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Full Length Research Paper

Growth and nutrient uptake of cashew (*Anacardium occidentale* L.) seedlings as affected by nut-size in the nursery

L. A. Hammed[1]*, B. A. Lawal[2] and K. A. Kolapo[2]

[1]Department of Horticulture, University of Agriculture Abeokuta (UNAAB), Nigeria.
[2]Department of Agronomy, Ladoke Akintola University of Technology (LAUTECH), Nigeria.

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Cashew (*Anacardium occidentale*) is a tree crop with economic values traded for its nuts world-wide. Seedlings growth and uptake of N, P, K, Ca and Mg as influenced by size of nuts sown was investigated in the nursery. Three nut sizes: Jumbo (> 16 g), medium (4 to 8 g) and madras (< 2 g) were tried. The experiment was in completely randomized design with 4 replications. Data were collected on seedlings height, stem girth, number and area of leaves and dry matter yield. Nutrient uptake was calculated monthly from nutrient content and dry matter yield of the seedlings' samples for 3 months. Cashew seedlings raised from jumbo nut-size had 71.5, 55.5 and 83.3% height advantages, compared with the seedlings raised from madras nut-size at 1, 2 and 3 months after sowing (MAS) respectively. The leaf production of cashew seedlings raised from jumbo nut-size was more than those of seedlings raised from medium and madras nut sizes by 41.4 and 43.6% at 1 MAS, 14.7 and 28.0% at 2 MAS, 13.4 and 73.0% at 3 MAS in that order. The stem girth of the seedlings raised from jumbo nut-size was 51.6, 41.4 and 64.1% larger than the stem that of the seedlings raised from madras nut-size at 1, 2 and 3 MAS respectively. The differences were all significant (P < 0.05). The dry matter analysis shows that at 1 MAS, seedlings raised from jumbo nut-size had 31.7 and 311.6% higher dry matter yield, than the seedlings raised from medium and madras nut sizes respectively. At 2 MAS, seedlings raised from jumbo nut-size had 34.2 and 140.8% dry matter advantages compared with the seedlings raised from medium and madras nut sizes respectively. The differences were all significant at P < 0.05. Nitrogen content was highest in all seedlings irrespective of the nut-size. This was followed by Ca, Mg, K and P contents in that order. Uptake of these nutrients was used to predict nutrient needs of the seedlings in the nursery. Uptake of N was highest followed by uptake of Ca, while that of P was lowest irrespective of nut-size used to raise the seedlings. Seedlings raised from jumbo nut-size had highest uptake of each of these macronutrients with 0.111, 0.011, 0.0154, 0.0379 and 0.0206 g/plant of N, P, K, Ca and Mg respectively. It can be concluded that, Jumbo sized nut of cashew is hence preferred for cashew seedlings production followed by medium sized nut.

Key words: *Anacardium occidentale*, nut-size, seedlings growth performance, nutrient uptake.

INTRODUCTION

Cashew (*Anacardium occidentale*, L.) is a nut crop traded worldwide for its highly nutritious nuts (Azam-Ali and Judge, 2001; Grundon, 2000; Umeh, 2007). The major activities of growth of seedlings involve the establishment of root and shoot tissues for autotrophism. This is accomplished through stored food energy and primarily influenced by the soil environment (Nelson and Larson, 1984). In cashew nuts, the cotyledons of the seedlings have been reported to serve as repository of all classes of nutrients and minerals (Nandi, 1998; Opeke, 2005).

The cotyledons in conjunction with soil nutrient reserves provide sources of nutrients to the germinating.

*Corresponding author. E-mail: kunlecashew@yahoo.com.

seedlings of cashew (Hammed and Adeyemi, 2005). The field establishment of the crop starts from the nursery Good performance of seedlings in the nursery translates into good and encouraging field establishment of crops (Brown, 1984). Top soil, which happens to be one of the requirements for the production of seedlings in the nursery, has become a competitive material due to high demands for construction of buildings. This had led to the use of different types of soils, especially sub soil with shallow nutrient status compared to the top soil, for raising seedlings in the nursery. This might have led to reduced performance of the seedlings in the nursery and could have corresponding effects on the plant's performance after transplanting into the field (Brown, 1984). This might have contributed to the earlier observations that cashew does not perform well after being transplanted into the field (Adenikinju et al., 1996), whereas lack of understanding of the growth pattern of the crop seedlings in the nursery (Hammed, 2008) and its poor growth conditions in the nursery, might have been translated into poor field establishment of the crop after transplanting into the field. Besides, the earlier belief that cashew flourishes in soils where most other crops fail (Ohler, 1979) might have again contributed in no small measure to the problem.

In a related study, Lucas et al., (1979), while studying content and uptake of nutrients in oil palm seedlings in the nursery reported that K is highest followed by N, Ca, Mg and P in that order. They further reported that most of the nutrients were in the leaves and petiole, with a dramatic increase in amount of nutrient uptake in November probably due to increased evapotranspiration at this period of the year in the tropics. This had formed the basis for fertilizer application in oil palm seedlings in Nigeria. In Australia, Grundon, (2001) tried a similar study on cashew plants using dry matter yield of cashew plants obtained by Falade (1978), Reddy and Reddy (1987) and Richards (1990, 1992, 1993) to formulate fertilizer application regimes for cashew plants of different ages on the field in Australia.

It has been reported, in Nigeria, that the thriveness of cashew plants under conditions where most other crops fail (Ohler, 1979) had similarly been affecting the performance of the crop, especially under a situation where rich top soil is being competed for by urbanization. Therefore, to formulate an acceptable nutrient supplement for the crop's seedlings in the nursery, the uptake of the nutrients especially N, P, K, Mg and Ca is deemed important. Of equal importance is the period of increased uptake of these nutrients. This empirical information will provide an insight into the pattern of uptake of these nutrients by cashew seedlings and when to make them available to the plants in the nursery. The experiment is therefore set up to study the performance of cashew seedlings as affected by size of nuts sown and at the same time study the content and uptake of some major nutrient elements namely N, P, K, Ca and Mg by cashew seedlings.

