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BIOLOGICAL YIELD AND PROXIMATE COMPOSITION OF BAMBARA GROUNDNUT (*VIGNA SUBTERRANEA* (L) VERDC.) AS INFLUENCED BY SOWING DEPTHS AND SOIL TYPES

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ABSTRACT

Seeding at the appropriate depth and planting under suitable soil types are important factors for improvement of crop performance. In light of this, potted experiment was carried out at the University of Ilorin Botanical Garden to examine the effects of different sowing depths and soil types on the growth, yield and seed quality of bambara groundnut. The experimental layout followed completely randomized design with four replications. The treatment consisted of 0, 1, 2, 4 6 and 8 cm sowing depths and three different soil types (sand, loam and clay). Sowing at a depth of 1 cm produced the highest seedling emergence, tallest plant height, highest number of leaves, highest leaf area, highest yield components in terms of number of pods per plants, pod weight and seed weight per plant. The deepest sowing depth (8 cm), produced the lowest values of all the aforementioned parameters. Growth attributes were found to be highest in sandy soil compared to loamy and clayey soils. However, yield components were higher in loamy soil than other soil types. Sowing depths of 4-8 cm and clayey soil increased the percentage ash, fibre and carbohydrate contents of the seeds when compared to other sowing depths and soil types respectively. Therefore, for improved seedling emergence and biological yield, sowing depth of 1 cm under suitable soil types such as sandy and loamy soils could be considered appropriate for the cultivation of this crop. Fluctuation exists in all the proximate composition. However, sowing depth of 4-8 cm and clayey soil had a remarkable influence on some of the proximate compositions.

KEY WORDS: *bambara groundnut, Depth of sowing, Soil types, Growth, Yield, Seed quality.*

INTRODUCTION

Vigna subterranea (L) Verdc. belongs to the family Fabaceae. It is a crop of West African origin and cultivated in tropical Africa (Yamaguchi, 1983). The plant is cultivated primarily for its seeds which are used as human food. In Africa, it is the third most commonly eaten after groundnut and cowpea (Omoikhoje, 2008). In Nigeria, there are numerous traditional recipes such as chewing the roasted seed with palm kernel as snack item or milled into flour to prepare bean balls popularly known as *"Akara"* after frying the paste in vegetable oil. Alternatively, the slurry can be used to prepare a steamed gel known as "Okpa" (Uvere *et al.,* 1999). In many West African countries the fresh pods are boiled with salt and pepper, and eaten as snack and so many others uses such as porridge, soup and traditional weaning foods (Mbata *et al.,* 2009). Despite its usefulness and high and balanced protein content, the nut remains neglected and underutilized. The reasons that can be adduced for its under utilization is that it takes a long time to cook (3-4 hours). It also contains anti-nutritional factors such as tannins and trypsin inhibitor and its poor milling characteristics (Brimallaa & Anoghalu, 1997).

Bambara groundnut has been reported to yield better on poor soil in an area of low rainfall (500-800 kg/ha). The implication of this is that it can be grown without fertilizer which is costly and often difficult to access by rural farmers. The plant also thrives well on acidic laterites soils which are common in Africa but does less well on calcareous soils (Mkandawire, 2007). Depth of sowing has a number of effects on crop performance. For instance, deep sowing has been found to increase the time between seed germination as seedling emergence. This to a larger extent determines the ranking of seedlings in their competitive hierarchy for growth resources (Li, 1997). Different soil types and depth of sowing have also been reported to affect weed plants in terms of their germination and growth (Etejere & Okoko, 1989; Etejere & Olayinka, 2015). The biological productivity and composition of seeds harvested from different soil types and sowing depth is scanty. It is in this light, the present investigation was undertaken to provide information on the optimum sowing depth and soil type suitable for production of this crop for improvement of nutritional content of the seeds of this underutilized crop.

