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Influence of Seed Size on Seedling Emergence, Growth and Yield of Potted Groundnut (*Arachis hypogea* L.)

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Authors' contributions

This work was carried out in collaboration between both authors. Author OCI designed the study, supervised field operations, monitored data collections, conducted statistical analysis, results interpretations and final write up. Author AP did the field works, collected data, managed literature search and wrote draft of the manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

Pot experiments were conducted at the Faculty of Agriculture, Kogi State University, Anyigba, Kogi State in the Southern Guinea savannah ecological zone of Nigeria 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 hypogea*). The treatment consisted of three different seed sizes: small, medium and large seeds apportioned to a Randomized Complete Block Design (RCBD) with ten replications. For seed size, 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

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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.

Keywords: Canopy height; leaf number; leaf area; stem girth; days to first flower; yield components.

1. INTRODUCTION

1.1 Groundnut

Groundnut (*Arachis hypogea* L.), of the family Fabaceae is one of the most valuable legume crops grown as an annual and whose remarkable characteristic is underground seed production [1]. On average, seed contains 26% protein, 46% oil, 26% carbohydrate and 2.5% minerals. The two main types of the herbaceous plant are bunchy, growing to a height of 30-50 cm and do not spread and the runner varieties, which grows to height of 25-35 cm creeping along the ground for 30-60 cm. However, there are many intermediate forms or hybrids [2].

According to Lourduraj [3], Vessey and Buss [4], the importance of groundnut in the world's economy is increasing rapidly due to its demand for by-products of crop such as oil for making margarine, cooking oil, soaps and many other domestic uses. It is also a veritable source of protein for human and livestock [5] and 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 [6]. It is also rich in calcium, potassium, phosphorus, magnesium and vitamin E. Groundnut meal, a by-product of oil extraction, is an important ingredient in livestock feed. Groundnut haulms are nutritious and widely used for feeding livestock. The groundnut oil is composed of mixed glycerides, and contain a high proportion of unsaturated fatty acids, in particular Oleic (50–56%) and Linoleic (18-30%) [7]. Groundnuts are also important in the confectionary trade and the stable oil is preferred by the deep-frying industries since it has a smoke point of 229.4°C compared to 193.5°C of soybean oil. The oil is also used to make margarine and mayonnaise [8]. Confectionary products such as snack nuts, sauce, flour, peanut butter and cookies are made from high quality nuts of the crop.

In the Northern part of Nigeria, apart from being consumed whole, groundnuts are processed into or included as an ingredient in a wide range of other products. These products include groundnut paste which is fried to obtain groundnut cake (*kulikuli*), salted groundnut (*gyadamaigishiri*), a gruel or porridge made with millet and groundnut (*kunungyada*), groundnut candy (*kantungyada*) and groundnut soup (*miyargyada*). The shells are used as fuel by some local oil factories or as a soil amendment. It could also be used as bulk in livestock rations or in making chipboard for use in joinery [1].

The production of groundnut is concentrated in Asia and Africa where the crop is grown mostly by small holder farmers under rain fed conditions with limited inputs. The Nigeria groundnut production was reported at 6,217.000 tonneth in June 2017 this record is an increase from previous year of 6,054.560 tonneth for 2016 [9]. However the country was previously the third highest producer of groundnut in the world after China and India with a production of 16,114,231, 6,933,000 and 2,962,760 tons [10].

In Nigeria, the leading producing states includes Niger, Kano, Jigawa, Zamfara, Kebbi, Sokoto, Kastina, Kaduna, Adamawa, Yobe, Borno, Taraba, Plateau, Nasarawa, Bauchi and Gombe States [11]. Groundnut is presently grown throughout the country except the riverine and swampy areas. It is either cultivated sole or in mixture with other crops like maize, sorghum, millet or cassava. Generally fifty five percent of the groundnuts produced in Nigeria are in mixtures [11].

Studies of the relationship between seed size and early growth have been reported [12]. 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 [12]. The main purpose of seed grading is to understand the better physiological quality of the seed lot [13]. This gives impetus to this study with the specific objective of identifying the most yielding seed size among the available seed sizes evaluated. The objectives of the trial were to evaluate the growth development and yield performance of three seed size (large, medium and small) of Samnut 24 variety.

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 [14]. 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 [14]. Effect of seed size on crop development has engaged the attention of research workers for many years. Volumes of controversial literature on this aspect are available, indicating the need for conducting further detail investigation. Seed lot may differ by size, weight and density due to production environment and cultivation practices [15].