MATERIALS AND METHODS

This study is based on a nursery experiment carried out at the Cocoa Research Institute of Nigeria (CRIN), Ibadan, located at the southern part of Oyo State in the Western part of Nigeria, Longitude 3.90°E, Latitude 7.43°N and Altitude 122 m above sea level, with an annual rainfall of between 1,250 and 1,500 mm and an average temperature of 27°C (CRIN, 2001). The rainfall pattern is bimodal with peaks in June / July and September. Thus, the climate is monsoon-type with rainforest ecology. The months of December to February were periods of dry season in which there is virtually no rain. Out of the six nut sizes (jumbo, extra-large, large, medium, small and madras) identifiable in cashew, cashew nuts used for this study were the jumbo nuts (> 16 g), the medium nuts (4 to 8 g) and the madras nuts (< 2 g).

Each of the three nut sizes selected for this study is produced by a specific cashew tree. This implies that each of the three nut-sizes is not a blend of any two nut-sizes. The three nut-sizes of cashew constituted the treatments and experiment is laid out in completely randomized design with four replications. Black plastic pots (capacity, 5 kg) were filled with top-soil, leaving a space of 5 cm to the brim (in order to allow for watering). The nuts were sown flat, on the seed sides, as recommended by CRIN (1971); Hammed and Adeyemi (2005) at seeding rate of 1 nut per pot and 6 pots per treatment per replication. There were 72 pots in the experiment, arranged on black polythene sheet spread on the ground, in order to prevent the roots of cashew seedlings from growing out of the rhizosphere - plastic pots. Cultural operations of watering and weeding were regularly carried out.

The plants were destructively sampled monthly for three months. Two cashew seedlings from each of the three nut sizes per replication were randomly selected each month. Therefore, a total of eight seedlings of cashew per nut-size were harvested each month. The following morphological plant parameters were measured on each of the cashew seedlings: plant height (cm), stem circumference (cm), total leaf area (cm^2), canopy area (cm^2) and number of branches. The plastic pots were later emptied of the soils and the cashew seedlings. The seedlings' roots were carefully removed from soil particles by immersing the roots in water and carefully washed clean. The plants were spread on laboratory side-benches and tissue-paper was used to dry off the water droplets. The plants were later separated into leaf, stem and root components and their fresh weights measured with a satorious (310 g) weighing balance. They were enveloped, labeled and oven-dried at 80°C, until a constant weight was obtained, in a force drought oven. The plant's parts were separately weighed, milled using a micro-pulverizer, bagged and labeled for nutrient content analysis.

Analysis of data

The data generated from the plants' morphological parameters were subjected to analysis of variance procedure using CoStat software programme (CoStat, 1986). The treatment means were separated using standard error bars.

Analyses of nutrient contents of cashew seedlings in the nursery

The milled monthly plant (seedling) samples were analyzed for nitrogen, phosphorus, potassium, calcium and magnesium contents at the analytical laboratory of

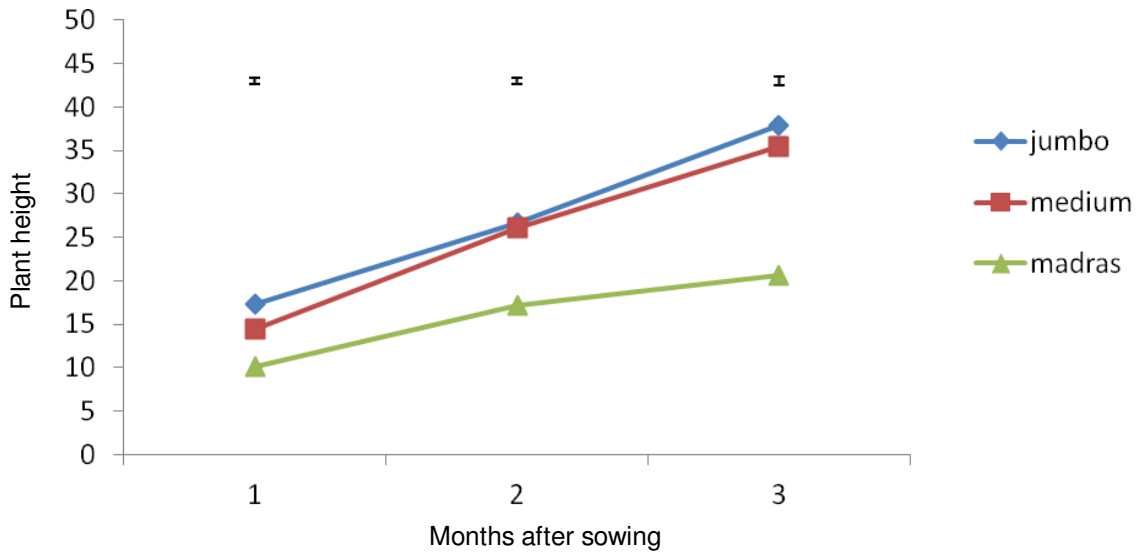

Figure 1. Plant height (cm) of cashew seedlings as affected by nut-size in the nursery.

the Department of Agronomy, University of Ibadan. The analyses were carried out for each of the component parts (leaf, stem and root) of the cashew seedlings. 2 g of the milled samples were digested using wet digestion method. The percent contents of K, Ca and Mg were determined from the digest using atomic absorption spectrophotometer (AAS). Phosphorus content was determined through vanadomolybdate (orange-yellow) method. Total nitrogen was determined by micro-Kjeldahl method.

