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Original Article

Effect of Planting Method and Spacing on the Yield and Yield Components of Three Bambara Groundnut Cultivars in two Agro-Climatic Zones of Sierra Leone

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Abstract - *Identification of optimum inter-row spacing, planting method, and suitable cultivar is essential for maximizing the yield of any crop. The study was conducted in two agro-climatic zones to determine the appropriate inter-row spacing, planting method, and suitable Bambara groundnut cultivars that can improve crop yield and yield components. The treatments consisted of two planting methods, three inter-row spacing, and three Bambara groundnut cultivars. The study shows those yield parameters, including grain yield, biomass yield, total biomass yield, 100 seed weight, and fresh pod weight, were higher in Lungi when planting was done on a mound, whilst the value of these variables was higher in Kabala when planting was done on flat. For inter-row spacing, higher values were recorded using the wider inter-row spacing (50 cm x 20 cm) for most of the assessed yield and yield-related components. The result further shows that lubam1 recorded higher values for the yield and yield-related components at both locations. In addition, values for all the yield and yield-related components were, on average higher in Kabala compared to Lungi. In conclusion, to achieve higher yield and yield-related components of Bambara groundnut, it lubam1should be planted on a mound at Lungi and on flat land at Kabala using the wider inter-row spacing of 50 cm x 20 cm.*

Keywords *- Agro-climatic zone, Bambara groundnut, Biomass yield, Inter-row spacing, Yield component.*

1. Introduction

Bambara groundnut (*Vigna subterranea* (L.) Verdc.) is a crop that originated from Africa and is grown by small-scale subsistence farmers in sub-Saharan Africa and tropical South West Asia. It is the fourth most important grain legume after cowpea (*Vigna unguiculata* L.) and groundnut (*Arachis hypogea* L.) (Hillocks *et al.*, 2012; Jakusko, 2015). It has a huge potential to improve food security, particularly in drought-prone agricultural systems. Its drought tolerance attribute makes it ideal for resource-poor farmers' production, especially in communal and resettlement areas. It has many agronomic and nutritional potentials, making it an important crop to develop (Dakora and Muofhe, 1995). The protein and carbohydrate content of Bambara groundnut is in the range of 18.0-24.0 % and 42-70%, respectively (Adu-Dapaah *et al*., 2004; Amarteifio *et al*., 1997; FAO, 1964; Nwokolo, 1996).

According to Linnemann and Azam-Ali (1993), the yields of Bambara groundnut vary significantly among sites, seasons, and genotypes, with yields ranging from 650-850kg/ha, as reported by Stanton et al. (1966).

However, Sesay et al. (2004) got a seed yield of 2.6 t ha^{-1} in field trials in Swaziland. Bertie (2010) also reported pod and seed yields of 4.6 and 3.4 $ha^{-1,}$ respectively, which suggests that Bambara groundnut has a potential for high yield.

Other studies from different parts of Africa report significant variations in seeding rates and planting methods (Linnemann, 1992). Studies in highly leached soils of Bukoba in North Western Tanzania (Dunbar, 1969) showed that farmers plant Bambara groundnut at an average spacing of 30 cm x 30cm. In West Africa, Ameyaw and Doku (1983) recommended a plant spacing of 60 cm x 30 cm. Duke *et al.* (1977) also reported seed rate differences from 25 – 75 kg ha^{-1} with plant spacing varying from 30 cm-75 cm and 10 cm–50 cm respectively. Furthermore, in Zambia, it was shown that planting on a flat and spacing of (30 cm x 30 cm) with or without earthing-up resulted in no significant differences in yield (Kannaiyan, 1988, cited by Linnemann, 1992). Regarding the woodland savannas of Cote d'Ivoire, the highest yield was obtained with a plant density of 25 plants per square meter (Kouassi and Zoro, 2010).

In another study, at Ukiriguru in Tanzania, planting on either ridge or flat land resulted in no considerable difference in yield (Tanzania Ministry of Agriculture, 1970).

Animal protein is very expensive and therefore not easily affordable by the average Sierra Leonean whose income is very low. As such, the need to find alternative sources of protein that are cheaper and more affordable cannot be overemphasized in preventing malnutrition, especially in children. Thus, research priorities need to be re-directed to develop our local under-utilized crops like Bambara groundnut, which has a lot to offer in terms of nutritional value, drought tolerance, and relatively high pod yield (Linnemann and Azam-Ali, 1993).

