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ESTABLISHMENT TECHNIQUES: EFFECT ON GROWTH POTENTIALS OF *SYNSEPALUM DULCIFICUM* SEEDLINGS

Yisau, J. A.

Department of Forestry and Wildlife Management, Federal University of Agriculture, Abeokuta, Ogun Sate, Nigeria

Correspondence Author: yisauja@funaab.edu.ng

ABSTRACT

One of the most common errors in tree planting is to adopt the wrong method which can cause serious problems after planting out. The study elucidated the effect of some plantation establishment techniques on growth potentials of *Synsepalum dulcificum* seedlings. This research was carried out at the forest nursery of the Federal University of Agriculture Abeokuta, Ogun State, Nigeria. Techniques tested were planting depth (9cm, 18cm and 27cm), planting width (200cm and 400cm) and fertilizer application (with and without organic fertilizer). Obtained data was analyzed using Analysis of Variance and Fisher's Least Significant Difference was used to separate significant means. Results showed that number of leaves (53.13), height (24.50 cm), collar diameter (4.88 mm) and root length (42.41 cm), Fresh weight (18.46 g), turgid weight (19.10 g), shoot dry weight (2.62 g), root dry weight (4.99 g) were significantly ($p<0.05$) in seedlings established 27cm deep. Total dry weights (4.03 g and 7.79 g) were significantly ($p<0.05$) increased in seedlings spaced of 2m apart and the interaction of 2m spacing and 27cm depth respectively while 4m planting space enhanced seedling chlorophyll content (68.96 mg/l) significantly ($p<0.05$). Hence, *Sysepalum dulcificum* seedlings are best established 27cm deep and 2m by 2m spacing for maximum growth.

Keywords: *Synsepalum dulcificum,* seedlings, establishment techniques, growth potentials

INTRODUCTION

There has being increasing decline in forest estate as recorded by FAO (1993), and an increase in demand of forest resources as a result of a growing awareness of the social and environmental problems arising from overpopulation (Nieuwenhuis and O'Connor, 2000; Lee, 2002). There is much concern with rapidly accelerating losses of species diversity especially because a reduction in the genetic diversity of crops and wild species may lead to loss of ecosystem stability and function (Wilson, 1989; Solbrig, 1991). According to Mnzava, (1985) there is a fast rate at which trees are disappearing and forest tree importance cannot be over emphasized because of present increase in fuel wood consumption. Where some other developing countries have been noted as the largest fuel wood user as consumption of commercial energy for cooking is of little use, there will be urgent need of more trees for fuel as the production of other sources of energy wanes in the nearest future therefore, farmers and foresters should be motivated to plant trees.

Forest regeneration is an act of renewing tree cover which is achieved by establishing young trees either artificially or naturally. The output of regeneration is however determined by the quality of seeds available for germination thereby enhancing production of quality seedlings (Roshetko *et al.*, 2010), growth potentials of the seed, seedling vigour, and site conditions, producing high-quality seedlings which determine their performance when planted out on the field (Grossnickle and Sutton, 1999). In this quest for regeneration, there are some establishment techniques on which the survival of the transplant is dependent such as tree ecophysiology, plant quality, planting and post planting practices, rooting environment, depth of planting (Hirons and Percival, 2011). Planting practices that will overcome failures after planting out include the assessment of the root or root ball for potential defects, preparation of the planting site and tree planting. One of the most common errors in tree planting is to adopt the wrong method such as plants root ball is either planted too deep or too high, both of which can cause serious problems as (Arnold *et al.*, 2007) reported that planting trees 7–8 cm below the root ball, resulted in 30–50% death rates of several different species representing a wide range of different genera. Proper and deep planting depth gives the plant the ability to anchor itself in the soil whereby, it is able to with stand destruction against wind and to be able to absorb water and nutrients adequately from the soil through the root. The correct planting depth should be at least as deep as the plant grew in the nursery as greater exposure to the soil and its water content significantly improves survival rates (Georgia Forestry Commission, 2005).

Synsepalum dulcificum fruit has proved to be of high importance to diabetic patients and attempts have been made to produce commercial sweetener from the fruit. In addition to the value of the fruit as a taste modifier, the skin and pulp of miracle berries may also have antioxidant properties with possible benefits for human health (Inglett and Chen, 2011). Also, report has it that there has been a small demand from cancer patients, because the fruit allegedly counteracts a metallic taste in the mouth that may be one of the many side effects of chemotherapy (Slater, 2007). In Japan, miracle fruit is popular among patients with diabetes and dieters (McCurry, 2005; Balko, 2007). This study elucidated some establishment techniques for successful plantation procedure for *Synsepalum dulcificum* seedlings as there is dearth of information on this successful establishment and the varying importance of this specie to human health.

