

Growth and Yield Performance of Groundnut (*Arachis hypogea* L.) at Different Planting Dates in the Savannah Grassland Agro-Ecology of Sierra Leone

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Abstract

The experiment was conducted at the Magbosi Land Water and Environment Research Center (MLWERC) experimental site of Sierra Leone Agricultural Research Institute (SLARI) in Mile 91. The objectives of this study were to determine the appropriate planting date for groundnut in the Savannah agroecology and to investigate the effect of different planting dates on some agronomic traits, yield, and yield components of the two farmers' preferred local cultivars in the area. A split-plot arrangement in a randomized complete block design with three replicates was used. Planting dates were assigned to the main plots and genotypes to the sub-plots. Two local groundnut varieties (Senegal and Bandugu) were planted over four (4) dates at fourteen days intervals from 8th May to 20th June 2021 for the first planting season and from 14th August to 25th September 2021 for the second planting season. Plant height, number of leaflets per plant, number of pods/plots, dry groundnut biomass, fresh pod weight, dry pod weight, and pod yield (Kg/ha) were measured. Combined analysis of the two seasons showed that the yield produced was statistically significantly affected by the season ($P < 0.001$) planting date ($P = 0.013$) and planting date with season interaction ($P = 0.003$). The first season's crop significantly had a significantly higher yield (48.5%) than the second planting. These results showed that the first season planting of groundnuts had a significantly higher yield than the second planting. Results revealed that both planting date and cropping season significantly influenced yield, with earlier plant-

ing and the first season producing higher yields. The number of pods per plant strongly correlated with total yield. The research showed that the optimum planting dates of groundnut are between 8th May and 22nd in the first cropping season and the 28th of August to 11th September during the second cropping season under rainfed conditions.

Keywords

Groundnut (*Arachis hypogaea* L.), Planting Date, Cropping Season, Biomass, Yield

1. Introduction

Groundnut (*Arachis hypogaea* L.), also known as peanut, is an important food and cash crop across West Africa. The crop is cultivated mainly by small-household and resource-poor farmers (including women). Groundnut belongs to the genus *Arachis* in the subtribe *Stylosanthinae* of tribe *Aeschynomeneae* of family *Leguminosae*. It is a self-pollinated, tropical annual legume [1]. It is a legume that ranks 4th among the oilseed crops and 13th among the world's food crops. In addition, it produces high-quality fodder for livestock [2].

Groundnut is the most important grain legume in Sierra Leone. The area under groundnut cultivation was 97,014 ha in 2023; total production 121, 881, 136 kg and the average yield was 1.03 t/ha [3].

Groundnut is a dual-purpose grain legume that is used for human food and soil. It is the only legume eaten in many forms: roasted, fresh, dry, boiled, or cooked with soup. It derives a large proportion of its Nitrogen needs from biological N-fixation and produces a substantial amount of both grain and biomass, making it attractive to smallholder farmers [4] [5]. Groundnut provides a regular source of cash income for many small-scale farmers who sell raw and dried harvested unshelled nuts. The raw nuts can be consumed either directly or boiled. The dried nuts are normally roasted and sold as snacks. They can also be mixed with molten sugar to make groundnut cake or ground into a paste to use as an ingredient in the popular local groundnut soup dish and a local snack called ***Kanya***. The fodder and residue (cake) after oil extraction are useful as livestock feed.

The correct planting date is one of the key factors that strongly affect groundnut production in rain-fed agriculture [6]. This is especially true in many parts of Africa, as the rainy season starts with some light showers followed by dry spells, which can cause poor crop emergence or desiccate young plants [7]. Differences in time of planting may relate to different climatic conditions (rainfall, temperature, and photoperiod). The optimization of planting dates is of considerable relevance in the generation of the revenue stream to growers. The selection of the best planting date is also one that is poorly understood by our smallholder farmers.

Agriculture in Sierra Leone is mostly rain-fed and is therefore mainly conducted during the rainy season. In an age of growing weather extremes, episodes of intensive rainfall can be punctuated, by periods of prolonged dry spells or insufficient rain. This has significant implications for crop growth as rainfall may be concentrated within a given period.