Also, not much work has been done on variations in terms of yield among the different Bambara groundnut landraces, planting methods, and plant spacing in Sierra Leone. Field observations indicate that Bambara groundnut production by subsistence farmers is low, with unpredicted yields. A major reason for this could be probably because subsistence farmers mostly use their local varieties without any recommended spacing. Because of this, an experiment was conducted to determine the optimum plant spacing and planting method for cultivating Bambara groundnut.

Therefore, the research's objective was to establish the optimum plant spacing and planting method that will enhance the improved productivity of Bambara groundnut.

2. Materials and Methods

2.1. Experimental Site

The study was conducted under rain-fed conditions in 2018 and 2019 cropping seasons in two agro-climatic zones, namely, Lungi (8.5555N, 13.1636W) representing the coastal plains with a mean annual rainfall of 3,911.39 mm, mean annual temperatures of 25.08^{0}C and mean annual relative humidity of 83.59% and Kabala (9.5797N, 11.4408W) representing the savannah highland with an annual mean rainfall of 2,841.35 mm, mean annual temperatures of 24.86^{0}C, and mean annual relative humidity of 75.86%. The soil properties and locations of the trial are shown in table1 and figure 1, respectively.

2.2. Soil Collection and Analysis

Soil samples from the two experimental sites were collected at 0~30cm depth using a soil auger during the 2018 and 2019 cropping seasons. The collected samples were bulked, air-dried, and sieved. The bulked soil was used to determine the physical and chemical properties at Njala University Quality Control Laboratory (NUQCL), Njala, Sierra Leone. The Kjedhal distillation method was used to determine the total nitrogen content (Unkovich *et al*., 2008). Potassium was extracted by Ammonium acetate and determined by the flame photometer method. The Bray 1 method was used in determining the available Phosphorus. Soil pH (1:1) was determined using the pH Meter. The Organic soil carbon was determined by the Walkley-Black procedure. The hydrometer method was utilized in carrying out particle size analysis.

2.3. Land Preparation

The land at the two locations was slashed with a cutlass, burnt down, de-stumped, and dug using a hoe, and the plots were laid out using a measuring tape, garden line, and pegs.

2.4. Experiment Design, Treatments, and Planting

The experiment was a 3 x 3 x 2 factorial arranged in a randomized complete block design (RCBD) with three replications. The treatments consisted of three Bambara groundnut varieties (Lubam1, Lubam2, and Kabam1), three plant spacings (50 cm x 10 cm, 50 cm x 15 cm, and 50 cm x 20 cm), and two planting methods (Flat and mound). The plot size was 3 m x 3 m. The seeds for the trials were collected from the local farmers at the two zones, and seeds were sown in June of each cropping season at the rate of one seed per hill at a depth of 3cm. Weeding was done at two weeks intervals till harvest. Harvesting was done at the respective maturity dates of the three Bambara groundnut varieties.

2.5. Data Collection

The important yield and yield-related components collected included grain yield, biomass yield, total biomass yield, 100 seed weight, number of filled pods, and fresh pod weight. At harvest of the legume, the number of plants in the net plots was counted and recorded. Matured pods were harvested from the net plot. The grains were weighed on a sensitive balance, and the weight obtained was then extrapolated to Kg/ha. Biomass yield was determined by establishing a sample area within the net plot and the number of plants within the area recorded. The plants in the sampled area were removed by cutting them at ground level, and the total fresh weight was determined. This weight was extrapolated to Kg/ha. The hundred seed weight was determined by selecting at random 100 matured, well-dried seeds from a seed lot for each treatment and weighed. The number of filled pods was determined by counting the number of filled pods on five randomly selected plants in the net plot and the mean recorded. The fresh pod weight was determined at 77 days after sowing by harvesting all the matured pods from five randomly selected plants and weighed on a sensitive scale.

2.6. Data Analysis

The data collected were subjected to analysis of variance (ANOVA) using the SAS statistical package (SAS Institute, 2014), and means were separated using the Student Newman-Keuls Test (SNK) at a 0.05 level of significance.