Nutrient uptake of cashew seedlings in the nursery

From the results of the nutrient content of the plant samples, the nutrient uptake was calculated thus:

$$\text{Nutrient uptake} = \frac{\text{Nutrient content x Dry Matter per plant (g/plant)}}{100}$$

(Lucas, 1977)

RESULTS

Quantitative plant vigour of cashew seedlings

Plant vigour was assessed using the plant height (cm), number of leaves, total leaf area (cm^2), stem circumference (cm), number of shoot and canopy area (cm^2) of cashew seedlings. The height of cashew seedlings was significantly affected ($P < 0.05$) by the size of nuts sown in the nursery. Cashew seedlings raised from jumbo nut-size had 71.47, 55.46 and 83.28% height advantages compared with the seedlings raised from madras nut-size at 1, 2 and 3 months after sowing (MAS) respectively. The differences were significant at $P < 0.05$ (Figure 1).

The leaf production of cashew seedlings was influenced significantly ($P < 0.05$) by nut-size of cashew sown in the nursery (Figure 2). The leaf production of cashew seedlings raised from jumbo nut-size was more than those of seedlings raised from medium and madras nut-sizes by 41.43 and 43.61% at 1 MAS, 14.74 and 28.03% at 2 MAS, 13.40 and 72.97% at 3 MAS in that order and the differences were significant at $P < 0.05$ (Figure 2). However, differences in leaf production between the seedlings raised from medium and madras nut-sizes began to show from 2 MAS and the differences became significant at 3 MAS. At this period, the seedlings raised from medium nut-size had 52.54% more leaf production than the seedlings raised from madras nut-size (Figure 2).

Cashew seedlings responded differently to the size of nuts sown with respect to their stem circumferences and these differences were significant at $P < 0.05$ (Figure 3). The stem circumference of the seedlings raised from jumbo nut-size was 51.56, 41.36 and 64.095% higher than the stem circumference of the seedlings raised from the madras nut-size at 1, 2 and 3 MAS respectively. The differences were significant at $P < 0.05$ (Figure 3). The size of cashew nuts shown had significant effects ($P < 0.05$) on the leaf areas of the seedlings raised (Figure 4). The total leaf area of cashew seedlings raised from raised from jumbo nut-size was larger than the those from medium and madras nut-sizes by 93.28 and 345.03% at 1MAS, 75.45 and 280.50% at 2MAS, 18.83 and 228.68% at 3MAS in that order and the differences were significant at $P < 0.05$ (Figure 4). With regard to the plants' canopy area, the seedlings raised from jumbo nut-size had larger canopy than the seedlings raised from

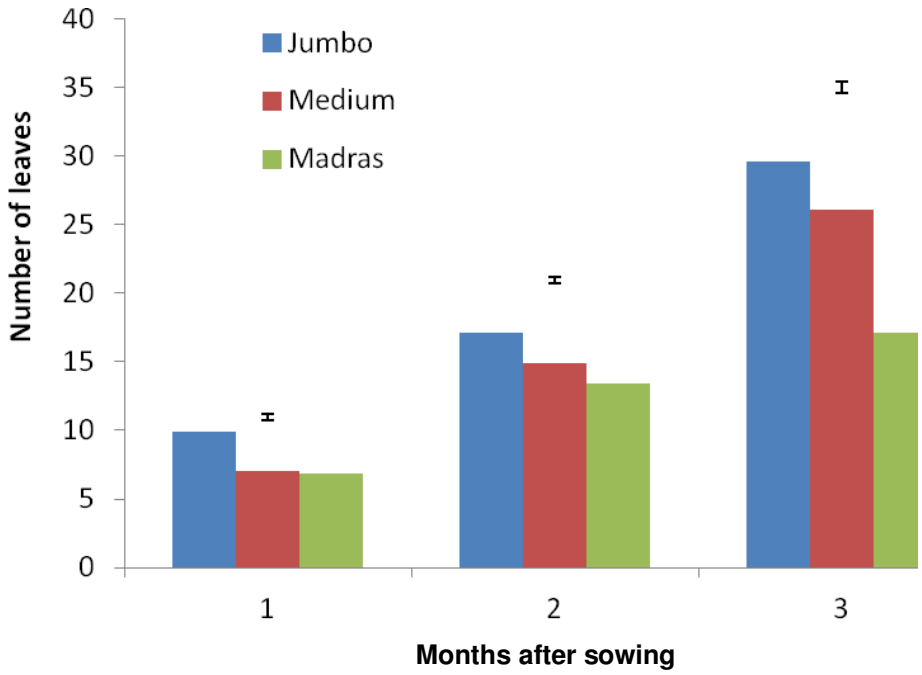

Figure 2. Number of leaves of cashew seedlings as affected by nut-size in the nursery.