One of the factors responsible for the low productivity of groundnut in Sierra Leone is sowing time. Most groundnut farmers do not plant at the optimum time to achieve maximum yield potential, which negatively impacts yield and profitability. Although early planting has been reported to increase yields and prevent rosettes, farmers normally delay planting due to the variability in rainfall. Among the numerous factors that contribute to a successful groundnut crop in Sierra Leone, management decisions regarding variety selection and planting dates can have a profound effect on the development and outcome of the crop. Increased productivity of groundnut will increase farmers' income and the national production of the crop. To minimize the adverse effects of weather variability on the yield reduction of groundnut, there is a need to determine the appropriate planting time for optimum productivity. Identifying an appropriate sowing time will go a long way in increasing the yield of groundnuts.

Crop management practices such as cultivar selection, time of sowing and duration of cultivar's life cycle may influence the growth, yield, and seed quality of groundnut. Sowing date is an important production component that can be manipulated to counter the adverse effects of environmental stresses. This is accomplished through shifting sowings so that any stress caused by the environment is avoided during the critical stages of plant growth.

Climate change has caused significant modifications to cropping seasons in different regions, and the effect of this alteration is a variation in the performance of crop species grown in different environments. Sierra Leone is presently experiencing untimely thunderstorms, destructive landslides, and floods claiming tens of lives, particularly in coastal towns and lowland farm settlements. Rainfall patterns have become seasonally unreliable and unpredictable, causing farmers to miss their start-of-farming dates. In addition, the main food crops produced in the country (rice, maize, groundnut, potato, cassava, and vegetables) survive under varying climatic conditions. The present state of rainfall and its duration are of concern for agricultural yields in Sierra Leone.

A serious decline in rainfall has been observed in recent years. There are four agro-climatic regions in the country, but these might have been shifted considerably due to climate change impacts. Changes in temperature cause changes in rainfall. Even though climate change observations have been done for several years, the need to develop an early warning system in the country is essential. In particular, Start-of-Season (SOS) and Start-of Farming (SOF) systems must be in place to inform farmers and flood-prone coastal and lowland dwellers in the country.

Increasing temperature negatively influences crop production at local, regional, and global levels. While direct effects are associated with increasing trends in min-

imum and maximum temperature, indirect effects like water availability, changing soil moisture status, and pests and disease occurrence are expected to be felt due to climate change [8]. Sustainable productivity of various agronomic crops is very important in providing food and fiber for the population at a global level and feeding the farm and domestic animals, which might be potentially supported by suitable adaptive crop husbandry practices like optimum sowing date, etc. [9].

Determination of planting date aims to find the appropriate planting time for cultivars so that the existing set of environmental factors can be suitable for plant germination and survival. Groundnut can be planted throughout a considerable part of the year with potentially reasonable, and at times very good yield results in Sierra Leone. The adjustment of suitable planting dates considering the weather and/or other circumstances should have a profound impact on the selection of a suitable variety. Groundnut cultivars are grown under a wide range of conditions such as soil types, moisture levels, temperatures, and management practices [10] [11]. Little information is available on the effects of variety and planting dates on the growth and yield response of groundnut in the savanna grassland of Sierra Leone. The aim of this study was to determine the optimum groundnut planting dates for increased productivity in a savannah grassland agro-ecology of Sierra Leone.

SPECIFIC OBJECTIVES

- i. Evaluate the growth and yield response of two local groundnut varieties at different planting dates.
- ii. Determine the appropriate planting date under the savanna ecological conditions of northern Sierra Leone.
- iii. To assess the performance of the two groundnut genotypes in two cropping seasons in the Savanna grassland agroecology.