MATERIALS AND METHOD

STUDY SITE

The study was carried out at the forest nursery unit of the Federal University of Agriculture, Abeokuta situated North-East of Abeokuta, in Odeda Local Government of Ogun State, latitude $7^0 10^1$N and $7^0 58^1$N, and longitude $3^0 20^1$E and $4^0 37^1$N. This site falls within the tropical lowland with two distinct seasons: the longest- wet season last for eight months and the shortest-dry season lasted four months. It is characterized with mean annual rainfall of 1250- 1500mm, and mean monthly temperature ranges between 25.7^0C in July and 30.2^0C in February with sandy-loamy soil (Ogun-Osun River Basin Development Authority).

PROCEDURE

Seeds of *Synsepalum dulcificum* were collected from the mother trees at Akinyele local government Oyo State, and were raised in germination boxes. Collected seeds were sown on germination bed without any specification to the depth of sowing and were watered both morning and evening till germination. Germinated seedlings were transplanted into poly pots from germination bed at the rate of one seedling per ploy pot and were nurtured for three months in order to withstand the field conditions. Three months old *Synsepalum dulcificum* seedlings were transplanted from the nursery to the field after site clearing. Sixty (60) seedlings were transplanted and established at three planting depths (9cm, 18cm and 27cm), two planting widths (2m and 4m) and planting with fertilizer and without fertilizer. The performance of *Synsepalum dulcificum* seedlings were examined when planted out in the field using a 3x2x2 factorial in CRD experimental design. Planting depths made up the first factor, planting width made up the second factor and fertilizer application made up the third factor with 6 seedlings in each treatment replicated 5 times. Watering and weeding were done every other day and data were collected once in a month for twelve months.

DATA COLLECTION

Morphological and physiological variables taken during and after the experiment were: Seedling height- (SH), Leaf area - (LA), Collar diameter- (CD), Root length- (RL) Shoot/root ratio- (S/R), Shoot weight- (SW), Root weight- (RW), Total dry weight- (TDW), Total fresh weight- (TFW), Net assimilation rate- (NAR), Relative growth rate- (RGR), Absolute growth rate- (AGR), Chlorophyll content, Relative turgidity and Relative water content. Morphological variables were measured on seedlings for 12 months while, physiological variables were measured and derived after 12 months, a process of destructive analysis. Seedlings height was measured from the soil level to the terminal bud of the plant, collar diameter was measured at 0.5cm above the soil level with Veneer Caliper, and leaves were counted and recorded.

Leaf area was measured both at the width and length of leaf and was calculated using Ugese *et al.,* (2008c)

$$LA = (4.41 + 1.14)\, L * B \quad \ldots\ldots 1$$

Measurement of Root to shoot ratio,

Plants were carefully lifted from the soil after 12 months and were washed off any loose soil. Removed plant was blotted to remove any free surface moisture and roots were separated from the shoots by cutting at soil line, fresh weights of the plants were obtained and plants were immersed in water for 24 hours, the plants were removed, surface water was blotted-off and turgid weight was recorded. These same plants were oven dried at 70^0C to a constant weight for 48 hours and the dried weight was recorded. The following variables were obtained

The root to shoot ratio was calculated using

$$\text{Ratio}=\frac{dry\ weight\ of\ root}{dry\ weight\ of\ shoot} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

$$\text{Relative water content} = (F_{wt} - D_{wt}/T_{wt} - D_{wt})x\ 100 \ldots\ldots\ldots\ldots\ldots 3$$ (Turner, 1981):

$$\text{Relative Growth rate} = \frac{\log_e W_2 - \log_e W_1}{T_1 - T_2} \ldots\ldots\ldots\ldots\ldots 4$$

$$\text{Absolute growth rate} = \frac{W_2 - W_1}{T_2 - T_1} \ldots\ldots\ldots\ldots\ldots 5$$

$$\text{Net assimilation rate}=\frac{(W_2 - W_1)(\log_e A_2 - \log_e A_1)}{(A_1 - A_2)(T_2 - T_1)} \ldots\ldots\ldots\ldots\ldots 6$$

$$\text{Leaf Area Ratio} = \frac{(LA_1 - LA_2)}{(W_1 - W_2)} \ldots\ldots\ldots\ldots\ldots 7$$

where T_2 = Final time of harvesting, T_1 = Initial time of harvesting, T_2-T_1 = Time interval between initial time and final time, A_2 = Leaf area at T_2, A_1 = Leaf area at T_1, W_2 = Total dry weight of plant at T_2, W_1 = Total dry weight of plant at T_1

Procedure for chlorophyll Analysis

The fresh tissue were collected from the field and were ground in a mortar in the presence of excess acetone until all the colour was released from the tissue. The extract and washings were then made up to a known volume. Measurement of chlorophyll was made by direct determination of the absorbance at different wavelengths using a standard spectrophotometer (read at 400-700nm) and 80% acetone extract was measured at 663 and 645 nm in 1cm cells. The concentration was calculated using the following formulae Arnon (1949).