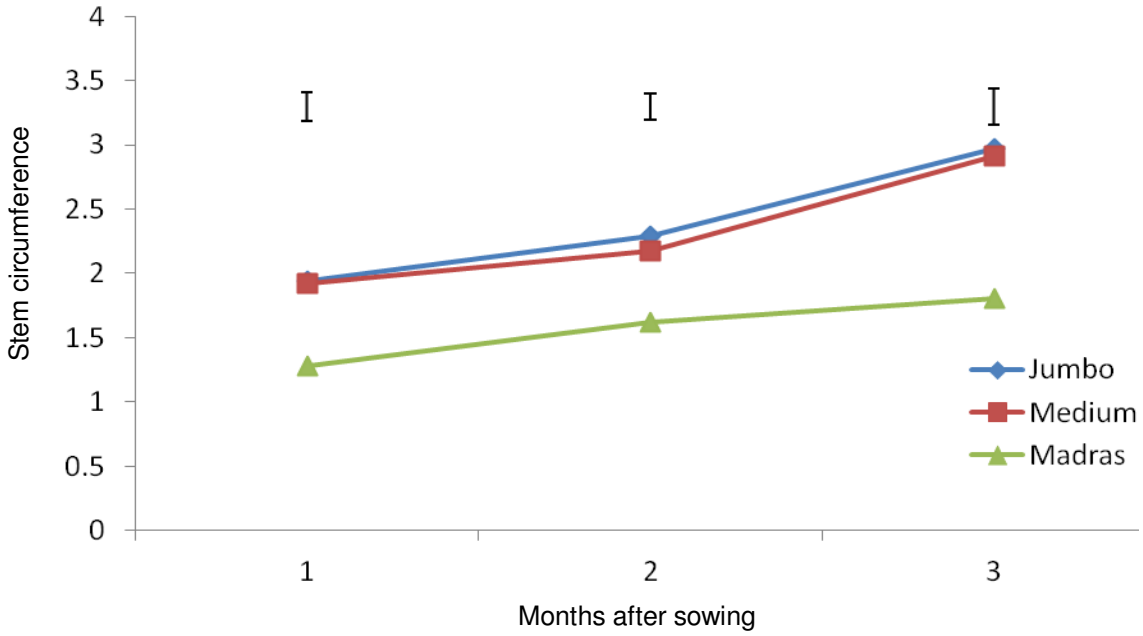

Figure 3. Stem circumference (cm) of cashew seedlings as affected by nut-size in the nursery.

both the medium and madras nut-sizes.

At 1 MAS, the cashew seedlings raised from jumbo nut-size had 36.95 and 382.94% larger canopy than those seedlings raised from medium and madras nut-sizes respectively. Also, at 2 MAS, cashew seedlings raised from jumbo nut-size had 50.68 and 239.56% larger plant canopy than those seedlings raised from medium and madras nut-sizes respectively. Similarly, at 3 MAS, the seedlings raised from jumbo nut-size had 58.31 and 257.21% larger plant canopy area compared to seedlings raised from medium and madras nut-sizes in that order and the differences were significant at $P < 0.05$ (Figure 5). The cashew seedlings raised from jumbo nut-size had significantly higher ($P < 0.05$) number of shoot production

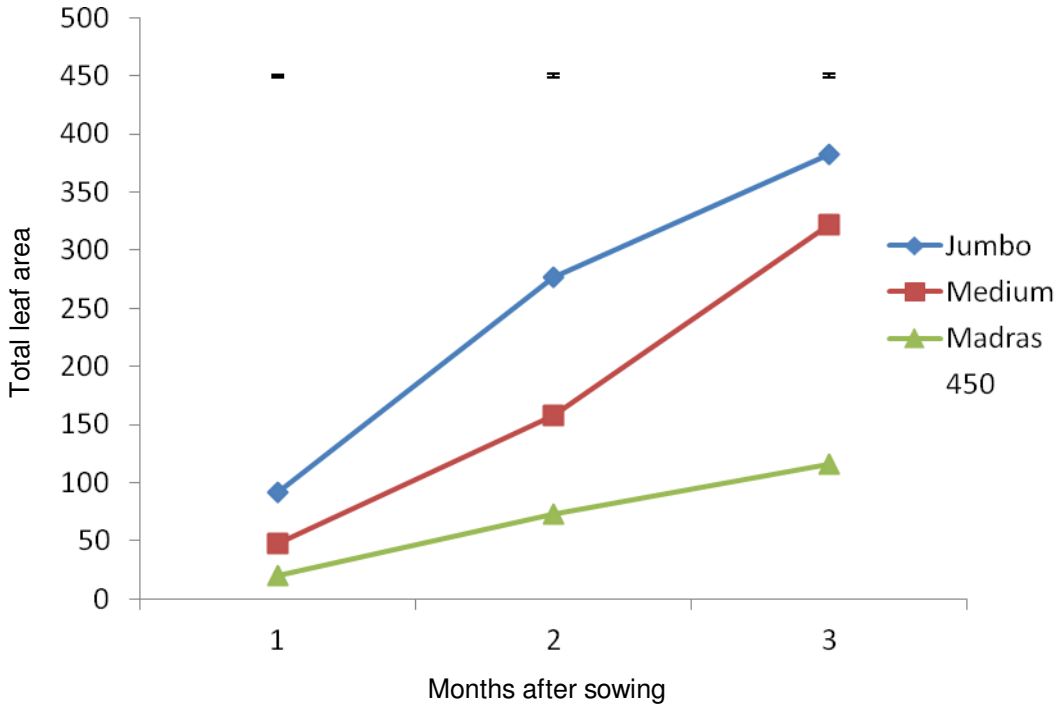

Figure 4. Total leaf area (cm^2) of cashew seedlings as affected by nut-size in the nursery.

