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Full Length Research Paper

Effect of sowing depth and mulch application on emergence and growth of shea butter tree seedlings (*Vitellaria paradoxa* C. F. Gaertn.)

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Shea butter tree seeds from three sources (Makurdi, Akwanga and Kano), were sown at five depths (2, 4, 6, 8 and 10 cm) under mulch and no-mulch conditions at Makurdi in 2006. The aim was to determine the effect of seed source, sowing depth and mulching status on seedling emergence and growth. Factorial combinations of the treatments were arranged in randomized complete block design (RCBD) replicated three times. Analysis of variance (ANOVA) showed significant main effects of treatment on seedling emergence and growth parameters. Similarly, both first and second order interactions were significant. The Akwanga seed source gave significantly higher percentage seedling emergence and growth than all other seed sources. While seeds obtained from Makurdi emerged better at 2 - 8 cm depth, those from Kano did so when sown at 2 - 4 cm. On the other hand, the Akwanga accession showed better emergence at 4 - 8 cm depth, giving poorer E% values at 2 and 10 cm depths. Generally, sowing depths giving better emergence also variously showed better seedling growth in one or two characters at various monitoring intervals. The superior seedling emergence of no-mulch treated plots across most depths was more apparent with the Makurdi and Akwanga seed sources. However, seedling growth was generally more vigorous in plots that did not receive any mulch, although with the Kano seed source, this became more apparent at the final seedling growth stage (50 WAS). It has been inferred that the better emergence and growth of the Akwanga provenance could be due to their larger seed size. Also, while smaller seeds could be planted at 2 - 8 cm depths, larger ones may do better at 4 - 8 cm depth. The study could not establish any positive effect of mulching on shea seedling emergence and growth.

Key words: Accession, sowing depth, mulching, emergence, seedling growth.

INTRODUCTION

The shea butter tree, *Vitellaria paradoxa*, is the best known member of the family Sapotaceae. It is an African species that occupies a 5,000 km belt of the African Savanna, from Senegal to Sudan and Ethiopia (Umali and Nikiema, 2002), covering 19 countries (Salle et al., 1991). In Nigeria, the species is widely distributed across the Guinea and Sudan Savanna belts (Keay, 1989).

The long standing use of shea fat in the chocolate industry is well recognized (Hall et al., 1996). It is also an important commodity in the cosmetic industries of both importing and exporting countries, due to its superior cosmetic properties (Boffa et al., 1996). Shea butter is popular locally as a cooking fat, illuminant and as an ingredient for soap and pomade production (Vickery and Vickery, 1969). The oil extracted from the kernels, as well as other plant parts, have been credited with medicinal properties (Badifu, 1989; Awoleye, 1995). In addition, the protein rich defoliatory caterpillar, *Cirina butyrospermi*, associated with the species is a delicacy among some ethnic groups in Nigeria (Ande, 2004; Ugese et al., 2005). The ripe fruit from the tree is eaten both by man and livestock (ICRAF, 2000).

The overwhelming usefulness of the shea tree has compelled efforts towards its domestication (Leakey,

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1999). Available information indicates that not much is known about the production practices of the species (Awoleye, 1995). Obviously, some of its wild characters, such as the long gestation period need to be improved upon to make its cultivation more attractive and profitable. Equally of concern is the long time it takes the seedlings to emerge above the ground (Joker, 2000; Ugese et al., 2005), as well as its disappointingly slow growth rate (Jackson, 1968). Studies by Ugese et al. (2005) to improve emergence speed using various means did not result in remarkable improvement in emergence speed. In nature, *Vitellaria* seeds are known to germinate and grow under the shade of trees where they drop after the pulp has been eaten by birds (Jackson, 1968). Mulching was thought to provide the cool natural conditions for shea seedling growth and therefore to assist in hastening the emergence and subsequent growth.