2. Materials and Methods

2.1. Description of the Study Area

The experiment was conducted at the Magbosi Land, Water and Environment Research Center (MLWERC) experimental site of the Sierra Leone Agricultural Research Institute (SLARI). MLWERC is located at Yoni Mabanta Chiefdom, Tonkolili District in the North-Eastern Province of Sierra Leone on latitude 8° 28' 17.88" N and longitude 12° 14' 33.02" W. The climatic condition experienced in the study area is not too different from the rest of the country with two distinct seasons, the rainy season (May-October) and the dry season (November-April). The ecology in this area is mainly grassland savanna mostly covered with grasses like *Andropogon* species, *Pennisetum* species, etc., and shrubs like *Lophira*. The soils are mostly sandy loam in texture, porous and black. The bulk density and cation exchange capacity are also low in this region. As the soil is porous, the water holding capacity is very low in this region. Soils of the savanna grassland area are mostly Alfisols and Ultisols. These soils are very old and low in fertility and very porous with rapid drainage of water.

2.2. Experimental Design and Cultural Practices

A split-plot arrangement in a randomized complete block design with three replicates was used. Planting dates were assigned to the main plots and genotypes to the sub-plots. The total area for the trial was 36 m × 21 m and each sub-plot was 4.5 m². Each sub-plot was separated by 0.5 m and 1 m spacing between replicates. A total of 8 sub-plots per replication were planted and the whole trial had 24 plots.

The experimental area was cleared and plowed using a hand hoe. Two local groundnut genotypes (Senegal and Bandugu) were cultivated. The two genotypes were planted at four (4) dates with fourteen days intervals from 8th May to 19th June 2021 for the first planting season and from 14th August to 20th September 2021 for the second planting season.

The genotypes were sown at 20 cm between plants in a row and 30 cm between rows. No fertilizer was applied. Weeding was done 1 month after planting and as and when necessary. Harvesting was done when pods were physiologically matured that is when 80% of the inside of the pods shell have dark markings and kernels are plump with colour characteristics of that variety.

Sketch of the experimental design

Rep 1		Rep 2		Rep 3	
P1V1	P1V2	P3V1	P3V2	P2V2	P2V1
P2V1	P2V2	P4V2	P4V1	P1V2	P1V1
P3V1	P3V2	P2V2	P2V1	P4V1	P4V2
P4V1	P4V2	P1V1	P1V2	P3V2	P3V1

P-Planting date (4), V-Variety (2).

3. Data Collection: Data Were Collected on the Following

3.1. Weather Data

Assessment of the rainfall and temperature regimes over the experimental site: Both the watchdog and the rain gauge were used to collect data on rainfall, relative humidity and temperatures. Data from the watchdog were collected every month and the rainfall data was collected daily at the end of any rainfall till the end of the experiment.

3.2. Agronomic Data

Plant height was measured with a meter rule on 4 plants of each plot. Height was measured from ground level to the topmost leaf axil of the main stem and the mean height was expressed in centimetres. Number of leaflets per plant-was determined by counting the number of leaflets on 4 plants at five stages and mean recorded. Fresh groundnut biomass (FGB) and Dry groundnut biomass were measured from 4 plants randomly harvested for each treatment by destructive sampling at 1, 2 and 3 months after planting. For Dry groundnut biomass, plants

were dried in an oven for 2 days and the dry weight were measured using an electronic weighing balance. Mean dry weight per plant was recorded in grams. Fresh and Dry pod weight (FPW) were measured from 4 plants randomly harvested for each treatment by destructive sampling at 1, 2 and 3 months after planting. The pods were plucked from the groundnut plants immediately after harvest. Weights were measured using an electronic weighing balance. Pod yield (kg/ha) was calculated by using the formula.

$$\text{Pod yield (kg/ha)} = \frac{\text{Pod weight (kg)}}{\text{Harvested area (m}^2\text{)}} \times 10000 \text{ m}^2$$

4. Statistical Analysis

The data were statistically analyzed by using a standard analysis of variance technique for a split-plot design using GENSTAT statistical software. Significance of the differences among treatment means were tested using the Least Significant Difference (LSD). Means were considered significantly different at $P < 0.05$ (5% Level of probability). Regression analysis was done to find the relationship among the variables.

5. Results and Discussion

5.1. Weather Data during the Major and Minor Cropping Seasons

Table 1. Weather data during the first and second cropping seasons, 2021.