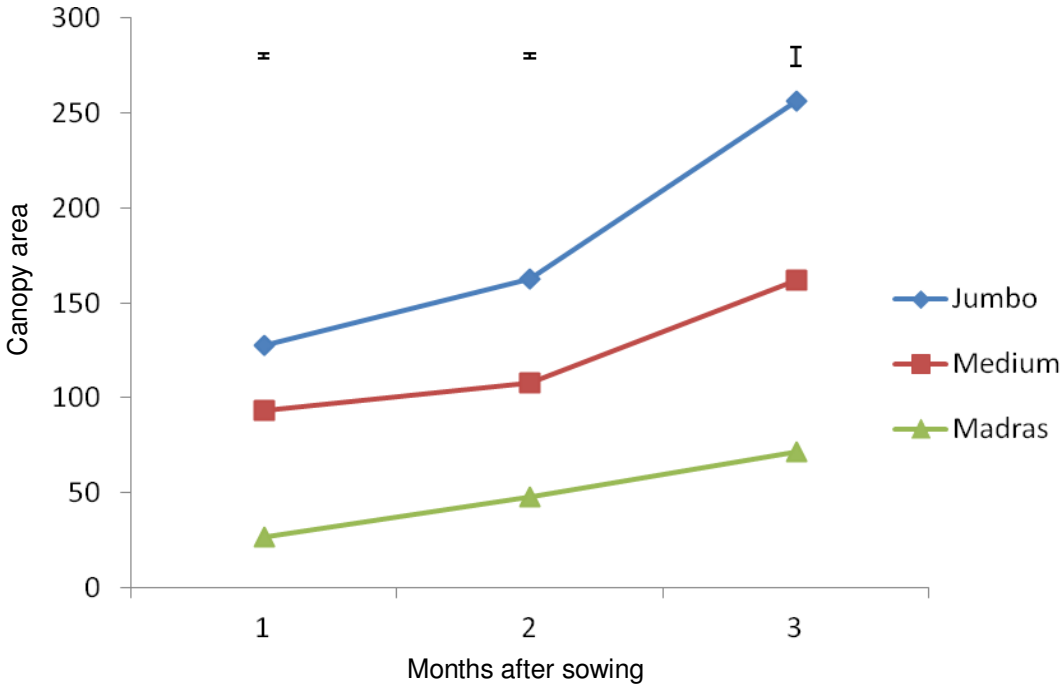

Figure 5. Canopy area (cm^2) of cashew seedlings as affected by nut-size in the nursery.

compared to seedlings raised from madres nut-size. The shoot production of the seedlings raised from jumbo nut-size was 76.99, 100.00 and 122.70% higher than the shoot production of the seedlings raised from madras nut-size (Figure 6). The differences were significant at $P < 0.05$.

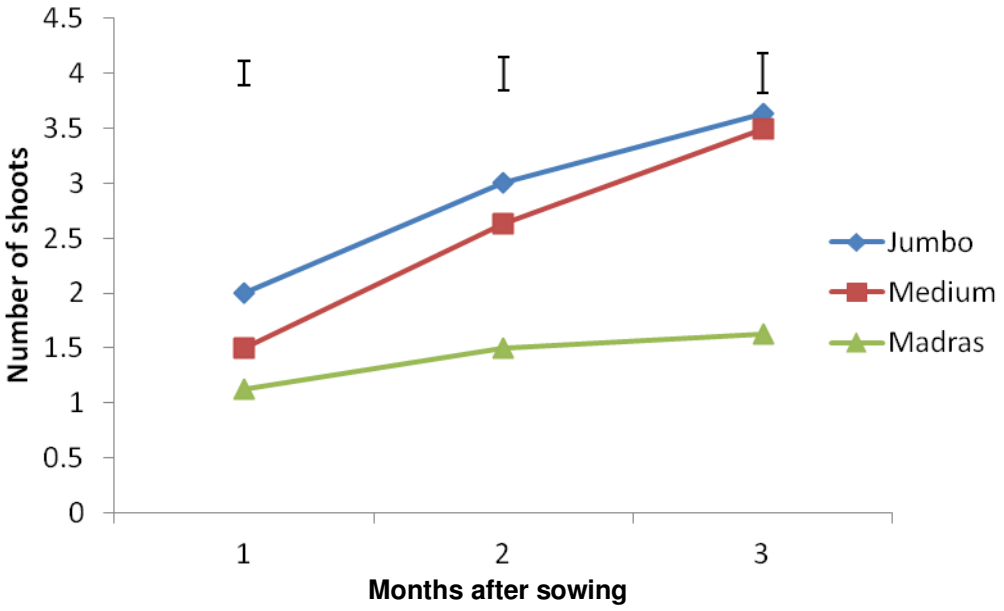

Figure 6. Number of shoots of cashew seedlings as affected by nut-size in the nursery.

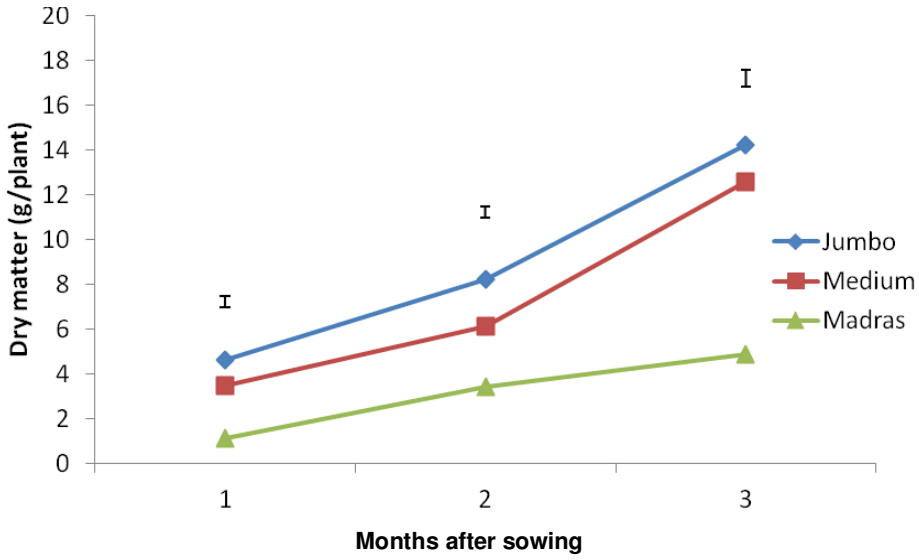

Figure 7. Dry matter yield (g/plant) of cashew seedlings as affected by nut-size in the nursery.

Dry matter yield of cashew seedlings

The dry matter analysis showed that nut-size used to raise seedlings of cashew in the nursery, had significant effects ($P < 0.05$) on dry matter yield of the seedlings (Figure 7). At 1 MAS, seedlings raised from jumbo nut-size of cashew had 31.71 and 311.61% higher dry matter yield than the seedlings raised from medium and madras nut-sizes respectively and the differences were significant at $P < 0.05$. Similarly, at 2 MAS, seedlings raised from jumbo nut-size also had 34.15 and 140.76% dry matter yield advantages compared to the seedlings raised from medium and madras nut-sizes respectively. The differences were significant at $P < 0.05$. However, at 3 MAS, seedlings raised from jumbo nut-size were higher than the seedlings raised from medium nut-size in dry matter yield by 12.78%, but the differences were not significant at $P < 0.05$. During the same period, seedlings raised from jumbo nut-size were superior to the seedlings raised from madras nut-size in dry matter yield to the tune of 190.59% and the differences were significant at $P < 0.05$ (Figure 7).