Sowing depth has been reported to be a key factor determining germination (or emergence) percentage and speed (Tripathi and Bajpai, 1985) as well as subsequent seedling growth (Bhatia and Chawan, 1983). Earlier studies (Ugese et al., 2007) using depths of 2, 3, 4, 5 and 6 cm did not reveal any significant influence of planting depth on seedling emergence and early growth. In the light of those findings, the current study aimed at determining: i.) whether mulching could accelerate emergence and growth of shea seedlings, and ii.) the sowing depth that is most suitable for enhancing speedy emergence and growth of shea butter tree seedlings.

MATERIALS AND METHODS

Fresh fruits of the shea butter tree were collected from Makurdi, Akwanga and Kano in early July, 2006. Makurdi and Akwanga fall within the Southern Guinea Savanna while Kano lies in the Sudan Savanna zone of Nigeria. Depulped seeds were sown on flat seed beds at a spacing of 50 x 20 cm in single row plots of seven seeds each. Average weights of seeds from Makurdi, Akwanga and Kano were 10.1, 20.3 and 12.0 g respectively. The soil in the experimental area [the Teaching and Research Farm of the University of Agriculture, Makurdi (7.41^{o} N, 8.37^{o} E, 97 m above mean sea level)] was a sandy loam. The seeds were sown on July 17, 2006 in a 3 x 5 x 2 factorial in a randomized complete block design (RCBD) with three replications. Treatments comprised the three accessions (Makurdi, Akwanga and Kano), five (5) sowing depths (2, 4, 6, 8 and 10 cm) and mulching status (in which case some plots were mulched with dry grass material, dominated by spear grass (*Imperata cylindrica*), while other plots were not mulched). The thin layer of mulch was reinforced after the first seedling data was taken. Plots were hoe-weeded and watered as the need arose.

Seedling emergence was monitored at weekly intervals up to October 28, 2006, while data on seedling growth was taken at 26, 38 and 50 weeks after sowing (WAS). Parameters considered were seedling height, girth, petiole length, number of leaves and linear dimensions of length and maximum width of leaves. From the leaf linear dimensions, leaf area was calculated based on the model developed by Ugese et al. (2008) as shown below:

$$LA = 4.41 + 1.14LW$$

Where LA stands for leaf area and LW stands for the product of linear dimensions of the length and width at the broadest part of the leaf.

Formulae used in calculating emergence parameters were those adopted by Fakorede and Ayoola (1980) as follows:

$$E\% = \frac{No\ of\ Seedlings\ emerged}{Total\ number\ of\ seeds\ planted}\ X100$$

$$EI = \frac{\sum (Number\ emerged)(DAP)}{Total\ seedlings\ emerged}$$

$$ERI = \frac{EI}{E\%\,(in\ decimal)}$$

Where E% = Emergence percentage, EI = emergence index, ERI = emergence rate index, and DAP = days after planting. Data collected were subjected to analysis of variance (ANOVA), using GENSTAT Discovery edition 3, Release 7.2DE, while treatment means were separated using Least Significant Difference (LSD) at 5% probability level.

RESULTS

Main effect of accession, sowing depth and mulching on shea seedling emergence and growth

The main effects of accession, sowing depth and mulching on emergence and growth of shea tree seedlings are presented in Table 1. Accession exerted significant influence on emergence and growth of seedlings, with Akwanga provenance recording higher E% values (69.5) compared to the other two provenances. Its ERI value (141.3) was lower than that of Kano (156.9) but statistically similar to that of Makurdi (152.1). Seedling growth characters varied widely at all times of measurement. Generally, for most characters measured, Makurdi seedlings showed inferior performance throughout the seedling growth period.