1.2 Influence of Seed Size on Number of Days to Emergence, Establishment and Growth

While positive relationship between seed size and seedling emergence rate was found in some crops [16], contradictory results have been reported for soybean and groundnut [17,18]. Hojjat [19] 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 [20]. However, Uyoh and Ikong [21] observed that seed weight had no effect on seedling emergence, leaf area and number of branches per plant in *Telfairia occidentalis*. Willie and Okoronkwo [22] 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 [23]; generally, because bigger seeds germinate quicker and would take lesser duration when compared to that of smaller ones [24]. Manonmani et al. [25] have recorded higher seed germination and seedling establishment by using bigger size seed in *Pongamia pinnata* and *Vateriaindica.* Menaka and Balamurugan [26] proved that larger seed of Amaranthus possess highly physiological quality with increased seed size, higher germination and emergence was determined in triticale [27]. While Mandel et al. [28] noted that in *Hypatis suaveolous*, 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 [29]. However with advance in growth stage, the difference are generally less marked, diminishing and in certain cases completely disappearing [30,31].

Finally Nagaraju [32] 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).

1.3 Influence of Seed Size on Yield Components and Crop Yield

Seed size has been observed to affect yield. Large seeds of spring wheat produce higher yield but not under optimum management conditions [33]. Baalbaki and Copeland [34] reported that wheat seed size does not only influence emergence and establishment but also affects yield components and ultimately grain yield. While another author [35] 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 [36]. Similar result obtained by Roozrokh et al. [37] on chickpea, Taleghani et al. [38] on sugar beet. Nagaraju [32] 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). Grain yield advantages of 4.2% in bread wheat [39] and 16% in durum wheat [40] have been reported from large seeds over small sized ones. Roy et al. [40] also reported that larger seeds resulted in high biomass, green area index, number of spikes per m^2 and heavier kernels. Tawaha and Turk [41], 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.

2. MATERIALS AND METHODS

2.1 Experimental Location

The experiment which was rain-fed was laid out in the nursery of Department of Crop Production, Faculty of Agriculture, Kogi State University, Anyigba in the southern guinea savannah on the agro-ecological zone of Nigeria. The experimental location is latitude 7° 28^{1}, 51.39^{11} N and longitude 7° 02^{1}, 37.68^{11}E with bimodal rainfall with the peak pattern occurring in July and September. Seeds were sown on the 2nd of July 2019.

2.2 Treatment and Experimental Design

A variety of Samnut 24 treated to three seed size (large, medium and small) laid out in a Randomized Complete Block Design (RCBD) with ten (10) replications. The groundnut used for the experiment was obtained from Institute of Agricultural Research (IAR) Samuru Zaria, Kaduna State, Nigeria. Seeds were adequately sorted and graded into three batches of 100-seeds of uniform sizes (apportioned to large, medium and small-sized seeds) measured as 100-seed weight (Table 1). The seeds were then sown to a depth of 5 cm into black 5 litre plastic buckets maintaining 25 cm between buckets. Weeding was carried out manually by hand picking at regular intervals: at 3, 6 and 9 weeks after sowing. Phosphorus fertilizer in form of single superphosphate (SSP) at the rate of 0.6 gm per pot was applied uniformly at planting using the ring method [42].

Table 1. Seed grading

Variety	Seed size (100 seed weight) g		
	Large	Medium	Small
Samnut – 24	69.27	46.64	24.98

2.3 Harvesting

Harvesting was done at 4 months when about 70 – 80% of the inside of the pod shells have dark markings and the kernels were plumped with colour characteristics of the variety. Harvested plants were allowed to dry in the sun for two days then air-dried for five days before stripping the pods. This was done to achieve rapid but steady drying of pods in other to avoid aflatoxin contamination. The stripped pods were then laid out in a thin layer in the sun on dry ground for further five days before weighing.