Total chlorophyll (mg/l) = 20.2 A_{645} + 8.02 A_{663}

DATA ANALYSIS

Data collected were subjected to statistical Analysis of Variances (ANOVA) on the general linear model of SAS Software (SAS institute, inc.1999). Fisher's Least Significant Difference (LSD) was used to further separate the means that were significantly different.

RESULTS

Effect of planting depth, fertilizer application and planting width on morphological variables in *Synsepalum dulcificum* seedlings

The study showed that seedlings established 27cm deep had the highest number of leaves (53.13), height (24.50 cm), collar diameter (4.88 mm) and root length (42.41 cm). These variables were significantly ($p<0.05$) different from seedlings established 9cm deep which had least (18.50, 13.7cm, 3.19mm and 22.65cm respectively) significant effect. However, leaf area (32.72 cm^2/plt) was significantly ($p<0.05$) enhanced in seedlings planted 9cm deep compared to seedlings planted 18cm deep with the least leaf dimension (25.35 cm^2/plt) (Table 1).

The result on Table 2 showed that fertilizer application to the established plantation had no significant effect on the variables. It was observed that there was no significant difference ($p>0.05$) between fertilized and non-fertilized seedlings. However, non-fertilized seedlings had the highest number of leaves (38.46), collar diameter (4.11mm), leaf area (30.42 cm^2/plt) and root length (32.78cm). Similarly, there was no significant difference in the spacing employed on seedling growth. Table 3 revealed that plant's height (21.03cm), diameter (4.17mm) and leaf area (30.42cm^2/plt) were higher in plant spaced 4m apart compared to seedlings spaced 2m apart.

Table 1: Effect of planting depth on morphological variables in *Synsepalum dulcificum* seedlings

Planting depth (cm)	Number of leaves	Plant Height (cm)	Collar Diameter (mm)	Leaf area (cm^2/plt)	Root length (cm)
9	18.50 ^{c}	13.75 ^{b}	3.19 ^{b}	32.72 ^{a}	22.65 ^{c}
18	**37.00** ^{b}	**21.71** ^{a}	**4.19** ^{a}	**25.35** ^{b}	**30.13** ^{b}
27	**53.13** ^{a}	**24.50** ^{a}	**4.88** ^{a}	**29.69** ^{a}	**42.41** ^{a}

Means within a column with the same superscripts are not significantly different ($p>0.05$), LSD $p=0.05$

Table 2: Effect of fertilizer application on morphological variables in *Synsepalum dulcificum* seedlings

Fertilizer application	Number of leaves	Plant Height (cm)	Collar Diameter (mm)	Leaf area (cm^2/plt)	Root length (cm)
NF	38.46 ^{a}	19.34 ^{b}	4.11 ^{c}	30.42 ^{d}	32.78 ^{e}
F	33.96 ^{a}	20.64 ^{b}	4.07 ^{c}	28.09 ^{d}	30.68 ^{e}

Means within a column with the same superscripts are not significantly different ($p>0.05$), LSD $p=0.05$

Table 3: Effect of planting width on morphological variables in *Synsepalum dulcificum* seedlings

Planting width (m)	Number of leaves	Plant Height (cm)	Collar Diameter (mm)	Leaf area (cm^2/plt)	Root length (cm)
2	36.21 ^{a}	18.94 ^{b}	4.00 ^{c}	28.42 ^{d}	32.31 ^{e}
4	36.21 ^{a}	21.03 ^{b}	4.17 ^{c}	30.42 ^{d}	31.15 ^{e}

Means within a column with the same superscripts are not significantly different ($p>0.05$), LSD $p=0.05$

In addition, the interaction of planting depth, fertilizer application and planting space had no significant effect ($p>0.05$) on seedling's height, number of leaves, collar diameter, leaf area and root length. However, Table 4 showed that non-fertilized seedlings spaced 2m and planted 27cm deep had the highest number of leaves (64.50), collar diameter (5.51mm) and root length (45.33cm).

