007).

Willie and Okoronkwo (2016) exploited the phenomenon of polyembryony to raise multiple seedlings through fragmenting seeds of fluted pumpkin and reported that number of days to seedling emergence increased, while establishment count, number of branches per plant, number of leaves per plant, stem girth, leaf area, and fresh vegetative yield, all decreased, as seed fragmentation increased (that is, as effective seed size was artificially being reduced). Some research showed that large soybean seeds are preferable in stress condition (Hanley *et al*., 2007); generally, because bigger seeds germinate quicker and would take lesser duration when compared to that of smaller ones (Gunaga *et al*., 2007).

Manonmani *et al*. (1996) have recorded higher seed germination and seedling establishment by using bigger size seed in *Pongamia pinnata* and *Vateria indica*. Menaka and Balamurugan (2008) proved that larger seed of Amaranthus possess highly physiological quality with increased seed size, higher germination and emergence was determined in triticale.

Mandal *et al*. (2008) noted that in *Hypatia suaveolens*, variation in seed size and mass influenced emergence, large seeds showed a higher emergence potential than smaller seeds from greater planting depths. Generally, seed size is a widely accepted measure of seed quality and large seeds have higher seedling survival growth and establishment (Jerlin and Vadivelu, 2004). However, with advance in growth stage, the differences are generally less marked, diminishing and in certain cases completely disappearing (Oyewole and Koffa, 2010; Oyewole *et al*., 2019).

With increased seed size, higher germination and emergence was determined in triticale (Kaydan and Yagmur, 2008). In bengal gram, larger size seeds retained on 19/64" round perforated metal sieves recorded the maximum germination, seedling vigour, protein content, dehydrogenase and alpha-amylase activity (Anuradha *et al.*, 2009).

Large seeds produced vigorous seedling growth due to a lower ion accumulation under NaCl stress (Mehmet *et al.*, 2011). Plant grown from large seeds compared to those grown from small seeds was more vigorous and produces greater dry matter in wheat (Nik *et al.*, 2011).

Ahirwar (2012) reported that *Alangium lamarckii Thwaites* of large size seeds gave maximum (76.00%) germination followed by medium size (74.00%) and small size seeds characterized by low germination percentage (59.00%).

Lima *et al.* (2005) noted that crop growth rate at the beginning of the growth cycle was higher in plants originating from large seeds. Yogeesha *et al.* (2005) reported that in french bean cv. Arka Komal, the seed size of >4.35 mm can be used for better field performance instead of seeds with >4.75 size as presently practicing. In mustard pronounced effect of seed size was observed, in large seed size category by having higher values of yield attributing parameters.

Khurana and Singh (2000), noted that seed size variations affected leaf area, large seeds producing greater leaf area. They added that large seeds increased leaf area production of *Abizia* plants, particularly at the beginning of the growth cycle.

Bicer (2009) stated that in chickpea, effect of seed size on yield and 100 seed weight was positive. He also opinioned that plants (Chickpea + lentil) from large seeds yielded 6% more than medium seeds and 10% more than mixed seeds.

Chiamai *et al.* (2010) opinioned that large seeds of mung beans *(Vigna radiata)* produced larger sprouts including sprout mass and head diameter characters. Adejare (2010) reported that large seed size of elite maize had higher seed quality and higher seed yield compared to other medium and small sizes.

Nagaraju (2001) reported higher plant height, number of leaves and stem girth in plants raised from large size seeds (more than 3.0 mm) followed by medium (seeds passed through 3.0 mm sieve) and small seeds (passed through 2.8 mm sieve). He also recorded significantly higher yield and yield trait in sunflower with large seed (retained over 3.00 mm sieve) the higher head diameter (15.08 cm). Janzen reported grain yield advantages of 4.2% in bread wheat and Roy *et al*. (1996) observed 16% in durum wheat have been reported from large seeds over small sized ones.

Seed size has been observed to affect yield. Large seeds of spring wheat produce higher yield but not under optimum management conditions (Kalita and Choudhury, 1984). Wheat seed size does not only influence emergence and establishment but also affects yield components and ultimately grain yield (Baalbaki and Copeland, 1995).

Reddy and Setty (1995) indicated that size of seed has a strong effect on germination as well as growth and biomass increment of the plant. With increasing seed size, spike production and density, number of tillers, main stem, length, thousand kernel mass, test mass, seed vigour and yield increased in Croatian

spring malting barley (Ali and Malik, 1992). Similar result obtained by Roozrokh *et al*. (2005) in chickpea and Taleghani *et al*. (2002) in sugar beet.

Roy *et al*. (1996) reported that larger seeds resulted in high biomass, green area index, number of spikes per m^2 and heavier kernels in rice. Tawaha and Turk (2004), in a study with field pea, noted that plants produced from heavier seeds had 100-seed weight that was 12% larger than these produced from lighter seeds.

CHAPTER III

MATERIALS AND METHODS

The experiment was carried out at the Agronomy farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2019 to April 2020 to study the performance of groundnut varieties with different seed size. The materials and methods that were used for conducting the experiment are presented under the following headings:

3.1 Experimental location

The present piece of research work was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site was 90°33´E longitude and 23°77´N latitude with an elevation of 8.2 m from sea level. Location of the experimental site presented in Appendix I.

3.2 Soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28 and was dark grey terrace soil. The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI, Khamarbari, Dhaka. The details of morphological and chemical properties of initial soil of the experiment plot were presented in Appendix II.

3.3 Climate

The climate of experimental site was subtropical, characterized by three distinct seasons, the winter from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al*., 1979). Details on the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was

collected from the Weather Station of Bangladesh, Sher-e-Bangla Nagar, presented in Appendix III.

3.4 Test crop

Three groundnut variety, *viz*. BARI chinabadam-8, Binacheenabadam-4 and Binacheenabadam-6 were considered for the present study.

3.5 Experimental details

3.5.1 Treatments

Factor A: Variety - 3

1. BARI Chinabadam-8 (V_1)
2. Binacheenabadam-4 (V_2)
3. Binacheenabadam-6 (V_3)

Factor B: Seed size - 4

1. Unsorted (S_1)
2. Small (S_2)
3. Medium (S_3)
4. Large (S_4)

Treatment combinations - Twelve treatment combinations: V_1S_1, V_1S_2, V_1S_3, V_1S_4, V_2S_1, V_2S_2, V_2S_3, V_2S_4, V_3S_1, V_3S_2, V_3S_3 and V_3S_4.

3.5.2 Experimental design and layout

The experiment was laid out in a Split-plot Design with three replications where varieties were considered in the main plot and seed size in sub plot. Three groundnut varieties and four different seed sizes gave altogether 12 treatment combinations of the experiment. The area of the experimental plot was divided into three equal blocks. Each block was divided into 3 equal main plots and the main plots were further divided into 4 sub-plots. The size of each unit plot was 3.00 m × 2.00 m. Distances between plots and replications were 0.5 m and 0.75 m, respectively. The layout of the experimental field is presented in Figure 1.

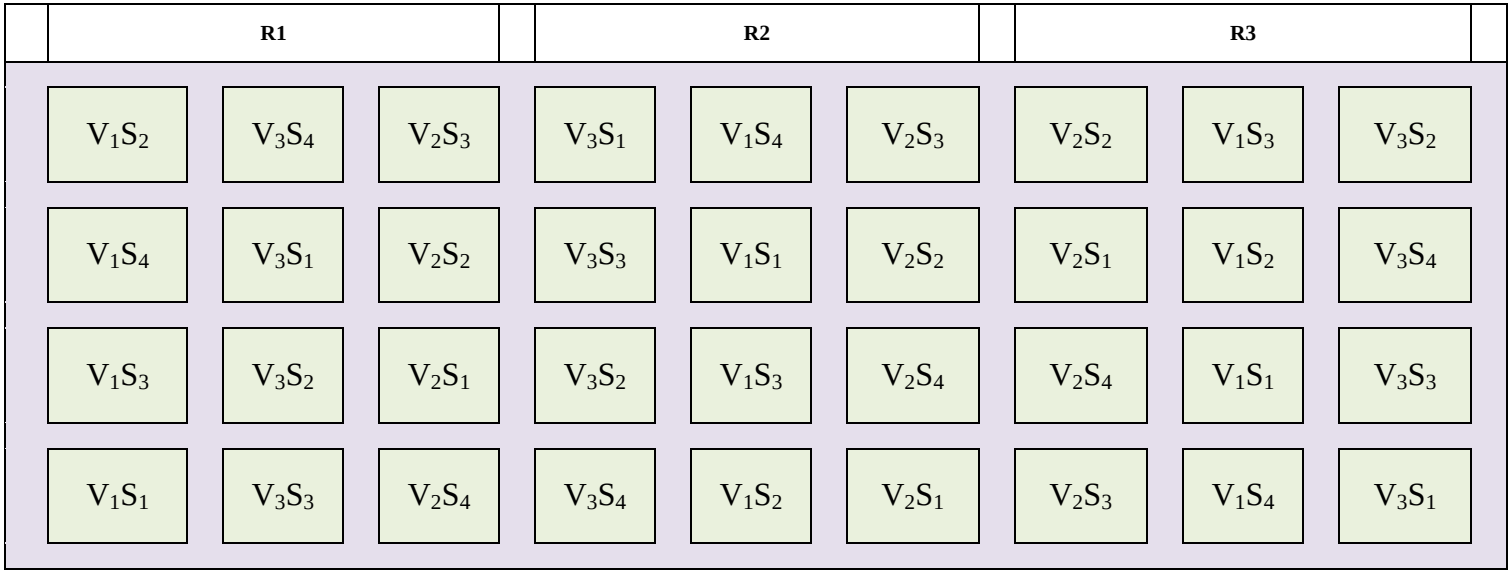


Figure 1. Layout of the experimental field

3.6 Seed collection

The seeds of groundnut variety, BARI Chinabadam-8, was collected from Bangladesh Agricultural Research Institute (BARI) and Binacheenabadam-4 and Binacheenabadam-6 were collected from Bangladesh Institute of Nuclear Agriculture (BINA). The seeds were initially graded into small, medium and large seeds based on visual assessment for length and diameter and from each group 100-seed weight because the parameter for measuring seed size as used in this experiment. A random sample of the original seed lot was used as the mixed category for each variety. The 100-seed weight of graded seeds were 43.17, 30.33, 41.40 and 49.30 g for BARI Chinabadam-8; 30.62, 26.82, 34.51 and 40.31 g for Binacheenabadam-4 and 31.94, 26.12, 33.05 and 39.24 for Binacheenabadam-6 considering unsorted, small, medium and large sized seeds respectively.

3.7 Description of the variety

3.7.1 BARI Chinabadam-8

BARI Chinabadam-8 is a high yielding variety of groundnut that developed by the Oil Seed Research Center, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, Bangladesh. The pedigree line (ICGV-94322) of the variety was suitable with Bangladesh climatic condition and crossed with some released varieties in deferent steps for experimentation, after that the variety was released in 2006 by the authorization of National Seed Board. It takes about 140-150 days to mature in Rabi season and 125-140 days during Kharif season. It attains a plant height of 35-42 cm at maturity. Leaf color deep green, it contains 20-25 nuts per plant with cluster, the shells are smooth and whitish in color and soft in nature, seeds are reddish brown in color. Medium 100 seeds weight of about 55-60 g with a shelling percentage is about 65-70%. The cultivar gives a pod yield of 2.3-2.5 t ha^{-1} of unshelled nuts. This is a Spanish class variety. This is one of the best variety so far released by BARI.

3.7.2 Binacheenabadam-4

High yielding groundnut variety (maximum: 3.5 tons/ha, average 2.6 tons/ha) released in 2008. Duration: 140-150 days in winter and 100-120 days in summer season. Pod and kernels are medium bold sized. It can tolerate cercospora leaf spot, collar root and rust diseases and also performs better under drought and saline conditions.

3.7.3 Binacheenabadam-6

It was released in 2011. It can tolerate 8.0 dSm^{-1} salinity during flowering till harvest stages. Plants are dwarf and erect. Leaves are small, ovate and light green. Pod and kernel are also medium in size, tolerant to collar rot and rust diseases. Maximum pod yield potential is 2.9 t ha^{-1} and average is 2.4 tha^{-1} under saline field conditions at Bagerhat, Khulna and Noakhali districts. Maturity period ranges between 140-150 days. Seeds contain 48.51% oil and 28.68% protein.

3.8 Land preparation

The plot selected for the experiment was opened in the last week of October, 2019 with a power tiller, and was exposed to the sun for a few days, after, which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed and finally obtained a desirable tilth of soil for seed sowing. The land preparation was completed on 2nd November 2019. The individual plots were made by making ridges (20 cm high) around each plot to restrict lateral runoff of irrigation water.

3.9 Collection and preparation of initial soil sample

The initial soil samples were collected before land preparation from a 0-15 cm soil depth. The samples were collected by means of an auger from different location covering the whole experimental plot and mixed thoroughly to make a composite sample. After collection of soil samples, the plant roots, leaves etc. were picked up

and removed. Then the samples were air-dried and sieved through a 10-mesh sieve and stored in a clean plastic container for physical and chemical analysis and subsequently analyzed from Soil Resources Development Institute (SRDI), Farmgate, Dhaka- 1215.

3.10 Fertilizers and manure application

Application of fertilization (basal dose) was completed on 3rd November, 2019. Fertilizers were applied to the experimental plot considering the recommended doses of BARI (2019).

Manures/fertilizers	Doses ha^{-1}
Urea	25 kg
TSP	160 kg
MoP	85 kg
Gypsum	170 kg
$ZnSO_4$	4 kg
Boric acid	10 kg

Half of urea along with other fertilizers were applied during final land preparation as basal dose and thoroughly mixed with soil. The rest half urea was applied at 45 days after sowing (DAS) when flowers were initiated by side dressing.

3.11 Seed sowing

Seeds of the 3 varieties of groundnut (BARI Chinabadam-8, Binacheenabadam-4 and Binacheenabadam-6) were sown at the rate of 100 kg ha^{-1} (unshelled groundnut) on 4 November, 2019. Before sowing seeds, germination percentage was recorded. The groundnuts were first unshelled and treated with Bavistin 250 WP @ 2 g kg^{-1} seed, then sown in lines maintaining a line to line distance of 30 cm and seed to seed distance of 15 cm having 2 seeds $hole^{-1}$ in the well prepared plot.

3.12 Intercultural operations

After establishment of seedlings, various intercultural operations were accomplished for better growth and development of the groundnut.

3.12.1 Irrigation and drainage

Pre-sowing irrigation was given to ensure the maximum germination percentage. Generally for upland soil 2 irrigations are required but considering the experiment field soil condition several time irrigations was given. Irrigations were given depending on the soil moisture content after soil moisture testing by hand. Before harvesting a last irrigation was given for convenience harvesting.

3.12.2 Gap filling, thinning, weeding

Thinning and gap filling were done at 20 and 23 DAS, respectively to maintain the uniformity of plant population. The crop was infested with some weeds during the early stage of crop establishment. Two hand weeding were done. After irrigation the soil surface became crusty, so there needed several operations done manually to break down the hard soil crust.

3.12.3 Earthing up

Earthing up was done lightly on 40 days after sowing. It was done to encourage pegging and potential pod development.

3.12.3 Plant protection

Bavistin 250 WP was directly applied in the row to control ant. Insecticide Ripcord 10 EC @ 1 ml litre^{-1} water were mixed and then sprayed on the leaves two times by knapsack sprayer to control jute hairy caterpillar, jessed and cutworm to protect the crop. Autistin 50 WDG and Mancer 75WP were used as fungicide to control foot and root rot of groundnut.

3.13 Harvesting and postharvest operation

There is a thumb rule that the crop should be harvested when about 75% of the pods became mature at 115 DAS. After observing some maturity indices such as leaf became yellow, spots on the leaf, pod became hard and tough and dark tannin discoloration inside the shell crops were harvested. The samples were collected from the area of 1 m^2 of each plot avoiding the border plants. During harvest the pod contained 35% moisture. The harvested crops were tied into bundles and carried to the threshing floor. Then the pods were separated from the plants. The separated pod and the stover were sun dried by spreading those on the threshing floor. The seeds were separated from the pod and dried in the sun for 3 to 5 consecutive days for achieving safe moisture (8%) of seed.

3.14 Data collection and recording

Experimental data were recorded from stipulated dates and continued until harvest. The followings data were recorded during the experimentation:

3.14.1 Growth parameters

1. Percent germination
2. Plant height
3. Number of branches $plant^{-1}$
4. Number of leaves $plant^{-1}$
5. Leaf length
6. Leaf breadth
7. Shoot length
8. Root length
9. Number of nodules $plant^{-1}$
10. Dry weight $plant^{-1}$

3.14.2 Dry matter partitioning

1. Leaf dry weight $plant^{-1}$

2. Root dry weight plant^{-1}
3. Shoot dry weight plant^{-1}
4. Nodule dry weight plant^{-1}
5. Pod dry weight plant^{-1}

3.14.3 Yield contributing parameters

1. Fresh weight plant^{-1}
2. No. of pods plant^{-1}
3. Pod length
4. Fresh weight of pods plant^{-1}
5. Dry weight of pods plant^{-1}
6. 100 seed weight

3.14.4 Yield parameters

1. Pod yield plot^{-1}
2. Pod yield ha^{-1}
3. Stover yield
4. Biological yield
5. Harvest index

3.15 Procedure of recording data

3.15.1 Growth parameters

3.15.1.1 Percent germination (seedling emergence)

Percent germination was measured by calculation seedling emergence after sowing. Daily observation was done for the first ten days in each plot and number of seedling emergence was counted. Percent germination was calculated by the following formula:

$$\text{Percent germination} = \frac{\text{Total number of seedling emergence}}{\text{Total seeds sown in the plot}} \times 100$$

3.15.1.2 Plant height

Five plants were selected randomly from the inner rows of each plot. The height of the plants was measured from the ground level to the tip of the plant at 25, 50, 75 and 100 DAS. The mean value of plant height was recorded in cm.

3.15.1.3 Number of branches plant^{-1}

The branches plant^{-1} was counted from five randomly sampled plants. It was done by counting total number of branches of all sampled plants then the average data were recorded.

3.15.1.4 Number of leaves plant^{-1}

Five plants were selected randomly from the inner rows of each plot. Leaves plant^{-1} was counted from each plant sample and then averaged at 25, 50, 75 and 100 DAS.

3.15.1.5 Leaf length

Leaf length was measured by using a meter scale. The measurement was taken from base of leaf to tip of the petiole. Average length of leaves was taken from five randomly selected plants sampled from inner rows of each plot. Data was recorded at 25, 50, 75 and 100 DAS. Mean data was expressed in centimeter (cm).

3.15.1.6 Leaf breadth

Leaf breadth was recorded as the average of leaves from randomly selected five plants of inner rows of each plot at 25, 50, 75 and 100 DAS. Thus mean was recorded and expressed in centimeter (cm).

3.15.1.7 Shoot length

Five plants were selected randomly from the inner rows of each plot. The shoot length of the plants was measured from the ground level to the top of the shoot at 30, 60, 90 and 120 DAS. The mean value of shoot length was recorded in cm.

3.15.1.8 Root length

Root length was measured from randomly selected five plants from each plot at 30, 60, 90 and 120 DAS. The root length of the plants was measured from the ground level to end of the longest root. The mean value of root length was recorded in cm.

3.15.1.9 Number of nodules plant^{-1}

Number of nodules plant^{-1} was measured from randomly selected five plants from each plot at 30 and 60 DAS. Nodule number was counted from five plants and mean value was recorded.

3.15.1.10 Dry weight plant^{-1}

Five plants were collected randomly from each plot at 30, 60, 90 and 120 DAS. Leaves, roots, and shoots were separated and put into envelop separately and placed in oven maintaining 70°C for 72 hours for oven dry until attained a constant level. Total dry weight of separated parts were measured and the mean of dry matter weight plant^{-1} was determined in gram.

3.15.2 Dry matter partitioning

3.15.2.1 Leaf dry weight plant^{-1}

From five randomly collected plants, leaves were separated and put into envelop and placed in oven maintaining 70°C for 72 hours for oven dry until attained a constant level and the mean leaf dry weight plant^{-1} was determined in gram at 30, 60, 90 and 120 DAS.