Month	Temperature (°C)		Relative Humidity (%)	Total Rainfall (mm)	Evapotranspiration (mm)
	Min	Max			
First Cropping Season					
May	22.6	34.3	90	195.9	84.6
June	22.5	32.2	90	302.6	72.1
July	22.8	31.1	92	409	62.3
August	22.3	30.8	91	450	61
Total				1356	280
Second Cropping Season					
September	22.6	32.8	70	163	72.3
October	22.4	33.2	67	239	69.1
November	22.8	33.4	72	179	71.2
December	22.8	33.5	75	151	60.5
Total				732	273.1

The total rainfall distribution for the growing period of 2021 during the experimental periods is shown in **Table 1**. The total amount of rainfall recorded in the first cropping season 1356 mm was 46% higher than in the second cropping sea-

son (732 mm). August recorded the highest amount of rainfall (450 mm) followed by July (409 mm) in the first cropping season. Conversely, August and July months recorded the lowest evapotranspiration (61 mm and 62.3 mm respectively). The total evapotranspiration rate for the first cropping season was 280 mm and the second cropping season was 273.1 mm.

Air temperatures ranged between 22.3°C to 34.3°C in the first cropping season and from 22.4°C to 33.5°C in the second cropping season. Relative humidity was between 90% to 92% in the first cropping season and 67 and 75% in the second cropping season.

5.2. Soil Analysis of Experimental Site

The results of the soil analysis of the experimental site are presented in **Table 2**. The results showed that the 0 - 20 cm depth had a sandy - loam soil type whilst the 20 - 40 cm depth had a sandy - clay loam soil type. Organic carbon, total Nitrogen, total Phosphorus, exchangeable Ca, Mg, electrical conductivity, and exchangeable acidity were higher in the 0 - 20 cm soil depth than the 20 - 40 cm soil depth. Organic carbon percent is low (1.4%) in the topsoil of the experimental site. Generally, the soil can be described as acidic with pH ranging from 4.9 to 5.3.

Table 2. The initial physical and chemical properties of the experimental soil in 2021.

Soil Property	Soil Depth	
	0 - 20 cm	20 - 40 cm
pH (H ₂ O)	5.3	4.9
Organic C (%)	1.4	0.5
Electrical Conductivity (µS/cm)	34	32
Particle Size analysis	-	-
- Sand (%)	74	72
- Silt (%)	9	8
- Clay (%)	17	20
- Texture	Sandy Loam	Sandy Clay Loam
Total Nitrogen (kg/ha)	19.2	10.5
Total Phosphorus (kg/ha)	15.3	9.5
Available Potassium (kg/ha)	12.1	12.4
Exchangeable Calcium (meq/100 g)	4.3	3.9
Exchangeable Magnesium (meq/100 g)	1.3	1.1
Exchangeable Acidity (Cmol/100 g)	2.1	1.8
Exchangeable Aluminium (Cmol/100 g)	2.3	2.3

5.3. Effect of Planting Date and Variety on Fresh and Dry Groundnut Biomass

The results of the present study showed that highly significant differences ($p <$

0.001) were observed in fresh and dry groundnut biomass during the first cropping season due to planting date. The 22nd May planting date had significantly higher fresh and dry groundnut biomass than the other planting dates (**Table 3**). Variety did not influence the fresh and dry groundnut biomass as no significant difference ($p > 0.05$) was obtained from the analysis. The interaction between planting date and variety was also statistically not significant ($p > 0.05$).

5.4. Effect of Planting Date and Variety on Fresh and Dry Groundnut Biomass in the First Cropping Season

Table 3. Effect of planting date and variety on Fresh and dry groundnut biomass in the first cropping season.