Table 4: Effect of planting width, depth and fertilizer application on morphological variables in *Synsepalum dulcificum* seedlings (Interaction)

Planting width (m)	Planting depth (cm)	Fertilizer	Number of leaves	Plant height (cm)	Collar diameter (mm)	Leaf area (cm^2/plt)	Root length (cm)
2	9	F	14.50^a	12.59^b	2.59^c	29.35^d	18.80^e
	9	NF	10.25^a	10.09^b	2.95^c	38.04^d	26.00^e
	18	F	39.00^a	20.69^b	4.03^c	21.11^d	30.83^e
	18	NF	34.00^a	21.26^b	4.09^c	20.95^d	25.75^e
	27	F	55.00^a	24.96^b	4.86^c	32.94^d	40.18^e
	27	NF	64.50^a	24.06^b	5.51^c	28.11^d	45.33^e
4	9	F	21.75^a	18.06^b	4.34^c	32.24^d	25.95^e
	9	NF	27.50^a	14.25^b	2.90^c	31.23^d	19.83^e
	18	F	28.75^a	22.50^b	3.76^c	24.78^d	29.40^e
	18	NF	46.25^a	22.37^b	4.89^c	34.55^d	34.53^e
	27	F	44.75^a	25.00^b	4.85^c	28.10^d	38.90^e
	27	NF	48.25^a	23.99^b	4.31^c	29.62^d	45.25^e

Means within a column with the same superscripts are not significantly different ($p>0.05$), LSD $p=0.05$

Effect of establishment depth, width and fertilizer application on physiological variables in *Synsepalum dulcificum* seedlings

Result revealed on Table 5 showed that seedling physiological variables were generally directly proportional to transplanting depth. Fresh weight (18.46 g), turgid weight (19.10 g), shoot dry weight (2.62 g), root dry weight (4.99 g), leaf dry weight (0.85 g), stem dry weight (1.77 g), total dry weight (6.05 g), R/S ratio (1.94), absolute growth rate (0.0024 g/wk) and relative growth rate (0.006g/g/wk) were significantly ($p<0.05$) enhanced with increased depth (27cm deep). These effect was significantly different from seedlings planted at 9cm depth with the least significant mean 3.85 g, 3.98 g, 0.62 g, 0.83 g, 0.27 g, 0.34 g, 1.06 g, 1.20, -0.0003g/wk, 0.001g/g/wk respectively.

However, effect of fertilizer application was not significant ($p>0.05$) in seedlings physiological variables measured as shown on table 6. Seedlings total dry weight (4.03 g) was significantly ($p<0.05$) increased with decreased spacing of 2m while 4m planting space had the least effect (2.80 g). On the other hand, 4m planting space enhanced the chlorophyll content (68.96 mg/l) of the seedlings and this was significantly different ($p<0.05$) from seedlings established 2m apart (Table 7). Similarly, total dry weight (7.79 g) was highly significant ($p<0.05$) in seedlings established 27cm deep and spaced 2m apart. However, seedlings spaced 2m at 9cm planting depth had the least (0.96 g) weight (Table 8). However, obtained result on table 9 shows that the interaction of planting depth, width and the fertilizer applied had no significant effect ($p>0.05$) on the growth of the plant.

Table 5: Effect of establishment depth on physiological variables in *Synsepalum dulcificum* seedlings

Planting depth (cm)	FW	TW	SHDW	RDW (g/plant)	LDW	SDW	TDW	R/S Ratio	RWC (%)	AGR (gwk^{-1})	RGR (gg^{-1} wk^{-1})	LAR (cm^{2}g^{-1})	NAR (gcm^{-2}wk^{-1})	Chlorophyll (mg/l)
9	3.85^{c}	3.98^{b}	0.62^{c}	0.83^{c}	0.27^{c}	0.34^{c}	1.06^{c}	1.20^{b}	87.11^{a}	-0.0003^{c}	0.001^{c}	-59.92^{a}	-0.0003^{a}	-
18	9.41^{b}	10.08^{b}	1.62^{b}	2.38^{b}	0.56^{b}	1.05^{b}	3.13^{b}	1.53^{ab}	90.35^{a}	0.0011^{b}	0.004^{ab}	-5.87^{a}	-0.0027^{a}	66.57^{g}
27	18.46^{a}	19.10^{a}	2.62^{a}	4.99^{a}	0.85^{a}	1.77^{a}	6.05^{a}	1.94^{a}	95.14^{a}	0.0024^{a}	0.006^{a}	-5.76^{a}	-0.0006^{a}	65.66^{g}

Means within a column with the same superscripts are not significantly different (*p>0.05*), LSD *p=0.05*

Table 6: Effect of fertilizer application on physiological variables in *Synsepalum dulcificum* seedlings

Fertilizer	FW	TW	SHDW	RDW (g/plant)	LDW	SDW	TDW	R/S Ratio	RWC (%)	AGR (gwk^{-1})	RGR (gg^{-1} wk^{-1})	LAR (cm^{2}g^{-1})	NAR (gcm^{-2}wk^{-1})	Chlorophyll (mg/l)
F	10.16^{a}	10.58^{b}	1.49^{a}	2.69^{a}	0.51^{a}	0.99^{a}	3.22^{a}	1.73^{a}	91.66^{a}	-0.0008^{a}	0.003^{a}	-37.65^{a}	-0.000^{a}	67.43^{a}
NF	10.99^{a}	11.54^{b}	1.74^{a}	2.77^{a}	0.62^{a}	1.12^{a}	3.61^{a}	1.39^{a}	90.07^{a}	0.0013^{a}	0.004^{a}	-10.05^{a}	-0.003^{a}	64.80^{a}