3.15.2.2 Root dry weight plant^{-1}

From five randomly collected plants, roots were separated and put into envelop and placed in oven maintaining 70°C for 72 hours for oven dry until attained a

constant level and the mean root dry weight plant^{-1} was determined in gram at 30, 60, 90 and 120 DAS.

3.15.2.3 Shoot dry weight plant^{-1}

From five randomly collected plants, shoots were separated and put into envelop and placed in oven maintaining 70°C for 72 hours for oven dry until attained a constant level and the mean shoot dry weight plant^{-1} was determined in gram at 30, 60, 90 and 120 DAS.

3.15.2.4 Nodule dry weight plant^{-1}

Nodules were separated from five randomly collected plants and put into envelop and placed in oven maintaining 70°C for 72 hours for oven dry until attained a constant level and the mean nodules dry weight plant^{-1} was determined in gram at 30 and 60 DAS.

3.15.2.5 Pod dry weight plant^{-1}

Pods were separated from five randomly collected plants and put into envelop and placed in oven maintaining 70°C for 72 hours for oven dry until attained a constant level and the mean pod dry weight plant^{-1} was determined in gram at 90 and 120 DAS.

3.15.3 Yield contributing parameters

3.15.3.1 Fresh weight plant^{-1} at harvest

At the time of harvest, randomly selected whole five plants with pod was taken after removing soil and other stubbles from the plants and then mean weight was recorded and expressed in gram (g).

3.15.3.2 Number of pods plant^{-1}

The pods plant^{-1} was counted from five randomly sampled plants. It was done by counting total number of pods of all sampled plants then the average data were recorded.

3.15.3.3 Number of seeds pod^{-1}

The seeds pod^{-1} was counted from 50 randomly sampled pods of each plot. It was done by counting total number of seeds of all sampled pods then it was calculated from total number of seeds divided by total number of pods.

3.15.3.4 Pod length

Pod length was recorded from randomly selected 20 pods of each plot and the average was taken and expressed in centimeter (cm).

3.15.3.5 Fresh weight of pods plant^{-1} at harvest

At the time of harvest, pods were separated from randomly collected five plants and fresh pod weight was taken and the mean pod fresh weight plant^{-1} was determined in gram.

3.15.3.6 Dry weight of pods plant^{-1} at harvest

At the time of harvest, from five randomly collected plants, pods were separated and put into envelop and placed in oven maintaining 70°C for 72 hours for oven dry until attained a constant level and the mean pod dry weight plant^{-1} was determined in gram.

3.15.3.7 Weight of 100-seed

From the seed stock of each plot 100 seeds were counted randomly and the weight was measured by an electrical balance. It was recorded in gram (g).

3.15.4 Yield parameters

3.15.4.1 Pod yield plot^{-1}

Pod yield plot^{-1} was calculated from unshelled, cleaned and well dried grains collected from each plot and expressed as t ha^{-1} on 8 % moisture basis.

3.15.4.2 Pod yield ha^{-1}

Pod yield was calculated from unshelled, cleaned and well dried grains collected from the central 1 m^2 area of inner rows of each plot (leaving boarder rows) and expressed as t ha^{-1} on 8 % moisture basis.

3.15.4.3 Stover yield

Stover yield was determined from the central 1 m^2 area of inner rows of each plot. After threshing, the sub sample was oven dried to a constant weight and finally converted to t ha^{-1}.

3.15.4.4 Biological yield

It was the total yield including both the economic and stover yield as follows:

Biological yield = Grain yield + Stover yield

3.15.4.5 Harvest Index

Harvest index is the ratio of economic (grain) yield and biological yield. It was calculated by dividing the grain yield from the harvested area by the biological yield of the same area and multiplying by 100.

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

3.16 Statistical Analysis

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program MSTAT-C and then mean difference were adjusted by Least Significant difference (LSD) test at 5% level of significance (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

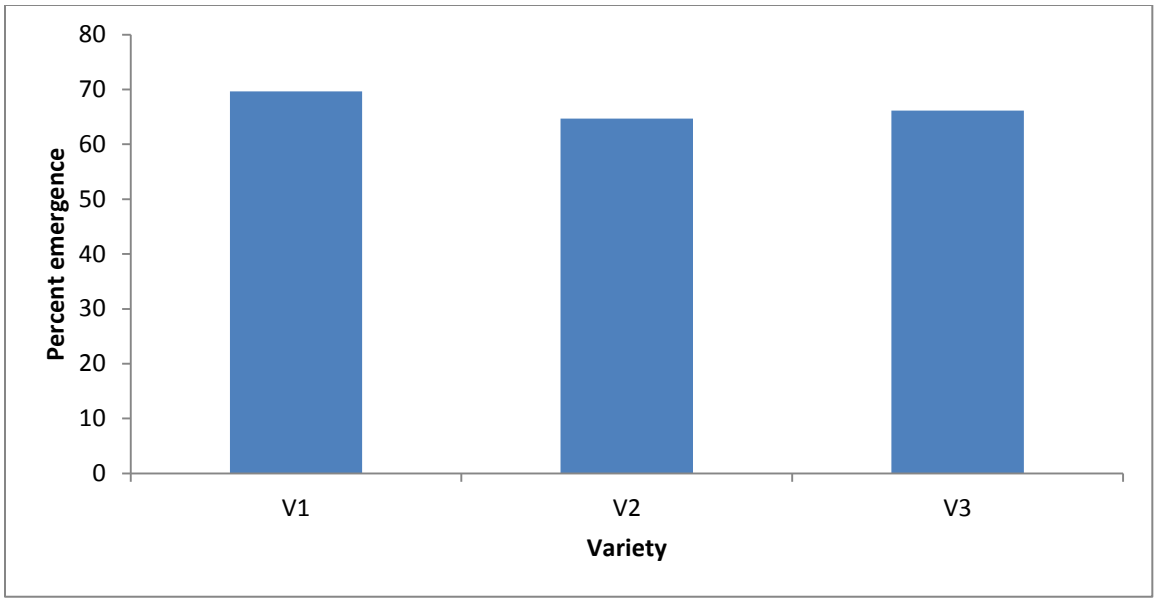
The experiment was conducted to evaluate the growth and yield of groundnut varieties as influenced by seed size. Data on different growth, yield contributing characters and yield of groundnuts were recorded. The results have been presented and discussed with the help of graphs and tables and possible interpretations given under the following headings:

4.1 Growth parameters

4.1.1 Percent germination/seedling emergence

Effect of variety

Percent seedling emergence varied significantly due to different varieties of groundnut at 10 days after sowing (Fig. 2 and Appendix IV). Results showed that the highest percent germination (69.67%) was found from the varietyV_1 (BARI Chinabadam-8) followed by V_3 (Binacheenabadam-6) whereas the lowest percent germination (64.67%) was found from the varietyV_2 (Binacheenabadam-4). Genetic formations of genotypes of different origin and environmental factors during crop period might be responsible for variation of genotypes for this trait as repeated by Manaf *et al*. (2017).

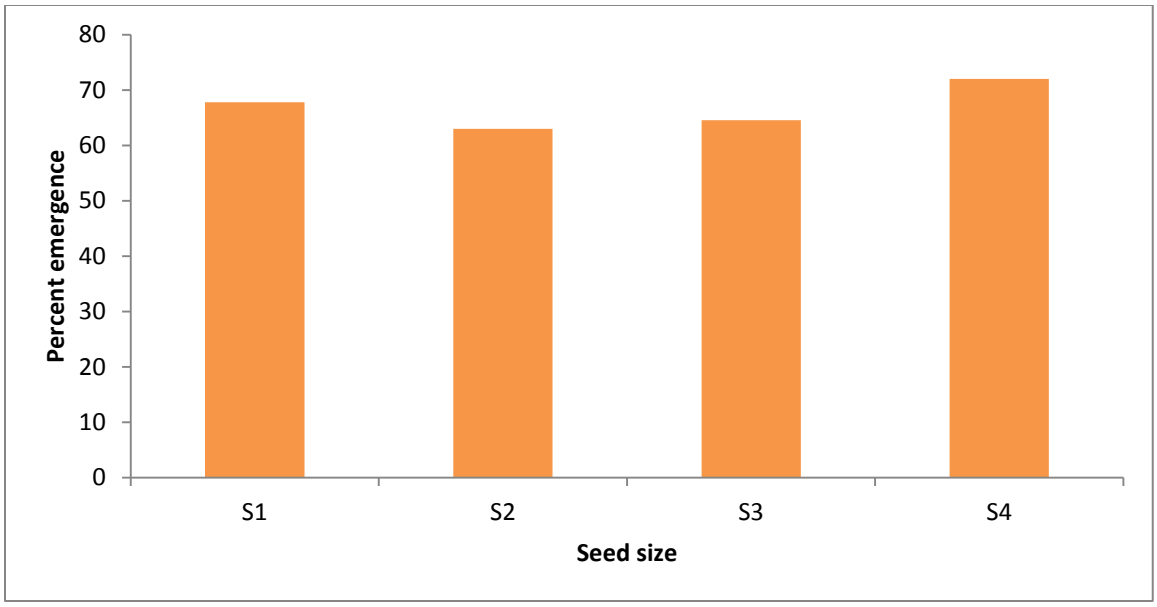


V_1 = BARI Chinabadam-8, V_2 = Binacheenabadam-4, V_3 = Binacheenabadam-6

Figure 2. Percent emergence of groundnut seeds as influenced by varieties ($LSD_{(0.05)}$ = 0.495).

Effect of seed size

Significant variation was remarked on percent emergences influenced by different seed size (Fig. 3 and Appendix IV). It was observed that the highest percent emergence (72.00%) was found from the seed sizeS_4 (large) followed by S_1 (unsorted) whereas the lowest percent germination (63.00%) was found from the seed size S_2 (small), which was statistically same with S_3 (medium) seed size. The result obtained from the present study was similar with the findings of Olayinka *et al*. (2016) and Oyewole *et al*. (2020) who found significant influence of seed size on seedling emergence and it was higher from relatively larger seeds. Supported result was also observed by Nagaraju (2001) and Hojjat (2011). They found 54, 42 and 10% emergence at 10 days after planting with large, medium and small sized seeds gradually, which supported the present study.

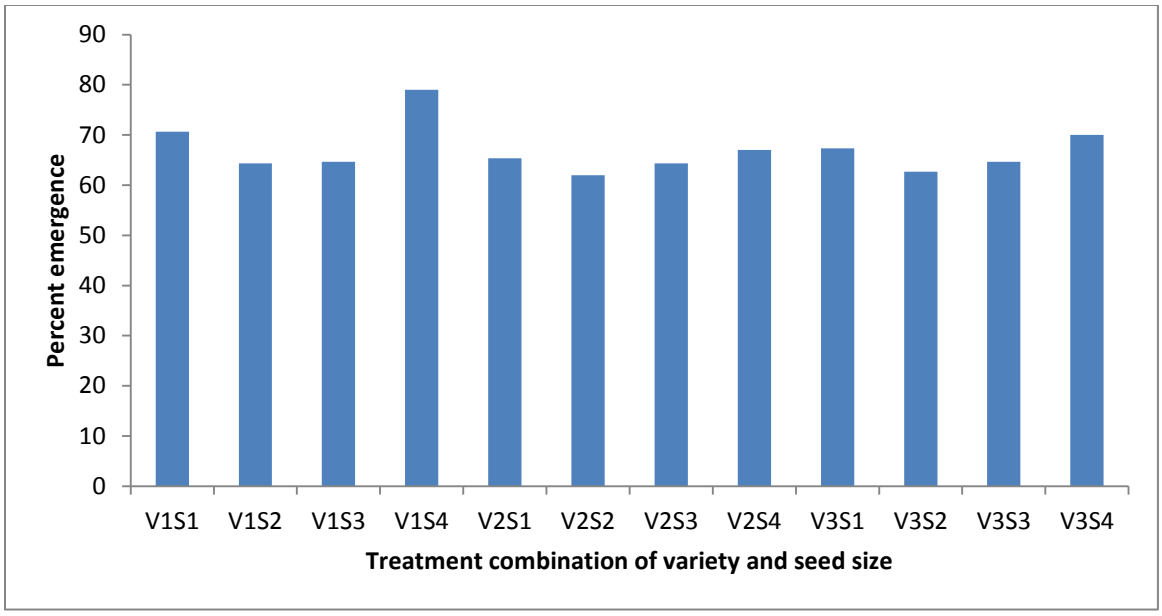


S_1 = Unsorted, S_2 = Small, S_3 = Medium, S_4 = Large

Figure 3. Percent emergence of groundnut seeds as influenced by seed size ($LSD_{(0.05)}$ = 2.099).

Combined effect of variety and seed size

Percent seed emergence was found significant with the combined effect of variety and seed size (Figure 4 and Appendix IV). Results showed that the highest percent germination (79.00%) was found from the treatment combination of V_1S_4 (BARI Chinabadam-8 with larger seed), which was significantly different from other treatment combinations followed by V_1S_1 and V_3S_4. The lowest percent germination (62.00%) was found from the treatment combination of V_2S_2, which was statistically similar with the treatment combination of V_3S_2, V_1S_2, V_1S_3, V_2S_1, V_2S_3 and V_3S_3. Larger seeds as BARI Chinabadam-8 showed 17% higher germination compared to that of lowest performer Binacheenabadam-4 with smaller seeds.



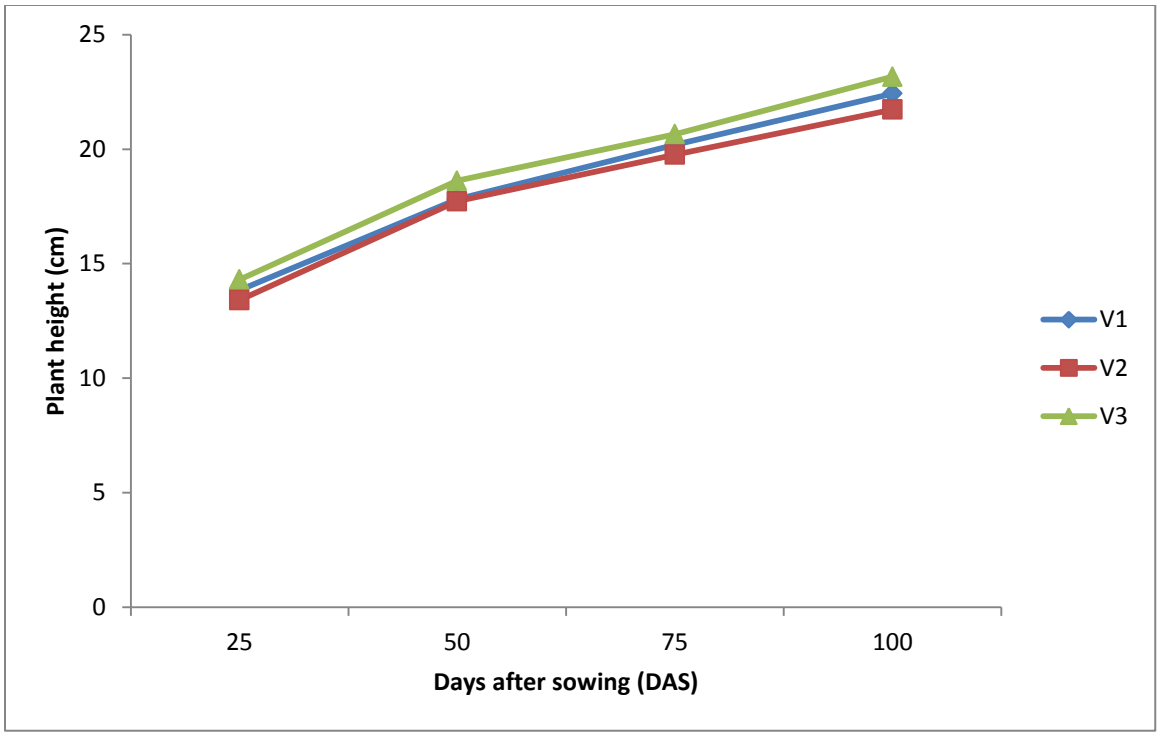
V_1 = BARI Chinabadam-8, V_2 = Binacheenabadam-4, V_3 = Binacheenabadam-6
S_1 = Unsorted, S_2 = Small, S_3 = Medium, S_4 = Large

Figure 4. Percent emergence of groundnut seeds as influenced by the interaction of varieties and seed size ($LSD_{(0.05)}$ = 3.635).

4.1.2 Plant height

Effect of variety

Non-significant variation was found among the varieties of groundnut regarding plant height at different growth stages (Fig. 5 and Appendix V). However, the highest plant height (14.31, 18.62, 20.65 and 23.16 cm at 25, 50, 75 and 100 DAS, respectively) was recorded from the variety V_3 (Binacheenabadam-6) whereas the variety V_2 (Binacheenabadam-4) showed the lowest plant height (13.41, 17.73, 19.76 and 21.73 cm at 25, 50, 75 and 100 DAS, respectively). Variation on plant height among different groundnut genotypes was also found by Yousif and Hussain (2019). Results reflect the effect of the genetic base diversity among the genotypes and the other environmental factors concerned with plant distribution (Singh and Singh, 1999).

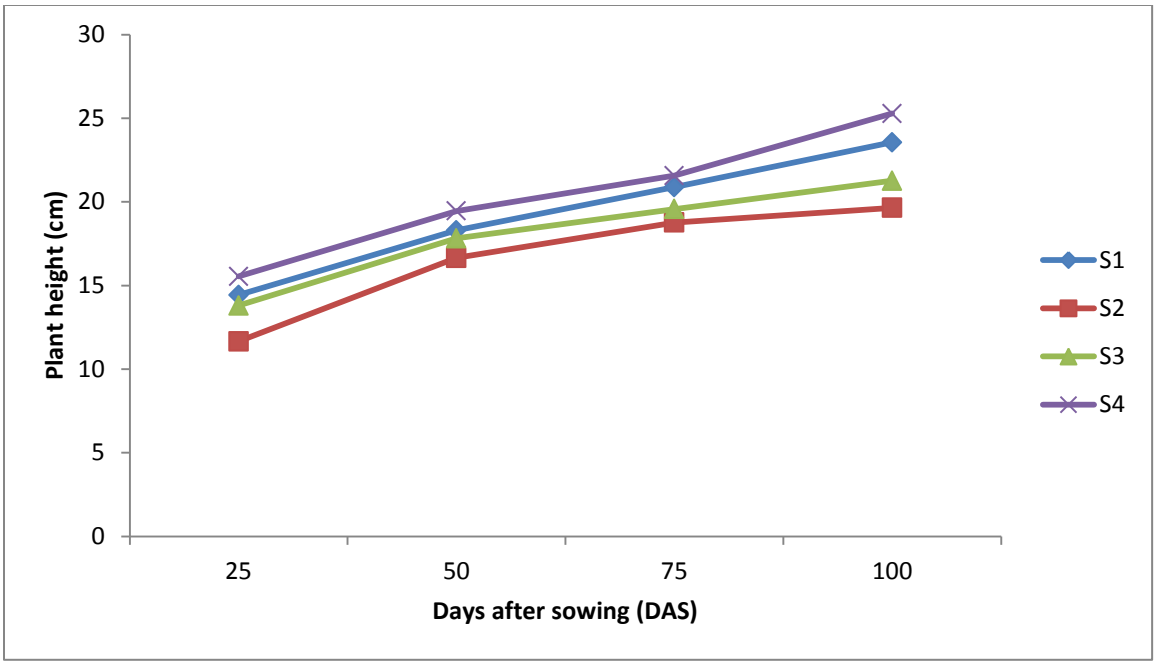


V_1 = BARI Chinabadam-8, V_2 = Binacheenabadam-4, V_3= Binacheenabadam-6

Figure 5. Plant height of groundnut as influenced by varieties ($LSD_{0.05}$ = 1.040, 1.033, 1.445 and 1.645 at 25, 50, 75 and 100 DAS respectively).

Effect of seed size

Significant influence was found at different growth stages on plant height of groundnut caused by different seed size (Fig. 6 and Appendix V). The seed size S_4 (large) showed the highest plant height (15.54, 19.46, 21.57 and 25.28 cm at 25, 50, 75 and 100 DAS, respectively), which was statistically identical with S_1 (unsorted) at 75 DAS. The lowest plant height (11.66, 16.65, 18.77 and 19.65 cm at 25, 50, 75 and 100 DAS, respectively) was recorded from the seed size S_2 (small) which was statistically identical with S_3 (medium) at 75 DAS. Olayinka *et al.* (2016) also found similar result with the present study. They observed plant height was higher in plants from relatively larger seeds at various crop stages.