3. Results

3.1. Grain Yield

Analysis using ANOVA reveals significant differences (P < 0.05) in grain yield concerning planting method, inter-row spacing, and cultivar (Table 2). For the planting method, grain yield was higher for the mound (703.41) in Lungi than planting on a flat (471.01). In the case of Kabala, grain yield was higher when planting was done on a flat (817.70) compared to the mound (752.84) (Table 2). For the location, grain yield was higher in Kabala (785.27) than in Lungi (587.21). The grain yield was 25.00 % higher in Kabala compared to Lungi.

Concerning inter-row spacing, higher grain yield was recorded for S3 (50 cm x 20 cm) followed by S2 (50 124 cm x 15 cm) and S1 (50 cm x 10 cm) at both locations. Grain yield was also higher at Kabala (785.27) than at Lungi (587.24) (Table 2). The grain yield concerning location was also 25.00 % higher at Kabala compared to Lungi.

Relating to cultivars at both locations, Lubam1 recorded a higher grain yield, followed by Lubam 2 and Kabam 1. Also, it was observed that Kabala registered a higher grain yield (845.33) with respect to cultivars compared to Lungi (587.24) (Table 2). The grain yield to cultivar was 31.00 % higher at Kabala than at Lungi. In addition, the three-way interactions among planting methods x plant spacing x cultivar with respect to grain yield at both locations were not significant (P > 0.05).

3.2. Biomass Yield

Concerning biomass yield, significant differences were recorded for planting methods and cultivars at both locations. However, for plant spacing, significant differences were only observed at Kabala (Table 2). With regards to planting method, the mound was observed to have recorded the highest biomass yield at Lungi, whilst planting on flat registered the highest in Kabala. In general, biomass yield was higher in Kabala (276.84) tha in Lungi (232.92). The biomass yield recorded at Kabala was 16.00 % higher compared to Lungi.

With regards to inter-row spacing, biomass yield was higher for S3 (50 cm x 20 cm) followed by S2 (50 139 cm x 15 cm) and S1 (50 cm x 10 cm) at Lungi, whilst biomass yield was higher for S3 (50 cm x 20 cm) followed by S1 (50 cm x 10 cm) and S2 (50 cm x 15 cm) at Kabala (Table 2). Generally, biomass yield was higher in Kabala (276.84) than in Lungi (232.93).

In the case of cultivars, higher biomass yield was reported for Kabam1 (370.78), followed by Lubam 2 (173.25) and Lubam 1 (154.74) at Lungi. On the other hand, a higher biomass yield was registered for Lubam1 (377.25), followed by Lubam 2 (336.04) and Kabam 1 (117.23) at Kabala. In general, biomass yield was higher in Kabala compared to Lungi (Table 2). Furthermore, the interactions among planting methods x plant spacing x cultivar with respect to biomass yield at both locations were not significant (P > 0.05).

3.3. Total Biomass Yield

Regarding total biomass yield, significant differences were registered for planting method, plant spacing, and cultivar (Table 2). For the planting method, at Lungi, the mound recorded the highest total biomass yield (998.59) than planting on a flat (641.75) (Table 2). Conversely, at Kabala, the flat registered the highest total biomass yield (1132.52) compared to when planting was done on the mound (991.71). For the location, Kabala registered the highest total biomass yield (1062.12) compared to Lungi (820.17) (Table 2). The total biomass yield recorded at Kabala was 23.00 % higher than at Lungi.

Concerning inter-row spacing, higher total biomass yield was recorded with respect to S3 (50 cm x 20 cm) followed by S2 (50 cm x 15 cm) and S1 (50 cm x 10 cm) for both locations. Also, the total biomass yield for plant spacing was higher at Kabala (1062.12) compared to Lungi (870.17) (Table 2).

Kabam1 registered the highest total biomass yield for cultivars at Lungi, followed by Lubam 2 and Lubam 1. On the other hand, Lubam 1 recorded the highest total biomass yield at Kabala, followed by Lubam 2 and Kabam1. The total biomass yield was generally higher at Kabala (1122.22) compared to Lungi (820.17) (Table 2). In addition, the three-way interactions among planting method x plant spacing x cultivar for the total biomass yield at both locations were insignificant (P > 0.05).

3.4. 100 Seed Weight

Regarding 100 seed weight, significant differences (P < 0.05) were recorded concerning the planting method at Lungi, wherein the mound registered a higher 100 seed weight (49.17) compared to when planting was done on a flat (40.58). At Kabala, no significant differences (P > 0.05) were registered (Table 3). Generally, a higher 100 seed weight was registered at Kabala (59.79) compared to Lungi (44.87). The 100 seed weight for Kabala was 25.00 % higher than Lungi.