Means within a column with the same superscripts are not significantly different (*p>0.05*), LSD *p=0.05*

Table 7: Effect of establishment width on physiological variables in *Synsepalum dulcificum* seedlings

Planting width	FW	TW	SHDW	RDW (g/plant)	LDW	SDW	TDW	R/S Ratio	RWC (%)	AGR (gwk^{-1})	RGR (gg^{-1} wk^{-1})	LAR (cm^{2}g^{-1})	NAR (gcm^{-2}wk^{-1})	Chlorophyll (mg/l)
2m	9.44^{a}	10.11^{b}	1.54^{c}	2.49^{d}	0.53^{e}	1.01^{f}	4.03^{a}	1.42^{h}	88.07^{a}	0.0009^{b}	0.003^{c}	-43.44^{a}	-0.002^{f}	63.27^{a}
4m	11.70^{a}	11.99^{b}	1.71^{c}	2.97^{d}	0.61^{e}	1.09^{f}	2.80^{b}	1.69^{h}	93.66^{a}	0.0013^{b}	0.004^{c}	-4.26^{a}	-0.001^{f}	68.96^{b}

Means within a column with the same superscripts are not significantly different (*p>0.05*), LSD *p=0.05*

Table 8: Effect of Interaction of establishment width and planting depth on physiological variables in *Synsepalum dulcificum* seedlings

Planting width (m)	Planting depth (cm)	FW	TW	RDW	SHDW (g/plant)	SDW	LDW	TDW	R/S Ratio	RWC (%)	AGR (gwk^{-1})	RGR ($gg^{-1}wk^{-1}$)	LAR (cm^2g^{-1})	NAR ($gcm^{-2}wk^{-1}$)	Chlorophyll (mg/l)
2	9	2.46[a]	2.59[b]	0.47[c]	0.48[d]	0.27[e]	0.21[f]	0.96[c]	0.90[h]	87.08[i]	-0.001[a]	-0.001[b]	-85.28[c]	-0.000[d]	-
	18	7.63[a]	8.38[b]	1.87[c]	1.47[d]	0.95[e]	0.53[f]	3.35[b]	1.32[h]	85.21[i]	0.001[a]	0.004[b]	-25.82[c]	-0.006[d]	62.02[e]
	27	18.24[a]	19.38[b]	5.15[c]	2.65[d]	1.81[e]	0.84[f]	7.79[a]	2.05[h]	91.90[i]	0.002[a]	0.006[b]	-19.24[c]	0.001[d]	64.53[e]
4	9	5.25[a]	5.37[b]	1.19[c]	0.76[d]	0.42[e]	0.34[f]	1.17[c]	1.50[h]	87.14[i]	0.000[a]	0.002[b]	-34.57[c]	-0.000[d]	-
	18	11.18[a]	11.79[b]	2.88[c]	1.77[d]	1.15[e]	0.61[f]	2.92[b]	1.75[h]	95.48[i]	0.001[a]	0.005[b]	14.07[c]	0.000[d]	71.11[e]
	27	18.68[a]	18.83[b]	4.83[c]	2.59[d]	1.72[e]	0.87[f]	4.31[b]	1.84[h]	98.37[i]	0.002[a]	0.006[b]	7.72[c]	-0.002[d]	66.80[e]

Means within a column with the same superscripts are not significantly different (*p>0.05*), LSD *p=0.05*

Table 9: Effect of Interaction of planting width, depth and fertilizer application on physiological variables in *Synsepalum dulcificum* seedlings