S_1 = Unsorted, S_2 = Small, S_3 = Medium, S_4 = Large

Figure 6. Plant height of groundnut as influenced by seed size ($LSD_{(0.05)}$ = 1.108, 0.494, 0.805 and 1.160 at 25, 50, 75 and 100 DAS, respectively).

Combined effect of variety and seed size

Plant height of groundnut at different growth stages showed significant variation by combined effect of variety and seed size (Table 1 and Appendix V). At 25 DAS, the highest plant height (15.86 cm) was given by V_3S_4 and that similar to V_1S_4 (15.55 cm) and V_2S_4 (15.22 cm) whereas the lowest plant height (10.80 cm) was recorded from V_2S_2 combination that similar to V_1S_2 (11.54 cm). At 50 DAS, the highest plant height (20.21 cm) was found in V_3S_4 combination that significantly different to others and the lowest plant height (16.08 cm) was given by V_2S_2 combination that similar to V_1S_2 (16.24 cm). At 75 DAS, the highest plant height (22.04 cm) was also recorded in V_3S_4 combination that similar to V_1S_4 (21.54 cm), V_2S_4 (21.14 cm) and V_3S_1 (21.12 cm) whereas the lowest plant height (18.11 cm) was found in V_2S_2 combination that similar to V_1S_2 (19.02 cm). Similarly, the highest plant height at 100 DAS (26.33 cm) was given by V_3S_4

combination that was not similar to others, which followed by V_1S_4 (25.15 cm) and V_2S_4 (24.36 cm) and lowest plant height (19.08 cm) was recorded in V_2S_2 combination that similar to V_1S_2 (19.24 cm).

Table 1. Plant height of groundnut as influenced by the interaction of varieties and seed size

Treatments	Plant height (cm) at different days after sowing (DAS)			
	25	50	75	100
V_1S_1	14.51 bc	18.13 cd	20.94 bc	23.90 c
V_1S_2	11.54 f	16.24 e	19.02 ef	19.24 f
V_1S_3	13.81 cd	17.75 d	19.27 de	21.42 e
V_1S_4	15.55 a	19.15 b	21.54 ab	25.15 b
V_2S_1	14.26 c	18.07 cd	20.59 bc	22.73 d
V_2S_2	10.80 f	16.08 e	18.11 f	19.08 f
V_2S_3	13.35 de	17.74 d	19.19 e	20.74 e
V_2S_4	15.22 ab	19.03 b	21.14 abc	24.36 bc
V_3S_1	14.51 bc	18.71 bc	21.12 abc	24.04 c
V_3S_2	12.63 e	17.63 d	19.18 e	20.63 e
V_3S_3	14.23 c	17.95 cd	20.26 cd	21.63 e
V_3S_4	15.86 a	20.21 a	22.04 a	26.33 a
$LSD_{(0.05)}$	0.859	0.856	1.031	1.046
CV (%)	8.07	8.31	6.38	5.22

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

V_1 = BARI Chinabadam-8, V_2 = Binacheenabadam-4, V_3 = Binacheenabadam-6
S_1 = Unsorted, S_2 = Small, S_3 = Medium, S_4 = Large

4.1.3 Number of branches plant^{-1}

Effect of variety

Non-significant variation was recorded on number of branches plant^{-1} at all growth stages due to varietal difference (Table 2 and Appendix VI). However, the numerically maximum number of branches plant^{-1} (3.33, 5.83, 6.00 and 6.25 at 25, 50, 75 and 100 DAS, respectively) was recorded from the variety V_1 (BARI Chinabadam-8) whereas the minimum number of branches plant^{-1} (2.83, 5.42, 5.58

and 5.67 at 25, 50, 75 and 100 DAS, respectively) was recorded from the variety V_2 (Binacheenabadam-4). Genetic formations of genotypes of different origin and environmental factors during crop period might be responsible for variation of genotypes for this trait. These results were also in close agreement with the findings of Mouri *et al*. (2018); who found that BARI Chinabadam-8 produced higher number of branches plant^{-1} than Binacheenabadam-6. Similar result was also observed by Yousif and Hussain (2019).

Effect of seed size

Non-significant influence was found on number of branches plant^{-1} at all growth stages due to varied seed size (Table 2 and Appendix VI). However, the numerically maximum number of branches plant^{-1} (3.67, 5.89, 6.33 and 6.44 at 25, 50, 75 and 100 DAS, respectively) was recorded from the seed size S_4 (large) whereas the minimum number of branches plant^{-1} (2.56, 5.22, 5.22 and 5.33 at 25, 50, 75 and 100 DAS, respectively) was recorded from the seed size S_2 (small). Similar result was also observed by Olayinka *et al*. (2016) who found number of leaves was higher in plants from relatively larger seeds at various crop stages. Supported result was also observed by Willie and Okoronkwo (2016). Detroja *et al*. (1993) found that the differences in seed size did not influence the number of branches plant^{-1} of groundnut.

Combined effect of variety and seed size

Significantly varied influence was found on number of branches plant^{-1}at different growth stages due to combined effect of variety and seed size (Table 2 and Appendix VI). Results revealed that at 25 DAS, treatment combination of V_1S_4 gave the highest number of branches plant^{-1} (4.00) that similar to V_3S_1 and V_3S_4 (3.67) whereas V_2S_2 combination gave the lowest number of branches plant^{-1} (2.33) that similar to V_1S_2, V_2S_3 and V_3S_2 (3.00). At 50 DAS, the highest number of branches plant^{-1} (6.33) was found in V_1S_4 combination that similar to V_1S_1

(6.00) and the lowest number of branches plant^{-1} (5.00) was given by V_2S_2 combination that similar to V_1S_2, V_2S_3 and V_3S_2 (5.33).

Table 2. Number of branches plant^{-1} of groundnut as influenced by varieties and seed size

Treatments	Number of branches plant^{-1} at different days after sowing (DAS)			
	25	50	75	100
Effect of variety				
V_1	3.33	5.83	6.00	6.25
V_2	2.83	5.42	5.58	5.67
V_3	3.25	5.58	5.83	5.83
$LSD_{(0.05)}$	NS	NS	NS	NS
CV (%)	7.33	8.46	9.64	10.33
Effect of seed size				
S_1	3.44	5.78	6.11	6.22
S_2	2.56	5.22	5.22	5.33
S_3	2.89	5.56	5.56	5.67
S_4	3.67	5.89	6.33	6.44
$LSD_{(0.05)}$	NS	NS	NS	NS
CV (%)	8.39	10.85	11.84	11.50
Combined effect of variety and seed size				
V_1S_1	3.67 ab	6.00 ab	6.33 ab	6.67 ab
V_1S_2	2.67 de	5.33 cd	5.33 de	5.67 de
V_1S_3	3.00 cd	5.67 bc	5.67 cd	5.67 de
V_1S_4	4.00 a	6.33 a	6.67 a	7.00 a
V_2S_1	3.00 cd	5.67 bc	6.00 bc	6.00 cd
V_2S_2	2.33 e	5.00 d	5.00 e	5.00 f
V_2S_3	2.67 de	5.33 cd	5.33 de	5.67 de
V_2S_4	3.33 bc	5.67 bc	6.00 bc	6.00 cd
V_3S_1	3.67 ab	5.67 bc	6.00 bc	6.00 cd
V_3S_2	2.67 de	5.33 cd	5.33 de	5.33 ef
V_3S_3	3.00 cd	5.67 bc	5.67 cd	5.67 de
V_3S_4	3.67 ab	5.67 bc	6.33 ab	6.33 bc
$LSD_{(0.05)}$	0.395	0.454	0.460	0.431
CV (%)	8.39	10.85	11.84	11.50

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

V_1 = BARI Chinabadam-8, V_2 = Binacheenabadam-4, V_3 = Binacheenabadam-6

S_1 = Unsorted, S_2 = Small, S_3 = Medium, S_4 = Large

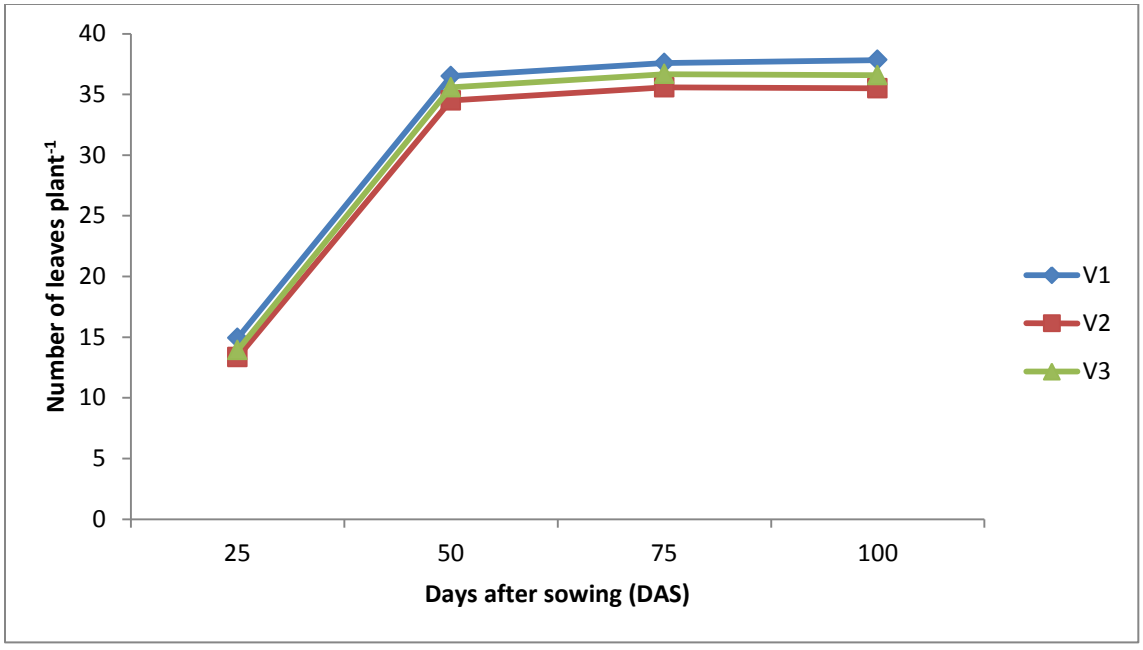
At 75 DAS, the highest number of branches plant^{-1} (5.54) was also recorded in V_1S_4 combination that similar to V_1S_1 (5.50) and V_3S_1 (6.33) whereas the lowest number of branches plant^{-1} (5.00) was found in V_2S_2 combination that similar to

V_1S_2, $V_2S_3$and V_3S_2 (5.33). Similarly, the highest number of branches plant^{-1} at 100 DAS (7.00) was given by V_1S_4 combination that similar to V_1S_1 (6.67) and lowest number of branches plant^{-1} (5.00) was recorded in V_2S_2 combination that similar to V_3S_2 (5.33).

4.1.4 Number of leaves plant^{-1}

Effect of variety

There was no significant effect on number of leaves plant^{-1} of groundnut at different growth stages due to varietal effect (Fig. 7 and Appendix VII). However, the numerically maximum number of leaves plant^{-1} (14.92, 36.50, 37.58 and 37.83 at 25, 50, 75 and 100 DAS, respectively) was recorded from the variety V_1 (BARI Chinabadam-8) and the minimum number of leaves plant^{-1} (13.33, 34.50, 35.58 and 35.50 at 25, 50, 75 and 100 DAS, respectively) was recorded from the variety V_2 (Binacheenabadam-4). The result was in line with that of Gabisa *et al*. (2017).

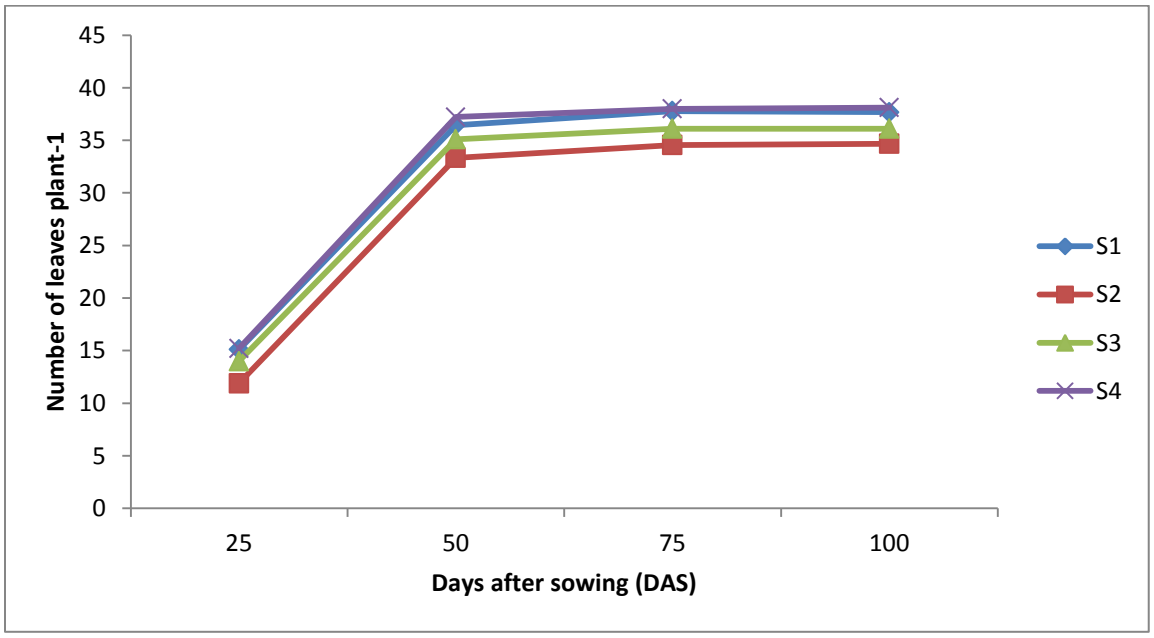


V_1 = BARI Chinabadam-8, V_2 = Binacheenabadam-4, V_3 = Binacheenabadam-6

Figure 7. Number of leaves plant^{-1} of groundnut as influenced by varieties as different days after sowing.

Effect of seed size

Number of leaves plant^{-1} was affected significantly at different growth stages due to different size of seeds (Fig. 8 and Appendix VII). The seed size S_4 (large) showed the highest number of leaves plant^{-1} (15.22, 37.22, 38.00 and 38.11 at 25, 50, 75 and 100 DAS, respectively) which was statistically similar with S_1 (unsorted) at all growth stages followed by S_3 (medium) whereas the lowest number of leaves plant^{-1} (11.89, 33.33, 34.56 and 34.67 at 25, 50, 75 and 100 DAS, respectively) was recorded from the seed size S_2 (small). The result obtained from the present study on number of leaves plant^{-1} was similar with the findings of Willie and Okoronkwo (2016).



S_1 = Unsorted, S_2 = Small, S_3 = Medium, S_4 = Large

Figure 8. Number of leaves plant^{-1} of groundnut as influenced by seed size at different days after sowing ($LSD_{(0.05)}$ = 1.634, 1.132, 1.433 and 0.904 at 25, 50, 75 and 100 DAS, respectively).

Combined effect of variety and seed size

Combined effect of variety and seed size confirmed significant influence on number of leaves plant^{-1} at different growth stages (Table 3 and Appendix VII). At

25 DAS, the highest number of leaves plant^{-1} (15.67) was given by V_1S_4 and that identical to V_1S_1 whereas the lowest number of leaves plant^{-1} (10.33) was recorded from V_2S_2 combination. At 50 DAS, the highest number of leaves plant^{-1} (38.67) was found in V_1S_4combination that similar to V_1S_1 (36.67), V_2S_4 (36.33), V_3S_1 and V_3S_4 (36.67) and the lowest number of leaves plant^{-1} (31.33) was given by V_2S_2 combination that similar to V_3S_2 (33.67). At 75 DAS, the highest number of leaves plant^{-1} (39.00) was also recorded in V_1S_4combination that similar to V_1S_1, V_1S_2, V_1S_3, V_2S_1, V_2S_4, V_3S_1, V_3S_3 and V_3S_4 whereas the lowest number of leaves plant^{-1} (32.67) was found in V_2S_2 combination. Similarly, the highest number of leaves plant^{-1} at 100 DAS (39.67) was given by V_1S_4combination that similar to V_1S_1 (39.00) and lowest number of leaves plant^{-1} (33.33) was recorded in V_2S_2 combination that similar to V_3S_2 (34.67).

Table 3. Number of leaves plant^{-1} of groundnut as influenced by varieties and seed size at different days after sowing combination

Treatments	Number of leaves plant^{-1} at different days after sowing (DAS)			
	25	50	75	100
V_1S_1	15.67 a	36.67 ab	38.33 a	39.00 ab
V_1S_2	14.00 ab	35.00 bc	36.33 ab	36.00 de
V_1S_3	14.33 a	35.67 bc	36.67 ab	36.67 cd
V_1S_4	15.67 a	38.67 a	39.00 a	39.67 a
V_2S_1	14.67 a	36.00 bc	37.33 ab	36.67 cd
V_2S_2	10.33 c	31.33 d	32.67 c	33.33 f
V_2S_3	13.67 ab	34.33 bc	35.00 bc	35.00 e
V_2S_4	14.67 a	36.33 ab	37.33 ab	37.00 cd
V_3S_1	15.00 a	36.67 ab	37.67 ab	37.33 cd
V_3S_2	11.33 bc	33.67 cd	34.67 bc	34.67 ef
V_3S_3	14.00 ab	35.33 bc	36.67 ab	36.67 cd
V_3S_4	15.33 a	36.67 ab	37.67 ab	37.67 bc
$LSD_{(0.05)}$	2.830	2.605	3.017	1.566
CV (%)	11.74	9.04	9.50	7.13

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

V_1 = BARI Chinabadam-8, V_2 = Binacheenabadam-4, V_3 = Binacheenabadam-6
S_1 = Unsorted, S_2 = Small, S_3 = Medium, S_4 = Large

4.1.5 Leaf length

Effect of variety

Leaf length of groundnut showed non-significant variation at different growth stages due to varietal difference (Table 4 and Appendix VIII). However, the numerically maximum leaf length (4.30, 5.00, 5.18 and 5.02 cm at 25, 50, 75 and 100 DAS, respectively) was recorded from the variety V_3 (Binacheenabadam-6) and the minimum leaf length (4.05, 4.85, 4.94 and 4.73 cm at 25, 50, 75 and 100 DAS, respectively) was recorded from the variety V_2 (Binacheenabadam-4). Genetic response and prevailing environmental status might be the reason for variations found on leaf length among genotypes.

Effect of seed size

At 100 DAS, significant variation was recorded on leaf length of groundnut but at 25, 50 and 75 DAS, non-significant variation was found for different seed size (Table 4 and Appendix VIII). At 25, 50 and 75 DAS, the numerically maximum leaf length (4.56, 5.19 and 5.48, respectively) was recorded from the seed size S_4 (large) whereas the minimum leaf length (3.74, 4.66 and 4.68 cm, respectively) was recorded from the seed size S_2 (small). But at 10 DAS, the highest leaf length (5.40 cm) and the lowest leaf length (4.29 cm) was given by S_2 (small) that similar to S_3 (4.68 cm).

Combined effect of variety and seed size

At 25 DAS, the highest leaf length (4.63 cm) was given by V_3S_4 and that identical to V_1S_4 whereas the lowest leaf length (3.50 cm) was recorded from V_2S_2 combination. At 50 DAS, the highest leaf length (5.30 cm) was found in V_3S_4 combination that similar to V_1S_4 (5.15 cm), V_1S_1 and V_3S_1 (5.05 cm) and the lowest leaf length (4.55 cm) was given by V_2S_2 combination that similar to V_1S_2 (4.70 cm), $V_2S_3$and V_3S_2 (4.73 cm) and V_1S_3 (4.80 cm). At 75 DAS, the highest leaf length (5.54 cm) was also recorded in V_3S_4 combination that similar to V_1S_4

(5.50 cm), V_2S_4 (5.39 cm) and V_3S_1 (5.36 cm) whereas the lowest leaf length (4.31 cm) was found in V_2S_2 combination. Similarly, the highest leaf length at 100 DAS (5.44 cm) was given by V_3S_4 combination that similar to V_1S_4 (5.38 cm), V_2S_4 (5.37 cm), V_3S_1 (5.30 cm) and V_1S_1 (5.22 cm) and lowest leaf length (4.03 cm) was recorded in V_2S_2 combination.

