Original Research Article

Effects of Polybag size and Seedling age (nursery period) on Field Establishment of Cashew (*Anacardium occidentale*) Transplants in Northern Ghana.

.

ABSTRACT

Cashew cultivation in Ghana has been seriously hampered by high cost of establishment. This necessitated investigation into modifying the size of polybag to reduce top soil, enhance seedling conveyance and improve field establishment. This experiment was carried out to study the effect of different polybag sizes and seedling age on survival and growth of cashew transplants in the field. Cashew seeds were sown in polybags measuring 17.5 cm x 25 cm (Larger), 14.0 cm x17.8 cm (medium), 12.7 cm x 17.8 cm (small) and 10.2 cm x17.8 cm (smaller) and transplanted at 6 and 8 weeks after sowing at Bole, substation of the Cocoa Research Institute of Ghana. The experiment was laid out in a randomized complete block design with four replicates. Data collected included percentage survival and growth of cashew transplants two years after transplanting and ease of seedling portage. The results showed that percentage survival was not significantly ($P < 0.05$) affected by the size of the polybag and age at transplanting. However bag size significantly ($P < 0.01$) influenced plant growth. Larger polybag size seems to produce more vigorous plants in the field. Growth of plants nursed with the medium bag sizes were also superior ($P < 0.05$) to the small sized bags. Seedling age did not significantly affect plant girth and height but plant leaf number was significantly ($P < 0.05$) affected with 8 weeks transplants producing more leaves. Medium and small sized bags enhanced more seedling conveyance at planting time. It was concluded that polybag sizes 14.0 cm x 17.8 cm and 12.7 cm x 17.8 cm could be used to raise cashew seedlings and transplanted at 6-weeks old to achieve higher establishment success and for easy seedling portage.

Keywords: Cashew, polybag size, seedling age, survival percentage, growth

1. INTRODUCTION

Cashew (*Anacardium occidentale*) is an important non-traditional export crop in Ghana. It is a direct source of income to the farmer and a source of foreign exchange for the country, contributing approximately US $170 million in foreign exchange earnings to the Ghanaian economy in 2013 [1]. Cashew cultivation in Ghana began in the 1960s under the then government's savanna afforestation programme which resulted in the establishment of cashew plantations in the coastal savannah belts of the Greater Accra and the Central regions and the forest savannah transition of Brong Ahafo region [2]. In subsequent years cashew production declined due to poor management practices and the cashew farms were subsequently abandoned despite its huge export potential. Since 1990, a renewed interest for cashew cultivation was demonstrated by farmers as a result of government's support for the industry Ghana. This resulted in the increase of cashew cultivation and expansion of cashew farms in Ghana. Annual export of raw nuts reached 50,000 metric tonnes in 2013

[1]. In spite of this achievement, the crop is still challenged with field establishment difficulties which sometimes lead to high cost of establishment.

Most farms in Ghana are established either by direct seed planting or with seedlings nursed in polybags. Although direct seeding is one of the recommended field planting methods, technical advice has mainly emphasized the use of seedlings raised in polybags for establishing cashew farms because of some disadvantages associated with direct seed planting [3]. Direct seeding results in wastage of improved seeds during planting as farmers have to sow two or more seeds per hill in assurance against losses and possible mortalities [3, 4, 5]. However, in the case of seedlings nursed in polybags, the farmers have the chance to select vigorous and healthy seedlings for planting ensuring higher seedling survival and better plant growth after establishment. Seedlings may be raised in black polybags measuring 17.5 cm x 25 cm and transplanted onto the field after three months. Despite the usefulness of the polybag method, factors such as unavailability of topsoil, high cost of nursery and transportation affects polybag use [4].

The larger polybags (17.5cm x 25cm) require approximately 3kg of soil per bag. This size may allow about 7 to 10 seedlings to be transported by head portage per person: thus increasing time and cost of transporting seedlings for planting. Again the quantity of soil needed to fill the bags creates pressure on the limited top soil. As top soil continues to be scarce in Ghana, there is the need to find alternative polybag size to utilize less volume of soil and reduce cost and time for transporting seedlings for establishing cashew farms. Earlier work [5, 6] demonstrated the feasibility of raising cashew and cocoa seedlings in smaller size bags. However the effect of the use of small size bags on establishment and plant development in the field is yet to be determined. Varying seedling age at transplanting will also determine the appropriate age to transplant cashew seedlings in small polybags to enhance survival. This study was therefore carried out to determine the effect of using smaller polybag sizes in raising and planting cashew on establishment and growth of cashew transplants in the field and to determine the appropriate age to transplant the seedlings in the field.