The 4 cm sowing depth registered higher E% (72.2) with correspondingly lower ERI (131.6) values. Seedling growth monitored 26 WAS indicated a lack of significant effect of sowing depth on number of leaves. It was generally observed that lower planting depths tended to produce taller plants with wider leaves at this growth stage. Seedlings arising from plants sown at 8 cm depth also produced leaves with longer petioles (0.8 cm). When seedling growth was measured at 50 WAS, a correlation was observed between increasing plant height, leaf number and sowing depth. The highest values of stem girth were obtained at 4 (0.56 cm) and 8 cm (0.57 cm) respectively.

Mulching, or its absence, did not significantly affect the amount and speed of emergence. At 26 WAS, plant height and petiole length did not vary significantly, regardless of mulching status. However, in all other seedling parameters, plots without mulch performed better. At

Table 1. The main effects of accession, sowing depth and mulching on emergence and growth of ahea seedlings.

Parameter	Emergence			26 WAS					38 WAS					50 WAS				
	E%	EI	ERI	PLHT (cm)	SG (cm)	NLEV	LA (cm^2)	PETL (cm)	PLHT (cm)	SG (cm)	NLEV	LA (cm^2)	PETL (cm)	PLHT (cm)	SG (cm)	NLEV	LA (cm^2)	PETL (cm)
Accession																		
Makurdi	62.8	88.3	152.1	3.2	0.27	4.6	14.31	0.7	4.1	0.27	4.0	16.2	0.6	7.2	0.45	9.0	42.6	1.4
Akwanga	69.5	89.6	141.3	4.1	0.32	4.2	23.5	0.6	5.3	0.32	4.6	32.9	0.7	8.8	0.56	9.5	74.5	1.8
Kano	60.0	86.2	156.9	3.9	0.35	4.6	23.2	0.6	5.5	0.35	5.1	32.2	0.8	8.7	0.55	9.7	64.5	2.0
LSD (0.05)	6.7	NS	12.3	0.2	0.01	0.3	1.1	0.08	0.4	0.01	0.4	2.7	0.09	0.7	0.03	NS	6.4	0.18
Sowing Depth (cm)																		
2	66.7	92.7	151.4	3.7	0.29	4.2	17.7	0.6	5.2	0.29	4.7	23.1	0.6	7.7	0.48	8.5	59.7	1.6
4	72.2	85.7	131.6	3.4	0.33	4.4	20.8	0.6	4.6	0.33	4.6	28.7	0.7	7.8	0.56	9.3	64.3	1.8
6	63.9	87.7	153.2	3.6	0.28	4.6	18.6	0.6	4.8	0.28	4.6	23.0	0.6	8.1	0.47	10.3	48.1	1.4
8	61.9	87.1	150.4	4.1	0.32	4.8	22.9	0.8	5.0	0.32	4.6	35.3	0.9	8.2	0.57	9.1	62.8	2.0
10	56.0	87.0	164.0	4.0	0.33	4.5	21.7	0.7	5.3	0.33	4.4	26.2	0.8	9.4	0.52	9.7	67.7	1.8
LSD (0.05)	8.7	NS	15.9	0.3	0.02	NS	2.9	0.10	0.5	0.02	NS	2.5	0.12	1.0	0.04	0.8	8.2	0.24
Mulching																		
Mulch	64.6	91.0	152.1	3.8	0.30	4.2	18.8	0.6	5.3	0.30	4.4	25.9	0.7	8.3	0.49	9.0	51.3	1.5
No mulch	63.6	85.0	148.2	3.8	0.32	4.7	21.8	0.7	4.7	0.32	4.7	28.7	0.7	8.2	0.55	9.8	69.7	2.0
LSD (0.05)	NS	NS	NS	NS	0.01	0.3	1.8	NS	0.3	0.01	NS	2.2	NS	NS	0.03	0.5	5.2	0.15

E% = Emergence percentage, EI = emergence index, ERI = emergence rate index, PLHT = plant height, SG = stem girth, NLEV = number of leaves, LA = leaf area, PETL = petiole length; NS = non-significant difference.

38 and 50 WAS, all seedling characters showing significant variation (except plant height at 38 WAS), had better values from plots that were not mulched.