Planting Width	Planting depth	Fertilizer	FW	TW	RDW	SHDW (g/plt)	SDW	LDW	TDW	R/S Ratio	RWC (%)	AGR (gwk^{-1})	RGR (gg^{-1} wk^{-1})	LAR (cm^{2}g^{-1})	NAR (gcm^{-2}wk^{-1})
2	9	F	2.15^{a}	2.38^{b}	0.41^{c}	0.43^{d}	0.25^{e}	0.18^{f}	0.84^{g}	0.81^{h}	79.39^{i}	-0.001^{a}	-0.002^{b}	-146.55^{c}	0.000^{d}
	9	NF	2.77^{a}	2.80^{b}	0.53^{c}	0.53^{d}	0.29^{e}	0.24^{f}	1.07^{g}	0.99^{h}	94.78^{i}	-0.000^{a}	0.000^{b}	-24.00^{c}	-0.001^{d}
	18	F	8.77^{a}	9.53^{b}	2.36^{c}	1.50^{d}	0.94^{e}	0.56^{f}	3.86^{g}	1.66^{h}	87.13^{i}	0.001^{a}	0.004^{b}	-58.42^{c}	-0.000^{d}
	18	NF	6.50^{a}	7.23^{b}	1.39^{c}	1.45^{d}	0.96^{e}	0.49^{f}	2.84^{g}	0.98^{h}	83.29^{i}	0.001^{a}	0.004^{b}	6.79^{c}	-0.011^{d}
	27	F	16.60^{a}	17.57^{b}	4.62^{c}	2.47^{d}	1.74^{e}	0.73^{f}	7.09^{g}	1.90^{h}	91.07^{i}	0.002^{a}	0.006^{b}	6.43^{c}	0.000^{d}
	27	NF	19.88^{a}	21.20^{b}	5.67^{c}	2.83^{d}	1.88^{e}	0.95^{f}	8.50^{g}	2.19^{h}	92.73^{i}	0.003^{a}	0.007^{b}	-44.92^{c}	0.001^{d}
4	9	F	7.55^{a}	7.18^{b}	1.82^{c}	0.89^{d}	0.46^{e}	0.44^{f}	1.35^{g}	2.14^{h}	103.67^{i}	0.000^{a}	0.003^{b}	-44.76^{c}	-0.001^{d}
	9	NF	2.95^{a}	3.57^{b}	0.56^{c}	0.62^{d}	0.38^{e}	0.24^{f}	0.99^{g}	0.87^{h}	70.62^{i}	-0.000^{a}	0.000^{b}	-24.37^{c}	-0.000^{d}
	18	F	9.78^{a}	9.88^{b}	2.53^{c}	1.33^{d}	0.83^{e}	0.49^{f}	2.16^{g}	2.04^{h}	100.29^{i}	0.001^{a}	0.004^{b}	9.59^{c}	-0.000^{d}
	18	NF	12.60^{a}	13.70^{b}	3.23^{c}	2.21^{d}	1.48^{e}	0.73^{f}	3.68^{g}	1.47^{h}	90.66^{i}	0.002^{a}	0.005^{b}	18.56^{c}	0.000^{d}
	27	F	16.10^{a}	16.93^{b}	4.40^{c}	2.35^{d}	1.69^{e}	0.66^{f}	4.04^{g}	1.82^{h}	88.44^{i}	0.002^{a}	0.005^{b}	7.08^{c}	-0.000^{d}
	27	NF	21.25^{a}	20.73^{b}	5.25^{c}	2.83^{d}	1.75^{e}	1.07^{f}	4.58^{g}	1.86^{h}	108.29^{i}	0.003^{a}	0.007^{b}	7.63^{c}	-0.004^{d}

Means within a column with the same superscripts are not significantly different ($p>0.05$), LSD $p=0.05$

DISCUSSION

Effect of establishment techniques on morphological variables in *Synsepalum dulcificum* seedlings

According to Parry (1994) and Stroempl (1990) as reported by Giblin *et al.,* (2011) that depth of planting in field can increase stability and tree survival. The leafiness, height and collar diameter were increased with increasing planting depth regardless of the planting width and fertilizer applied. The general growth of this species was influenced due to the availability of water and nutrients that was accessed for its growth at this depth, as well as its ability to photosynthesize with the increased leaf number especially the new growth. Hirons and Pervical, (2011) opined that the survival and establishment of transplant seedlings is dependent on root environment and planting depth among other factors. However, Ash tree stem diameter and root volume of birch tree were influenced by shallow depth of 5cm (Giblin *et al.,* 2011). This observation was in contract to Aduradola and Okoro (2001) who observed that deeper planting depth of 30cm enhanced collar diameter and root length of *Parkia biglobosa* and *Prospis cineriara* seedlings.

In addition, Harris (1992) suggested that root length is a probable better measure to determine the rate of growth of a plant than the transpiration surface. This therefore shows that the above ground variables (leaf number, collar diameter and plant height) are determined by the root survival as root grows in length to explore the soil environment. The length of the root determines its ability to absorb and supply the top with water, nutrients, stored carbohydrates, and certain growth regulators and anchors the tree against wind erosion.

Struve (2009) attributed transplant survival and regrowth to factors such as planting depth, mulching, backfill amendments, and site quality while he stressed the importance of proper planting depth for transplant survival and growth.