2. MATERIAL AND METHODS

The experiment was carried out at the Cocoa Research Institute of Ghana (CRIG) substation at Bole between 2010 and 2011. Bole (9◦ 01' N, 2◦ 29' W, altitude 309m above sea level) is in the Guinea Savannah zone of northern Ghana with mean annual rainfall and temperature of 1087 mm and 26.1◦C, respectively. The soils are mainly Ferric Luvisols with smaller areas of Eutric Regosols and Lithosols [7]. The mean annual rainfalls between 2010 and 2011 were 112.6 mm and 94.3mm respectively; and temperatures (min/max) were (20.9/33.2) and (20.4/32.8) during the experimental periods (source: CRIG meteorological station, Bole).

Cashew seedlings were raised in four different polybags of sizes 17.5 cm x 25cm (larger), 14.0 cm x 17.8 cm (medium), 12.7 cm x 17.8 cm (small) and 10.2 cm x 17.8cm (smaller) at two different times in the nursery to obtain seedlings of 6 and 8 weeks old at the time of planting. The treatment combinations of polybag sizes and seedling ages were laid out in a randomized complete block design with four replicates. Each replicate had thirty plants. The plants were spaced at 4 m x 4 m in plots measuring 24 m x 20 m.

Data collected included the ease of seedling portage per person over a distance of 200 meters to the field (recorded as the average of the number of polybags filled with top soil that could be carried per person over the distance), percentage survival, plant girth (mm), height (cm) and leaf number one year after field planting. Plant survival was recorded 3 months

after transplanting because after this period plant mortality may be influenced by field maintenance operations. Seedling girth was measured 10 cm from the ground using a veneer caliper and plant height was recorded using a metre rule. Measurements started at planting and were repeated at 3-monthly intervals over a period of two years.

2.1 Data Analysis

Data were analyzed using ANOVA (GenStat 11.0 for Windows, VSN International) and treatment means compared using least significant difference (Lsd) values. Data on leaf numbers was square root transformed before analysis.

3. RESULTS

3.1 Ease of seedling portage.

The number of seedlings that could be conveyed per person by head portage to the field (200 meters) for planting is shown in Table 1. The average weight of the larger polybag size (17.5 cm x 25 cm) filled with top soil was 2.6 kg whilst the other polybag sizes weighed between 0.6 kg and 1 kg. Averagely ten (10) of the larger bags (with total weight of 26 kg) could be accommodated in a head pan to be carried per person over the 200 m distance. Whilst the same weight of 26 kg equals 25 to 40 bags of the medium and small size bags for the same distance. Handling of the small bags was quicker than the larger bags. Averagely a person could fill 400 pieces of the larger bags with top soil whilst 800 to 1200 pieces of the smaller bags were filled within the same time.

Table 1. Average number of (a) bags filled (b) seedlings conveyed per person.

Polybag size	AW of filled bag (kg)	AN of bags filled per person	AN bags carried per person
T0 – 17.5 cm x 25.0 cm	2.6	400	10
T1 – 14.0 cm x 17.8 cm	1.0	800	25
T2 – 12.7 cm x 17.8 cm	0.8	1000	31
T3 – 10.2 cm x 17.8 cm	0.6	1200	40

AW- average weight; AN- average number

3.2 Seedling survival

The size of bag in which the seedlings were nursed and seedling age at transplanting did not significantly ($P<0.05$) affect survival of cashew transplants in the field (Figure1). Polythene bag size and seedling age interaction was also not significant ($P < 0.05$). However seedlings transplanted at 6 weeks after sowing was observed to have higher survival than the eight weeks old seedlings after planting. Seedlings nursed with small polybag size (12.7 cm x 17.8) cm recorded no mortalities either planted at 6 and 8 weeks after sowing.