Interaction effect of accession and depth on seedling emergence and growth

The effect of the interaction between accession and sowing depth on emergence and growth performance of shea seedlings is presented in Table 2. There was a clear pattern of decreasing emergence with depth in the Makurdi provenance. With the Akwanga seed source, the E % of the 2 and10 cm depths appeared to be inferior to the rest. Emergence capacity seemed to be enhanced at the 4-8 cm depths. However, differences in the seedlings on the basis of sowing depths were not as wide compared to what obtained among Makurdi seedlings. With the Kano provenance, the highest E % was recorded at the 2-4 cm depths. Seeds sown at 6 cm from this provenance had the lowest E % (46.4). Sowing depths having higher E % values also had better ERI scores.

Seedling growth of the Makurdi provenance monitored at 26 WAS showed that the 2 and 4 cm depths produced the tallest plants, with the 2 and 6cm depths producing plants with higher leaf numbers. When measured at 38 WAS, plant height was significantly better at 6 cm (4.4 cm), a trend that persisted up to 50 WAS. Leaf petioles were longer at 6-10 cm. At 50 WAS, seedlings arising from lower depths were found to have higher values for stem girth and petiole length. Other characters did not show any consistent trend in response to treatment.

With the Akwanga provenance the 4 cm depth produced the shortest plants (4.3 cm), with narrow girths (0.33 cm) and fewer leaves (4.4) when seedling growth was measured early (26 WAS). At 38 WAS, plants sown 8 cm deep had wider leaves. At 50 WAS lower depths favoured stem girth and number of leaves. Seedlings of the Kano provenance had their growth hampered at 6 cm

Table 2. Interaction effects of accession and sowing depth on emergence and growth of shea seedlings.

Accession	Sowing depth (cm)	Emergence			26 WAS					38 WAS					50 WAS				
		E%	EI	ERI	PLHT (cm)	SG (cm)	NLEV	LA (cm^2)	PETL (cm)	PLHT (cm)	SG (cm)	NLEV	LA (cm^2)	PETL (cm)	PLHT (cm)	SG (cm)	NLEV	LA (cm^2)	PETL (cm)
Makurdi	2	73.8	91.2	128.0	3.7	0.24	5.1	13.2	0.5	2.9	0.23	4.0	15.7	0.7	6.9	0.41	9.8	39.0	1.1
	4	63.1	87.2	158.3	3.7	0.29	3.5	12.6	0.6	2.8	0.21	3.9	16.5	0.6	6.4	0.42	8.9	34.2	1.2
	6	66.7	85.0	135.0	4.4	0.27	4.4	15.9	0.5	4.2	0.23	5.8	19.3	0.8	9.2	0.48	10.6	49.3	1.5
	8	60.7	91.8	165.2	3.6	0.24	3.5	16.7	0.4	3.1	0.22	4.5	15.6	0.8	6.4	0.47	8.7	44.9	1.5
	10	50.0	86.3	174.3	5.2	0.30	3.5	13.3	0.8	3.2	0.21	4.9	16.0	0.8	7.0	0.48	7.1	45.5	1.5
Akwanga	2	61.9	99.3	176.4	6.1	0.31	4.7	20.3	0.7	4.2	0.24	4.2	24.9	0.8	8.1	0.52	7.5	76.7	1.9
	4	75.0	88.2	125.7	4.3	0.33	4.4	22.8	0.8	3.3	0.27	4.2	36.0	0.6	6.9	0.57	8.6	75.3	2.0
	6	78.6	88.6	119.1	5.0	0.34	4.8	24.5	0.9	4.0	0.25	4.0	32.3	0.6	10.3	0.67	10.5	66.4	2.0
	8	71.4	84.8	126.0	5.7	0.34	4.8	26.8	0.9	4.9	0.26	4.5	42.5	0.7	10.3	0.67	10.5	77.2	2.0
	10	60.7	87.0	159.4	5.3	0.33	4.7	23.4	0.5	4.5	0.28	4.0	28.9	0.5	9.5	0.50	11.1	76.6	1.4
Kano	2	64.3	87.4	149.9	5.8	0.32	4.2	19.7	0.6	4.0	0.24	4.4	28.6	0.4	8.1	0.52	8.3	63.4	1.7
	4	78.6	81.6	110.7	5.7	0.37	5.9	27.2	0.6	4.2	0.30	5.2	33.5	0.7	10.1	0.69	10.5	83.5	2.2
	6	46.4	89.4	205.7	5.1	0.30	5.0	15.5	0.4	2.8	0.21	3.5	17.4	0.4	5.9	0.40	10.8	28.5	1.0
	8	57.1	84.6	160.2	5.7	0.39	5.4	25.3	1.4	4.2	0.27	5.4	47.9	0.8	7.8	0.56	8.0	66.1	2.7
	10	53.6	87.8	158.2	5.2	0.37	5.1	28.3	0.9	4.4	0.27	4.6	33.6	0.8	11.6	0.57	10.8	81.1	2.4
	$LSD_{(0.05)}$	15.1	NS	13.8	0.8	0.03	1.2	5.0	0.21	0.4	0.02	0.5	6.0	0.08	1.6	0.05	1.0	14.2	0.20