Concerning inter-row spacing, no significant differences (P > 0.05) were recorded with regards to S1 (50 cm x 10 cm), S2 (50 cm x 15 cm), and S3 (50 cm x 20 cm) for both locations. The 100 seed weight for Kabala (59.79) was generally higher than Lungi's (44.67).

About cultivars, significant differences were recorded in relation to 100 seed weight in which, Kabam 1 registered the highest 100 seed weight (51.96) followed by Lubam 2 (42.85) and Lubam 1 (39.81) at Lungi. However, in Kabala, the highest 100 seed weight was also registered for Kabam 1, followed by Lubam 2 and Lubam 1 (Table 3). Also, the interactions among planting method x plant spacing x cultivar with respect to 100 seed weight at both locations were not significant (P > 0.05).

3.5. Number of Filled Pods

Pertaining to the number of filled pods, no significant differences (P > 0.05) were observed in relation to planting methods at Kabala. However, significant differences (P < 0.05) were recorded with regard to planting methods at Lungi. A higher number of filled pods were registered for the mound (5.14) compared to when planting was done on the flat (3.66). The number of filled pods for the mound was 29.00 % higher compared to the flat.

With regards to inter-row spacing, significant differences (P < 0.05) were registered for both locations for S1 (50 cm x 10 cm), S2 (50 cm x 15 cm), and S3 (50 cm x 20 cm). At both Lungi and Kabala, S3 186 (50 cm x 20 cm) recorded a higher number of filled pods, followed by S2 (50 cm x 15 cm) and S1 (50 cm x 10 cm) (Table 3). It was further observed that, on average, Kabala recorded a higher number of filled pods (12.51) compared to Lungi (4.40) (Table 3).

With regards to cultivars, significant differences (P < 0.05) were observed among Lubam 1, Lubam 2, and Kabam 1 at the two locations (Table 3). At Lungi, Kabam 1 registered the highest number of filled pods, followed by Lubam 2 and Lubam 1. However, Lubam 1 recorded the highest number of filled pods at Kabala, followed by Lubam 2 and Kabam 1. Moreover, Kabala recorded a higher number of filled pods (12.52) compared to Lungi (4.40) (Table 3). In addition, the three-way interactions among planting methods x plant spacing x cultivar with respect to the number of filled pods at the two locations were not significant (P > 0.05).

3.6. Fresh Pod Weight

Relating to the fresh pod weight, no significant differences (P > 0.05) were recorded in relation to planting method, plant spacing, and cultivar at both locations. For the planting method, even though there were no significant differences at both locations, the mound recorded a slightly higher value at Lungi, whilst the flat recorded a slightly higher value at Kabala (Table 3). Concerning location, kabala recorded a significantly (P < 0.05) higher value (2.12) compared to Lungi (1.71).

About inter-row spacing, S2 (50 cm x 15 cm) recorded a higher fresh pod weight (0.22) at Lungi, followed by S1 (50 cm x 10 cm) (0.20) and S3 (50 cm x 20 cm) (0.18). At Kabala, S1 (50 cm x 10 cm) registered a higher fresh pod weight (1.99), followed by S3 (50 cm x 20 cm) (1.96) and S2 (50 cm x 15 cm). Generally, Kabala registered a higher fresh pod weight (1.92) compared to Lungi (0.20). The fresh pod weight for Kabala was 90.00% higher than Lungi.

In the case of cultivars, Lubam 2 recorded a higher fresh pod weight (0.22) at Lungi, followed by Kabam 1 (0.20) and Lubam 1 (0.18). Conversely, at Kabala, Lubam 1 registered a higher fresh pod weight (2.14), followed by Lubam 2 (2.14) and Kabam 1 (Table 3). Furthermore, the three-way interactions among planting methods x plant spacing x cultivar with respect to fresh pod weight at both locations were not significant (P > 0.05).