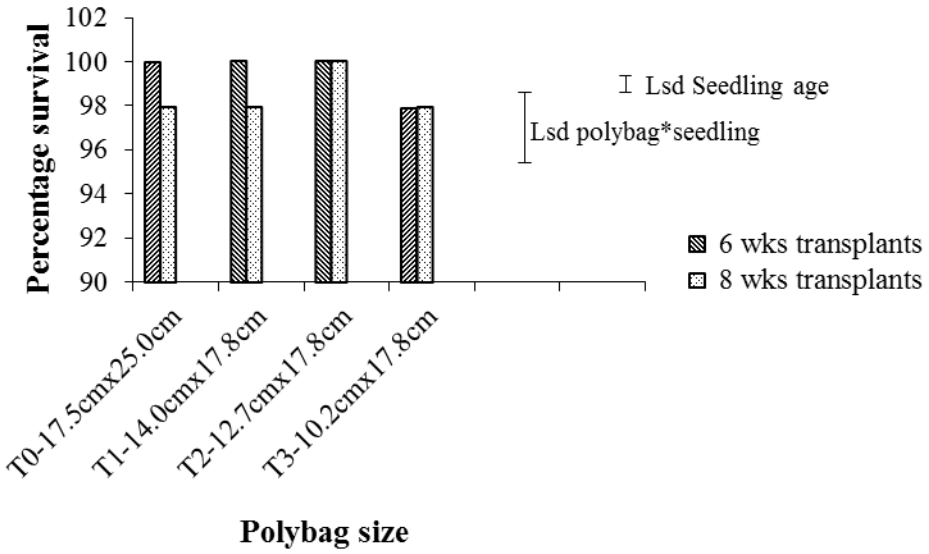

Fig. 1. Effects of polybag size and seedling age on plant percentage survival.
lsd (P < 0.05): polythene bag size: not significant, seedling age at transplanting: not significant, polythene bag size x seedling age: not significant.

3.3 Plant girth (mm)

Polybag size significantly (P < 0.01) influenced the girth of cashew transplants two years in the field (Table 2). Plants raised in the larger bag size (17.5 cm x 25 cm) had significantly (P < 0.05) bigger girths compared to those raised in the smaller bags (10.2 cm x 17.8 cm) which recorded the least girth. Seedling age at planting did not significantly (P < 0.05) influence girth of cashew transplants in the field. Similarly polythene bag size and seedling age interaction on plant girth was also not significant (P < 0.05).

Table 2. Effects of polybag size and seedling age on plant girth (mm)

Polybag size	**Plant girth (mm)**		**Mean**
	6 weeks transplants	8 weeks transplants	**(Polybag size)**
T0 - 17.5cm x 25.0cm	17.7	17.8	**17.7**
T1 - 14.0cm x 17.5cm	16.7	16.9	**16.8**
T2 - 12.7cm x 17.8cm	15.9	16.3	**16.1**
T3 - 10.2cm x 17.8cm	14.9	15.4	**15.1**
Mean (seedling age)	**16.3**	**16.6**	

Lsd ($P < 0.05$): Polybag size		0.98**
	: Seedling age	ns
	: Polybag size * seedling age	ns
CV(%)	:	20.4

*Lsd = least significant difference, CV = Coefficient of variation, ns = not significant, * = significant at P < 0.05, ** = significant at P < 0.01*

3.4 Plant height (cm)

The height of cashew transplants also showed significant differences (P < 0.01) between the polybags used two years in the field. Similar to observations on girth, plants raised in larger bags (17.5 cm x 25 cm) were significantly taller, followed by medium (14.0 cm x 17.5 cm) bags which were not significantly different to those raised in the small bags (12.7cm x 17.8 cm) (Table 3). Plants raised with the smaller bags (10.2 cm x 17.8 cm) recorded the least height. Again seedling age at transplanting did not significantly influence plant height in the field. The bag size x seedling age interaction on plant height was also not significant.