2.4 Data Collection

2.4.1 Growth parameters

i. **Days to seedling emergence:** Daily observations were made at 7:30 am until seedling emergence.
ii. **Plant canopy height:** This was measured with the aid of a measuring tape as the distance from the soil surface to the collar of the top most leaf [43] at 3, 6 and 9 weeks after sowing (WAS).
iii. **Number of leaves per plant:** Determination of the total number of leaves per plant was carried out at 3, 6 and 9 WAS. This was achieved by manually counting the total number of leaves/plant.
iv. **Leaf area:** The leaf area was determined by measuring the length and widest breadth of the middle leaflets. It was calculated as the product of the total length and the breadth at the broadest point of the leaf on the plant, where leaf Area is determined as lamina length × maximum width × k, where k is a coefficient [44].
v. **Number of branches per plant:** The total numbers of branches per plant were determined at 3, 6 and 9 WAS.
vi. **Stem girth:** Determined with the aid of a veneer caliper as the width of the point just above the soil.

2.4.2 Development

i. **Number of days to first flowering:** This was determined by counting the number of days it took any plant in any plot to initiate blossom flowers.

2.4.3 Yield parameters

i. **Number of pods per plant:** This involves counting the total number of pods on each plant per pot.
ii. **Pod weight:** This was achieved by weighing samples of 20 randomly selected clean pods / pot multiply by 5 to obtain pod weight (gm).
iii. **Shelling percentage:** This was determined according to Abdullah et al. [45], Virender and Kandhola [46] as follows:

$$\text{Shelling \%} = \frac{WS}{WP} \times 100$$

Where:

WS = weight of shelled groundnut seed (g)
WP = weight of unshelled groundnut (pods) (g)

iv. **100-seed weight:** This was achieved by weighing samples of 20 randomly selected clean seeds / pot multiply by 5 to obtain 100-seed weight (g).

2.4.4 Data analysis

Data collected was subjected to Analysis of Variance (ANOVA) as recommended by Snedecor and Cochran [47] for Randomized Complete Block Design and significance mean difference were separated using Least Significant difference (LSD).

3. RESULTS AND DISCUSSION

3.1 Growth Components

Seedling emergence was found to be significantly ($p \leq 0.05$) influenced by seed size; with large seeds having the lowest mean days to seedling emergence (4 days), while medium sized seeds recorded a mean days to seedling emergence of 5 days and small seed size had the highest mean number of days to seedling emergence (5.20 days) (Table 2). This observation confirms previous reports of a positive relationship between seed size and seedling emergence [23,24,25,26,27,28]. Bigger seed as an indication of higher food reserve connotes higher stored energy for the push through the soil thus culminating in faster seedling emergence, particularly where seeds are buried deep during seed sowing.

However plant canopy heights at 3 WAS, 6 WAS and 9 WAS were not significantly ($p \geq 0.05$) influenced by seed size (Table 3), which is not unexpected as effect of seed size may diminish and in certain cases completely disappear with advance in growth stage [29]. In reports by Oyewole and Koffa [30] on the effect of storage, size of nut and soaking length on sprout emergence in Cashew [30] and Oyewole et al. [31] on the effect of cashew (*Anacardium occidentale* L) nut size on nursery and field performance [30], the early gains by large or medium-sized cashew nuts over small-sized nuts had relatively diminished before nursery seedlings were even transplanted to the field and by the third year on the field, small-sized nuts have caught up with medium or large-sized nuts in their performance relating to their growth, development and yield of cashew. The same reason may be adduced for the observed non-significant ($p \geq 0.05$) effect of seed size on number of leaves, leaf areas (Table 4) as well as stem girth (Table 5) at 3 WAS, 6 WAS and 9 WAS.

Table 2. Days to seedling emergence as influenced by groundnut seed size

Seed size	Days to seedling emergence
Large	4.00
Medium	5.00
Small	5.20
LSD	1.041**

*** LSD - Significantly different at 5% level of probability*

Table 3. Plant canopy height as influenced by groundnut seed size

Seed size	Plant height (cm)		
	3 WAS	6 WAS	9 WAS
Large	15.02	27.92	32.28
Medium	16.90	25.14	28.72
Small	14.86	26.96	30.90
LSD	Ns	Ns	Ns

Ns - LSD not significantly different at 5% level of probability

Table 4. Number of leaves and leaf area as influenced by groundnut seed size

Seed size	Number of leaves			Leaf area		
	3 WAS	6 WAS	9 WAS	3 WAS	6 WAS	9 WAS
Large	32.30	83.40	104.80	428	890	969
Medium	32.80	68.60	89.60	512	891	1023
Small	39.80	84.60	103.40	412	955	1027
LSD	Ns	Ns	Ns	Ns	Ns	Ns