MATERIALS AND METHODS

Sample collection. The bambara groundnut used for this study was collected from the Department of Agriculture Unit of Lafiagi Local Government Area of Kwara State (latitude 8^0, 50^1N and longitude 5^0, 25^1E). The seeds were spread on tray to remove foreign particles. Healthy seeds were selected for the study. The soil types used (sand, loam and clay) were collected at different sites from the University of Ilorin Campus. The soil used for the sowing depth experiment was collected at University of Ilorin, Botanical Garden where the potted experiment for both soil types and sowing depths were carried out.

Biological productivity of bambara groundnut at different sowing depths and soil types. The effect of sowing depth on bambara groundnut was determined by sowing 10 cleaned seeds in pots (12cm x 17 cm) at depth of 0, 1, 2, 4, 6 and 8 cm. The depth was determined by inserting a graduated stick from the soil surface. The germination counts were made on daily basis for 10 days and the index of germination was protrusion of the cotyledon from the soil surface. After 10 days, the seedlings were thinned down one per hole within each sowing depth. In separate experiment, the effect of three soil types- loamy, sandy and clayey soils on growth of *V. subterranean* of were monitored for 15 weeks. In each soil type, twelve plastic of dimension 17 cm by 14 cm were used filled with different soil types. In both experiments, the pots were arranged following complete randomized design with four replications. The growth of *V. subterranean* at various depths and soil types in terms of plant height and number of leaves were determined at different crop growth stages. The parameters were evaluated at interval of three weeks. At 15^{th} week, the plants were carefully uprooted in each pot and parameters such as number of pod per plant pod and seed weights per plant were determined.

Seed quality of bambara groundnut under the influence of sowing depth and soil type. The harvested seeds after being air-dried for a period of seven days in different sowing depths and soil types were ground using Hammer mill and thereafter analyzed for proximate composition (moisture, ash, fibre, protein, fat and carbohydrate) at Nigerian Stored Product

Research Institute Biochemistry Laboratory Unit. The procedures employed were according to the standard methods of Association of Official Analytical Chemists (AOAC, 2000). Moisture contents were determined by heating five grams (5.0g) of well mixed ground sample in an oven (Gravity Convection Oven) at 103^{o}C for five hours to a constant weight. Ash content was determined by incinerating 5.0g of well mixed ground sample using hammer mill machine in a muffle furnace at600^{o}C for 3 hours until a light-grey ash was produced. Crude fibre was determined by extracting 5.0g of the ground sample with hexane in a thimble for six hours to free the sample of fat. Thereafter, 200 ml of 1.25% sulphuric acid was added to three grams (3.0g)of the free fat to remove the digestible nutrient in the fat. The resulting mixture was filtered in a Buchner funnel. The residue on the filter paper was in a muffle furnace at 600^{o}C for 30 minutes cooled in a desiccator and weighed. Crude fat determination was achieved by extraction procedure. Five grams of the ground sample was extracted with 150 ml petroleum ether as solvent in a Soxhlet extractor at a boiling point of 60-80^{o}C.The extraction was done for 6 hours with moderate boiling using Elecrothermal heater. Crude protein was determined by the Kjeldahl method by weighing out 1 g of the ground sample into Kjeldahl flask. The crude proteinwas calculated by a multiplying factor (% N x6.25). Carbohydrate was determined by difference. This was achieved by subtracting the sum of moisture, ash, protein, crude fat and crude fibre percentage from hundred. The energy value in each sample was calculated by multiplying the percentage protein and carbohydrate with 4 and percentage fat with 9. It should be noted that each of the foregoing was done in three replicates.

Data analysis. Fisher's method of analysis of variance was applied for the analysis and interpretation of data collected SAS. The level of significance used in F ratio was $p \leq 0.05$. Where F ratio is significant, means were separated using Duncan multiple range test.

RESULTS AND DISCUSSIONS

Effects of sowing depths on emergence of bambara groundnut. Various sowing depths significantly influenced ($p \leq 0.05$) percentage germination (Table 1). Seedling emerged at all depths investigated. Seedling emerged readily between 0-4 cm from 7 to 8 days after planting. At 10 days after planting significantly highest percentage emergence was recorded in seeds sown at 1 cm (92.3%) and followed by those sown on the soil surface (78.6%). Significant differences were not recorded in the percentage emergence of bambara groundnut seeds sown at the soil surface and those at 2 and 4 cm. Sowing depths at 6 and 8 cm significantly reduced emergence of bambara groundnut (Table 1).