Table 3. Effects of polybag size and seedling age on plant height (cm)

Polybag size	**Plant height (cm)**		**Mean**
	6 weeks transplants	8 weeks transplants	**(polybag size)**
T0 - 17.5cm x 25.0cm	59.3	64.7	**62.0**
T1 – 14.0cm x 17.5cm	58.8	59.1	**58.9**
T2 - 12.7cm x 17.8cm	54.4	57.5	**55.9**
T3 - 10.2cm x 17.8cm	50.5	52.9	**51.7**
Mean (seedling age)	**55.7**	**58.6**	
Lsd ($P < 0.05$): Polybag size		4.37**	
: Seedling age		ns	
: Polybag size * seedling age		ns	
CV(%) :		26.9	

*Lsd = least significant difference, CV = Coefficient of variation, ns = not significant, * = significant at P < 0.05, ** = significant at P < 0.01*

3.5 Plant number of leaves

The number of leaves produced by cashew plants after transplanting was significantly influenced by polythene bag sizes and seedling age at transplanting. Transplants of the larger bags (17.5 cm x 25 cm) produced significantly ($P < 0.05$) higher number of leaves when planted at 6 weeks or at 8 weeks after sowing (Table 4). Transplants from the small bag size (12.7 cm x 17.8 cm) had less leaf numbers when transplanted at 6 weeks but produced more leaves when planted at 8 weeks after sowing. Averagely leaves produced by cashew transplants planted at 8 weeks after sowing were significantly ($P < 0.05$) high compared to 6 weeks old transplants.

Table 4. Effects of polybag size and seedling age on leaf intensity per plant.

Polybag size	**Plant number of leaves**		**Mean**
	6 weeks transplant	8 weeks transplant	**(Polybag size)**
T0 -17.5cm x 25cm	67.7 (8.1)	68.1 (8.1)	**67.9 (8.1)**
T2 -14.0cm x 17.5cm	57.1 (7.5)	60.9 (7.7)	**59.0 (7.6)**
T3 -12.7cm x 17.8cm	48.6 (6.9)	64.6 (7.9)	**56.6 (7.4)**
T4 -10.2cm x 17.8cm	56.1 (7.3)	57.6 (7.4)	**56.9 (7.4)**
Mean (seedling age)	**57.4 (7.4)**	**62.8 (7.8)**	
Lsd (P<0.05) : Polybag size		(0.38)**	
: Seedling age		(0.27)*	
: Polybag size * seedling age		(0.53)	
CV (%) :		17.4	

*Values in parenthesis are square root transformation of the actual values. Lsd = least significant difference, CV = Coefficient of variation, ns = not significant, * = significant at P < 0.05, ** = significant at P < 0.01.*

4. DISCUSSION

Establishing farms with nursery raised seedlings ensures higher establishment success and better plant growth in the field. The rapid growth of cashew transplants raised in larger polybag size (17.5 cm x 25.0 cm) in the field was expected. Similar findings [8, 9] were reported in mango and Indian sandalwood where larger containers produced better growth of seedlings. The relatively large volume of soil in the bag allowed the seedling roots to be exposed to more nutrients and soil moisture resulting in the initial rapid growth of seedlings which was still visible after planting in the field. It is also reported [9, 10] that, seedlings raised in larger bags have a well-developed root system contributing to better uptake of nutrient and water for vigorous plant growth. Considering the high survival rate associated

with this method of transplanting, one would have expected very high adoption of the polybag method of planting cashew seedlings. However its use by the cashew farmers' in Ghana has been low because of the invariably high cost involved in nursery care and difficulty in transporting seedlings [11]. Farmers therefore opt for direct seed planting which may be cost effective but is also associated with some disadvantages such as low seedling emergence especially should planting coincide with a protracted dry season. Seedlings may also be damaged during weeding and other maintenance operation. Competition with weeds for nutrients and water at the early establishment phase may also result in poor establishment.

The use of smaller polybags may be an alternative option which may be better accepted by cashew farmers because the cost of raising and transporting seedlings with smaller polybags is low compared to larger bags. It was observed in this study that, the medium to smaller polybags required less volume of soil to fill compared to the larger bags. Thus about half the volume of top soil is required. More pieces of the smaller polybags could be filled in the working hours compared to the larger bags. Therefore quantity of top soil and labor (man hours) required in filling the bags was reduced. Cost and time of transporting the smaller polybags to the field was also less compared to the larger polybags since more seedlings could be conveyed per person by head portage. Despite the cost effectiveness and ease of portage of the smaller polybags, it was observed that many of the 8-weeks old seedlings had their taproots penetrating the polythene bags and inevitably getting damaged during operations. Although seedling survival was not significantly influenced either by size of bag in which the seedlings were raised or the age of seedlings at transplanting, it was observed that seedlings transplanted at 6 weeks after sowing survived better than 8 weeks old seedlings. Similar observations were reported in earlier studies [12, 13]. This could be attributed to tap root damage which caused the older seedlings to suffer severe transplanting shock thereby affecting establishment success. Damage to seedling tap root during transplanting has been observed as one of the main causes of transplanting failure more common in older cashew seedlings [14]. Based on these observations, it would be reasonable to suggest that nursery periods of cashew seedlings raised in smaller polybags should not extend beyond 6 weeks. This is also an advantage since time and labour needed for nursery activities will be reduced. Although significant differences were observed in plant growth amongst the different polybag sizes in the field, subsequent performance cannot be predicted. The use of smaller bags is envisaged for easy adoption by many cashew farmers to enhance seedling portage and establishment.