4. Discussion

The identification of optimum plant spacing, planting method, and suitable cultivar is essential for maximizing the yield of any crop. Significant differences were recorded concerning grain and biomass yield with respect to planting method, with the mound recording the highest grain yield in Lungi compared to the flat. On the contrary, planting on flat land was observed to have recorded the highest grain and biomass yields in Kabala. The reasons for the disparity in grain and biomass yield between the two planting methods at the two locations could have been due to the differences in the rainfall pattern between the two locations. This result conforms to the findings of Mkandawire and Sibuga (2002), who reported higher grain yield for Bambara groundnut when planted on flats in areas where rainfall was higher, as in Lungi compared to Kabala. Similar results were reported by Valenciano *et al*. (2006) relating to peas and Neumann *et al.* (2007) for common beans. These authors reported that planting common beans on raised beds enhanced fast emergence without any increase in yield. Furthermore, Kannaiyan (1988), cited by Linnemann (1992) in Zambia, and Rweyemamu and Boma (1990) in Tanzania reported high yields of Bambara groundnut and groundnut (*Arachis hypogaea*), respectively, when planted on flat in the wet season, because of good drainage.

For the number of filled pods and 100 seed weights, no significant differences were recorded in Kabala relating to the planting method. On the other hand, differences in 100 seed weight and the number of filled pods were observed with respect to the planting method at Lungi, with the mound recording a higher value of the number of filled pods and 100 seed weight, respectively. The possible reason for the higher values of the 100 seed weight and the number of filled pods when planting was done on the mound compared to the flat could probably be due to the higher nutrient concentration and moisture attributed to the mound compared to the flat.

No significant differences were observed in the fresh pod weight between the two planting methods at the two locations. In general, all the yield and yield-related components were, on average higher in Kabala than at Lungi. The possible reasons for the above observation could be due to both climatic and soil factors. Kabala soil was generally higher in total nitrogen and organic carbon with a relatively higher pH value than Lungi (Table 1).

Concerning plant spacing, significant differences were recorded concerning grain yield, biomass yield, and the number of filled pods with S3 (50 cm x 20 cm), representing the least plant population recording the highest value for the measured parameters. One of the reasons for the above observation could be attributed to the fact that there was lower intra-plant competition and higher availability of growth factors in the plots with low plant populations compared to those with higher plant populations. Another possible reason could be the higher efficient utilization of growth factors in the plant spacing with a low plant population compared to a higher one. The positive influence of plant spacing on Bambara groundnut productivity could be related to the fact that in plots with the least population densities, developing pods could easily gain access to the soil surface due to the spreading growth habit of the plants, resulting in enhanced development. Plant growth could also be improved with lower planting densities due to less competition for resources (light, moisture, and nutrients), leading to better pod formation and growth. This result concords with the findings of Chandrasekaran 250 *et al*. (2007) and Bahr (2007), who reported a decrease in the seed yield of peanuts and chickpeas with increased plant density. Likewise, Eliesen and Freira (1992) and Edje *et al.* (1971) reported a decrease in the number of pods with an increase in plant population in groundnut and beans, respectively.

On the contrary, Agasimani and Hosmani (1989), working on different groundnut populations, have reported higher pod and grain yield in narrow plant spacing than in wider spacing. Annadurai et al. (2009) also reported higher pod and haulm yield of peanuts with close spacing than wider spacing. Also, while working with mung beans, Guriqbal et al. (2011) reported higher grain yield in higher plant populations. The reason adduced by these authors was that increase in the number of plants per unit area compensated for the reduction in the number of pods per plant at greater plant populations.

In the case of the 100 seed weight, there was no significant difference with respect to spacing in both locations. This result agrees with the work of Olukayode and Kolapo (2014), who reported a similar 100 seed weight of legumes with respect to inter-row spacing.

Concerning the cultivar effect on the grain yield of Bambara groundnut, Lubam1 recorded the highest grain yield at both locations, probably because of the early maturing characteristic of this variety compared to Kabam 1. This result agrees with the findings of Karikari (2000), who reported that early maturing Bambara groundnut varieties were high yielding because they emerged rapidly, flowered earlier, and had enough time to fill the pods. The number of filled pods and fresh pod weight for Lubam1 was higher in Kabala, which probably accounted for the higher yield of this variety in this location. However, even though the fresh pod weight and the number of filled pods for Lubam1 were the lowest in Lungi, the higher yield reported for this variety at this location could be attributed to its earliness.

For 100 seed weight, Kabam1 recorded the highest at both locations, even though its grain yield at both locations was the lowest. This could be attributed to its larger pod and seed size.