TABLE 1: Influence of sowing depth on emergence of bambara groundnut

Sowing depth (cm)	Emergence (%)
0	78.6^{ab}
1	92.3^{a}
2	76.3^{ab}
4	76.3^{ab}
6	43.4^{b}
8	32.3^{c}
Mean	66.53
p-value	0.03
SEM	8.65

Within column mean values followed by the same superscripts are statistically similar at $p<0.05$

Effects of sowing depths and soil types on biological productivity of bambara groundnut. Plant heights of bambara groundnut response to sowing depth and soil types showed an increasing pattern with the age of the crop (Fig. 1.) Significant differences in plant height under different sowing depth were recorded in all the crop growth stages except at 15 weeks after planting (WAP). Plant height was generally enhanced in all the sowing depths. However, depth of sowing at 0, 1 and 2 cm had higher plant heights at 3, 6, 9 and 12 WAP when compared to other sowing depths (Fig. 1). In the soil types, significantly higher plant height was recorded in sandy soil when compared to other soil types. At all crop growth stages, plant height of barmbara groundnut in clay and loam soils were statistically the same (Fig 1.).

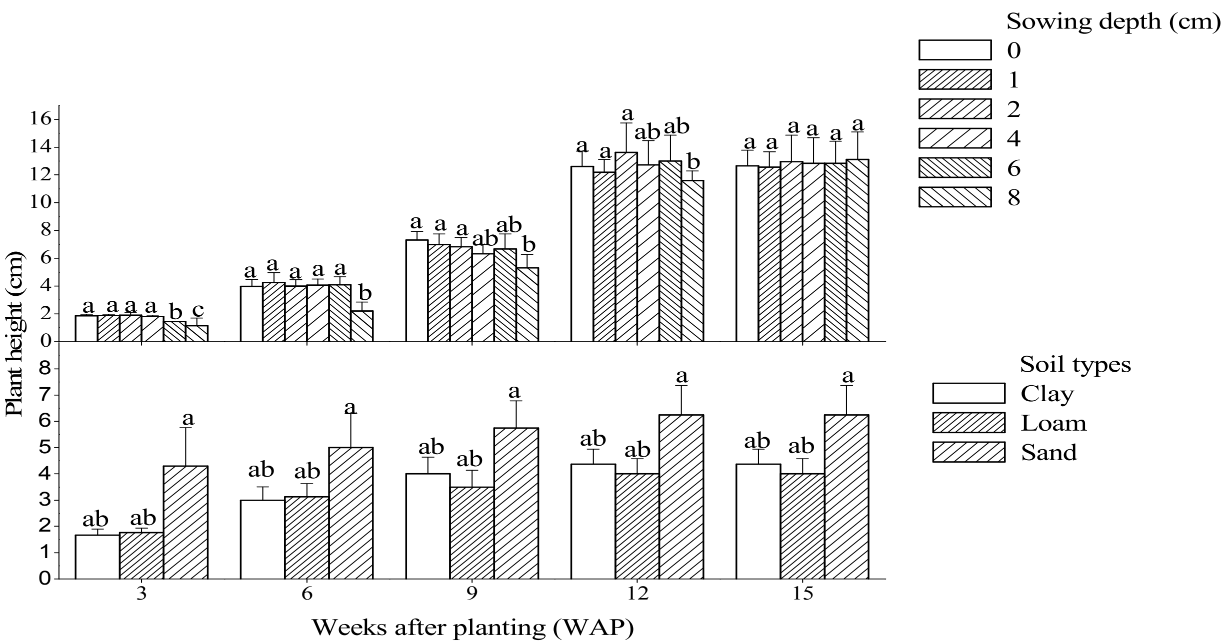

FIGURE 1. Plant height of bambara groundnut as affected by different sowing depths and soil types

Significant differences were recorded in number of leaves produced at all crop stages assessed under the influence of sowing depth and soil types. Number of leaves production decreased with increase in sowing depth. Highest number of leaves was produced when bambara nut was shown at the surface except at 6 and 9 WAP (Fig 2.). Number of leaves with respect to soil types showed similar trend of results as recorded for plant height (Fig 2).