5. CONCLUSION

Based on the results of this study, we conclude that cashew seedlings can be raised in polybag size 14.0 cm x 17.8 cm (medium) and 12.7 cm x 17.8 cm (small) and transplanted into the field with high survival percentage. Seedlings raised in small bags are best transplanted at 6-weeks after sowing for higher establishment success. Although growth of plants raised in the larger bags was superior to those in the small bags, cost of topsoil and seedling portage was drastically reduced with the small bag use which is of benefit to the cashew farmer.

REFERENCES

1. Anonymous, Statistics from the Export Promotion Authority Ghana. 2013.

2. Addaquay, J. and K. Nyamekye-Boamah. The Ghana Cashew Industry Study. In Report prepared for the Ministry of Food and Agriculture (MOFA) under the Agricultural Diversification Project. 1998.

3. Adenikinju, S., E. Esan, and A. Adeyemi. Nursery techniques, propagation and management of cacao, kola, coffee, cashew and tea. Progress in Tree Crop Research in Nigeria. 2nd ed., CRIN, Ibadan, Nigeria. 1989; 224.

4. Esan, E. Studies on cocoa seedling (*Theobroma cacao L.*) transportation from the nursery and bare-root transplanting into the field. In Proceedings 8th International Cocoa Research Conference, Cartagena, Colombia. Cocoa Producers' Alliance.1981.

5. Adu-Berko, F., I. Idun, and F. Amoah. Influence of the Size of Nursery Bag on the Growth and Development of Cashew (*Anacardium occidentale*) Seedlings. American Journal of Experimental Agriculture. 2011; 1(4): 440-441.

6. Oppong, F., K. Ofori-Frimpong, and R. Fiakpornu. Effect of polybag size and foliar application of urea on cocoa seedling growth. Ghana Journal of Agricultural Science. 2008; 40(2): 207-213.

7. FAO-UNESCO, Soil maps of the world: 1:50,000,000 Africa 6, Paris: UNESCO. 1977; 299.

8. Annapurna, D., T.S. Rathore, and G. Joshi. Effect of container type and size on the growth and quality of seedlings of Indian sandalwood (*Santalum album L.*). Australian Forestry. 2004; 67(2): 82-87.

9. Haldankar, P., Y. Parulekar, M. Kulkarni, and K. Lawande. Effect of Size of Polybag on Survival and Growth of Mango Grafts. Journal of Plant Studies. 2014; 3(1): 91.

10. Abugre, S. and C. Oti-Boateng. Seed source variation and polybag size on early growth of Jatropha curcas. Journal of Agricultural & Biological Science. 2011; 6(4).

11. Donkor, M.A., C.P. Henderson, and A.P. Jones. Survey to quantify adoption of CRIG recommendations. In Farming Systems Unit Research Paper 3. Cocoa Research Institute of Ghana. 1991.

12. Hammed, L., A. Olaniyan, and E. Lucas. Field Establishment of Cashew (Anacardium occidentale L.) Transplants as Affected by Nursery Periods. Journal of Agricultural Science and Technology. 2012; 2(11B): 1158-1164.

13. Opoku-Ameyaw, K., F. Amoah, F. Oppong, and V. Agene. Determination of optimum age for transplanting cashew (Anacardium occidentale) seedlings in Northern Ghana. African Journal of Agricultural Research. 2007; 7: 296-299.

14. Deckers, J., E. Cundall, S.H. Shomari, A. Ngatunga, and G. Bassi, Cashew. In: RH, Raemaekers (ed) Crop Production in Tropical Africa. Directorate General for international Co-operation (DGIC) Brussel Belgium. 2001; 691-700.