Planting Date	Fresh Groundnut Biomass (kg)			Dry Groundnut Biomass (DGB)		
	Variety			Variety		
	Bandugu	Senegal	Mean	Bandugu	Senegal	Mean
8 th May	0.63	0.79	0.71	0.27	0.37	0.32
22 nd May	1.02	1.33	1.18	0.75	0.82	0.79
5 th June	0.61	0.54	0.58	0.27	0.32	0.30
19 th June	0.48	0.54	0.51	0.36	0.25	0.31
Mean	0.69	0.80		0.41	0.44	
LSD (0.05) PD	0.28			0.21		
LSD (0.05) V	0.20			0.15		
LSD (0.05) PD x V	0.40			0.30		
CV (%)	30.8			39.6		

Table 4. Effect of planting date and variety on Fresh and dry groundnut biomass in the first cropping season.

Planting Date	Fresh Groundnut Biomass			Dry Groundnut Biomass		
	Variety			Variety		
	Bandugu	Senegal	Mean	Bandugu	Senegal	Mean
14 th August	0.59	0.64	0.61	0.34	0.40	0.37
28 th August	0.87	1.27	1.07	0.66	0.85	0.76
11 th September	0.56	0.59	0.57	0.24	0.28	0.26
25 th September	0.45	0.52	0.49	0.15	0.20	0.18
Mean	0.62	0.76		0.35	0.43	
LSD (0.05) PD	0.25			0.14		
LSD (0.05) V	0.17			0.09		
LSD (0.05) PD x V	0.35			0.19		
CV (%)	29.1			28		

The results from the analysis revealed that highly significant ($p < 0.001$) were observed in fresh and dry groundnut biomass. The August 28th planting date significantly had higher fresh and dry groundnut biomasses after harvest (1.07 and 0.76 kg) respectively. The lowest fresh and dry groundnut biomass were recorded from the 28th of September planting time. (Table 4). The Senegal groundnut variety had higher fresh and dry groundnut biomass than the Bandugu variety.

5.5. Number of Pods as Affected by Cropping Season

Results obtained from the combined analysis of first and second cropping seasons indicate that the mean number of pods was higher in the first cropping season (125.6) than the second cropping season. Planting in the second season decreased number of pods by 26%. Yield components such as the number of pods per plants, pod yield per hectare were significantly affected by the planting dates in the two seasons indicating that environmental conditions are essential for yield of groundnut. Where such environmental conditions such as temperature and rainfalls are favorable yield is increased, as such planting dates must target such favorable periods for optimum yield.

Table 5. Mean number of pods from combined analysis of first and second cropping season.

Season	Mean Number of Pods
1 st Cropping Season	125.60
2 nd Cropping Season	91.20
Mean	108.40
LSD (0.05)	14.80
CV (%)	23.10

Combined analysis of the two seasons showed that the yield produced was significantly affected by the season ($p < 0.001$), planting date ($p = 0.013$) and planting date interaction with season ($p = 0.003$). The first season cropping significantly had higher yield (48.5%) than the second planting. These results are consistent with those of [12] who reported seasonal differences significantly affected crop phenology, growth, and productivity of groundnut cultivars. This was attributed to early and normal planting dates allowed a long growth period and plants been exposed to suitable temperature regimes during the vegetative and reproductive growth stages for the entire growing period. The results obtained from this study also confirmed earlier results from [13] who observed that May 20 and genotype ICGV-8623 produced the highest pod and seed yield in Ghana. Similar results were reported by [14] also found first season planting of groundnut in Bimodal rainy season in Kumasi, Ghana had significantly higher yield than second season planting. This can be attributed to the uniform and higher rainfall experienced during the first cropping season (1356 mm) (Table 5).

Mean Yield (t/ha) of groundnut genotypes as affected by different planting dates

From the results of the analysis of variance, planting date significantly ($p < 0.05$) influenced yield. The 8th May planting date recorded the highest yield (0.89 t/ha) followed by the 22nd May planting date (0.77 t/ha). The lowest yield obtained was from the late planting on 19th June (**Table 6**). These results are in agreement with earlier results obtained by [15]. Senegal variety had a higher yield than Bandugu though the difference was not statistically significant. Previous results of [16] confirmed that early sowing of groundnut resulted in maximum yield and delay in sowing resulted in significant decline in pod yield due to decrease in vegetative cycle. The difference observed among the groundnut varieties regarding the number of pods/plants could largely be attributed to the genetic traits of the varieties (**Figure 1**).