5. Conclusion

The result of this study revealed that the yield and yield-related components such as grain yield, biomass yield, total biomass yield, and fresh pod weight were higher when Bambara groundnut was planted on mounds in Lungi compared to Kabala. On the other hand, the values of these yield parameters were higher when planting was done on a flat in Kabala. Yield components such as 100 seed weight and the number of filled pods were higher when planting was done on the mound at both locations.

For plant spacing, the values of the yield components were, on average higher when Bambara groundnut was planted using the wider planting spacing regime. Lubam1 recorded the highest grain yield across the two locations in the case of the cultivars. Generally, all the yield-related components were higher in Kabala than in Lungi on average.

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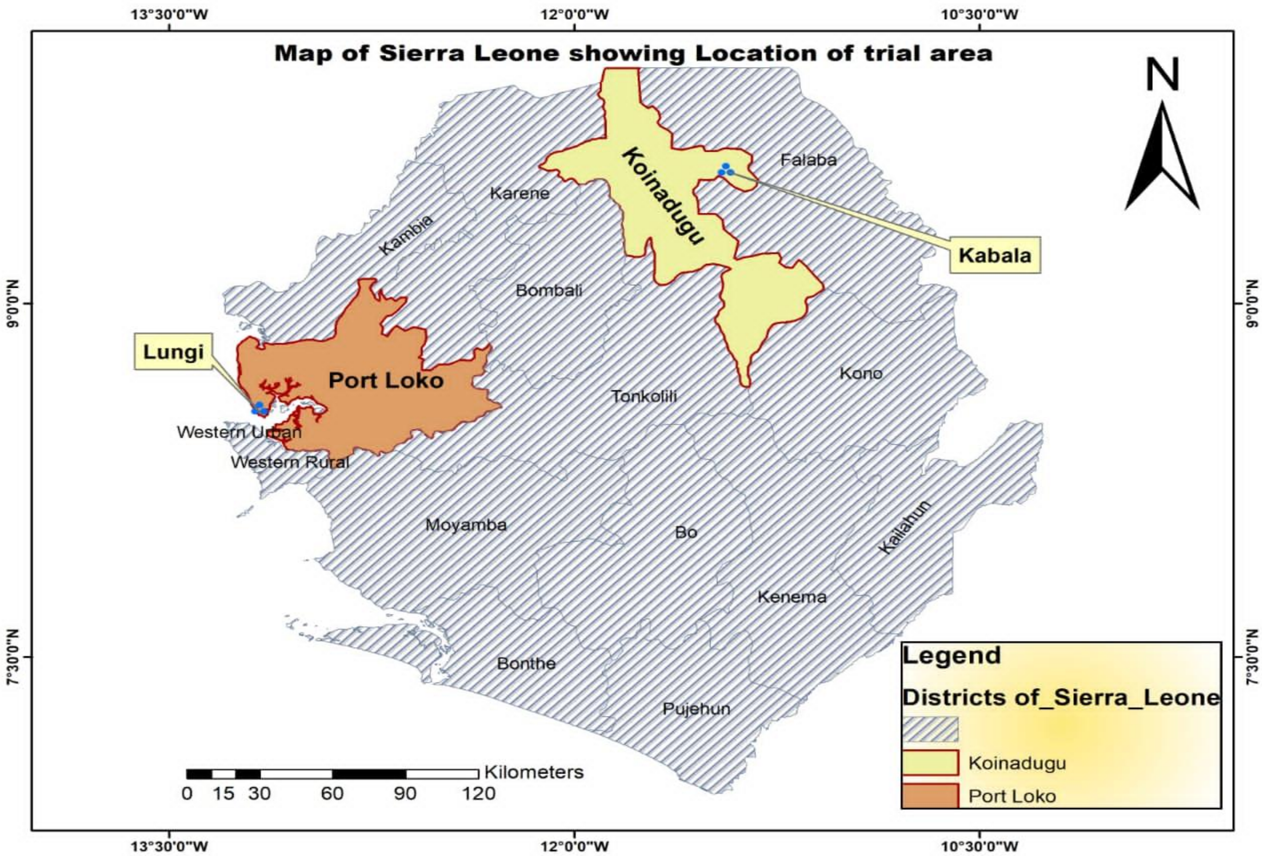