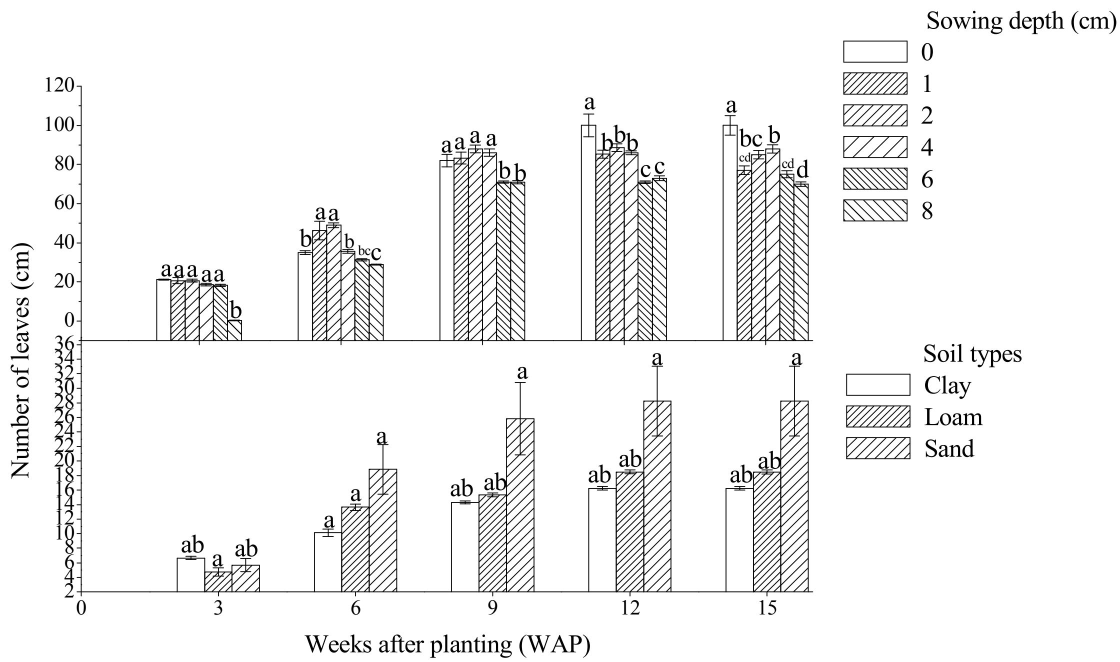

FIGURE 2. Number of leaves as affected by different sowing depths and soil types

The results of leaf area are presented in Fig 3. This was found to increase with the age of the crop with slight declination at final sampling date under different sowing depth. During most of the crop growth, highest leaf area was produced from seed sown on the soil surface and followed in decreasing order of magnitude by those of 1, 2, 4 and 6 cm. significantly lowest leaf area was recorded at highest sowing depth of 8 cm. Soil types significantly influence leaf area production except at 3 and 6 WAP. At 6 to 15 WAP, highest leaf area of the nut was recorded in sandy soil and followed in decreasing other of magnitude by those of loamy and clay whose values remain statistically the same (Fig 3).