E% = Emergence percentage, EI = emergence index, ERI = emergence rate index, PLHT = plant height, SG = stem girth, NLEV = number of leaves, LA = leaf area, PETL = petiole length; NS = non-significant difference.

sowing depth. At the later seedling stage however, performance of seedlings sown at the 4, 8 and 10 cm depths was statistically similar to those of treatments arising from the 2 and 6 cm sowing depths.

Interaction effect of accession and mulching on seedling emergence and growth

Across all accessions, application of mulch or its absence did not significantly influence emergence (Table 3). Thus plots of the Makurdi provenance that did not receive any mulch had statistically higher ERI (165.1) values and showed superior seedling vigour throughout the growth period. A similar pattern was observed with the Akwanga provenance. However, with the Kano seed source, the superior seedling growth of the no-mulch treatment became more pronounced only at the last seedling growth measurement.

Interaction effect of sowing depth and mulching on Shea seedling emergence and growth

At all sowing depths, plots without mulch appeared to exhibit better seedling emergence (Table 4). Generally, across all depths, seedling growth appeared to receive a boost with absence of mulch. The only exception was the 6 cm depth in which the apparent superiority of the no-mulch treatment was not clearly noticeable.

Interaction effect of accession, sowing depth and mulching on seedling emergence and growth

Results of the second order interaction are presented in Table 5. Application of mulch or its absence did not appear to influence seedling emergence of the Makurdi seed source in any consistent way. However, with most depths, the

Table 3. Interaction effect of accession and mulching on emergence and growth of shea seedlings.

Accession	Mulching	Emergence			26 WAS					38 WAS					50 WAS				
		E%	EI	ERI	PLHT (cm)	SG (cm)	NLEV	LA (cm^2)	PETL (cm)	PLHT (cm)	SG (cm)	NLEV	LA (cm^2)	PETL (cm)	PLHT (cm)	SG (cm)	NLEV	LA (cm^2)	PETL (cm)
Makurdi	Mulch	59.0	91.6	165.1	3.1	0.22	3.9	13.2	0.7	4.3	0.27	3.6	16.5	0.5	7.4	0.40	8.6	38.8	1.3
	No mulch	66.7	85.0	139.1	3.3	0.22	5.3	15.4	0.8	3.9	0.27	4.4	16.8	0.6	6.9	0.50	9.5	46.4	1.4
Akwanga	Mulch	70.5	92.2	142.8	4.3	0.25	3.9	21.9	0.6	5.6	0.29	4.3	28.9	0.7	9.0	0.54	8.6	68.2	1.7
	No mulch	68.6	87.0	139.8	4.1	0.26	4.5	25.2	0.6	5.0	0.34	4.8	37.0	0.8	8.6	0.58	10.3	80.7	1.9
Kano	Mulch	64.3	89.2	148.2	3.9	0.24	4.8	21.4	0.5	5.9	0.34	5.4	32.4	0.8	8.5	0.52	9.7	47.0	1.5
	No mulch	55.7	83.1	165.6	3.9	0.28	4.4	25.0	0.7	5.1	0.36	4.8	31.9	0.7	9.0	0.58	9.7	82.1	2.5
	LSD(0.05)	NS	NS	12.3	NS	0.02	0.5	3.1	NS	NS	0.02	0.5	3.8	NS	NS	NS	0.9	9.0	0.13