Table 1. Nutrient content (%) of cashew seedlings as influenced by nut-size in the nursery.

MAS	Plant organ	N			P			K			Ca			Mg		
		Jum	Med	Mad	Jum	Med	Mad	Jum	Med	Mad	Jum	Med	Mad	Jum	Med	Mad
1	Leaf	4.67	4.61	5.00	0.038	0.036	0.035	0.373	0.358	0.446	0.939	0.853	1.170	0.620	0.623	0.955
	Stem	2.57	2.67	2.73	0.065	0.075	0.075	0.513	0.415	0.468	1.232	0.920	1.024	0.564	0.534	0.503
	Root	2.67	1.86	2.60	0.068	0.035	0.050	0.526	0.507	0.850	1.330	1.224	1.922	0.833	0.689	0.744
	Total	9.91	9.14	10.33	0.171	0.146	0.160	1.412	1.280	1.764	3.501	2.997	4.116	2.017	1.846	2.202
2	Leaf	2.96	3.41	3.37	0.028	0.028	0.023	0.452	0.484	0.593	1.209	0.914	1.888	0.641	0.589	0.831
	Stem	3.60	2.67	2.67	0.047	0.031	0.029	0.481	0.934	0.655	0.982	0.874	0.971	0.655	0.548	0.652
	Root	2.88	1.68	1.38	0.035	0.015	0.032	0.453	0.488	0.581	0.994	0.859	1.345	0.759	0.518	0.465
	Total	9.44	7.76	7.78	0.110	0.074	0.084	1.386	1.906	1.829	3.185	2.647	4.204	2.055	1.691	1.948
3	Leaf	4.78	4.85	3.23	0.017	0.022	0.022	0.574	0.619	0.486	0.812	1.150	0.969	0.606	0.642	0.633
	Stem	0.69	1.65	2.33	0.027	0.020	0.026	0.573	0.514	0.524	0.915	0.955	0.974	0.621	0.532	0.623
	Root	0.93	1.74	1.75	0.020	0.021	0.027	0.634	0.589	0.520	0.917	1.021	0.943	0.682	0.781	0.684
	Total	6.40	8.24	7.31	0.064	0.063	0.075	1.781	1.722	1.530	2.644	3.126	2.886	1.909	1.955	1.940

Note: MAS = Months after sowing; Jum = Jumbo cashew nuts; Med = Medium cashew nuts; Mad = Madras cashew nuts

Nutrient content of cashew seedlings

The percentage nutrient content as well as nutrient uptake (g/plant) of cashew seedlings as influenced by nut-size is as shown on Tables 1 and 2 respectively. Compared to other nutrients, nitrogen content is highest in cashew seedlings irrespective of the nut-size. This was followed by calcium, magnesium, potassium and phosphorus contents in that order, throughout the period of study. The nitrogen content reduced as the stay of seedlings in the nursery increased. At 1 MAS cashew seedlings raised from madras nut-size had higher nitrogen of 10.33% which was 4.06 and 11.52% higher than nitrogen contents of the seedlings raised from jumbo and medium nut sizes respectively (Table 1). The phosphorus content of cashew seedlings was lowest among the five major nutrient elements considered. The content of this nutrient element in the leaf was reducing with increasing nursery period. It was between 0.036 and 0.017%, 0.036 and 0.022% and 0.035 and 0.022% in seedlings raised from jumbo, medium and madras nut sizes respectively. Phosphorus content was also reducing with time, in stems and roots of cashew seedlings. The seedlings raised from jumbo nut-size was 14.6 and 6.4% higher in phosphorus content than the seedlings raised from medium and madras nut sizes respectively at 1 MAS, while at 2 MAS, the corresponding percentage difference was 37.7 and 23.6%. However, the seedlings raised from madras nut-size had 14.7 and 16.0% higher phosphorus content compared to seedlings raised from jumbo and medium nut sizes respectively.

The pattern of potassium content was neither consistent with time in the nursery nor nut-size. Potassium content of cashew seedlings raised from jumbo nut-size reduced from 1.41% at 1 MAS to lowest value of 1.39% at 2 MAS and later rose to highest value of 1.78% at 3 MAS. However, seedlings raised from medium and madras nut-sizes were highest in potassium content at 2 MAS with corresponding values of 1.91 and 1.83%. The nutrient was highest in the roots, stems and roots of the three types of cashew seedlings at 1, 2 and 3 MAS respectively (Table 1). Calcium content was the second largest nutrient element, after nitrogen, in the three types of cashew seedlings studied. At 1 MAS, cashew seedlings raised from madras nut-size was 17.60 and 37.30% higher in calcium content than seedlings raised from jumbo and madras nut sizes respectively while at 2 MAS, the percent difference increased to 32.0% and 58.8% in that order. However, at 3 MAS, seedlings raised from medium nut-size had increased calcium content which was 18.20 and 8.30% higher than those of the seedlings raised from jumbo and madras nut sizes respectively (Table 1).

The magnesium content of cashew seedling raised from madras nut-size was highest with 2.20% and this was 9.2 and 19.30% higher than those of seedlings raised from jumbo and medium nut sizes respectively at 1 MAS. At 2 MAS, while the magnesium content of the seedlings raised from madras nut-size was reducing, that of the seedlings raised from jumbo nut-size was increasing to a highest value of 2.06%, and this was 21.50 and 5.50% higher than the magnesium content in the seedlings raised from medium and madras nut sizes respectively. However, as the magnesium contents in cashew seedlings raised from madras and jumbo nut sizes were reducing, that of the seedlings raised from medium nut-size was increasing and got to a highest level of 1.96% at 3 MAS. This was higher than that of the

Table 2. Nutrient uptake (g/plant) of cashew seedlings as influenced by nut-size in the nursery.