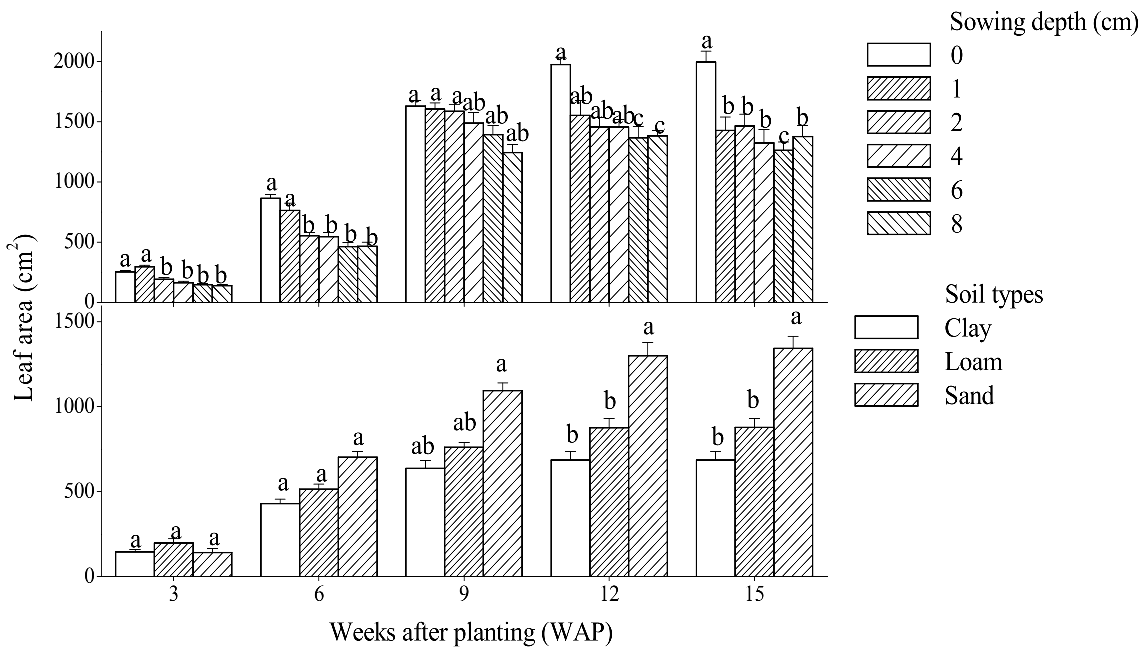

FIGURE 3. Leaf area of bambara groundnut as affected by different sowing depths and soil types

The results of yield components as influenced by differences in sowing depth and soil types are presented in Table 2. Sowing depth significantly affect number of pod per plant, pod and seed weight per plant. Depth of sowing at 1 cm had highest number of pods per plant (11.00 ±0.11), pod weight (8.01±0.45 g) and seed weight per plant (.5.85±0.87 g). These values wre not statistically different from those recorded from sowing depths of 2, 6 and 8 cm except for number of pod per plant. Seed sown at 4 cm depth showed significantly lowest number of pod per plant, pod and seed weight per plant with respective mean values of 2.56±0.05g 1.15±0.03g and 0.63±0.02g (Table 2). Significant differences were not recorded for soil types on all the yield components except pod weight per plant. However, loamy soil had the highest number of pod per plant pod and seed weight per plant and followed in decreasing order of magnitude by those of sandy soil. Lowest yield components were recoreded in clayey soil (Table 2).

TABLE 2: Influence of different sowing depths and soil types on yield components of bambara groundnut

Sowing depth (cm)	Number of pods per plant	Pod weight per plant (g)	Seed weight per plant (g)
0	8.67±0.34[ab]	5.36±0.22[a]	4.14±0.43[a]
1	11.00±0.11[a]	8.01±0.45[a]	5.85±0.87[a]
2	8.33±0.23[ab]	5.78±0.01[a]	3.92±0.76[ab]
4	2.56±0.05[d]	1.15±0.03[b]	0.63±0.02[b]
6	6.91±0.01[bc]	4.86±0.56[a]	3.38±0.04[ab]
8	10.86±0.12[a]	5.52±0.02[a]	3.78±0.011[ab]
Mean	7.39	5.12	3.61
P-value	<0.001	0.013	0.04
Soil types			
Clay	5.25 ± 0.25[a]	7.66 ± 1.36[ab]	5.54±0.17[a]
Loamy	9.75 ±0.85[a]	13.08 ±1.34[a]	9.78±0.45[a]
Sand	7.50 ± 0.65[a]	10.45 ±0.45[a]	6.12±0.23[a]
Mean	7.50	10.39	7.15
P-value	0.07	0.04	0.09