Ns – LSD not significantly different at 5% level of probability

Table 5. Stem girth and leaf area asinfluenced by groundnut seed size

Seed size	Stem girth		
	3 WAS	6 WAS	9 WAS
Large	0.88	1.02	1.12
Medium	0.96	1.00	1.12
Small	0.90	1.00	1.06
LSD	Ns	Ns	Ns

Ns -Not significantly Different at 5% level of probability

Table 6. Days to first and 50% flowering as influenced by groundnut seed size

Seed size	Days to first flowering	Days to 50 % flowering
Large	36.60	38.80
Medium	37.40	40.80
Small	37.00	41.00
LSD	Ns	1.47**

*Ns -Not significantly different at 5% level of probability; ** LSD-Least significant difference significantly different at 5% level of probability*

3.2 Days to First Flowering

Days to first flowering was not significantly ($p \geq 0.05$) influenced by seed size (Table 6). However, days to 50% flowering responded significantly ($p \leq 0.05$) to seed size with large seeds been the earliest to attain 50% flowering (38.80 days), followed by medium sized seeds (40.80 days) and lastly small sized seeds (41.00 days) (Table 6). The significant variation observed in days to 50% flowering among the treatment, was probably the result of faster seedling emergence demonstrated by both large and medium sized seeds in comparison to small sized seeds.

The observation is similar to previous reports that larger seeds responded faster to seedling emergence [20,23,24,27,31]. The time gained by these bigger seeds in emerging earlier, could not be evened out by the medium or smaller sized seeds, thus culminating in significant earlier days to 50% flowering. Such a significant gap in days to 50% flowering may also influence crop maturity in favour of bigger seeds.

3.3 Yield Components and Yield

The results obtained (Table 7) indicate no significant ($p \geq 0.05$) effect of seed size on number of pods/plant, pod weight, and shelling percentage, but significantly ($p \leq 0.05$) influenced 100-seed weight. Large sized seeds gave the highest 100-seed weight (45.26 g) followed by medium sized seeds (37.42 g) while small seed size had the least (23.10 g). The significant effect of seed size on 100-seed weight could significantly influence grain yield/ha [31,38,39, 40].

3.4 Length of Tap Root

The results obtained (Table 8) indicate that seed size significantly ($p \leq 0.05$) influenced tap root length with large seed size having the longest root length (25.30 cm), medium sized seeds having (17.00 cm) and small sized seeds with the shortest tap root length (11.40 cm). The significant effect of seed size taproot length could significantly influence depth of root forage for nutrients and water, thus crop survival.

Table 7. Number of pods/plant, pod weight shelling percentage and 100-seed weight as influenced by groundnut seed sizes

Seed size	Pods/plant	Pod weight	Shelling %	100-seed weight
Large seed size	7.40	7.84	72.45	45.26
Medium seed size	5.20	6.42	71.25	37.42
Small seed size	5.00	5.64	72.97	23.19
LSD	Ns	Ns	Ns	4.77**

*Ns -Not significantly Different at 5% level of probability; ** LSD-Least Significant Difference significantly different at 5% level of probability*

Table 8. Tap root length as influenced by groundnut seed size

Seed sizes	Root length from tap root
Large seed size	25.30
Medium seed size	17.00
Small seed size	11.40
LSD	5.23**

*** LSD-Least Significant Difference significantly different at 5% level of probability*

4. CONCLUSION

From the research carried out, some important parameters have been evaluated which could be used for predicting seedling vigour as determined by seed size (large, medium and small). These parameters are: days to seedling emergence, days to first flowering, days to 50% flowering, number of leaves per plant, plant height, stem girth, leaf area, number of pods per plant, pod weight per plant, 100-seed weight, as well as length of tap root. No significant effect of seed size was observed on groundnut canopy height, leaf number, leaf area, stem girth, days to first flower, number of pods / plant, pod weight, and shelling percentage, but seed size significantly influenced 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 tap root length could significantly influence farmers' opinion in the choice of seeds used in planting a field; as this will determine, crop maturity, grain yield/ha while length of tap root will affect depth of root forage for nutrients and water, thus crop survival. However, it is not uncommon for the early gains usually experienced in bigger seeds compared to smaller seeds to be smothered over time particularly in perennial crops. For annuals, such gains, could be the determining factor between a successful and a failed crop. This could also determine crops ability to compete for nutrients or survive hostile environment - including competition against weeds, or other pests. Early maturity could also mean produce getting to the market early, thus attracting better price.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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