MAS	Plant organ	N			P			K			Ca			Mg		
		Jum	Med	Mad	Jum	Med	Mad	Jum	Med	Mad	Jum	Med	Mad	Jum	Med	Mad
1	Leaf	0.056	0.037	0.017	0.0005	0.0003	0.0001	0.0044	0.0029	0.0015	0.0112	0.0068	0.0040	0.0074	0.0050	0.0033
	Stem	0.044	0.025	0.007	0.0011	0.0007	0.0002	0.0087	0.0039	0.0012	0.0210	0.0086	0.0027	0.0096	0.0049	0.0013
	Root	0.011	0.006	0.003	0.0003	0.0001	0.0001	0.0023	0.0016	0.0009	0.0057	0.0039	0.0019	0.0036	0.0022	0.0007
	Total	0.111	0.068	0.027	0.0019	0.0011	0.0004	0.0154	0.0084	0.0036	0.0379	0.0193	0.0086	0.0206	0.0121	0.0053
2	Leaf	0.095	0.078	0.041	0.0009	0.0006	0.0003	0.0145	0.0110	0.0065	0.0388	0.0209	0.0201	0.0205	0.0136	0.0091
	Stem	0.070	0.046	0.022	0.0009	0.0005	0.0003	0.0094	0.0159	0.0054	0.0191	0.0149	0.0080	0.0129	0.0099	0.0053
	Root	0.037	0.017	0.009	0.0005	0.0002	0.0002	0.0058	0.0049	0.0038	0.0127	0.0086	0.0088	0.0096	0.0052	0.0031
	Total	0.202	0.141	0.072	0.0023	0.0013	0.0008	0.0297	0.0318	0.0157	0.0706	0.0444	0.0376	0.0431	0.0287	0.0175
3	Leaf	0.279	0.258	0.057	0.0010	0.0012	0.0004	0.0333	0.0330	0.0086	0.0473	0.0612	0.0170	0.0356	0.0341	0.0110
	Stem	0.036	0.077	0.029	0.0014	0.0010	0.0003	0.0295	0.0238	0.0065	0.0476	0.0448	0.0120	0.0321	0.0248	0.0077
	Root	0.026	0.050	0.019	0.0006	0.0006	0.0003	0.0173	0.0170	0.0057	0.0252	0.0294	0.0103	0.0186	0.0225	0.0074
	Total	0.341	0.385	0.105	0.0030	0.0028	0.0010	0.0801	0.0738	0.0208	0.1201	0.1354	0.0393	0.0863	0.0814	0.0261

Note: MAS = Months after sowing; Jum = Jumbo cashew nuts; Med = Medium cashew nuts; Mad = Madras cashew nuts.

seedlings raised from both madras and jumbo nut sizes by 0.01 and 0.02% respectively (Table 1).

Nutrient uptake of cashew seedlings

The uptake of N, P, K, Ca and Mg nutrient elements by cashew seedlings increased with increasing age of the seedlings in the nursery. Uptake of N being highest followed by uptake of Ca while the uptake of P was lowest and the observations cut across the three nut sizes (Table 2). The cashew seedlings raised from jumbo nut-size had the highest uptake of each of these nutrient elements at 1 MAS. Therefore, the nutrient uptake advantages of the seedlings raised from jumbo over the seedlings from medium nut sizes were 63.20, 72.80, 83.30, 96.40 and 70.30% for N, P, K, Ca and Mg respectively at 1 MAS. At the same period, the uptake advantages of N, P, K, Ca and Mg by the seedlings raised from jumbo nut-size compared to seedlings raised from madras nut-size were 311.11, 375.00, 327.80, 340.70 and 288.70% respectively. The seedlings raised from medium nut-size had higher nutrient uptake advantages compared to cashew seedlings raised from madras nut-size at 1 MAS. The percentage differences were 151.9, 175.0, 133.3, 124.4 and 128.3% for N, P, K, Ca and Mg respectively (Table 2).

At 2 MAS, while cashew seedlings raised from jumbo nut-size had highest uptake of N, P, Ca and Mg, cashew seedlings raised from medium nut-size had highest uptake of K (Table 2). However, there were reductions in the percentage differences of the uptake of these nutrients. Cashew seedlings raised from jumbo nut-size had 43.3, 76.9, 59.0 and 50.2% uptake advantages of N, P, Ca and Mg nutrients respectively, over cashew seedlings raised from medium nut-size, which, in turn had 7.1% higher K uptake compared to seedlings from jumbo nut-size. Within the same period, cashew seedlings raised from jumbo nut-size was better in the uptake of N, P, K, Ca and Mg than cashew seedlings raised from madras nut-size, by 180.6, 187.5, 89.2, 87.8 and 146.3% in that order. Similarly, comparing the uptake of N, P, K, Ca and Mg between cashew seedlings raised from medium and madras nut sizes in the nursery, the former had 95.8, 62.5, 102.6, 18.1 and 64.0% uptake advantages of N, P, K, Ca and Mg than the latter respectively (Table 2).

However, at 3 MAS, while the percentage differences in nutrient uptake between the seedlings raised from jumbo and madras nut sizes further reduced, those between seedlings raised from jumbo and medium nut sizes and between medium and madras nut sizes were on the increase. Cashew seedlings raised from jumbo nut-size had 7.1, 8.5 and 6.0% higher uptake of P, K and Mg compared to seedlings raised from medium nut-size respectively, which in turn was better in the uptake of N and Ca by 12.9 and 12.7% respectively than seedlings raised from jumbo nut-size. Comparing the performance of cashew seedlings raised from jumbo and madras nut sizes with respect to uptake of N, P, K, Ca and Mg, the former was 224.8, 200.0, 285.1, 205.6 and 230.7% better than the latter respectively. Similarly, the percentage differences in the uptake of N, P, K, Ca and Mg between cashew seedlings raised from medium and madras nut sizes were to the tune of 266.7, 180.0, 254.8, 244.5 and 211.9% respectively in favour of the seedlings raised from medium nut-size (Table 2).