E% = Emergence percentage, EI = emergence index, ERI = emergence rate index, PLHT = plant height, SG = stem girth, NLEV = number of leaves, LA = leaf area, PETL = petiole length; NS = non-significant difference.

Table 4. Interaction effect of sowing depth and mulching on emergence and growth of shea seedlings†

Sowing depth (cm)	Mulching	Emergence			26 WAS					38 WAS					50 WAS				
		E%	EI	ERI	PLHT (cm)	SG (cm)	NLEV	LA (cm^2)	PETL (cm)	PLHT (cm)	SG (cm)	NLEV	LA (cm^2)	PETL (cm)	PLHT (cm)	SG (cm)	NLEV	LA (cm^2)	PETL (cm)
2	Mulch	60.3	96.0	171.2	3.4	0.24	3.8	16.2	0.6	5.7	0.28	4.8	20.1	0.6	8.4	0.47	8.0	47.5	1.2
	No mulch	73.0	89.3	131.6	3.9	0.23	4.6	19.2	0.7	4.7	0.30	4.5	26.0	0.6	7.0	0.49	9.1	71.9	1.9
4	Mulch	73.0	91.4	142.5	3.3	0.24	3.7	18.0	0.5	4.2	0.30	4.1	24.7	0.5	7.0	0.49	8.1	53.8	1.5
	No mulch	71.4	79.9	120.6	3.6	0.28	5.1	23.6	0.7	4.9	0.35	5.1	32.6	0.8	8.6	0.62	10.5	74.9	2.1
6	Mulch	73.0	89.4	127.7	3.9	0.22	4.5	17.5	0.6	5.9	0.28	4.7	22.0	0.5	8.6	0.46	11.3	46.8	1.3
	No mulch	54.8	86.0	178.8	3.4	0.25	4.4	19.8	0.5	3.7	0.29	3.6	24.0	0.6	7.5	0.49	9.3	49.4	1.6
8	Mulch	57.1	91.9	164.9	4.0	0.24	4.3	21.4	0.7	4.8	0.32	4.2	39.1	1.1	7.4	0.54	8.5	57.9	1.9
	No mulch	66.7	82.3	136.0	4.1	0.26	5.3	24.5	0.8	5.2	0.32	4.9	31.6	0.7	8.5	0.59	9.7	67.7	2.2
10	Mulch	59.5	86.3	154.0	4.3	0.25	4.6	21.1	0.7	5.7	0.32	3.5	23.7	0.7	10.0	0.47	8.8	50.6	1.6
	No mulch	52.4	87.7	173.9	3.8	0.26	4.4	22.0	0.6	4.8	0.35	5.4	28.7	0.8	8.7	0.57	10.5	84.8	2.0
	LSD(0.05)	NS	7.1	15.9	0.4	NS	0.6	4.0	0.07	0.7	NS	0.7	4.9	0.17	1.3	NS	1.1	11.6	NS

E% = Emergence percentage, EI = emergence index, ERI = emergence rate index, PLHT = plant height, SG = stem girth, NLEV = number of leaves, LA = leaf area, PETL = petiole length; NS = non-significant difference.

absence of mulch significantly improved all the emergence parameters. Similarly, with most depths, seedling growth was more vigorous among plots that were not mulched, a trend that was more pronounced at 50 WAS.

