



Effects of Polybag Size and Seedling Age at Transplanting on Field Establishment of Cashew (*Anacardium occidentale*) in Northern Ghana

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Cashew cultivation in Ghana has been seriously hampered by high cost of production. This necessitated investigation into practices that will reduce establishment cost and improve field performance of cashew transplants. An experiment was conducted at Cocoa Research Institute of Ghana's (CRIG) substation at Bole (9° 01' N, 2° 29' W, altitude 309 m a s l) for optimizing the size of polybag to reduce volume of top soil required for nursing seedling, ease seedling conveyance and also improve plant establishment. Cashew seeds were sown in polybags measuring 17.5 cm x 25 cm (Large), 14.0 cm x 17.8 cm (medium), 12.7 cm x 17.8 cm (small) and 10.2 cm x 17.8 cm (smaller) and transplanted at 6 and 8 weeks after sowing. The experiment was laid out in a randomized complete block design with four replications. Data collected included percentage survival and growth of cashew transplants two years after transplanting and ease of seedling portage. The results showed that seedling survival was not significantly ($P > 0.05$) affected by the size of the polybag and age at transplanting. However bag size significantly ($P < 0.001$) influenced plant growth. Large polybag size produced more vigorous plants in the field. Growth of plants

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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. Seedlings in medium and small sized bags were easier to be conveyed at planting time. It is recommended that polybag sizes 14.0 cm x 17.8 cm and 12.7 cm x 17.8 cm should be used to raise cashew seedlings and transplanted at 6-weeks old to achieve higher establishment success.

Keywords: Cashew; polybag; seedling age; transplanting 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. Cashew exports contributed 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 low prices. 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 in Ghana. This resulted in the increase in 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 production.

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 [3-5]. 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 large polybags (17.5 cm x 25 cm) require approximately 3 kg 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 labour 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 small polybag sizes in nursing cashew seedlings, ease of seedling conveyance and on establishment and growth of cashew transplants in the field. It was also to determine the appropriate age to transplant the seedlings onto the field.

2. MATERIALS AND METHODS

The experiment was carried out at the Cocoa Research Institute of Ghana (CRIG) substation at Bole (9° 01' N, 2° 29' W, altitude 309 m above sea level) in the Northern Ghana between 2010 and 2011. Bole 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 total annual rainfalls in 2010

and 2011 were 1351.3 mm and 1132.0 mm 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 25 cm (large), 14.0 cm x 17.8 cm (medium), 12.7 cm x 17.8 cm (small) and 10.2 cm x 17.8 cm (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 replications. Each treatment plot had thirty plants. The plants were spaced at 4 m x 4 m in plots measuring 24 m x 20 m.

Data collected included seedling survival (percentage), plant girth (mm), plant height (cm) and leaf number two years after field planting and the ease of transporting seedlings per person over a distance of 200 meters to the field (recorded as the average of the number of seedlings that could be carried per person over the distance). Plant survival was recorded 3 months after transplanting because after this period plant mortality may be influenced by field maintenance operations. Plant 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 Handling and Portage

The results show that handling of smaller bags was quicker than the other size bags (Table 1). Average number of bags filled per person increased with a decrease in size of bag. The number of seedlings conveyed per person by head portage to the field (200 meters) was also

higher with the smaller size bags compared to the large bags.

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 (Fig. 1). Polybag 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.

3.3 Plant Girth (mm)

Polybag size significantly ($P < 0.001$) influenced the girth of cashew transplants two years in the field (Table 2). Plants raised in the large bag size (17.5 cm x 25 cm) had significantly ($P < 0.001$) 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 polybag size and seedling age interaction on plant girth was also not significant ($P > 0.05$).

3.4 Plant Height (cm)

The height of cashew transplants also showed significant differences ($P < 0.001$) between the polybags used two years in the field. Similar to observations on girth, plants raised in large 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 (12.7 cm 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 ($P > 0.05$) influence plant height in the field. The bag size x seedling age interaction on plant height was also not significant.

3.5 Plant Number of Leaves

The number of leaves produced by cashew plants after transplanting was significantly

influenced by polybag sizes and seedling age at transplanting. Plants from the large bags (17.5 cm x 25 cm) produced significantly ($P < 0.001$) higher number of leaves when planted at 6 weeks or at 8 weeks after sowing (Table 4). Plants 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 plants planted at 8 weeks after sowing were significantly ($P < 0.05$) high compared to 6 weeks old transplants.

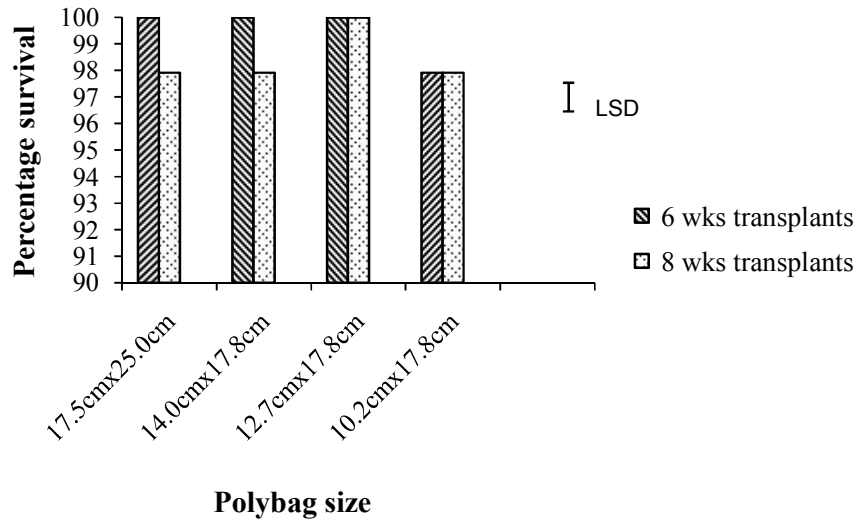


Fig. 1. Effects of polybag size and seedling age at transplanting on plant survival