Table 4. Leaf length of groundnut as influenced by variety and seed size and their interaction at different days after sowing

Treatments	Leaf length (cm) at different days after sowing (DAS)			
	25	50	75	100
Effect of variety				
V_1	4.19	4.93	5.12	4.92
V_2	4.05	4.85	4.94	4.73
V_3	4.30	5.00	5.18	5.02
$LSD_{(0.05)}$	NS	NS	NS	NS
CV (%)	9.48	6.32	6.14	8.71
Effect of seed size				
S_1	4.30	5.04	5.23	5.20 a
S_2	3.74	4.66	4.68	4.29 b
S_3	4.12	4.81	4.94	4.68 b
S_4	4.56	5.19	5.48	5.40 a
$LSD_{(0.05)}$	NS	NS	NS	NS
CV (%)	12.23	5.88	7.09	9.41
Combined effect of variety and seed size				
V_1S_1	4.27 bc	5.05 abc	5.19 bcd	5.22 ab
V_1S_2	3.80 e	4.70 de	4.87 d	4.41 e
V_1S_3	4.07 cd	4.80 cde	4.93 d	4.68 de
V_1S_4	4.63 a	5.15 ab	5.50 ab	5.38 ab
V_2S_1	4.27 bc	5.02 bc	5.14 cd	5.07 bc
V_2S_2	3.50 f	4.55 e	4.31 e	4.03 f
V_2S_3	4.03 d	4.73 de	4.93 d	4.45 e
V_2S_4	4.40 b	5.11 ab	5.39 abc	5.37 ab
V_3S_1	4.37 b	5.05 abc	5.36 abc	5.30 ab
V_3S_2	3.93 de	4.73 de	4.87 d	4.43 e
V_3S_3	4.27 bc	4.92 bcd	4.96 d	4.90 cd
V_3S_4	4.63 a	5.30 a	5.54 a	5.44 a
$LSD_{(0.05)}$	0.230	0.266	0.326	0.307
CV (%)	12.23	5.88	7.09	9.41

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability: V_1 = BARI chinabadam-8, V_2 = Binacheenabadam-4, V_3 = Binacheenabadam-6, S_1 = Unsorted, S_2 = Small, S_3 = Medium, S_4 = Large

4.1.6 Leaf breadth

Effect of variety

Leaf breadth of groundnut at different growth stages was not affected significantly due to varietal performance (Table 5 and Appendix IX). However, the numerically maximum leaf breadth (2.76, 2.94, 2.73 and 2.19 cm at 25, 50, 75 and 100 DAS, respectively) was recorded from the variety V_1 (BARI Chinabadam-8) whereas the minimum leaf breadth (2.42, 2.59, 2.53 and 1.98 cm at 25, 50, 75 and 100 DAS, respectively) was recorded from the variety V_2 (Binacheenabadam-4). Genetic formations of genotypes of different origin and environmental factors during crop period might be responsible for variation of genotypes for leaf breadth.

Effect of seed size

Non-significant variation was observed on leaf breadth at different growth stages influenced by different seed size of groundnut (Table 5 and Appendix IX). However, at 25, 50, 75 and 100 DAS, the seed size S_4 (large) showed the numerically maximum leaf breadth (2.85, 3.08, 2.83 and 2.31 cm, respectively) whereas the minimum leaf breadth (2.30, 2.40, 2.43 and 1.77 cm at 25, 50, 75 and 100 DAS, respectively) was recorded from the seed size S_2 (small).

Combined effect of variety and seed size

Non-significant variation was found regarding leaf breadth of groundnut at different growth stages caused by treatment combination of variety and seed size (Table 5 and Appendix IX). However, the numerically maximum leaf breadth (3.10, 3.41, 2.97 and 2.42 cm at 25, 50, 75 and 100 DAS, respectively) was recorded from the treatment combination of V_1S_4 whereas the minimum leaf breadth (2.23, 2.33, 2.28 and 1.66 cm at 25, 50, 75 and 100 DAS, respectively) was recorded from the treatment combination of V_2S_2.

Table 5. Leaf breadth of groundnut as influenced by variety and seed size and their interaction at different days after sowing

Treatments	Leaf breadth (cm) at different days after sowing (DAS)			
	25	50	75	100
Effect of variety				
V_1	2.76	2.94	2.73	2.19
V_2	2.42	2.59	2.53	1.98
V_3	2.58	2.70	2.64	2.06
$LSD_{(0.05)}$	NS	NS	NS	NS
CV (%)	13.27	11.89	10.14	9.56
Effect of seed size				
S_1	2.76	2.90	2.74	2.26
S_2	2.30	2.40	2.43	1.77
S_3	2.44	2.60	2.55	1.95
S_4	2.85	3.08	2.83	2.31
$LSD_{(0.05)}$	NS	NS	NS	NS
CV (%)	12.55	13.99	12.54	7.46
Combined effect of variety and seed size				
V_1S_1	2.93	3.12	2.85	2.36
V_1S_2	2.43	2.50	2.55	1.87
V_1S_3	2.57	2.73	2.56	2.11
V_1S_4	3.10	3.41	2.97	2.42
V_2S_1	2.58	2.75	2.64	2.18
V_2S_2	2.23	2.33	2.28	1.66
V_2S_3	2.30	2.49	2.54	1.83
V_2S_4	2.58	2.80	2.66	2.24
V_3S_1	2.77	2.83	2.72	2.25
V_3S_2	2.23	2.37	2.45	1.79
V_3S_3	2.47	2.58	2.55	1.91
V_3S_4	2.87	3.02	2.84	2.28
$LSD_{(0.05)}$	NS	NS	NS	NS
CV (%)	12.55	13.99	12.54	7.46

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability: V_1 = BARI Chinabadam-8, V_2 = Binacheenabadam-4, V_3 = Binacheenabadam-6; S_1 = Unsorted, S_2 = Small, S_3 = Medium, S_4 = Large

4.1.7 Shoot length

Effect of variety

There was no significant variation was found on shoot length of groundnut at different growth stages influenced by different varieties (Table 6 and Appendix

X). However, the variety V_3 (Binacheenabadam-6) showed the numerically maximum shoot length (12.71, 18.58, 21.24 and 24.07 cm at 30, 60, 90 and 120 DAS, respectively) whereas the minimum shoot length (11.88, 17.05, 19.35 and 22.52 cm at 30, 60, 90 and 120 DAS, respectively) was recorded from the variety V_2 (Binacheenabadam-4).

Table 6. Shoot length of groundnut as influenced by variety and seed size and their interaction at different after sowing

Treatments	Shoot length (cm) at different days after sowing (DAS)			
	30	60	90	120
Effect of variety				
V_1	12.26	18.00	20.37	23.48
V_2	11.88	17.05	19.35	22.52
V_3	12.71	18.58	21.24	24.07
$LSD_{(0.05)}$	NS	NS	NS	NS
CV (%)	11.72	8.37	11.43	10.27
Effect of seed size				
S_1	12.69 b	19.07 b	20.78 b	24.56 b
S_2	10.84 c	14.93 d	17.28 d	19.60 c
S_3	12.05 b	16.92 c	18.91 c	23.69 b
S_4	13.54 a	20.59 a	24.31 a	25.58 a
$LSD_{(0.05)}$	0.719	1.236	1.261	0.932
CV (%)	14.78	10.55	13.59	11.37
Combined effect of variety and seed size				
V_1S_1	12.83 bc	19.38 bc	21.33 cd	24.57 ab
V_1S_2	10.78 f	14.90 e	16.80 f	19.90 de
V_1S_3	12.12 de	17.38 cd	18.77 ef	23.87 b
V_1S_4	13.30 b	20.35 ab	24.57 ab	25.57 ab
V_2S_1	12.32 cd	18.30 bc	19.57 de	24.23 ab
V_2S_2	10.22 f	14.18 e	16.77 f	17.67 e
V_2S_3	11.82 de	15.93 de	18.63 ef	23.30 bc
V_2S_4	13.15 b	19.77 ab	22.43 bc	24.90 ab
V_3S_1	12.93 b	19.52 bc	21.43 cd	24.87 ab
V_3S_2	11.53 e	15.70 de	18.27 ef	21.23 cd
V_3S_3	12.22 d	17.43 cd	19.33 de	23.90 b
V_3S_4	14.17 a	21.67 a	25.93 a	26.27 a
$LSD_{(0.05)}$	0.611	2.140	2.183	2.356
CV (%)	14.78	10.55	13.59	11.37

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

V_1 = BARI Chinabadam-8, V_2 = Binacheenabadam-4, V_3 = Binacheenabadam-6

S_1 = Unsorted, S_2 = Small, S_3 = Medium, S_4 = Large

Effect of seed size

Different seed size of groundnut showed significant influence on shoot length at different growth stages (Table 6 and Appendix X). At 30, 60, 90 and 120 DAS, the highest shoot length (13.54, 20.59, 24.31 and 25.58 cm, respectively) was recorded from the seed size S_4 (large) which was significantly different from that of other treatments followed by S_1 (unsorted) seed size. On the other hand, S_2 (small) size seed showed the lowest shoot length (10.84, 14.93, 17.28 and 19.60 cm at 30, 60, 90 and 120 DAS, respectively). Olayinka *et al*. (2016) also found similar result who observed taller shoot from relatively larger seeds at various crop stages.

Combined effect of variety and seed size

Combined effect of variety and seed size had significant influence on shoot length at different growth stages (Table 6 and Appendix X). Results revealed that at 30 DAS, the maximum shoot length (14.17 cm) was given by V_3S_4 and that not similar to none whereas the minimum shoot length (10.22 cm) was recorded from V_2S_2 combination that similar to V_1S_2 (10.78 cm). At 60 DAS, the maximum shoot length (21.67 cm) was found in V_3S_4 combination that similar to V_1S_4 (20.35 cm) and V_2S_4 (19.77 cm) and the minimum shoot length (14.18 cm) was given by V_2S_2 combination that similar to V_1S_2 (14.90 cm), V_2S_3 (15.93 cm) and V_3S_2 (15.70 cm). At 90 DAS, the maximum shoot length (25.93 cm) was also recorded in V_3S_4 combination that similar to V_1S_4 (24.57 cm) whereas the minimum shoot length (16.77 cm) was found in V_2S_2 combination that similar to V_1S_2 (16.80 cm), V_1S_3 (18.77 cm), V_2S_3 (18.63 cm) and V_3S_2 (18.27 cm). Similarly, the maximum shoot length at 120 DAS (26.27 cm) was given by V_3S_4 combination that similar to V_1S_1 (24.57 cm), V_1S_4 (25.57 cm), V_2S_1 (24.23 cm), V_2S_4 (24.90 cm) and V_3S_1 (24.87 cm) and minimum shoot length (17.67 cm) was recorded in V_2S_2 combination that similar to V_1S_2 (19.90 cm).

4.1.8 Root length

Effect of variety

Significant influence was not found on root length at different growth stages persuaded by different groundnut varieties (Table 7 and Appendix XI). However, the maximum root length (7.97, 10.31, 9.13 and 8.72 cm at 30, 60, 90 and 120 DAS, respectively) was recorded from the variety V_1 (BARI Chinabadam-8) whereas the minimum root length (6.95, 9.76, 7.72 and 7.42 cm at 30, 60, 90 and 120 DAS, respectively) was recorded from the variety V_2 (Binacheenabadam-4).

Effect of seed size

The recorded data on root length at different growth stages was significantly influence by different seed size except at 30 and 60 DAS (Table 7 and Appendix XI). However, the highest root length (8.24, 10.49, 9.18 and 9.09 cm at 30, 60, 90 and 120 DAS, respectively) was recorded from the seed size S_4 (large). At 90 and 120 DAS, the highest root length obtained from S_4 (large) which showed statistically similar result with S_1 (unsorted). The lowest root length (6.77, 9.43, 7.53 and 6.83 cm at 30, 60, 90 and 120 DAS, respectively) was recorded from the seed size S_2 (small) which was statistically similar to that of S_3 (medium) at 90 and 120 DAS. Similar result was also observed by Oyewole *et al*. (2020); who observed higher root length with larger seed.

Combined effect of variety and seed size

At 30 DAS, V_1S_4 combination gave the maximum root length (9.83 cm) and V_2S_2 combination showed the minimum root length (6.60 cm) that similar to V_1S_2, V_2S_3, V_3S_2 and V_3S_3. At 60 DAS, V_1S_4 combination showed the maximum root length (10.98 cm) that similar to none which was followed by V_1S_1, V_3S_1 and V_3S_4 whereas the minimum root length (9.10 cm) was given by V_2S_2 combination that similar to V_2S_3 (9.63 cm) and V_3S_2 (9.43 cm). At 90 DAS, V_1S_4 combination also gave the maximum root length (10.95 cm) which was followed by V_1S_1 (9.93 cm)

whereas the minimum root length (7.34 cm) was found in V_2S_2 combination. Similarly, at 120 DAS, V_1S_4 combination gave the maximum root length (10.00 cm) that similar to V_1S_1 (9.88 cm) followed by V_3S_4 (9.87 cm) and the minimum root length (6.30 cm) was recorded in V_2S_2 combination that similar to V_2S_3 (7.03 cm) and V_3S_2 (6.87 cm).

Table 7. Root length of groundnut as influenced by variety and seed size and their interaction at different days after sowing

Treatments	Root length (cm) at different days after sowing (DAS)			
	30	60	90	120
Effect of variety				
V_1	7.97	10.31	9.13	8.72
V_2	6.95	9.76	7.72	7.42
V_3	7.24	10.04	8.10	7.94
$LSD_{(0.05)}$	NS	NS	NS	NS
CV (%)	10.55	13.74	9.93	12.22
Effect of seed size				
S_1	7.57	10.29	8.71 a	8.84 a
S_2	6.77	9.43	7.53 b	6.83 b
S_3	6.97	9.94	7.83 b	7.34 b
S_4	8.24	10.49	9.18 a	9.09 a
$LSD_{(0.05)}$	NS	NS	0.682	0.520
CV (%)	9.33	15.08	12.88	14.53
Combined effect of variety and seed size				
V_1S_1	8.08 b	10.40 b	9.93 b	9.88 a
V_1S_2	6.87 de	9.75 cd	7.65 d	7.33 ef
V_1S_3	7.08 cde	10.10 bc	7.94 cd	7.67 def
V_1S_4	9.83 a	10.98 a	10.95 a	10.00 a
V_2S_1	7.17 cde	10.15 bc	7.95 cd	8.03 cde
V_2S_2	6.60 e	9.10 e	7.34 d	6.30 g
V_2S_3	6.83 de	9.63 cde	7.62 d	7.03 fg
V_2S_4	7.20 cde	10.15 bc	7.97 cd	8.30 bcd
V_3S_1	7.45 bcd	10.32 b	8.25 cd	8.60 bc
V_3S_2	6.83 de	9.43 de	7.60 d	6.87 fg
V_3S_3	7.00 de	10.08 bc	7.93 cd	7.33 ef
V_3S_4	7.68 bc	10.33 b	8.61 c	8.97 b
$LSD_{(0.05)}$	0.640	0.566	0.946	0.901
CV (%)	9.33	15.08	12.88	14.53

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

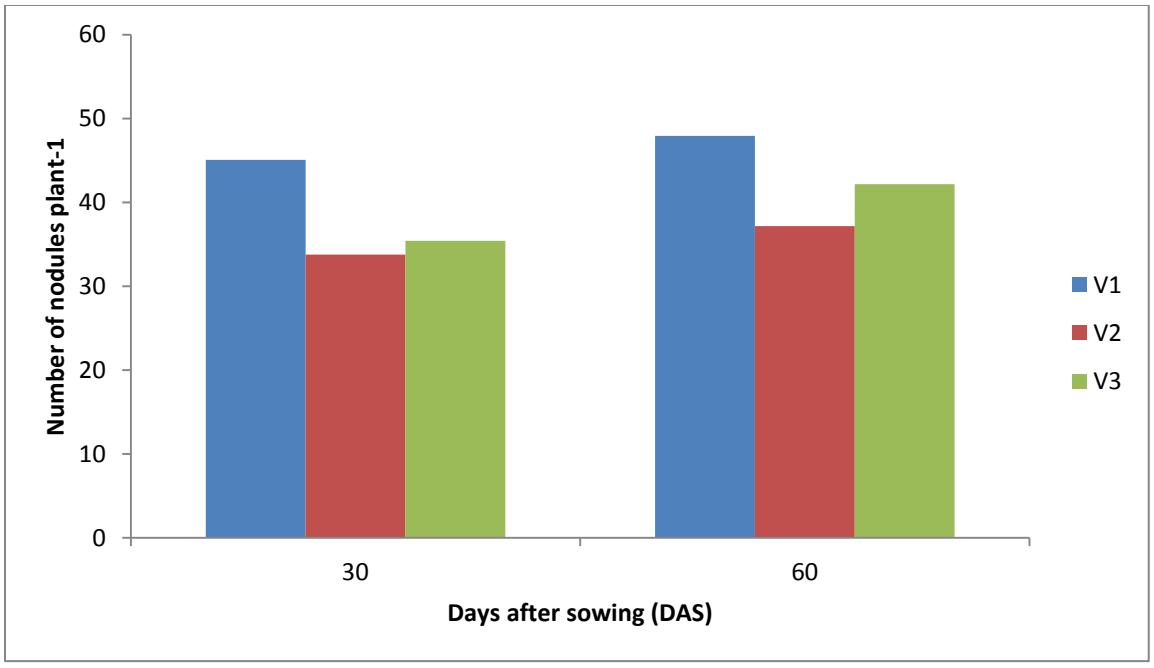
V_1 = BARI chinabadam-8, V_2 = Binacheenabadam-4, V_3 = Binacheenabadam-6

S_1 = Unsorted, S_2 = Small, S_3 = Medium, S_4 = Large

4.1.9 Number of nodules plant^{-1}

Effect of variety

Significant influence was identified on number of nodules plant^{-1} at 30 and 60 DAS caused by different varieties of groundnut (Fig. 9 and Appendix XII). The highest number of nodules plant^{-1} (45.08 and 47.92 at 30 and 60 DAS, respectively) was recorded from the variety V_1 (BARI Chinabadam-8) followed by V_3 (Binacheenabadam-6) whereas the lowest number of nodules plant^{-1} (33.75 and 37.17 at 30 and 60 DAS, respectively) was recorded from the variety V_2 (Binacheenabadam-4) which was statistically similar with V_3 (Binacheenabadam-6) at 30 DAS.



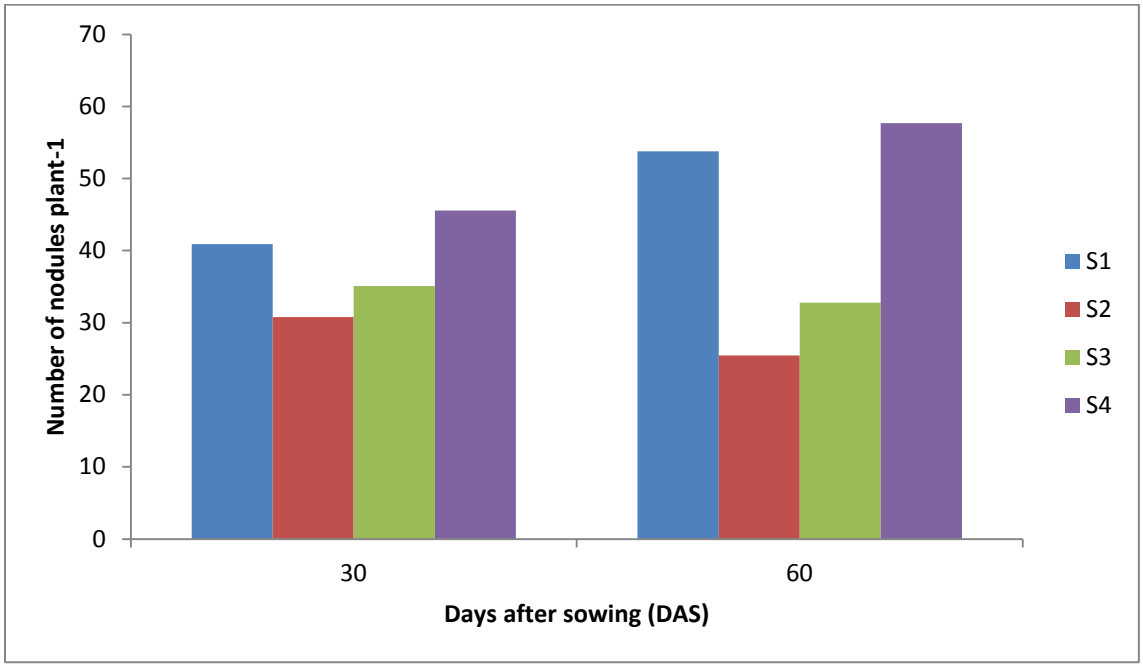
V_1 = BARI Chinabadam-8, V_2 = Binacheenabadam-4, V_3 = Binacheenabadam-6

Figure 9. Number of nodules plant^{-1} of groundnut as influenced by varieties ($LSD_{(0.05)}$ = 3.515 and 3.336 at 30 and 60 DAS, respectively).