Within column mean values followed by the same superscripts are statistically similar at $p<0.05$

Effects of sowing depths and soil types on bambara groudnut seed quality. Effects of sowing depth and soil type on seed quality of bambara nut are summarized in Table 2. Percentage moisture, protein, ash, fat, fibre and carbohydrate ranged from 11.17±0.55 ─ 10.42 ± 0.42%, 19.98±1.09 - 18.24±0.48%, 3.47±0.22 ─ 4.19±0.35%, 6.20±0.51 ─ 5.49±0.65%, 5.25±0.13 ─ 4.65±0.11%, 56.42±3.45 ─ 54.53±3.95 % respectively (Table 3). Differences recorded in all the proximate composition were significant ($p<0.05$). Seed quality such as moisture, protein and fat were found to show inverse relationship with the sowing depth. Whereas, ash, fibre and carbohydrate increased with increase in depth of sowing (Table 3). Percentage moisture, protein and fat were significantly higher when bambara seeds were sown between 0-2 cm compared to other sowing depths. Conversely, the ash, fibre and carbohydrate were significantly higher at sowing depths between 4-8 cm. Significantly highest values of these seed qualities were recorded at the highest sowing depth of 8 cm. Generally, the nut was very rich in carbohydrate followed by protein, moisture, fat, fibre and ash (Table 3).

Significant differences were also noticed in the seed quality of bambara nut under different soil types. Percentage moisture, protein, ash, fat fibre and carbohydrate had respective values which ranged 12.59 ±0.12 ─ 12.05±0.96%, 23.71±0.29 ─ 22.58±0.34%, 3.40±0.07 ─ 2.76±0.05% 6.18±0.04 ─ 7.88±0.06%, 4.06±0.03 ─ 4.06±0.03% and 51.15±0.28 ─ 48.99±0.22% (Table 2). Loam soil significantly enhanced percentage moisture, protein and fat and followed in decreasing order of magnitude by those of sandy and clayey soil. Percentage ash, fibre and carbohydrate were however significantly highest in clayey soil when compared to sandy soil and loamy soil. Seeds harvested in loamy soil showed significantly lowest ash, fibre and carbohydrate (Table 3).

TABLE 3: Seed quality of bambara groundnut as influenced be different sowing depths and soil types

Sowing depth	Moisture	Protein	Ash	Fat	Fibre	Carbohydrate
			%			
0	11.17±0.55[a]	19.98±1.09[a]	3.47±0.22[d]	6.20±0.51[a]	4.65±0.11[d]	54.53±3.95[e]
1	10.99±0.45[a]	19.71±1.01[a]	3.82±0.31[c]	5.89±0.31[b]	4.72±0.23[d]	54.86±5.66[d]
2	10.81±0.06[c]	19.33±0.90[b]	4.01±0.23[b]	5.80±0.41[b]	4.92±0.65[c]	55.01±1.89[d]
4	10.64± 0.52[d]	18.96±0.97[c]	4.07±0.18[ab]	5.67±0.11[c]	4.95±0.22[c]	55.71±1.51[c]
6	10.57±0.42[de]	18.61±0.78[d]	4.15±0.44[ab]	5.58±0.39[cd]	5.09±0.33[b]	56.03±2.43[b]
8	10.42±0.37[e]	18.24±0.48[e]	4.19±0.35[a]	5.49±0.65[d]	5.25±0.13[a]	56.42±3.45[a]
Mean	10.76	19.14	3.95	5.77	4.93	55.43
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Soil type						
Sand	12.56±0.35[b]	23.23±0.14[b]	2.97±0.02[b]	7.38±0.06[b]	4.36±0.02[b]	49.59±0.02[b]
Clay	12.05±0.96[a]	22.58±0.34[c]	3.40±0.07[a]	6.18±0.04[c]	4.63±0.05[a]	51.15±0.28[a]
Loam	12.59±0.12[a]	23.71±0.29[a]	2.76±0.05[c]	7.88±0.06[a]	4.06±0.03[c]	48.99±0.22[c]
Mean	12.40	23.18	3.04	7.15	4.35	49.88
p-value	0.02	<0.001	<0.001	<0.001	0.01	<0.001