LSD ($P > 0.05$): polybag size: not significant, seedling age at transplanting: not significant, polybag size * seedling age: not significant

Table 1. Average number of bags filled and seedlings conveyed per person

Polybag size	Average weight of filled bag (kg)	Average number of bags filled per person	Average number of bags carried per person
17.5 cm x 25.0 cm	2.6	400	10
14.0 cm x 17.8 cm	1.0	800	25
12.7 cm x 17.8 cm	0.8	1000	31
10.2 cm x 17.8 cm	0.6	1200	40

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

Polybag size	Plant girth (mm)		Mean (Polybag size)
	6 weeks transplants	8 weeks transplants	
17.5 cm x 25.0 cm	17.7	17.8	17.7
14.0 cm x 17.5 cm	16.7	16.9	16.8
12.7 cm x 17.8 cm	15.9	16.3	16.1
10.2 cm x 17.8 cm	14.9	15.4	15.1
Mean (seedling age)	16.3	16.6	
LSD	: 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 ($P < 0.001$)

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

Polybag size	Plant height (cm)		Mean (polybag size)
	6 weeks transplants	8 weeks transplants	
17.5 cm x 25.0 cm	59.3	64.7	62.0
14.0 cm x 17.5 cm	58.8	59.1	58.9
12.7 cm x 17.8 cm	54.4	57.5	55.9
10.2 cm x 17.8 cm	50.5	52.9	51.7
Mean (seedling age)	55.7	58.6	
LSD	: 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 ($P < 0.001$)

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

Polybag size	Plant number of leaves		Mean (Polybag size)
	6 weeks transplant	8 weeks transplant	
17.5 cm x 25 cm	67.7 (8.1)	68.1 (8.1)	67.9 (8.1)
14.0 cm x 17.5 cm	57.1 (7.5)	60.9 (7.7)	59.0 (7.6)
12.7 cm x 17.8 cm	48.6 (6.9)	64.6 (7.9)	56.6 (7.4)
10.2 cm x 17.8 cm	56.1 (7.3)	57.6 (7.4)	56.9 (7.4)
Mean (seedling age)	57.4 (7.4)	62.8 (7.8)	
LSD	: 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, * = significant at ($P < 0.05$), ** = significant at ($P < 0.001$).

4. DISCUSSION

Establishing farms with seedlings raised in polybags has considerable advantages. However its use by the cashew farmers' in Ghana has been low because of the invariably high cost involved in nursery care and in transporting seedlings to the field for planting [8]. The use of small polybags may be an alternative option which may be better accepted by cashew farmers because the cost of raising and transporting seedlings is low compared to large bags. It was observed in this study that, handling of the small bags was easier and less costly than the large bags. The medium to smaller polybags required less volume of soil to fill compared to the large 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 large bags. Therefore quantity of top soil and labor (man hours) required in filling the bags was also reduced. Labour and time for transporting the smaller polybags to the field was also less compared to the large polybags since more seedlings could be conveyed per person by head portage.

Seedling survival after transplanting was not significantly influenced either by bag size or seedling age at transplanting. However, it was observed that seedlings transplanted at 6 weeks after sowing tended to give slightly higher survival than 8 weeks old seedlings. Similar trends were reported in earlier studies [9,10]. This could be attributed to the observation that, at the time of transplanting many of the 8 weeks old seedlings had their roots penetrating the polybags and inevitably getting damaged during planting. This subjected those seedlings to greater 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 common in older cashew seedlings [11]. It is reported [12] that shock of transplanting due to tap root damage is larger in older seedlings than smaller seedlings. Based on these observations, it would be reasonable to suggest that nursery periods of cashew seedlings raised in small polybags should not extend beyond 6 weeks. This is also an advantage since time and labour needed for nursery activities will be reduced. Seedlings raised in the small bag size (12.7 cm x

17.8 cm) were observed to have survived better which may be attributed to ease of handling of the bags. It's small size ensured proper handling which prevented the contents of the bag from falling apart and breaking the brittle roots during planting. The successful planting of the seedlings with a ball of soil around the roots may have improved survival in the field. The rapid growth of cashew transplants raised in large polybag size (17.5 cm x 25.0 cm) in the field was expected. Similar findings [13,14] 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 [15] that, seedlings raised in large bags have a well-developed root system contributing to better uptake of nutrient and water for vigorous plant growth. 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

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. Seedling conveyance and handling was easy with the small polybags which is of benefit to the cashew farmer.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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