Effect of seed size

Number of nodules plant^{-1} was influenced significantly due to different seed size of groundnut at 30 and 60 DAS (Fig. 10 and Appendix XII). The large size seed

(S_4) showed the highest number of nodules plant^{-1} (45.56 and 57.67 at 30 and 60 DAS, respectively) which was significantly different from that of other treatments followed by S_1 (unsorted) whereas the smallsize seed (S_2) showed the lowest number of nodules plant^{-1} (30.78 and 25.44 at 30 and 60 DAS, respectively), which was significantly different from other treatments at 30 and 60 DAS.



S_1 = Unsorted, S_2 = Small, S_3 = Medium, S_4 = Large

Figure 10. Number of nodules plant^{-1} of groundnut as influenced by seed size ($LSD_{(0.05)}$ = 2.235 and 2.655 at 30 and 60 DAS, respectively).

Combined effect of variety and seed size

Treatment combination of variety and seed size showed significant influence on number of nodules plant^{-1} at 30 and 60 DAS (Table 8 and Appendix XII). The highest number of nodules plant^{-1} at 30 DAS (60.67) was recorded from V_1S_4 combination which was followed by V_1S_1 (48.33) and V_2S_2 combination showed the lowest number of nodules plant^{-1} (28.33) that was statistically similar to V_3S_2 (29.33). Similarly, at 60 DAS, the maximum number of nodules plant^{-1} (64.00) was recorded from V_1S_4combination that was statistically similar to V_1S_1(61.33)

followed by V_2S_4(61.33), V_3S_1(53.33) and V_3S_4(55.67) whereas V_2S_2combination showed the lowest number of nodules plant^{-1} (21.33) which was statistically similar to V_3S_3 (25.33).

Table 8. Number of nodules plant^{-1} of groundnut as influenced by varieties and seed size combination

Treatments	Number of nodules plant^{-1} at different days after sowing (DAS)	
	30	60
V_1S_1	48.33 b	61.33 a
V_1S_2	34.67 de	29.67 ef
V_1S_3	36.67 cde	36.67 d
V_1S_4	60.67 a	64.00 a
V_2S_1	36.67 cde	45.67 c
V_2S_2	28.33 f	21.33 g
V_2S_3	33.33 e	28.33 f
V_2S_4	36.67 cde	53.33 b
V_3S_1	37.67 cd	54.33 b
V_3S_2	29.33 f	25.33 fg
V_3S_3	35.33 de	33.33 de
V_3S_4	39.33 c	55.67 b
$LSD_{(0.05)}$	3.871	4.598
CV (%)	10.53	11.59

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

V_1 = BARI Chinabadam-8, V_2 = Binacheenabadam-4, V_3 = Binacheenabadam-6
S_1 = Unsorted, S_2 = Small, S_3 = Medium, S_4 = Large

4.1.10 Dry weight plant^{-1}

Effect of variety

Significant influence was recorded at 90 and 120 DAS but at 30 and 60 DAS there was no significant variation on dry weight plant^{-1} affected by different varieties of groundnut (Table 9 and Appendix XIII). The highest (1.74, 6.39, 14.18 and 19.62 g at 30, 60, 90 and 120 DAS, respectively) was recorded from the variety V_1 (BARI Chinabadam-8) at 90 DAS. At 120 DAS, statistically similar result was

found between V_1 (BARI Chinabadam-8) and V_3 (Binacheenabadam-6) on dry weight plant^{-1}. The lowest dry weight plant^{-1} (1.30, 5.31, 10.59 and 15.98 g at 30, 60, 90 and 120 DAS, respectively) was recorded from the variety V_2 (Binacheenabadam-4). At 90 DAS, the lowest dry weight plant^{-1} was recorded from V_2 (Binacheenabadam-4) that was statistically similar with V_3 (Binacheenabadam-6). Genetic response and prevailing environmental status might be the reason for variations found among genotypes for dry weight plant^{-1}. These results were also in close agreement with the findings of Mouri *et al*. (2018) and Meena *et al*. (2014).

Effect of seed size

The dry weight plant^{-1} was affected significantly by different seed size at all growth stages of groundnut except 30 DAS (Table 9 and Appendix XIII). The highest dry weight plant^{-1} (7.19, 15.07 and 23.07 g at 60, 90 and 120 DAS, respectively) was recorded from the seed size S_4 (large) which was statistically similar to S_1 (unsorted) at 60 and 90 DAS. The lowest dry weight plant^{-1} (4.00, 8.93 and 13.28 g at 60, 90 and 120 DAS, respectively) was recorded from the seed size S_2 (small). Nagaraju (2001) also found similar result with the present study who found plant from larger seed showed higher dry matter than plant from smaller seed. Similar result was also observed by Knauft *et al*. (1990).

Combined effect of variety and seed size

Combined effect of variety and seed size showed significant variation on dry weight plant^{-1} at all growth stages of groundnut except at 30 DAS (Table 9 and Appendix XIII). However, at 30 DAS, the numerically maximum dry weight plant^{-1} (2.41 g) was recorded from of V_1S_4 combination whereas the minimum dry weight plant^{-1} (1.03 g) was recorded in V_2S_2 combination. But at 60, 90 and 120 DAS, the maximum dry weight plant^{-1} (7.89, 18.69 and 24.93 g, respectively) was recorded from the treatment combination of V_1S_4, which was statistically similar

to V_1S_1 at all growth stages followed by V_3S_4 whereas the minimum dry weight plant^{-1} (3.86, 8.49 and 12.38 g, respectively) was recorded from the treatment combination of V_2S_2 which was statistically similar to V_3S_2, V_1S_2, V_2S_3 and V_3S_3 at 90 and 120 DAS.

Table 9. Dry weight plant^{-1} of groundnut as influenced by variety and seed size and their combination

Treatments	Dry weight plant^{-1} (g) at different days after sowing (DAS)			
	30	60	90	120
Effect of variety				
V_1	1.74	6.39	14.18 a	19.62 a
V_2	1.30	5.31	10.59 b	15.98 b
V_3	1.477	5.77	11.43 b	18.04 a
$LSD_{(0.05)}$	NS	NS	1.723	1.918
CV (%)	9.48	11.34	10.28	12.43
Effect of seed size				
S_1	1.68	6.96 a	14.30 a	20.28 b
S_2	1.11	4.00 b	8.93 b	13.28 d
S_3	1.35	5.13 b	9.97 b	14.89 c
S_4	1.89	7.19 a	15.07 a	23.07 a
$LSD_{(0.05)}$	NS	1.143	1.698	1.549
CV (%)	13.09	13.74	12.50	10.61
Combined effect of variety and seed size				
V_1S_1	1.82	7.61 a	17.90 a	23.34 ab
V_1S_2	1.24	4.24 e	9.37 e	14.45 cd
V_1S_3	1.50	5.83 cd	10.75 cde	15.76 c
V_1S_4	2.41	7.89 a	18.69 a	24.93 a
V_2S_1	1.51	6.46 bc	11.93 bcd	16.12 c
V_2S_2	1.03	3.86 e	8.49 e	12.38 d
V_2S_3	1.14	4.17 e	8.96 e	14.32 cd
V_2S_4	1.53	6.76 b	12.99 bc	21.10 b
V_3S_1	1.72	6.82 b	13.06 bc	21.37 b
V_3S_2	1.06	3.92 e	8.92 e	13.01 d
V_3S_3	1.40	5.40 d	10.22 de	14.60 cd
V_3S_4	1.72	6.93 b	13.53 b	23.18 ab
$LSD_{(0.05)}$	NS	0.651	2.388	2.682
CV (%)	13.09	13.74	12.50	10.61

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

V_1 = BARI Chinabadam-8, V_2 = Binacheenabadam-4, V_3 = Binacheenabadam-6

S_1 = Unsorted, S_2 = Small, S_3 = Medium, S_4 = Large

4.2 Dry matter partitioning

4.2.1 Leaf dry weight plant^{-1}

Effect of variety

Non-significant variation was found on leaf dry weight plant^{-1} at 30, 60 and 90 DAS, but at 120 DAS, significant variation was observed for different variety (Table 10 and Appendix XIV). However, at 30, 60 and 90 DAS the maximum leaf dry weight plant^{-1} (1.08, 3.76 and 7.18 g, respectively) was recorded from V_1 (BARI Chinabadam-8) whereas the minimum leaf dry weight plant^{-1} (0.81, 3.08, and 5.62 g, respectively) was recorded from the variety V_2 (Binacheenabadam-4). But at 120 DAS, the highest leaf dry weight plant^{-1} (9.92 g) was recorded from V_3 (Binacheenabadam-6) which was statistically similar to V_1 (BARI Chinabadam-8) whereas the lowest (7.69 g) was recorded from V_2 (Binacheenabadam-4).

Effect of seed size

Non-significant variation for leaf dry weight plant^{-1} at 30 DAS was found but at 60, 90 and 120 DAS significant variation was observed for different seed size (Table 10 and Appendix XIV). The highest leaf dry weight plant^{-1} (4.38, 7.82 and 12.55 g at 60, 90 and 120 DAS, respectively) was recorded from the larger sized seed (S_4) which was statistically similar with S_1 (unsorted) at 60 DAS. At 90 and 120 DAS, the highest leaf dry weight plant^{-1} from S_4 (large) that significantly different from others followed byunsortedseed (S_1). The lowest leaf dry weight plant^{-1} (2.02, 4.75 and 6.35 g at 60, 90 and 120 DAS, respectively) was recorded from the smallsized seed (S_2). At 90 DAS, the lowest leaf dry weight plant^{-1} was statistically similar to S_3 (medium).

Table 10. Leaf dry weight plant^{-1} of groundnut as influenced by variety and seed size and their combination

Treatments	Leaf dry weight plant^{-1} (g) at different days after sowing (DAS)			
	30	60	90	120
Effect of variety				
V_1	1.08	3.76	7.18	9.83 a
V_2	0.81	3.08	5.62	7.69 b
V_3	0.97	3.33	5.82	9.92 a
$LSD_{(0.05)}$	NS	NS	NS	1.348
CV (%)	11.57	10.91	11.89	10.64
Effect of seed size				
S_1	1.07	4.13 a	7.09 b	9.95 b
S_2	0.67	2.02 c	4.75 c	6.35 d
S_3	0.87	3.02 b	5.17 c	7.73 c
S_4	1.20	4.38 a	7.82 a	12.55 a
$LSD_{(0.05)}$	NS	0.516	0.626	0.566
CV (%)	13.21	12.48	13.84	12.66
Combined effect of variety and seed size				
V_1S_1	1.17	4.45 ab	8.41 b	10.60 c
V_1S_2	0.74	2.10 d	4.87 de	6.46 g
V_1S_3	0.92	3.57 bc	5.56 cd	8.64 d
V_1S_4	1.48	4.91 a	9.89 a	13.60 a
V_2S_1	0.91	3.79 bc	6.44 c	7.57 ef
V_2S_2	0.62	2.05 d	4.94 de	6.34 g
V_2S_3	0.70	2.25 d	4.99 de	6.67 fg
V_2S_4	1.00	4.22 ab	6.09 c	10.17 c
V_3S_1	1.12	4.15 ab	6.43 c	11.67 b
V_3S_2	0.66	1.92 d	4.42 e	6.24 g
V_3S_3	0.98	3.23 c	4.95 de	7.88 de
V_3S_4	1.13	4.00 bc	7.47 b	13.88 a
$LSD_{(0.05)}$	NS	0.893	0.938	0.981
CV (%)	13.21	12.48	13.84	12.66

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

V_1 = BARI Chinabadam-8, V_2 = Binacheenabadam-4, V_3 = Binacheenabadam-6
S_1 = Unsorted, S_2 = Small, S_3 = Medium, S_4 = Large

Combined effect of variety and seed size

At 30 DAS, leaf dry weight plant^{-1} was not affected significantly but at 60, 90 and 120 DAS, significant effect was found by combined effect of variety and seed size (Table 10 and Appendix XIV). At 60 and 90 DAS, the maximum leaf dry weight plant^{-1} (4.91 and 9.89 g, respectively) was recorded from the treatment combination of V_1S_4 whereas the minimum (2.05 and 4.94 g, respectively) was

recorded from the treatment combination of V_2S_2. At 120 DAS, the maximum leaf dry weight plant^{-1} (13.88 g) was recorded from V_3S_4, which was statistically similar with V_1S_4 followed by V_3S_1 whereas the minimum (6.34 g) was recorded from the treatment combination of V_2S_2 which was statistically similar with V_1S_2, V_3S_2 and V_2S_3.

4.2.2 Root dry weight plant^{-1}

Effect of variety

Root dry weight plant^{-1} at different growth stages was not influenced significantly by different varieties of groundnut (Table 11 and Appendix XV). However, the numerically maximum root dry weight plant^{-1} (0.16, 0.53, 1.88 and 2.40 g at 30, 60, 90 and 120 DAS, respectively) was recorded from the variety V_1 (BARI Chinabadam-8) whereas the minimum root dry weight plant^{-1} (0.12, 0.48, 1.26 and 2.06 g at 30, 60, 90 and 120 DAS, respectively) was recorded from the variety V_2.

Effect of seed size

Non-significant variation was found for root dry weight plant^{-1} at all growth stages except at 120 DAS by different seed size of groundnut (Table 11 and Appendix XV). However, the maximum root dry weight plant^{-1} (0.17, 0.64 and 1.94 g at 30, 60 and 90, respectively) was recorded from the seed size S_4 (large) whereas the minimum root dry weight plant^{-1} (0.12, 0.39 and 1.36 g at 30, 60 and 90 DAS, respectively) was recorded from the seed size S_2 (small). At 120 DAS, the maximum root dry weight plant^{-1} (2.61 g) was recorded from the seed size S_4 (large), which was significantly different from other treatments followed by S_1 (unsorted) and S_3 (medium) whereas the minimum (1.66 g) was recorded from the seed size S_2 (small). The relatively high establishment rate in favor of large seed size was in agreement with the work done by Swank *et al*. (1993) who reported that seedlings from larger and heavier seeds Utilised Cotyledonary reserve (UCR) at a faster rate to have greater rate of stem elongation and accumulation of root weight than the other seed sizes.

Table 11. Root dry weight plant^{-1} of groundnut as influenced by variety and seed size and their combination

Treatments	Root dry weight plant^{-1} (g) at different days after sowing (DAS)			
	30	60	90	120
Effect of variety				
V_1	0.16	0.53	1.88	2.40
V_2	0.12	0.48	1.26	2.06
V_3	0.15	0.50	1.74	2.13
$LSD_{(0.05)}$	NS	NS	NS	NS
CV (%)	8.56	9.14	10.75	7.98
Effect of seed size				
S_1	0.16	0.56	1.77	2.28 b
S_2	0.12	0.39	1.36	1.66 c
S_3	0.14	0.43	1.42	2.24 b
S_4	0.17	0.64	1.94	2.61 a
$LSD_{(0.05)}$	NS	NS	NS	0.201
CV (%)	10.74	11.11	13.01	10.71
Combined effect of variety and seed size				
V_1S_1	0.16	0.45	2.24 a	2.66 b
V_1S_2	0.14	0.46	1.59 b	1.79 de
V_1S_3	0.15	0.40	1.44 bc	1.82 de
V_1S_4	0.20	0.80	2.23 a	3.33 a
V_2S_1	0.12	0.63	1.46 bc	2.33 bcd
V_2S_2	0.10	0.36	0.89 d	1.37 e
V_2S_3	0.11	0.45	0.98 cd	2.47 bc
V_2S_4	0.14	0.48	1.70 b	2.09 cd
V_3S_1	0.19	0.59	1.63 b	1.84 de
V_3S_2	0.12	0.35	1.61 b	1.83 de
V_3S_3	0.16	0.43	1.82 ab	2.42 bc
V_3S_4	0.16	0.64	1.89 ab	2.41 bc
$LSD_{(0.05)}$	NS	NS	0.506	0.545
CV (%)	10.74	11.11	13.01	10.71

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

V_1 = BARI Chinabadam-8, V_2 = Binacheenabadam-4, V_3 = Binacheenabadam-6

S_1 = Unsorted, S_2 = Small, S_3 = Medium, S_4 = Large

Combined effect of variety and seed size

At 90 and 120 DAS, significant influence was found but at 30 and 60 DAS, non-significant variation was recorded on root dry weight plant^{-1} for combined effect of variety and seed size (Table 11 and Appendix XV). However, the maximum root dry weight plant^{-1} (0.20 and 0.80 g at 30 and 60 DAS, respectively) was recorded

from the treatment combination of V_1S_4 whereas the minimum root dry weight plant^{-1} (0.10 and 0.36 g at 30 and 60 DAS, respectively) was recorded from the treatment combination of V_2S_2. At 90 DAS, the highest root dry weight plant^{-1} obtained from V_1S_4 that statistically similar with V_1S_1, V_3S_3 and V_3S_4 but at 120 DAS (3.33 g), no similar result was found with V_1S_4. The lowest root dry weight plant^{-1} (1.37 g) at 120 DAS was recorded from V_2S_2, which was statistically similar toV_1S_2, V_1S_3, V_3S_1 and V_3S_2.

4.2.3 Shoot dry weight plant^{-1}

Effect of variety

There was no significant variation at 30 and 60 DAS but at 90 and 120 DAS, significant influence was recorded on shoot dry weight plant^{-1} (Table 12 and Appendix XVI). However, the maximum shoot dry weight plant^{-1} (0.50 and 2.11 g at 30 and 60 DAS, respectively) was recorded from the variety V_1 (BARI Chinabadam-8) whereas the minimum shoot dry weight plant^{-1} (0.35 and 1.75 g at 30 and 60 DAS, respectively) was recorded from the variety V_2 (Binacheenabadam-4). At 90 and 120 DAS, the highest shoot dry weight plant^{-1} recorded from the variety V_1 (BARI Chinabadam-8) that significantly different from others whereas the lowest shoot dry weight plant^{-1} obtained from V_2 (Binacheenabadam-4) that statistically similar with V_3 (Binacheenabadam-6).

Effect of seed size

Shoot dry weight plant^{-1} was affected significantly at all growth stages except 30 DAS by different seed size of groundnut (Table 12 and Appendix XVI). The highest shoot dry weight plant^{-1} (0.46, 2.28, 5.43 and 8.05 g at 30, 60, 90 and 120 DAS, respectively) was recorded from the seed size S_1 (unsorted), which was statistically similar to S_4 (large) at 60, 90 and 120 DAS. The lowest shoot dry weight plant^{-1} (0.32, 1.59, 2.82 and 4.92 g at 30, 60, 90 and 120 DAS, respectively) was recorded from the seed size S_2 (small) which was statistically

similar with S_3 (medium) at 60 and 120 DAS. Knauft *et al*. (1990) also found similar result who observed higher shoot dry weight with larger seeds of groundnut.