Although, planting width had no significant influence on variables such as seedling height, collar diameter, leaf number this was different with *Tectona grandis* plantation as increase in spacing increased height and stem diameter of the species (Zahabu *et al.,* 2015). Also, Bernardo *et al.* (1998) documented that increased spacing had little or no influence on the average height of *Eucalyptus camaldulensis, Eucalyptus pellita* and *Eucalyptus grandis* but had noticeable effect on diameter growth and basal area of these species in Brazil. On the other hand, Cockerham (2004) observed a decrease in height of *Eucalyptus camaldulensis* with wider spacing while tree diameter and weight increased with reduced spacing in California.

The study revealed that there was no significant interaction effect in establishment techniques on the growth of *S. dulcificum*. Cockerham, (2004) also observed that there was no significant interaction between fertilizer and planting density (spacing) in *Eucalyptus camaldulensis* trees.

Effect of planting depth, planting width and fertilizer application on physiological variables in *Synsepalum dulcificum* seedlings

The effect of planting depth on physiological variables could be related to the root length, increasing the ability of the seedlings to absorb more moisture and soil nutrients hence, increasing the moisture content of the seedling (fresh weight). Relating this finding to Bruce (1987), it was stressed that correlation must exist between the plants especially the root and soil moisture and the assessment of plant water status is dependent on soil moisture and plant growth. Turgid weight is the maximum amount of water the tissue can hold was also influenced by the depth of planting. Leaf water status is intimately related to several leaf physiological variables, such as leaf turgor, growth, stomatal conductance, transpiration, photosynthesis and respiration (Kramer and Boyer, 1995).

The effect of planting depth revealed that shoot dry weight which is the total of both leaves and stem, root dry weight and root to shoot weight ratio were influenced and a positive correlation exited between shoot dry weight, root dry weight and their ratios. Harris, (1992) discussed that a reduction in the root to shoot ratio is almost always in response to more favorable growing conditions which could be attributed to adequate planting depth.

Observations from the study showed that absolute growth rate and relative growth rate (which was decomposed as the product of net assimilation rate and leaf area ratio) of the seedlings were influenced by increased planting depth of 27cm. Although there was a weak positive correlation between the leaf area ratio and relative growth rate, the higher the leaf area of a seedlings, the higher the growth rate of the seedling over time because the more a plant invest in leaf area, the higher the total carbon gain and the faster the rate of growth (Poorter and Remekes, 1990). The negative correlation that existed between the NAR and LAR must have affected relative growth rate which was possibly masked. Poorter and Remekes (1990) opined that for any expected increase in net assimilation rate, there should be a proportionate increase in photosynthetic apparatus.

Spacing of trees varies with species, site, age and purpose of forest plantation as the total dry weight (total biomass) was enhanced by reduced spacing of 2m by 2m. However, Bernado *et al.,* (1998), increased spacing of 4x3m increased the biomass in *Eucalyptus urophylla* plant while total biomass was reduced in *Eucalyptus camaldulensis* tree at the same spacing (4x3m). On the other hand, increased spacing (4m by 4m) significantly influenced the amount of chlorophyll contained in *Synsepalum dulcificum* seedlings.

It was observed that planting depth interacting with and planting width (2m and 27cm) had influence positive on total dry weight (biomass). In line with the findings of Aduradola and Okoro, (2001) increased depth and reduced spacing influenced the growth of *Prosopis cineriara* and *Parkia biglobosa* seedlings.

CONCLUSION

The study has demonstrated that *Synsepalum dulcificum* seedlings transplanted to the field at a depth of 27cm were significantly influenced in both their morphological and physiological variables measured. It was also discovered that the total dry weights of *Synsepalum dulcificum* seedlings spaced 2m by 2m apart and those established 27cm deep at 2m spacing were significantly enhanced while chlorophyll content was increased in seedlings spaced 4m apart.

REFERENCES

Aduradola, A.M. and Okoro, S.P.A. (2001). A study of the establishment techniques for Balanities aegyptiaca, Parkia biglobosa and Prospis cineriara in Zamfara grazing reserve Nigeria. Nigeria Journal of Environmental Resources Management 1(1): 89-93

Arnold, M. A., McDonald, G. V., Bryan, D. L., Denny, G. C., Watson, W. T. and Lombardini, L. (2007). Below-grade planting adversely affects survival and growth of tree species from five different families. Journal of Arboriculture and Urban Forestry 33(1): 64–69.

Arnon, D. I. (1949). Copper enzymes in isolated chloroplasts, polyphenoxidase in Beta vulgaris. Plant physiology 24(1): 1-15.

Balko, R. (2007). Free the Miracle fruit! Found at http://reason.com/blog/2007/02/08/free-themiracle-fruit Accessed on May 16, 2014.