Fig. 1 Map of Sierra Leone showing trial locations

Appendix

Table 1. Physicochemical properties of the soil at the experimental sites

Physicochemical property	Lungi				Kabala			
	Initial	Final	Change	% Change	Initial	Final	Change	% Change
pH	4.99	4.65	-0.34	-6.81	5.40	5.18	-0.22	-4.25
Organic carbon (%)	1.83	1.57	-0.26	-14.21	2.06	1.78	-0.28	-13.59
Total nitrogen (%)	0.10	0.157	0.06	58	0.022	0.07	0.048	218.18
Available Phosphorus (mg /kg soil)	1.58	1.45	-0.04	-2.53	9.07	7.48	-1.59	-17.53
Exchangeable Potassium (mg/kg soil)	2.99	3.16	0.17	5.68	21.79	21.00	-0.79	-3.63
Soil texture	Loamy sand				Loamy sand			

Table 2. Effect of planting method, plant spacing, and Bambara groundnut cultivar on grain yield, biomass yield, and total biomass yield in two agro-climatic zones over two cropping seasons

Locations							
	Lungi			**Kabala**			
Treatments	**Yield Parameters (K/ha)**			**Yield Parameters (Kg/ha)**			**Mean**
	Yield	**Biomass yield**	**Total biomass yield**	**Yield**	**Biomass Yield**	**Total biomass yield**	
Planting method							
Flat	471.01	170.68	641.75	817.70	314.81	1132.52	**591.41 b**
mound	703.41	295.17	998.59	752.84	238.87	991.71	**663.43 a**
Mean	**587.21 b**	**232.92 b**	**820.17 b**	**785.27 a**	**276.84 a**	**1062.12 a**	
Plant spacing							
50 cm x 10cm	477.08	230.56	707.64	407.31	267.30	674.61	**460.75 c**
50cm x 15cm	547.26	233.08	780.34	753.04	254.15	1007.19	**595.84 b**
50cm x 20cm	737.38	235.14	972.53	1195.47	309.07	1504.55	**825.69 a**
Mean	**587.24 b**	**232.93 b**	**820.17 b**	**785.27 a**	**276.84 a**	**1062.12 a**	
Cultivar							
Lubam1	952.62	154.74	1107.37	1438.11	377.25	1815.37	**974.24 a**
Lubam 2	635.92	173.25	809.18	917.71	336.04	1253.75	**687.64 b**
Kabam 1	173.18	370.78	543.97	180.32	117.23	297.55	**280.51 c**
Mean	**587.24 b**	**232.92 b**	**820.17 b**	**845.33 a**	**276.84 a**	**1122.22 a**	

This means that columns with the same letter are not significantly different at P >0.05 (SNK)

Table 3. Effect of planting method, plant spacing, and bambara cultivar on number of pods, number of filled pods, and fresh pod weight in two agro-climatic zones over two cropping seasons

Locations							
	Lungi			**Kabala**			
Treatments	**Yield Parameters (K/ha)**			**Yield Parameters (Kg/ha)**			**Mean**
	100 Seed weight	**Number of filled pods**	**Fresh pod weight**	**100 Seed weight**	**Number of filled pods**	**Fresh pod weight**	
Planting method							
Flat	40.58	3.66	0.17	60.48	12.70	2.12	**4.66b**
mound	49.16	5.14	0.24	59.10	12.33	1.71	**4.86a**
Mean		**4.40b**	**0.21b**		**12.52a**	**1.92a**	
Plant spacing							
50 cm x 10cm	44.15	3.77	0.20	59.98	9.94	1.99	**3.98c**
50cm x 15cm	46.21	4.55	0.22	59.47	11.55	1.80	**4.53b**
50cm x 20cm	44.25	4.88	0.18	59.91	16.05	1.96	**5.77a**
Mean		**4.40b**	**0.20b**		**12.51a**	**1.92a**	
Cultivar							
Lubam1	39.81	5.61	0.18	52.98	17.88	2.14	**6.45a**
Lubam 2	42.85	4.88	0.22	54.73	14.38	2.11	**5.40b**
Kabam 1	51.96	2.72	0.20	71.65	5.27	1.48	**2.42c**
Mean		**4.40b**	**0.20b**		**12.52a**	**1.91a**	

This means that columns with the same letter are not significantly different at P >0.05 (SNK)