Table 6. Mean yield of the two groundnut at different planting dates in the first cropping season.

Planting date	Yield t/ha P (0.008)
8 th May	0.89 a
22 nd May	0.73 ab
5 th June	0.62 b
19 th June	0.57 b
Mean	0.70
LSD (0.05)	0.25
CV (%)	20.40

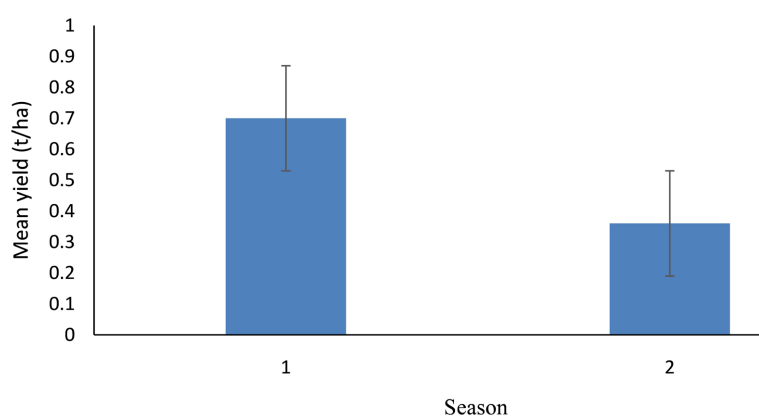


Figure 1. Mean yield of groundnut as influenced by cropping season.

The results of the regression analysis showed that number of pods per plant in the groundnut varieties is strongly positive correlated with yield ($R^2 = 0.92$) at different planting dates during the first cropping season. This implies that 92% of the variation of yield is explained by number of pods in groundnut. The number of pods per plant strongly correlated with total yield (**Figure 2**).

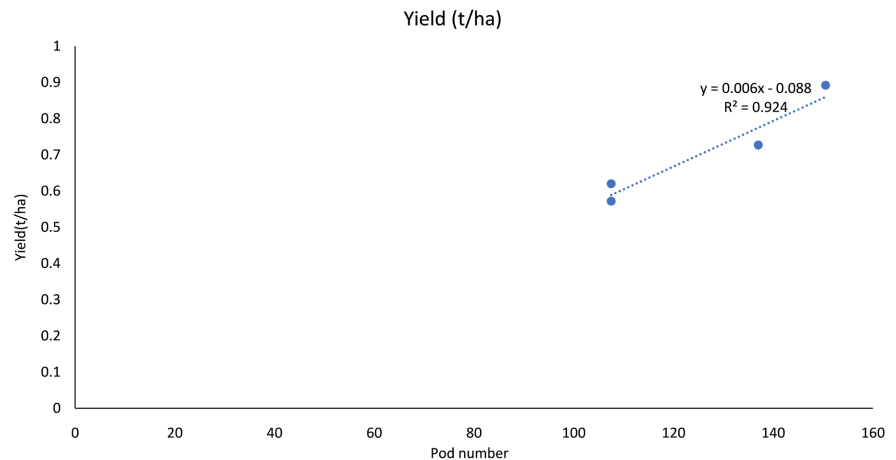


Figure 2. Relationship between number of pods and yield of groundnut in the first cropping season.

6. Conclusions

A simple technology for improving productivity which farmers could easily adopt is the appropriate planting date. This is because over many years farmers themselves have made observations on the best time to plant their crops. They have however not quantified the link between planting date, variety, and yield. This study was undertaken to determine the optimum planting date and season for improved groundnut yield in the savanna agroecology in Sierra Leone.

From the results of the study, the following conclusions can be made:

1. Cropping season significantly affected crop phenology, growth and productivity of groundnut.
2. There is a strong relationship between the number of pods and the yield of groundnut.
3. The yields obtained in the first season planting were higher than those in the second season planting.
4. The groundnut variety Bandugu had a higher yield in both cropping seasons.
5. The yield of groundnuts was reduced as the planting date was delayed from May to June.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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