Table 12. Shoot dry weight plant^{-1} of groundnut as influenced by varieties and seed size and their combination

Treatments	Shoot dry weight plant^{-1} (g) at different days after sowing (DAS)			
	30	60	90	120
Effect of variety				
V_1	0.50	2.11	5.12 a	7.39 a
V_2	0.35	1.75	3.72 b	6.00 b
V_3	0.37	1.94	3.87 b	6.23 b
$LSD_{(0.05)}$	NS	NS	0.940	0.874
CV (%)	10.73	10.45	8.18	11.64
Effect of seed size				
S_1	0.46	2.28 a	5.43 a	8.05 a
S_2	0.32	1.59 b	2.82 c	4.92 b
S_3	0.34	1.69 b	3.39 b	5.27 b
S_4	0.52	2.18 a	5.31 a	7.91 a
$LSD_{(0.05)}$	NS	0.394	0.405	0.655
CV (%)	13.73	11.02	10.49	12.03
Combined effect of variety and seed size				
V_1S_1	0.48	2.71 a	7.25 a	10.08 a
V_1S_2	0.36	1.68 de	2.91 ef	6.19 de
V_1S_3	0.43	1.85 cd	3.74 cd	5.29 ef
V_1S_4	0.72	2.18 b	6.57 a	8.00 bc
V_2S_1	0.48	2.04 bc	4.04 cd	6.22 de
V_2S_2	0.29	1.44 e	2.66 f	4.30 f
V_2S_3	0.33	1.46 e	2.98 ef	5.18 ef
V_2S_4	0.39	2.06 bc	5.20 b	8.84 b
V_3S_1	0.41	2.08 bc	5.01 b	7.85 bc
V_3S_2	0.30	1.65 de	2.88 ef	4.94 f
V_3S_3	0.26	1.75 d	3.44 de	4.67 f
V_3S_4	0.44	2.28 b	4.17 c	6.89 cd
$LSD_{(0.05)}$	NS	0.266	0.701	1.135
CV (%)	13.73	11.02	10.49	12.03

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

V_1 = BARI Chinabadam-8, V_2 = Binacheenabadam-4, V_3 = Binacheenabadam-6

S_1 = Unsorted, S_2 = Small, S_3 = Medium, S_4 = Large

Combined effect of variety and seed size

At 30 DAS, non-significant variation was found for shoot dry weight plant^{-1} influenced by treatment combination of variety and seed size but at 60, 90 and 120 DAS, significant variation was found (Table 12 and Appendix XVI). However, at30 DAS, V_1S_4 combination gave the highest shoot dry weight plant^{-1}(0.72g) whereas the lowest shoot dry weight plant^{-1}(0.29 g) was recorded from V_2S_2 combination. At 60 DAS, the highest shoot dry weight plant^{-1}(2.71 g) was found in V_1S_1 combination followed by V_1S_4 (2.18g) and V_3S_4 (2.28 g) and the lowest shoot dry weight plant^{-1}(1.44 g) was given by V_2S_2 combination that similar to V_2S_3 (1.46 g), V_1S_2(1.68 g) and V_3S_2 (1.65 g). At 90 DAS, the highest shoot dry weight plant^{-1}(7.25 g) was also recorded in V_1S_1 combination that similar to V_1S_4 (6.57 g) whereas the lowest shoot dry weight plant^{-1}(2.66 g) was found in V_2S_2 combination that similar to V_1S_2 (2.91 g), V_2S_3 (2.98 g) and V_3S_2 (2.88 g). Similarly, the highest shoot dry weight plant^{-1} at 120 DAS (10.08 g) was given by V_1S_1 combination, which was followed by V_2S_4 (8.84 g) and V_1S_4 (8.00 g) and lowest shoot dry weight plant^{-1}(4.30 g) was recorded in V_2S_2 combination that similar to V_3S_2 (4.94 g) and V_3S_3 (4.67 g).

4.2.4 Nodule dry weight plant^{-1}

Effect of variety

There was no significant variation on nodule dry weight plant^{-1} at 30 and 60 DAS observed by different groundnut varieties (Table 13 and Appendix XVII). However, the maximum nodule dry weight plant^{-1} (0.533 and 0.102 g at 30 and 60 DAS, respectively) was recorded from the variety V_1 (BARI Chinabadam-8) whereas the minimum nodule dry weight plant^{-1} (0.033 and 0.076 g at 30 and 60 DAS, respectively) was recorded from the variety V_2 (Binacheenabadam-4).

Table 13. Nodule dry weight plant^{-1} of groundnut as influenced by variety and seed size and their combination

Treatments	Nodule dry weight plant^{-1} (g) at different days after sowing (DAS)	
	30	60
Effect of variety		
V_1	0.053	0.102
V_2	0.033	0.076
V_3	0.043	0.084
$LSD_{(0.05)}$	NS	NS
CV (%)	8.47	6.08
Effect of seed size		
S_1	0.050	0.098
S_2	0.031	0.059
S_3	0.038	0.079
S_4	0.052	0.113
$LSD_{(0.05)}$	NS	NS
CV (%)	10.37	9.33
Combined effect of variety and seed size		
V_1S_1	0.057	0.107
V_1S_2	0.040	0.083
V_1S_3	0.040	0.090
V_1S_4	0.073	0.127
V_2S_1	0.040	0.090
V_2S_2	0.023	0.043
V_2S_3	0.030	0.067
V_2S_4	0.037	0.103
V_3S_1	0.053	0.097
V_3S_2	0.030	0.050
V_3S_3	0.043	0.080
V_3S_4	0.047	0.110
$LSD_{(0.05)}$	NS	NS
CV (%)	10.37	9.33

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

V_1 = BARI Chinabadam-8, V_2 = Binacheenabadam-4, V_3 = Binacheenabadam-6
S_1 = Unsorted, S_2 = Small, S_3 = Medium, S_4 = Large

Effect of seed size

Significant influence was not found on nodule dry weight plant^{-1} at 30 and 60 DAS by different seed size of groundnut (Table 13 and Appendix XVII). However, the maximum nodule dry weight plant^{-1} (0.052 and 0.133 g at 30 and 60 DAS, respectively) was recorded from the seed size S_4 (large) whereas the minimum nodule dry weight plant^{-1} (0.031 and 0.059 g at 30 and 60 DAS, respectively) was recorded from the seed size S_2 (small).

Combined effect of variety and seed size

Combined effect of variety and seed size of groundnut showed non-significant influence on nodule dry weight plant^{-1} at 30 and 60 DAS (Table 13 and Appendix XVII). However, the maximum nodule dry weight plant^{-1} (0.073 and 0.127 g at 30 and 60 DAS, respectively) was recorded from the treatment combination of V_1S_4 whereas the minimum nodule dry weight plant^{-1} (0.023 and 0.043 g at 30 and 60 DAS, respectively) was recorded from the treatment combination of V_2S_2.

4.2.5 Pod dry weight plant^{-1}

Effect of variety

At 90 DAS, non-significant difference was found for pod dry weight plant^{-1} but at 120 DAS, significant variation was recorded among the varieties (Table 14 and Appendix XVIII). However, at 90 DAS the maximum pod dry weight plant^{-1} (4.13 g) was recorded from the variety V_1 (BARI Chinabadam-8) whereas the minimum pod dry weight plant^{-1} (3.25 g) was recorded from the variety V_2 (Binacheenabadam-4).At 120 DAS, the maximum pod dry weight plant^{-1} (8.61 g) was recorded from the variety V_1 (BARI Chinabadam-8) whereas the minimum pod dry weight plant^{-1} (6.40 g) was recorded from the variety V_2 (Binacheenabadam-4),which was statistically similar with V_3 (Binacheenabadam-6).

Table 14. Pod dry weight plant^{-1} of groundnut as influenced by variety and seed size and their combination

Treatments	Pod dry weight plant^{-1} (g) at different days after sowing (DAS)	
	90	120
Effect of variety		
V_1	4.13	8.61 a
V_2	3.25	6.40 b
V_3	3.76	7.29 b
$LSD_{(0.05)}$	NS	0.905
CV (%)	9.46	9.33
Effect of seed size		
S_1	4.21 a	9.01 b
S_2	2.85 c	4.72 d
S_3	3.26 b	5.78 c
S_4	4.53 a	10.20 a
$LSD_{(0.05)}$	0.340	0.839
CV (%)	10.11	11.41
Combined effect of variety and seed size		
V_1S_1	4.72 ab	10.68 b
V_1S_2	3.15 ef	5.43 de
V_1S_3	3.40 def	6.14 d
V_1S_4	5.24 a	12.18 a
V_2S_1	3.64 de	7.89 c
V_2S_2	2.37 g	4.26 e
V_2S_3	3.08 ef	5.26 de
V_2S_4	3.92 cd	8.19 c
V_3S_1	4.26 bc	8.48 c
V_3S_2	3.04 f	4.45 e
V_3S_3	3.29 ef	5.96 d
V_3S_4	4.44 bc	10.27 b
$LSD_{(0.05)}$	0.589	1.455
CV (%)	10.11	11.41

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

V_1 = BARI Chinabadam-8, V_2 = Binacheenabadam-4, V_3 = Binacheenabadam-6

S_1 = Unsorted, S_2 = Small, S_3 = Medium, S_4 = Large

Effect of seed size

Significant difference was found for pod dry weight plant^{-1} at 90 and 120 DAS, influenced by different seed size of groundnut (Table 14 and Appendix XVIII). The highest pod dry weight plant^{-1} (4.53 and 10.20 g at 90 and 120 DAS, respectively) was recorded from the seed size S_4 (large) which was statistically similar with S_1 (unsorted) seed size at 90 DAS. The lowest pod dry weight plant^{-1} (2.85 and 4.72 g at 90 and 120 DAS, respectively) was recorded from the seed size S_2 (small), which was significantly different from others.

Combined effect of variety and seed size

Combined effect of variety and seed size showed significant variation among the treatment combinations on pod dry weight plant^{-1} (Table 14 and Appendix XVIII). The highest pod dry weight plant^{-1} (5.24 and 12.18 g at 90 and 120 DAS, respectively) was recorded from the treatment combination of V_1S_4. At 90 DAS, V_1S_4 was significantly similar toV_1S_1 but it was significantly different among the treatment combinations at 120 DAS. The lowest pod dry weight plant^{-1} (2.37 and 4.26 g at 90 and 120 DAS, respectively) was recorded from the treatment combination of V_2S_2, which was significantly different from other treatment combinations at 90 DAS but significantly similar with V_3S_2, V_1S_2 and V_2S_3 at 120 DAS.

4.3 Yield contributing parameters and yield of groundnut

4.3.1 Fresh weight plant^{-1} at harvest

Effect of variety

Significant variation on fresh weight plant^{-1} was found due to varietal variation (Table 15 and Appendix XIX). The highest fresh weight plant^{-1} (74.77 g) was recorded from the variety V_1 (BARI Chinabadam-8) followed by V_3 (Binacheenabadam-6) whereas the lowest fresh weight plant^{-1} (64.58 g) was recorded from the variety V_2 (Binacheenabadam-4).

Effect of seed size

Different seed size had significant effect on fresh weight plant^{-1} of groundnut (Table 15 and Appendix XIX). The highest fresh weight plant^{-1} (78.05 g) was recorded from the seed size S_4 (large) which was significantly different from other treatments followed by seed size S_1 (unsorted) whereas the lowest fresh weight plant^{-1} (59.52 g) was recorded from the seed size S_2 (small).

Combined effect of variety and seed size

Combined effect of variety and seed size of groundnut significantly influenced the fresh weight plant^{-1} of groundnut (Table 15 and Appendix XIX). Results revealed that the highest fresh weight plant^{-1} (85.24 g) was recorded from the treatment combination of V_1S_4, which was significantly different from other treatment combinations followed by V_1S_1. The lowest fresh weight plant^{-1} (54.67 g) was recorded from the treatment combination of V_2S_2, which was statistically similar with the treatment combination of V_2S_3 and V_3S_2.

4.3.2 Number of pods plant^{-1}

Effect of variety

Different variety of groundnut showed significant variation on number of pods plant^{-1} (Table 15 and Appendix XIX). It was observed that the highest number of pods plant^{-1} (14.33) was recorded from the variety V_1 (BARI Chinabadam-8) whereas the lowest number of pods plant^{-1} (10.42) was recorded from the variety V_2 (Binacheenabadam-4), which was statistically similar toV_3 (Binacheenabadam-6). Genetic response and prevailing environmental status might be the reason for variations found among genotypes for number of pods per plant. Supported result was also observed by Dapaah *et al*. (2014) and Meena *et al*. (2014) and Mouri *et al*. (2018); who found significant variation on pod yield among different genotypes.

Table 15. Yield contributing parameters of groundnut as influenced by varieties and seed size and their combination

Treatments	Fresh weight plant^{-1} (g)	No. of pods plant^{-1}	No. of seeds pod^{-1}	Pod length (cm)	Fresh weight of pods plant^{-1} (g)	Dry weight of pods plant^{-1} (g)	100-seed weight (g)
Effect of variety							
V_1	74.77 a	14.33 a	1.58 a	1.98	23.96 a	9.56 a	42.51 a
V_2	64.58 c	10.42 b	1.45 c	1.76	18.51 c	6.41 c	35.55 b
V_3	69.31 b	12.17 b	1.52 b	1.91	20.65 b	7.87 b	40.83 a
$LSD_{(0.05)}$	1.161	2.039	0.047	NS	1.916	0.959	1.691
CV (%)	7.34	12.88	4.63	10.91	9.67	13.70	6.48
Effect of seed size							
S_1	74.67 b	13.44 b	1.62 a	2.06 a	24.55 b	9.67 a	44.53 a
S_2	59.52 d	9.11 d	1.36 c	1.61 b	14.51 d	5.54 c	32.51 c
S_3	65.97 c	11.00 c	1.44 b	1.73 b	18.71 c	6.45 b	35.76 b
S_4	78.05 a	15.67 a	1.65 a	2.14 a	26.38 a	10.15 a	45.70 a
$LSD_{(0.05)}$	3.186	0.914	0.044	0.137	1.757	0.835	2.028
CV (%)	6.32	13.95	3.02	12.87	8.43	12.65	7.22
Combined effect of variety and seed size							
V_1S_1	78.52 b	15.33 b	1.68 ab	2.20 ab	27.16 b	12.36 a	48.73 ab
V_1S_2	65.63 f	10.67 ef	1.42 f	1.66 de	16.54 fg	6.07 de	34.14 de
V_1S_3	69.70 def	12.00 cde	1.51 e	1.78 cde	21.22 de	6.95 cd	36.86 cd
V_1S_4	85.24 a	19.33 a	1.73 a	2.30 a	30.92 a	12.86 a	50.29 a
V_2S_1	71.27 cde	12.33 cd	1.56 de	1.84 cd	22.08 cde	7.23 cd	38.20 c
V_2S_2	54.67 g	7.00 g	1.31 g	1.59 e	13.00 h	4.65 e	31.06 e
V_2S_3	59.80 g	10.00 f	1.35 g	1.66 de	15.53 gh	6.03 de	33.98 de
V_2S_4	72.58 cde	12.33 cd	1.58 cd	1.97 bc	23.43 cd	7.75 c	38.95 c
V_3S_1	74.23 bcd	12.67 c	1.62 bc	2.13 ab	24.42 bc	9.41 b	46.65 b
V_3S_2	58.27 g	9.67 f	1.36 g	1.59 e	14.01 gh	5.90 de	32.34 e
V_3S_3	68.40 ef	11.00 def	1.46 f	1.76 cde	19.39 ef	6.37 cd	36.44 cd
V_3S_4	76.33 bc	15.33 b	1.65 b	2.17 ab	24.78 bc	9.82 b	47.87 ab
$LSD_{(0.05)}$	5.518	1.583	0.054	0.237	3.043	1.446	3.513
CV (%)	6.32	13.95	3.02	12.87	8.43	12.65	7.22

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

V_1 = BARI Chinabadam-8, V_2 = Binacheenabadam-4, V_3 = Binacheenabadam-6

S_1 = Unsorted, S_2 = Small, S_3 = Medium, S_4 = Large

Effect of seed size

The recorded data on number of pods plant^{-1} of groundnut showed considerable influence for different seed size (Table 15 and Appendix XIX). Results indicated that the highest number of pods plant^{-1} (15.67) was recorded from the seed size S_4 (large) followed by S_1 (unsorted) seed size. The lowest number of pods plant^{-1} (9.11) was recorded from the seed size S_2 (small), which was significantly different from other treatments. Youdewei (1995) reported that the overall pod yields were relatively higher in plants from the large-sized seeds than the other seed sizes, which supported the present study.

Combined effect of variety and seed size

Combined effect of variety and seed size showed significant variation on number of pods plant^{-1} of groundnut (Table 15 and Appendix XIX). The highest number of pods plant^{-1} (19.33) was recorded from the treatment combination of V_1S_4 that followed by V_1S_1 and V_3S_4. The lowest number of pods plant^{-1} (7.00) was recorded from the treatment combination of V_2S_2, which was significantly different from other treatment combinations.

4.3.3 Number of seeds pod^{-1}

Effect of variety

Different groundnut variety showed significant influence on number of seeds pod^{-1} (Table 15 and Appendix XIX). It was observed that the highest number of seeds pod^{-1} (1.58) was recorded from the variety V_1 (BARI Chinabadam-8) followed by the variety V_3 (Binacheenabadam-6) (1.52) whereas the lowest number of seeds pod^{-1} (1.45) was recorded from the variety V_2 (Binacheenabadam-4). Yousif and Hussain (2019) also obtained supported result with the present study in terms of seeds pod^{-1} and they observed significant variation on number of seeds pod^{-1} due to varietal difference. Supported result was also observed by Meena *et al*. (2014).

Effect of seed size

Number of seeds pod^{-1} of groundnut influenced considerably due to different seed size (Table 15 and Appendix XIX). Results indicated that the highest number of seeds pod^{-1} (1.65) was recorded from the seed size S_4 (large) which was significantly same to S_1 (unsorted) seed size. The lowest number of seeds pod^{-1} (1.36) was recorded from the seed size S_2 (small), which was significantly different from other treatments.

Combined effect of variety and seed size

Combined effect of variety and seed size showed significant variation on number of seeds pod^{-1} of groundnut (Table 15 and Appendix XIX). The highest number of seeds pod^{-1} (1.73) was recorded from the treatment combination of V_1S_4 that significantly similar to the treatment combination of V_1S_1. The lowest number of seeds pod^{-1} (1.31) was recorded from the treatment combination of V_2S_2 which was significantly same to the treatment combinations of V_2S_3 and V_3S_2.

4.3.4 Pod length

Effect of variety

There was no significant variation on pod length observed by different varieties of groundnut (Table 15 and Appendix XIX). However, the maximum pod length (1.98 cm) was recorded from the variety V_1 (BARI Chinabadam-8) whereas the minimum pod length (1.76 cm) was recorded from the variety V_2 (Binacheenabadam-4).

Effect of seed size

Different seed size of groundnut had significant influence on pod length (Table 15 and Appendix XIX). The highest pod length (2.14 cm) was recorded from the seed size S_4 (large) which was statistically similar with seed size S_1 (unsorted). The

lowest pod length (1.61 cm) was recorded from the seed size S_2 (small), which was statistically similar with S_3 (medium) seed size.

Combined effect of variety and seed size

Pod length of groundnut was significantly varied due to combined effect of variety and seed size (Table 15 and Appendix XIX). Results revealed that the highest pod length (2.30 cm) was recorded from the treatment combination of V_1S_4, which was statistically similar with the treatment combination of V_1S_1, V_3S_1 and V_3S_4. The lowest pod length (1.59 cm) was recorded from the treatment combination of V_2S_2, which was statistically similar with V_1S_2, V_1S_3, V_2S_3 and V_3S_3.

4.3.5 Fresh weight of pods plant^{-1}

Effect of variety

Different groundnut varieties had significant influence on fresh weight of pods plant^{-1} (Table 15 and Appendix XIX). The highest fresh weight of pods plant^{-1} (23.96 g) was recorded from the variety V_1 (BARI Chinabadam-8) followed by V_3 (Binacheenabadam-6) whereas the lowest fresh weight of pods plant^{-1} (18.51 g) was recorded from the variety V_2 (Binacheenabadam-4).