The Akwanga seed source showed better response of ERI to no-mulch application at most depths (2, 4 and 8 cm). At 2 and 10 cm sowing depth, seedling growth was more vigorous without

Table 5. Interaction effect of accession, sowing depth and mulching on emergence and growth of shea seedlings 50 weeks after sowing (WAS).

Accession	Sowing depth (cm)	Mulching	Emergence percentage (E%)	Emergence index (EI)	Emergence rate index (ERI)	Plant height (cm)	Stem girth (cm)	Number of leaves	Leaf area (cm^2)	Petiole length (cm)
Makurdi	2	Mulch	71.4	88.8	127.7	8.3	0.43	9.7	33.2	0.9
		No mulch	76.2	93.6	128.2	5.6	0.39	9.9	44.8	1.4
	4	Mulch	47.6	97.0	207.2	5.8	0.33	8.0	29.7	1.2
		No mulch	78.6	77.5	109.5	6.9	0.50	9.9	38.7	1.3
	6	Mulch	76.2	86.2	114.0	8.6	0.40	8.9	50.4	1.7
		No mulch	57.2	83.7	155.9	9.8	0.56	12.3	48.2	1.2
	8	Mulch	50.0	97.1	198.1	6.0	0.40	7.5	39.0	1.1
		No mulch	71.4	86.5	132.2	6.8	0.55	9.9	50.9	1.9
	10	Mulch	50.0	88.8	178.7	8.5	0.45	8.7	41.5	1.5
		No mulch	50.0	83.8	169.0	5.5	0.50	5.5	49.6	1.5
Akwanga	2	Mulch	52.4	106.7	223.8	9.3	0.48	7.2	58.3	1.6
		No mulch	71.4	92.0	128.9	6.8	0.55	7.7	95.1	2.2
	4	Mulch	71.4	91.7	134.7	7.3	0.58	7.4	78.6	2.0
		No mulch	78.6	84.7	116.6	6.5	0.56	9.7	72.1	2.0
	6	Mulch	85.7	91.9	111.5	8.8	0.49	9.1	63.4	1.4
		No mulch	71.4	85.4	126.7	9.6	0.59	10.1	69.4	2.3
	8	Mulch	64.3	88.5	138.9	10.2	0.71	10.2	80.7	2.2
		No mulch	78.6	81.1	113.0	10.5	0.64	10.9	73.8	1.7
	10	Mulch	78.6	82.4	105.2	9.3	0.46	9.2	60.0	1.2
		No mulch	42.9	91.7	213.7	9.8	0.55	13.0	93.1	1.7
Kano	2	Mulch	57.1	92.5	162.0	7.5	0.50	7.0	51.0	1.2
		No mulch	71.5	82.4	137.8	8.7	0.54	9.7	75.9	2.2
	4	Mulch	100.0	83.7	85.7	7.8	0.57	9.0	53.1	1.4
		No mulch	57.1	77.5	138.7	12.4	0.80	12.0	114.0	3.0
	6	Mulch	57.1	90.0	157.6	8.5	0.50	16.0	26.6	0.7
		No mulch	35.8	88.9	253.7	3.3	0.31	5.5	30.5	1.3
	8	Mulch	57.1	90.0	157.6	6.2	0.53	7.7	53.9	2.3
		No mulch	50.0	79.2	162.8	9.5	0.59	8.3	78.3	3.1
	10	Mulch	50.0	87.9	178.1	12.3	0.49	8.5	50.3	2.1
		No mulch	64.3	87.8	138.2	10.9	0.65	13.0	111.8	2.8
		$LSD_{(0.05)}$	21.3	12.2	27.5	2.3	0.11	1.9	13	0.6

mulching. This was evident at the final growth stage (50 WAS), particularly in the 2 cm depth. With the rest of the sowing depths, there was no clear advantage of absence of mulching over its pre-sence.