Using the uptake of these macronutrients to estimate their percentage requirements with N as a reference nutrient, it was found that cashew seedlings raised from

jumbo nut-size require 100% N, 1.7% P, 13.9% K, 34.1% Ca and 18.6% Mg at 1 MAS while 100% N, 1.14% P, 14.7% K, 35% Ca and 21.3% Mg will be needed at 2 MAS and at 3 MAS, 100% N, 0.88% P, 23.5% K, 35.2% Ca and 25.3% Mg will be required. Seedlings raised from medium nut-size of cashew will require 100% N, 1.6% P, 12.4% K, 28.4% Ca and 17.8% Mg at 1 MAS. At 2 MAS, the percentage needs of these nutrients, according to this study, will be 100% N, 0.92% P, 22.6% K, 31.5% Ca and 20.4% Mg while at 3 MAS, 100% N, 0.73% P, 19.2% K, 35.2% Ca and 21.1% Mg will be needed by the seedlings. In the case of cashew seedlings raised from madras nut-size, 100% N, 1.5% P, 13.3% K, 31.9% Ca and 19.6% Mg shall be required at 1 MAS, while at 2 MAS, the requirement shall be 100% N, 1.1% P, 21.8% K, 52.2% Ca and 24.3% Mg and at 3 MAS, 100% N, 0.95% P, 19.8% K, 37.4% Ca and 24.9% Mg shall be required.

DISCUSSION

The size of cashew nuts is a direct reflection of the size of cotyledons contained. The superior performance in quantitative plant vigour of cashew seedlings raised from jumbo nut-size, might result from the larger size of the jumbo nuts compared to medium and madras nut sizes of the crop. This shows that the jumbo nut-size of cashew possesses higher nutrient reserves which its germinating seedlings made use of for its superior plant growth vigour. The reduced quantitative plant vigour of cashew seedlings raised from madras nut-size was attributable to limited or reduced nutrient reserves contained in the nut cotyledons. The improved plant vigour performance of cashew seedlings raised from medium nut-size was attributable to increased size of the nuts compared to madras nuts. This indicates that more nutrient reserves were made available to cashew seedlings raised from medium nut-size thus improved performance than those from madras nut-size. This corroborates the findings of Adebola et al. (1999) who found out that, the growth vigour of cashew seedlings in the nursery is determined by the weight of cashew nuts sown. The authors therefore advocated for heavier nut sizes for commercial production of cashew seedlings.

Uptake of N, P, K, Ca and Mg by cashew seedlings in the nursery, irrespective of size of nuts sown and plant organ, was found to be increasing with increasing age of the seedlings. This is indicative of the increasing demand for these macronutrients as cashew seedlings developed in the nursery. This was also observed by Grundon (2001) on cashew plants between the ages of 12 and 54 months after transplanting. In a similar study, Lucas et al. (1979) reported an increasing requirement of N, P, K, Ca and Mg by oil palm seedlings in the nursery. The findings in this study shows that, the soil or any other medium for raising cashew seedlings should be able to continuously supply these macronutrients, at least, for a period of three months. If not, specific nutrient supplementation arrangements should be designed to meet the needs of the seedlings within these periods in the nursery. Besides improving the seedlings growth vigour in the nursery, such treatment is an insurance against seedlings mortality when eventually transplanted into the field. This is in accordance with the recommendations of Brown (1984) that growth vigour of a crop's seedlings is one of the important determinants of seedlings survival on the field.

The uptake of N, P, K, Ca and Mg was increasing with increasing nursery period is a justification of the fact that, the soil on which the nuts would be sown should be able to sustain continuous supply of these macronutrients within the periods the seedlings last in the nursery. This will ensure good growth vigour and a guarantee of survival, if eventually transplanted into the field. While applying nutrient supplements to a crop, care must be taken of the correct ratio in order to avoid nutrient antagonism that will even create more problems. In this study therefore, nutrient application to cashew seedlings is predicted with reference to N because of its huge requirement compared to others. According to Streeter and Barta (1984), visual deficiency symptoms of N, P, K, Ca and Mg represent the most severe aberrations in plant growth and metabolism; however, significant reduction in plant growth and productivity can occur with no visual symptoms and this can only be detected by tissue analysis.

This in addition, is an indication that we should not observe deficiency symptoms before nutrient application is embarked upon but there should be an empirical guide which this study has provided. Though, Ohler and Coester (1978) had found that deficiencies of Ca and Mg become manifested within one month, while N, P and K deficiencies occur within two months in the nursery. Their trial was carried out in a pure nutrient culture media under a controlled environment. In a nursery that is subjected to environmental conditions, provisions should be made for these macronutrients in the right proportion as found in this study.

SUMMARY, CONCLUSION AND IMPLICATIONS

This study shows that the performance of cashew seedlings, in the nursery follows the order of nut-size. Seedlings raised from jumbo nut-size had higher quantitative plant vigour and dry matter yield followed by seedlings raised from medium nut-size while those from madras nut-size recorded lowest plant vigour and dry matter yield. The nitrogen content of these seedlings was highest followed by calcium content while phosphorus content was lowest. Cashew seedlings raised from jumbo nut-size had the highest uptake of N, P, K, Ca and Mg followed by seedlings raised medium and madras nut sizes in that order. This implies that, in the production of

the crop's seedlings using jumbo nut-size, there should be an appropriate nutrient supplementation arrangement in order to sustain the higher growth vigour of the seedlings in the nursery. In tree crop culture, higher plant vigour is a veritable selection determinant of trans-plantable seedlings in order to have appreciable survival rates of the seedlings after transplanting into the field.

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