Effect of seed size

Fresh weight of pods plant^{-1} was significantly varied due to different seed size of groundnut (Table 15 and Appendix XIX). It was observed that the highest fresh weight of pods plant^{-1} (26.38 g) was recorded from the seed size S_4 (large) that followed by S_1 (unsorted) seed size. The lowest fresh weight of pods plant^{-1} (14.51 g) was recorded from the seed size S_2 (small)

Combined effect of variety and seed size

There was a significant variation on fresh weight of pods plant^{-1}observed by combined effect of variety and seed size (Table 15 and Appendix XIX). The highest fresh weight of pods plant^{-1} (30.92 g) was recorded from the treatment

combination of V_1S_4, which was significantly different from other treatment combinations that followed by V_1S_1, V_3S_1 and V_3S_4. The lowest fresh weight of pods plant^{-1} (13.00 g) was recorded from the treatment combination of V_2S_2, which was statistically similar with V_2S_3 and V_3S_2.

4.3.6 Dry weight of pods plant^{-1}

Effect of variety

Remarkable variation was observed on dry weight of pods plant^{-1} that influenced by different groundnut varieties (Table 15 and Appendix XIX). The highest dry weight of pods plant^{-1} (9.56 g) was recorded from the variety V_1 (BARI Chinabadam-8) that followed by V_3 (Binacheenabadam-6) whereas the lowest dry weight of pods plant^{-1} (6.41 g) was recorded from the variety V_2 (Binacheenabadam-4).

Effect of seed size

Considerable influence was recorded on dry weight of pods plant^{-1} persuaded by different seed size of groundnut (Table 15 and Appendix XIX). The highest dry weight of pods plant^{-1} (10.15 g) was recorded from the seed size S_4 (large), which was statistically similar with S_1 (unsorted) seed size whereas the lowest dry weight of pods plant^{-1} (5.54 g) was recorded from the seed size S_2 (small).

Combined effect of variety and seed size

The recorded data on dry weight of pods plant^{-1} was significantly influenced by combined effect of variety and seed size (Table 15 and Appendix XIX). The highest dry weight of pods plant^{-1} (12.86 g) was recorded from the treatment combination of V_1S_4, which was statistically similar to that of V_1S_1 that followed by V_3S_1 and V_3S_4. The lowest dry weight of pods plant^{-1} (4.65 g) was recorded from the treatment combination of V_2S_2 which was statistically similar to that of V_1S_2, V_2S_3 and V_3S_2.

4.3.7 Weight of 100 seeds

Effect of variety

Weight of 100 seeds varied significantly due to varietal difference of groundnut (Table 15 and Appendix XIX). Results showed that the highest 100-seed weight (42.51 g) was recorded from the variety V_1 (BARI Chinabadam-8) which was statistically similar with V_3 (Binacheenabadam-6) whereas the lowest 100-seed weight (35.55 g) was recorded from the variety V_2 (Binacheenabadam-4). Results indicated the ability of investigating a high genetic advance for increasing seed weight by exploiting the genetic variability within genotypes and the high heritability which reflects the agreement with Singh and Singh (1999). Similar result was also observed by Yousif and Hussain (2019) who found significant variation on 100 seed weight of groundnut among different genotypes.

Effect of seed size

Different seed size showed variations on 100-seed weight of groundnut (Table 15 and Appendix XIX). The highest 100-seed weight (45.70 g) was recorded from the seed size S_4 (large) which was statistically similar with S_1 (unsorted) size seeds whereas the lowest 100-seed weight (32.51 g) was recorded from the seed size S_2 (small). These results were also in close agreement with the findings of Oyewole *et al*. (2020) who observed significant variation on 100-seed weight due to different seed size. Bicer (2009) stated that effect of seed size on 100-seed weight was positive.

Combined effect of variety and seed size

Treatment combination of variety and seed size gave significantly varied performance on 100-seed weight of groundnut (Table 15 and Appendix XIX). The highest 100-seed weight (50.29 g) was recorded from the treatment combination of V_1S_4 which was statistically similar with the treatment combination of V_1S_1 and

V_3S_4. The treatment combination of V_2S_2 showed lowest 100-seed weight (31.06 g) which was statistically similar with V_3S_2, V_1S_2 and V_2S_3.

4.4 Yield parameters

4.4.1 Pod yield plot^{-1}

Effect of variety

Significant variation was recorded for yield plot^{-1} by different varieties of groundnut (Table 16 and Appendix XX). The highest yield plot^{-1} (733.10 g) was recorded from the variety V_1 (BARI Chinabadam-8) followed by V_3 (Binacheenabadam-6) whereas the lowest yield plot^{-1} (566.40 g) was recorded from the variety V_2 (Binacheenabadam-4).

Effect of seed size

Considerable influence was found on yield plot^{-1} persuaded by different seed size of groundnut (Table 16 and Appendix XX). The highest yield plot^{-1} (807.10 g) was recorded from the seed size S_4 (large), which was significantly different from that of the other seed size treatments followed by unsorted seed (S_1). The lowest yield plot^{-1} (444.10 g) was recorded from the seed size S_2 (small), which was significantly different from other treatments.

Combined effect of variety and seed size

Pod yield plot^{-1} of groundnut affected significantly due to treatment combination of variety and seed size (Table 16 and Appendix XX). Results showed that the treatment combination of V_1S_4 gave the highest yield plot^{-1} (946.00 g) followed by V_1S_1 whereas V_2S_2 gave the lowest yield plot^{-1} (397.70 g), which was significantly different from other treatment combinations.

Table 16. Yield parameters of groundnut as influenced by variety and seed size and their combination

Treatments	Pod yield plot^{-1} (g)	Pod yield ha^{-1} (kg)	Stover yield ha^{-1} (kg)	Biological yield ha^{-1} (kg)	Harvest index (%)
Effect of variety					
V_1	733.1 a	1917.0 a	3277.00 a	5193.00 a	36.41 a
V_2	566.4 c	1481.0 c	2968.00 c	4448.00 c	32.81 b
V_3	631.9 b	1652.0 b	3122.00 b	4774.00 b	34.18 b
$LSD_{(0.05)}$	18.46	15.33	10.492	11.343	1.633
CV (%)	9.64	9.64	8.43	13.42	11.29
Effect of seed size					
S_1	751.3 b	1964.0 b	3399.00 b	5364.00 b	36.49 a
S_2	444.1 d	1161.0 d	2624.00 d	3785.00 d	30.59 c
S_3	572.7 c	1497.0 c	3014.00 c	4511.00 c	33.04 b
S_4	807.1 a	2110.0 a	3452.00 a	5562.00 a	37.75 a
$LSD_{(0.05)}$	16.910	20.471	12.112	13.091	1.886
CV (%)	8.43	8.43	7.88	12.75	10.53
Combined effect of variety and seed size					
V_1S_1	831.0 b	2173.0 b	3471.00 b	5644.00 b	38.49 b
V_1S_2	506.0 g	1323.0 h	2803.00 h	4126.00 i	32.03 f
V_1S_3	649.3 e	1698.0 f	3291.00 f	4989.00 g	34.03 e
V_1S_4	946.0 a	2473.0 a	3542.00 a	6016.00 a	41.10 a
V_2S_1	675.7 e	1766.0 e	3323.00 e	5090.00 f	34.66 de
V_2S_2	397.7 j	1040.0 k	2488.00 k	3527.00 l	29.47 h
V_2S_3	475.3 h	1243.0 i	2706.00 i	3949.00 j	31.36 fg
V_2S_4	717.0 d	1875.0 d	3353.00 d	5228.00 e	35.75 cd
V_3S_1	747.3 c	1954.0 c	3403.00 c	5357.00 d	36.33 c
V_3S_2	428.7 i	1121.0 j	2581.00 j	3702.00 k	30.27 gh
V_3S_3	593.3 f	1551.0 g	3044.00 g	4595.00 h	33.73 e
V_3S_4	758.3 c	1983.0 c	3461.00 b	5443.00 c	36.40 c
$LSD_{(0.05)}$	29.301	35.450	20.971	22.683	1.358
CV (%)	8.43	8.43	7.88	12.75	10.53

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability; V_1 = BARI Chinabadam-8, V_2 = Binacheenabadam-4, V_3 = Binacheenabadam-6; S_1 = Unsorted, S_2 = Small, S_3 = Medium, S_4 = Large

4.4.2 Yield

Effect of variety

Pod yield of groundnut varied significantly due to different varietal performance (Table 16 and Appendix XX). Results indicated that the variety V_1 (BARI Chinabadam-8) showed the highest yield ha^{-1} (1917.00 kg) that followed by the variety V_3 (Binacheenabadam-6) whereas the lowest yield ha^{-1} (1481.00 kg) was recorded from the variety V_2 (Binacheenabadam-4). Genetic formations of genotypes of different origin and environmental factors during crop period might be responsible for variation of genotypes for this trait. The result obtained from the present study on yield of groundnut was similar with the findings of Dapaah *et al*. (2014), Meena *et al*. (2014), Manaf *et al*. (2017) and Mouri*et al*. (2018). They observed yield variation among different genotypes.

Effect of seed size

Different seed size of groundnut showed significantly varied performance on yield (Table 16 and Appendix XX). It was found that the highest yield ha^{-1} (2110.00 kg) was recorded from the seed size S_4 (large), which was significantly different from other seed size treatments followed by unsorted seed (S_1). The lowest yield ha^{-1} (1161.00 kg) was recorded from the seed size S_2 (small), which was significantly different from other seed size treatments. The result was in line with that of Oyewole *et al*. (2020) and Olayinka *et al*. (2016). Bicer (2009) stated that in chickpea effect of seed size on yield was positive.

Combined effect of variety and seed size

Different varieties of groundnut in combination with different seed size showed varied difference on yield ha^{-1} (Table 16 and Appendix XX). Results revealed that the highest yield ha^{-1} (2473.00 kg) was recorded from the treatment combination of V_1S_4, which was significantly different from other treatment combinations

followed by V_1S_1. The treatment combination of V_2S_2 showed the lowest yield ha^{-1} (1040.00 kg), which was significantly different from other treatment combinations.

4.4.3 Stover yield

Effect of variety

Significant variation was recorded for stover yield by different varieties of groundnut (Table 16 and Appendix XX). The highest stover yield (3277 kg ha^{-1}) was recorded from the variety V_1 (BARI Chinabadam-8) followed by V_3 (Binacheenabadam-6) (3122 kg ha^{-1}) whereas the lowest stover yield (2968 kg ha^{-1}) was recorded from the variety V_2 (Binacheenabadam-4). Mouri *et al*. (2018) also found similar result with the present study and achieved highest stover yield (6.92 t ha^{-1}) from BARI Chinabadam-8 compared to Binacheenabadam-6.

Effect of seed size

Considerable influence was found on stover yield influenced by different seed size of groundnut (Table 16 and Appendix XX). Results revealed that the highest stover yield (3452 kg ha^{-1}) was recorded from the large sized seed (S_4) that was significantly different from other treatments followed by unsorted seed (S_1) (3399 kg ha^{-1}). The lowest stover yield (2624 kg ha^{-1}) was recorded from the seed size S_2 (small) which was significantly different from other treatments.

Combined effect of variety and seed size

Stover yield of groundnut varied significantly due to treatment combination of variety and seed size (Table 16 and Appendix XX). Results showed that the treatment combination of V_1S_4 gave the highest stover yield (3542 kg ha^{-1}) followed by V_1S_1 (3471 kg ha^{-1}) whereas V_2S_2 gave the lowest stover yield (2448 kg ha^{-1}) which was significantly different from other treatment combinations.

4.4.4 Biological yield

Effect of variety

Significant variation was recorded for biological yield by different varieties of groundnut (Table 16 and Appendix XX). The highest biological yield (5193 kg ha^{-1}) was recorded from the variety V_1 (BARI Chinabadam-8) followed by V_3 (Binacheenabadam-6) (4774 kg ha^{-1}) whereas the lowest biological yield (4448 kg ha^{-1}) was recorded from the variety V_2 (Binacheenabadam-4). Significant effect on biological yield of groundnut due to varietal difference was also achieved by Meena *et al*. (2014), which supported the present study.

Effect of seed size

Considerable influence was found on biological yield influenced by different seed size of groundnut (Table 16 and Appendix XX). Results revealed that the highest biological yield (5562 kg ha^{-1}) was recorded from the largesized seed (S_4) that was significantly different from other treatments followed by unsorted seed (S_1) (5364 kg ha^{-1}). The lowest biological yield (3785 kg ha^{-1}) was recorded from the seed size S_2 (small), which was significantly different from other treatments. Olayinka *et al*. (2016) also observed similar result with the present study and reported that large seeds of groundnut showed higher biological yield compared to smaller sized seeds.

Combined effect of variety and seed size

Biological yield of groundnut varied significantly due to treatment combination of variety and seed size (Table 16 and Appendix XX). Results showed that the treatment combination of V_1S_4 gave the highest biological yield (6016 kg ha^{-1}) followed by V_1S_1 (5644 kg ha^{-1}), whereas V_2S_2 gave the lowest biological yield (3527 kg ha^{-1}), which was significantly different from other treatment combinations.

4.4.5 Harvest index

Effect of variety

Different variety of groundnut showed significant variation on harvest index (Table 16 and Appendix XX). It was observed that the highest harvest index (36.41%) was recorded from the variety V_1 (BARI Chinabadam-8) whereas the lowest harvest index (32.81%) was recorded from the variety V_2 (Binacheenabadam-4) that statistically similar to V_3 (Binacheenabadam-6) (34.18%). Meena *et al*. (2014), Manaf *et al*. (2017) and Gabisa *et al*. (2017) reported significant variations of harvest index due to varietal difference that supported the present study.

Effect of seed size

The recorded data on harvest index of groundnut showed considerable influence for different seed size (Table 16 and Appendix XX). Results indicated that the highest harvest index (37.75%) was recorded from the seed size S_4 (large) that similar tounsorted seed (S_1) (36.49%). The lowest harvest index (30.59%) was recorded from the small sized seed (S_2) that was significantly different from other treatments. Olayinka *et al*. (2016) reported similar result with the present study and observed that large seeds of groundnut showed higher harvest index compared to smaller sized seeds.

Combined effect of variety and seed size

Combined effect of variety and seed size showed significant variation on harvest index of groundnut (Table 16 and Appendix XX). The highest harvest index (41.10%) was recorded inV_1S_4combination that followed by V_1S_1 (38.49%). The lowest harvest index (29.47%) was recorded from the treatment combination of V_2S_2 that similar to V_3S_2 combination (30.27%).

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was carried out at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during October 2019 to April 2020 to study the growth and yield of groundnut varieties as influenced by seed size. The experiment consisted of two factors. Factor A: Variety (3 levels); V_1: BARI Chinabadam-8, V_2: Binacheenabadam-4 and V_3: Binacheenabadam-6, and factor B: seed size (4 levels); S_1: Unsorted, S_2: Small, S_3: Medium and S_4: Large. There were 12 treatment combinations. Variety was placed along the main plot and seed size was placed along the sub plot. The groundnut seeds were sown in lines maintaining a line to line distance of 30 cm and plant to plant distance of 15 cm having 2 seeds hole^{-1}. The data on different growth, yield contributing parameters and yield of groundnut were recorded and statistically analyzed.

Results revealed that the highest percent germination (69.67%) was found from the variety, V_1 (BARI Chinabadam-8) whereas the lowest (64.67%) was recorded from V_2 (Binacheenabadam-4). Again, the highest percent germination (72.00%) was found from the seed size, S_4 (large) whereas the lowest (63.00%) was found from S_2 (small). Treatment combination of V_1S_4 showed the highest percent germination (79.00%) whereas the lowest percent germination (62.00%) was obtained from V_2S_2.

The highest plant height (23.16 cm at 100 DAS), leaf length (5.02 cm at 100 DAS) and shoot length (24.07 cm at 120 DAS) were recorded from the variety V_3 (Binacheenabadam-6) but the highest number of branches plant^{-1} (6.25 at 100 DAS), number of leaves plant^{-1} (37.83 at 100 DAS), leaf breadth (2.19 cm at 100 DAS), root length (8.72 cm at 120 DAS) and number of nodules plant^{-1} (47.92 at 60 DAS) were recorded from the variety V_1 (BARI Chinabadam-8) whereas the lowest plant height (21.73 cm at 100 DAS), number of leaves plant^{-1} (35.50 at 100

DAS), number of branches plant^{-1} (5.67 at 100 DAS), leaf length (4.73 cm at 100 DAS), leaf breadth (1.98 cm at 100 DAS), root length (7.42 cm at 120 DAS), shoot length (22.52 cm at 120 DAS) and number of nodules plant^{-1} (37.17 at 60 DAS) were recorded from the variety V_2 (Binacheenabadam-4). Similarly, large sized seed (S_4) showed the highest plant height (25.28 cm at 100 DAS), number of branches plant^{-1} (6.44 at 100 DAS), number of leaves plant^{-1} (38.11 at 100 DAS), leaf length (5.40 cm at 100 DAS), leaf breadth (2.31 cm at 100 DAS), shoot length (25.58 cm at 120 DAS), root length (9.09 cm at 120 DAS) and number of nodules plant^{-1} (57.67 at 60 DAS) whereas the lowest plant height (19.65 cm at 100 DAS), number of branches plant^{-1} (5.33 at 100 DAS), number of leaves plant^{-1} (34.67 at 100 DAS), leaf length (4.29 cm at 100 DAS), leaf breadth (1.77 cm at 100 DAS), shoot length (19.60 cm at 120 DAS), root length (6.83 cm at 120 DAS) and number of nodules plant^{-1} (25.44 at 60 DAS) were recorded from small sized seed (S_2). Accordingly, treatment combination of V_3S_4 showed the highest plant height (26.33 cm at 100 DAS), leaf length (5.44 cm at 100 DAS) and shoot length (26.27 cm at 120 DAS) but the highest number of branches plant^{-1} (7.00 at 100 DAS), number of leaves plant^{-1} (39.67 at 100 DAS), leaf breadth (2.42 cm at 100 DAS), root length (10.00 cm at 120 DAS) and number of nodules plant^{-1} (64.00 at 60 DAS) were recorded from V_1S_4 whereas V_2S_2 showed lowest plant height (19.08 cm at 100 DAS), number of branches plant^{-1} (5.00 at 100 DAS), number of leaves plant^{-1} (33.33 at 100 DAS), leaf length (4.03 cm at 100 DAS), leaf breadth (1.66 cm at 100 DAS), shoot length (17.67 cm at 120 DAS) and root length (6.30 cm at 120 DAS) and number of nodules plant^{-1} (21.33 at 60 DAS).

Variety BARI Chinabadam-8 (V_1) showed the highest total dry weight plant^{-1} (19.62 g at 120 DAS) and Binacheenabadam-4 (V_2) showed lowest total dry weight plant^{-1} (15.98 g at 120 DAS) large sized seed (S_4) gave the highest total dry weight plant^{-1} (23.07 g at 120 DAS) and small sized seed (S_2) showed lowest total dry weight plant^{-1} (13.28 g at 120 DAS). Treatment combination of V_1S_4 showed

the highest dry weight plant^{-1} (24.93 g at 120 DAS) whereas V_2S_2 gave lowest dry weight plant^{-1} (12.38 g at 120 DAS).The highest leaf dry weight plant^{-1} (9.92 g at 120 DAS) was recorded from V_3 (Binacheenabadam-6) but the the highest root dry weight plant^{-1} (2.40 g at 120 DAS), shoot dry weight plant^{-1} (7.39 g a at 120 DAS), nodule dry weight plant^{-1} (0.102 g at 60 DAS) and pod dry weight plant^{-1} (8.61 g at 120 DAS) were recorded from the variety V_1 (BARI Chinabadam-8) whereas the lowest leaf dry weight plant^{-1} (7.69 g at 120 DAS), root dry weight plant^{-1} (2.06 g at 120 DAS), shoot dry weight plant^{-1} (6.00 g at 120 DAS), nodule dry weight plant^{-1} (0.076 g at 60 DAS) and pod dry weight plant^{-1} (6.40 g at 120 DAS) were recorded from the variety V_2 (Binacheenabadam-4). The highest shoot dry weight plant^{-1} (8.05 g at 120 DAS) was recorded from the seed size S_1 (unsorted) but the highest leaf dry weight plant^{-1} (12.55 g at 120 DAS), root dry weight plant^{-1} (2.61 g at 120 DAS), nodule dry weight plant^{-1} (0.133 g at 60 DAS) and pod dry weight plant^{-1} (10.20 g at 120 DAS) were recorded from the seed size S_4 (large) whereas the lowest leaf dry weight plant^{-1} (6.35 g at 120 DAS), root dry weight plant^{-1} (1.66 g at 120 DAS), shoot dry weight plant^{-1} (4.92 g at 120 DAS), nodule dry weight plant^{-1} (0.059 g at 60 DAS) and pod dry weight plant^{-1} (4.72 g at 120 DAS) were recorded from the seed size S_2 (small). The highest leaf dry weight plant^{-1} (13.88 g at 120 DAS) was recorded from the treatment combination of V_3S_4 and the highest root dry weight plant^{-1} (3.33 g at 120 DAS) was recorded from V_1S_4 but the highest shoot dry weight plant^{-1} (10.08 g at 120 DAS), nodule dry weight plant^{-1} (0.127 g at 60 DAS) and pod dry weight plant^{-1} (12.18 g at 120 DAS) was recorded from V_1S_4, whereas the lowest leaf dry weight plant^{-1} (6.34 g at 120 DAS), the lowest root dry weight plant^{-1} (1.37 g at 120 DAS), the lowest shoot dry weight plant^{-1} (4.30 g at 120 DAS), the lowest nodule dry weight plant^{-1} (0.043 g at 60 DAS) and the lowest pod dry weight plant^{-1} (4.26 g at 120 DAS) were recorded from the treatment combination of V_2S_2.