Bernardo, A.L., Reis, M.G.F., Reis, G.G., Harrison, R.B. and Firme, D.J. (1998). Effect of spacing on growth and biomass distribution in Eucalyptus camaldulensis, Eucalyptuspellita and Eucalyptus urophylla plantations in southern Brazil. Forest Ecology and Management 104(1-3): 1–13

Bruce, R.R. (1987). Methods for Measuring Water Status and Reducing Transpirational Water Loss in Trees Journal of Arboriculture 13 (2):56-61

Cockerham, S.T. (2004). Irrigation and planting density affect river red gum growth California Agriculture 58(1):40-43

Food and Agriculture Organization 1993. Forest resources assessment (1990). Tropical countries. Retrived at http://www.fao.org/docrep/v7540e/V7540e23.htm Accessed on May 14, 2014

Georgia Forestry Commission, (2005). Seedling Care and Planting. Found at http://www.gfc.state.ga.us/reforestation/how-to-plant/Assessed on May 14, 2014.

Giblin, C.P., Gillman, J.H., Johnson, G.R., Hanson, D. and Weicherding, P.J. (2011). The Effects of Planting Depth on Windthrow, Stability, and Growth for Four Tree Species inContainers Arboriculture and Urban Forestry 37(5):247-253.

Grossnickle, S.C. and Sutton, B.C.S. (1999). Application of biotechnology for forest regeneration. New Forest 17(1): 213-226.

Harris, R.W. (1992). Root-Shoot Ratios Journal of Arboriculture 18(1): 39-42.

Hiron, A. D. and Percival, G. C. (2011). Fundamentals of tree establishment: a review. Found at http://www.forestry.gov.uk/pdf/Trees-people-and-the-buit environment_Hirons.pdf/$FILE/Trees-people-and-the-buit-environment_Hirons.pdf. Accessed on July 9, 2014.

Inglett, G.E. and Chen D. (2011). Contents of Phenolics and Flavonoids and Antioxidant Activities in Skin, Pulp, and Seeds of Miracle Fruit. Journal of Food Science 76(3): 479-482.

Kramer, P.J. and Boyer, J.S. (1995). Water relations of plants and soils. San Diego, Academic Press. P 495

Lee, M. (2002). The State of the Planet The Ecologist 32(7):6-11

McCurry, J. (2005). Miracle berry lets Japanese dieters get sweet from sour. Found at http://www.theguardian.com/world/2005/nov/25/japan.foodand drink Accessed on May 16, 2014.

Mnzava, E.M. (1985). Tanzania tree-planting: A voice from the villages. Found at http://www.fao.org/docrep/r5265e/r5265e05.htm. Accessed on May 14, 2014.

Nieuwenhuis, M. and O'Connor, N. (2000). Challenges and opportunities for small-scale tree nurseries in the East African highlands. Unasylva 51(203):56-60.

Parry, M.S. (1994). Depth of planting and anchorage of apple trees. Journal of Horticultural Science 49(4):349–354.

Poorter, H. and Remkes, C. (1990). Leaf area ratio and net assimilation rate of 24 wild species differing in relative growth rate Oecologia 83(4):553-559

Roshetko, J.M., Tolentino, E.L. Jr., Carandang, W.M., Bertomeu, M., Tabbada, A., Manurung, G.E.S. and Yao. C.E. (2010). Tree Nursery Sourcebook - Options in Support of Sustainable Development. World Agroforestry Center-ICRAF and Winrock International. Bogor, Indonesia. Pp. 52

Slater, J. (2007). To make lemons into lemonade, try miracle fruit. Found at http://online.wsj.com/news/articles/SB117522147769754148?mg=reno64wsj&url=http%3A%2F%2Fonline.wsj.com%2Farticle%2FSB117522147769754148.html Accessed on May 16, 2014.

Solbrig, O. T. 1991. Biodiversity: Scientific Issues and Collaborative Research Proposals. UNESCO, Paris 55pp.

Stroempl, G. (1990). Deeper planting of seedlings and transplants increas¬es plantation survival. Tree Planters' Notes 41(4):17–21.

Struve, D.K. (2009). Tree Establishment: A Review of Some of the Factors Affecting Transplant Survival and Establishment Arboriculture and Urban Forestry. 35(1):10–13.

Turner, N. (1981). Techniques and experimental approaches for the measurement of plant water status. Plant Soil, 58(1): 339 - 366.

Ugese, F. D., Baiyeri, K. P. and Mbah, B. N. (2008c). Leaf area determination of Shea butter tree (Vitellaria Paradoxa C. F. Gaertn.). International Agrophysics 22: 167-170.

Wilson, E. O. (1989). Threats to biodiversity. Science America 261:108–116.

Zahabu, E., Raphael, T., Chamshama, S.A.O., Iddi, S. and Malimwi, R.E. (2015). Effect of Spacing Regimes on Growth, Yield, and Wood Properties of Tectona grandis at Longuza Forest Plantation, Tanzania International Journal of Forestry Research 2015(469760):1-6