Within column mean values followed by the same superscripts are statistically similar at $p<0.05$

The germination of bambara groundnut seeds was significantly influenced by sowing depths as demonstrated in this study. It increased significantly with decrease in sowing depth. The results agreed with the finding of Etejere and Olayinka (2015) where highest percentage germination of *Tithonia diversifolia* was recorded at shallow depth of sowing. The enhanced emergence of the seeds at 1 cm depth and that of soil surface (0 cm) may be attributed to the distance of the seed to the soil surface, where the hypocotyl readily emerged from the seed and pushed it way up through the soil in a relatively short time as compared to those that were planted at the deeper depth (6-8 cm) which showed low percentage germination. Loughton *et al*. (1996) recorded delayed emergence, thinner stands and lower crop yield as depth increases in *Asparagus.* The enhanced growth attributes such as plant height, number of leaves and leaf area at shallow depth of sowing (0-2cm) could be linked to earlier emergence of the seeds which enable the plants sown under these depths to have access to growth resources over those sown far down from the soil surface (Li, 1997). In the soil type, sandy soil encouraged better growth of bambara groundnut as compared to clayey and loamy soils. The enhanced growth in sandy soil could be due to larger air space present in the soil particles and adaptability of bambara groundnut to poor soil (Brink, 1999).

Pod and seed yield were higher at sowing depth of 1cm compared to other sowing depths. This yield improvement could be attributed to increase in yield components such as number of matured pods and seeds per plant coupled with better access to growth resources as earlier indicated. Appropriate depth of sowing have been shown to be an important factor in maximizing the potential of seedling emergence and crop yield (Aikins *et al*., 2011). Loamy soil favoured higher yield as compared to other soil types on account of its higher organic nutrient, better water holding capacity and better aeration. Similar findings have been reported by Etejere and Olayinka (2015) in their studies of effect of sowing depths and soil types on growth of *Tithonia diversifolia*. Low yield components in clayey soil may be traced to the compact nature of the soil which promotes water logging, low nutrient content and poor aeration. However, significant differences were not recorded for yield components except for pod weight per plant. Yield stability characteristic of bambara groundnut is mainly due to its adaptability to poor soil, high temperature and low rain fall (Brink, 1999; Mikandawire & Sibuga, 2002; Mwale *et al*., 2007).

There were fluctuations on the values of proximate composition of the bambara groundnut seeds harvested from different sowing depths and soil types. For instance, shallow seeding favored increase moisture, protein, and fat contents of the seeds. Whereas, ash, fibre and carbohydrate were enhanced at deep sowing depths. Loamy soil had marked influence on moisture, protein, and fat when compared to other soil types. Seeds harvested from sandy soil were low in all the proximate composition except carbohydrate when compared to loamy soil. Variation in proximate composition had been reported for groundnut under different land preparation methods (Olayinka *et al*., 2015). Regardless of sowing depths and soil types, the fat content of the seeds was generally low when compared to those of groundnut cultivars (Atasie *et al*., 2009; Olayinka & Etejere, 2013; Olayinka *et al.,* 2015). Protein and carbohydrate contents were very high and this shows that the seeds are good sources of food supplement and energy for livestock feeds (Olayinka & Etejere, 2013). Crude fiber recorded in this study was generally low. Diets low in crude fibre are undesirable as they could cause constipation and colon diseases like piles, appendicitis and cancer (Atasie *et al*., 2009).

CONCLUSION

Different sowing depths and soil types have been shown to influence biological productivity and seed quality of bambara groundnut. For improved crop performance, the plant should be sown at depth of 1 cm under a suitable soil type such as sandy and loamy soils. However, deep sowing depths of 4-8 cm and clayey soil had positive influence on ash, fibre and carbohydrate contents of bambara groundnut seeds.

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