The variety BARI Chinabadam-8 (V_1) showed the highest fresh weight plant^{-1} (74.77 g), number of pods plant^{-1} (14.33), number of seeds pod^{-1} (1.58), pod length (1.98 cm), fresh weight of pods plant^{-1} (23.96 g), dry weight of pods plant^{-1} (9.56 g), 100-seed weight (42.51 g), pod yield (1917.00 kg ha^{-1}), stover yield (3277 kg ha^{-1}), biological yield (5193 kg ha^{-1}) and harvest index (36.41%) whereas Binacheenabadam-4 (V_2) showed the lowest fresh weight plant^{-1} (64.58 g), number of pods plant^{-1} (10.42), number of seeds pod^{-1} (1.45), pod length (1.76 cm), fresh weight of pods plant^{-1} (18.51 g), dry weight of pods plant^{-1} (6.41 g), 100 seed weight (35.55 g), pod yield (1481.00 kg ha^{-1}), stover yield (2968 kg ha^{-1}), biological yield (4448 kg ha^{-1}) and harvest index (32.81%). Again, large sized seed (S_4) gave the highest fresh weight plant^{-1} (78.05 g), number of pods plant^{-1} (15.67), number of seeds pod^{-1} (1.65), pod length (2.14 cm), fresh weight of pods plant^{-1} (26.38 g), dry weight of pods plant^{-1} (10.15 g), 100-seed weight (45.70 g),pod yield (2110.00 kg ha^{-1}), stover yield (3452 kg ha^{-1}), biological yield (5562 kg ha^{-1}) and harvest index (37.75%) whereas small sized seed (S_2) gave the lowest fresh weight plant^{-1} (59.52 g), number of pods plant^{-1} (9.11), number of seeds pod^{-1} (1.36), pod length (1.61 cm), fresh weight of pods plant^{-1} (14.51 g), dry weight of pods plant^{-1} (5.54 g), 100-seed weight (32.51 g),pod yield (1161.00 kg ha^{-1}), stover yield (2624 kg ha^{-1}), biological yield (3785 kg ha^{-1}) and harvest index (30.59%).

The treatment combination of V_1S_4 gave the highest fresh weight plant^{-1} (85.24 g), number of pods plant^{-1} (19.33), number of seeds pod^{-1} (1.73), pod length (2.30 cm), fresh weight of pods plant^{-1} (30.92 g), dry weight of pods plant^{-1} (12.86 g), 100-seed weight (50.29 g), pod yield (2473.00 kg ha^{-1}), stover yield (3542 kg ha^{-1}), biological yield (6016 kg ha^{-1}) and harvest index (41.10%) whereas treatment combination of V_2S_2 showed the lowest fresh weight plant^{-1} (54.67 g), number of pods plant^{-1} (7.00), number of seeds pod^{-1} (1.31), pod length (1.59 cm), fresh weight of pods plant^{-1} (13.00 g), dry weight of pods plant^{-1} (4.65 g), 100-seed

weight (31.06 g),pod yield (1040.00 kg ha^{-1}), stover yield (2488 kg ha^{-1}), biological yield (3527 kg ha^{-1}) and harvest index (29.47%).

It may be concluded that BARI Chinabadam-8 (V_1) showed the superiority over Binacheenabadam-4 (V_2) and Binacheenabadam-6 (V_3). Seed size is consistently important in groundnut cultivation for higher growth and yield as it is required in large sized (S_4) compared to small (S_2), medium (S_3) or unsorted (S_1). Large sized seed (S_4) of three varieties of groundnut especially BARI Chinabadam-8 (V_1) found effective for maximum pod yield (2.47 t ha^{-1}).

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APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location

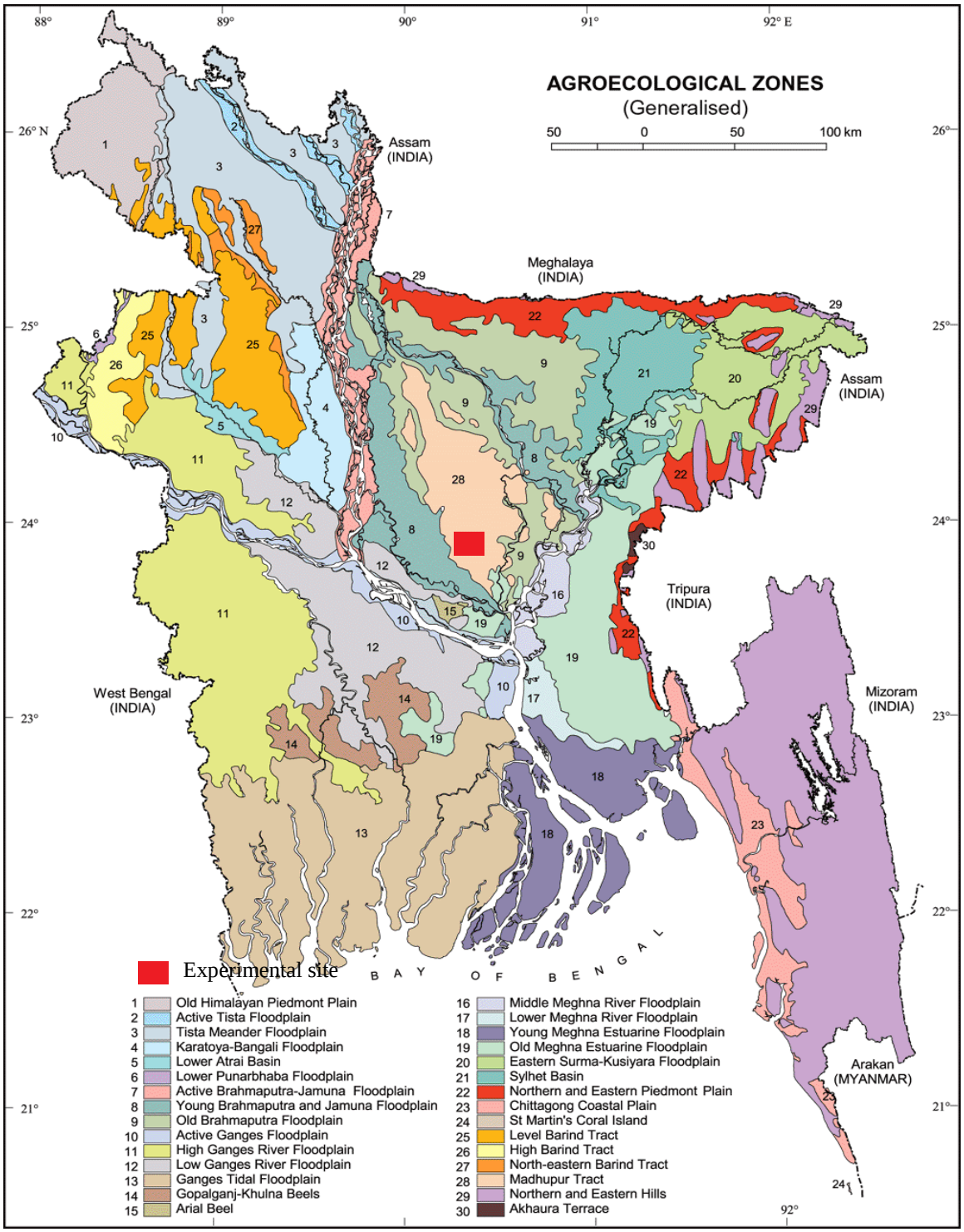

Figure. 11. Experimental site

Appendix II. Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Agronomy Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not Applicable

Source: Soil Resource Development Institute (SRDI), Dhaka

B. Physical and chemical properties of the initial soil

Characteristics	**Value**
Partical size analysis % Sand	27
%Silt	43
% Clay	30
Textural class	Silty Clay Loam (ISSS)
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.1
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix III. Monthly records of air temperature, relative humidity and rainfall during the period from October 2019 to April 2020.

Year	Month	Air temperature (°C)			Relative humidity (%)	Total Rainfall (mm)
		Max	*Min*	*Mean*		
2019	October	30.42	16.24	23.33	68.48	52.60
2019	November	28.60	8.52	18.56	56.75	14.40
2019	December	25.50	6.70	16.10	54.80	0.0
2020	January	23.80	11.70	17.75	46.20	0.0
2020	February	22.75	14.26	18.51	37.90	0.0
2020	March	35.20	21.00	28.10	52.44	20.4
2020	April	34.70	24.60	29.65	65.40	165.0

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix IV. Percent germination of groundnut seeds as influenced by variety and seed size and their combination

Sources of variation	Degrees of freedom	Mean square of percent germination
Replication	2	89.583
Factor A	2	79.000*
Error I	4	0.333
Factor B	3	142.40*
AB	6	21.407*
Error II	18	4.491

* = Significant at 5% level

Appendix V. Plant height of groundnut as influenced by variety and seed size and their combination

Sources of variation	Degrees of freedom	Mean square of plant height at different days after sowing (DAS)			
		25	50	75	100
Replication	2	0.533	0.012	14.36	2.816
Factor A	2	2.430 ^{NS}	2.914 ^{NS}	2.403 ^{NS}	6.121 ^{NS}
Error I	4	1.470	1.450	2.839	3.678
Factor B	3	24.04*	12.22*	14.37*	55.45*
AB	6	0.354**	0.311**	0.167**	0.393**
Error II	18	0.251	0.249	0.661	1.372

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VI. Number of branches plant^{-1} of groundnut as influenced by variety and seed size and their combination

Sources of variation	Degrees of freedom	Mean square of number of branches plant^{-1} at different days after sowing (DAS)			
		25	50	75	100
Replication	2	0.111	0.444	0.194	0.583
Factor A	2	0.861 ^{NS}	0.528 ^{NS}	0.527 ^{NS}	1.083 ^{NS}
Error I	4	0.378	0.278	1.111	0.492
Factor B	3	2.324 ^{NS}	0.778 ^{NS}	2.324 ^{NS}	2.324 ^{NS}
AB	6	0.046**	0.083**	0.046**	0.157**
Error II	18	0.043	0.070	0.072	0.063

NS = Non-significant ** = Significant at 1% level

Appendix VII. Number of leaves plant^{-1} of groundnut as influenced by varieties and seed size

Sources of variation	Degrees of freedom	Mean square of number of leaves plant^{-1} at different days after sowing (DAS)			
		25	50	75	100
Replication	2	9.528	7.444	7.694	1.361
Factor A	2	7.694^{NS}	12.02^{NS}	12.02^{NS}	16.36^{NS}
Error I	4	6.986	6.069	8.903	7.403
Factor B	3	21.51*	26.10*	23.29*	22.17*
AB	6	1.657**	1.657*	1.324**	0.620**
Error II	18	2.722	2.306	2.093	0.833

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VIII. Leaf length of groundnut as influenced by varieties and seed size

Sources of variation	Degrees of freedom	Mean square of leaf length at different days after sowing (DAS)			
		25	50	75	100
Replication	2	0.124	0.213	0.060	1.952
Factor A	2	0.189^{NS}	0.066^{NS}	0.185^{NS}	0.251^{NS}
Error I	4	0.142	0.090	0.088	0.350
Factor B	3	1.045^{NS}	0.491^{NS}	1.076^{NS}	2.264^{NS}
AB	6	0.024**	0.007**	0.061**	0.031**
Error II	18	0.018	0.024	0.036	0.032

NS = Non-significant ** = Significant at 1% level

Appendix IX. Leaf breadth of groundnut as influenced by varieties and seed size

Sources of variation	Degrees of freedom	Mean square of leaf breadth at different days after sowing (DAS)			
		25	50	75	100
Replication	2	0.416	1.254	0.207	1.042
Factor A	2	0.339^{NS}	0.379^{NS}	0.125^{NS}	0.138^{NS}
Error I	4	0.203	0.237	0.140	0.119
Factor B	3	0.602^{NS}	0.819^{NS}	0.289^{NS}	0.597^{NS}
AB	6	0.018^{NS}	0.029^{NS}	0.013^{NS}	0.003^{NS}
Error II	18	0.305	0.448	0.209	0.131

NS = Non-significant

Appendix X. Shoot length of groundnut as influenced by varieties and seed size

Sources of variation	Degrees of freedom	Mean square of shoot length at different days after sowing (DAS)			
		30	60	90	120
Replication	2	2.005	3.556	2.954	3.675
Factor A	2	2.109 ^{NS}	7.193 ^{NS}	10.75 ^{NS}	7.259 ^{NS}
Error I	4	5.485	3.237	9.600	6.893
Factor B	3	11.60*	55.28*	82.13*	61.78*
AB	6	0.188**	0.294**	1.501**	1.509**
Error II	18	0.127	1.557	1.620	1.886

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix XI. Root length of groundnut as influenced by varieties and seed size

Sources of variation	Degrees of freedom	Mean square of root length at different days after sowing (DAS)			
		30	60	90	120
Replication	2	1.575	1.736	0.184	1.480
Factor A	2	3.289 ^{NS}	0.908 ^{NS}	5.167 ^{NS}	6.367 ^{NS}
Error I	4	1.917	0.793	3.135	3.047
Factor B	3	3.945 ^{NS}	1.945 ^{NS}	11.03*	5.293**
AB	6	1.126**	0.081**	0.278**	1.595**
Error II	18	1.039	0.109	0.276	0.474

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix XII. Number of nodules plant^{-1} of groundnut as influenced by varieties and seed size

Sources of variation	Degrees of freedom	Mean square of number of nodules plant^{-1} at different days after sowing (DAS)	
		30	60
Replication	2	3.583	8.750
Factor A	2	449.33*	347.25*
Error I	4	16.792	15.125
Factor B	3	377.73*	2227.8*
AB	6	79.481*	12.250**
Error II	18	5.093	7.185

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

Appendix XIII. Dry weight plant^{-1} of groundnut as influenced by varieties and seed size

Sources of variation	Degrees of freedom	Mean square of dry weight plant^{-1} at different days after sowing (DAS)			
		30	60	90	120
Replication	2	0.397	1.762	7.637	5.331
Factor A	2	0.589 ^{NS}	3.528 ^{NS}	42.12*	39.96*
Error I	4	0.295	4.066	4.035	4.999
Factor B	3	1.070 ^{NS}	20.88*	84.70*	188.4*
AB	6	0.089 ^{NS}	0.327**	2.938**	5.978*
Error II	18	0.248	1.333	16.34	2.445

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix XIV. Leaf dry weight plant^{-1} of groundnut as influenced by varieties and seed size

Sources of variation	Degrees of freedom	Mean square of leaf dry weight plant^{-1} at different days after sowing (DAS)			
		30	60	90	120
Replication	2	0.098	9.345	5.104	4.704
Factor A	2	0.225 ^{NS}	1.415 ^{NS}	8.705 ^{NS}	19.13*
Error I	4	0.160	1.847	5.348	2.469
Factor B	3	0.484 ^{NS}	10.57*	19.76*	66.21*
AB	6	0.032 ^{NS}	0.340**	2.290**	3.422**
Error II	18	0.326	0.271	0.399	0.327

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix XV. Root dry weight plant^{-1} of groundnut as influenced by varieties and seed size

Sources of variation	Degrees of freedom	Mean square of root dry weight plant^{-1} at different days after sowing (DAS)			
		30	60	90	120
Replication	2	0.001	0.003	0.984	0.296
Factor A	2	0.006 ^{NS}	0.007 ^{NS}	1.264 ^{NS}	0.390 ^{NS}
Error I	4	0.004	0.016	0.595	0.538
Factor B	3	0.004 ^{NS}	0.119 ^{NS}	0.695 ^{NS}	1.398*
AB	6	0.001 ^{NS}	0.036 ^{NS}	0.165**	0.650**
Error II	18	0.005	0.041	0.087	0.141

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix XVI. Shoot dry weight plant^{-1} of groundnut as influenced by varieties and seed size

Sources of variation	Degrees of freedom	Mean square of shoot dry weight plant^{-1} at different days after sowing (DAS)			
		30	60	90	120
Replication	2	0.101	1.502	10.983	104.2
Factor A	2	0.077 ^{NS}	0.378 ^{NS}	7.044 ^{NS}	6.705 ^{NS}
Error I	4	0.049	0.355	1.202	1.038
Factor B	3	0.079 ^{NS}	1.068**	15.98*	25.16*
AB	6	0.018 ^{NS}	0.086**	1.986**	3.429**
Error II	18	0.019	0.158	0.167	0.438

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix XVII. Nodule dry weight plant^{-1} of groundnut as influenced by varieties and seed size

Sources of variation	Degrees of freedom	Mean square of nodule dry weight plant^{-1} at different days after sowing (DAS)	
		30	60
Replication	2	0.000	0.000
Factor A	2	0.001 ^{NS}	0.002 ^{NS}
Error I	4	0.001	0.001
Factor B	3	0.001 ^{NS}	0.005 ^{NS}
AB	6	0.000 ^{NS}	0.000 ^{NS}
Error II	18	0.001	0.004

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix XVIII. Pod dry weight plant^{-1} of groundnut as influenced by varieties and seed size

Sources of variation	Degrees of freedom	Mean square of pod dry weight plant^{-1} at different days after sowing (DAS)	
		90	120
Replication	2	0.334	5.573
Factor A	2	2.306 ^{NS}	14.79*
Error I	4	1.275	1.113
Factor B	3	5.597*	60.99*
AB	6	0.170**	1.816**
Error II	18	0.118	0.719

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix XIX. Yield contributing parameters of groundnut as influenced by varieties and seed size

Sources of variation	Degrees of freedom	Mean square of yield contributing parameters and yield of groundnut						
		Fresh weight plant^{-1}	No. of pods plant^{-1}	No. of seeds pod^{-1}	Pod length	Fresh weight of pods plant^{-1}	Dry weight of pods plant^{-1}	100 seed weight
Replication	2	5.071	2.694	0.001	0.019	8.94	1.108	5.340
Factor A	2	312.2*	46.19*	0.053*	0.15^{NS}	90.36*	29.72*	158.0*
Error I	4	1.831	5.653	0.003	0.102	4.990	1.249	3.888**
Factor B	3	635.6*	73.50*	0.177*	0.58**	266.5*	47.54*	379.4*
AB	6	11.65*	4.231**	0.001**	0.02**	3.995**	4.152**	18.88**
Error II	18	10.34	0.852	0.001	0.019	3.146	0.711	4.194

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix XX. Yield parameters of groundnut as influenced by varieties and seed size

Sources of variation	Degrees of freedom	Mean square of yield parameters of groundnut				
		Yield plot^{-1}	Pod yield ha^{-1}	Stover yield ha^{-1}	Biological yield ha^{-1}	Harvest index
Replication	2	83.02	94.3571	189.190	553.814	10.35
Factor A	2	846.44*	5782.80*	2868.48*	16736.1*	39.67*
Error I	4	463.23	319.500	214.343	255.886	8.392
Factor B	3	2495.6*	17053.9*	13370.0*	60367.7*	95.83*
AB	6	373.29*	2555.80*	312.640*	549.833*	2.847*
Error II	18	291.65	427.133	149.481	174.750	3.627