Assessments of seedling emergence from the Kano seed source indicated a general inconsistency with regard to effect of mulching across depths. However seedling performance evaluation at 50 WAS revealed the superior growth of seedlings from plots that were not mulched.

DISCUSSION

The significant differences observed in the emergence and growth of seeds of *Vitellaria paradoxa* from different sources obtained in this study are in agreement with the findings of Awoleye (1995), who attributed such differences to variations in climatic factors among seed sources. The effect of climate on seedling parameters could become magnified or extended when it gives rise to differences in physical attributes of seeds from different sources. Even among seeds of the same origin, Ugese et al. (2007), reported differences in emergence and seedling growth, when seeds were sorted into different weight classes, with the larger seeds giving higher emergence percentages and better seedling growth. This could also be the reason for the higher germination percentages obtained from the relatively heavier Akwanga seed source.

A progressive decline in the emergence of the Makurdi seed source with depth, compared to that of Akwanga, could still be explained on the basis of seed weight. Generally, heavier seeds are best planted more deeply than lighter ones (Garner, 1976) since they are capable of emerging from deeper depths due to higher food reserves (Schmdt, 2000). Thus seeds from Akwanga were able to maintain higher percentage emergence at all depths. Their tendency to record less amount of emergence at the 2 cm depth could have resulted from the greater risk they stood of being exposed to the harsh elements of climate such as high temperature and desiccation (Schmdt, 2000). It is possible that such large seeds may not be adequately covered when planted at such a shallow depth of 2 cm.

The Kano provenance did not show a recognizable pattern of seedling emergence and growth. Those planted at a depth of 6 cm recorded the least E% in the experiment. It was observed, in the course of the experiment that some plots of the Kano provenance planted at 6 cm fell into spots that were depressed and therefore suffered from water logging, a situation that may have resulted in the observed poor seed/seedling performance. Water logging has been previously reported to be detrimental to seedling growth (ICRAF, 2000) and also observed to cause seed rotting in this experiment. In general however, seedlings of this provenance sown at 10 cm had the least E% value (except for the observed anomalous behaviour of the 6 cm depth).

From results obtained, it could be inferred that in respect of seed size, shea seeds could be sown at depths ranging from 2 to 8 cm. In previous studies, Ugese et al. (2007) reported that E % and speed did not vary significantly across depths of 2-6 cm, indicating that the possibility of sowing shea seeds at deeper levels existed. In cashew, best seedling emergence was obtained at 2.5-8 cm planting depths, beyond which a drastic reduction in the amount and speed of emergence was found (Argles, 1976). The comparatively lower E % of shea seeds at deeper levels could be ascribed to the difficulty of seedlings to overcome the long distance of shoot growth to be able to make it to the surface of the soil, as was reported to be the case with cashew (Argles, 1976).

Contrary to the widely recognized role of mulch at enhancing seedling growth, its application neither improved seedling emergence nor facilitated the growth of seedlings. It was generally observed that many of the seedlings in the mulched plots emerged some distance away from the point of sowing, usually at the edges of the layer of mulch. This seems to suggest that the mulch may have constituted a barrier to seedling emergence. Seedlings in plots without mulch had no such barrier to contend with and were therefore, able to emerge earlier. In *Vitellaria*, seedlings emerging earlier normally exhibit faster growth rate than those emerging later (Ugese et al., 2005). It is conceivable that mulching may still have a positive impact on seedling growth if application is timed after seedling emergence, although such effects will have to be tested experimentally.

In general, variations in seedling growth in response to treatment became more apparent only at the last stage of measurement (50 WAS). This observation calls for patience and caution when evaluating seedling growth, since conclusions drawn too early, before seedlings have had the opportunity to reasonably display their maximum growth potential, might be misleading.

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