International Journal of Biosciences (IJB)
ISSN: 2220-6655 (Print) 2222-5234 (Online)
Vol. 2, No. 12, p. 146-152, 2012
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Effect of planting depth on the germination and initial growth and development of shea (*Vitellaria paradoxa* C.F. Gaertn.)

W.J. Asante, M.A. Banidiyia, D. Tom-Dery*

Faculty of Renewable Natural Resources, Department of Forestry and Forest Resources Management, University for Development Studies

Received: 23 November 2012
Revised: 11 December 2012
Accepted: 12 December 2012

Key words: *Vitellaria paradoxa*, sowing depth, germination percentage, leaf area index.

Abstract

The study was carried out to assess the effects of planting depth on the germination and initial growth and development of Shea (*Vitellaria paradoxa* C.F. Gaertn.) seedlings, at the Faculty of Renewable Natural Resources mango plantation, University for Development Studies-Nyankpala campus. The specific objectives were to determine the germination percentage and to assess the effects of planting depth on the initial growth and development of Shea seedlings, using a Completely Randomized Design. Seeds of Shea were sown in polythene bags at 2 cm, 4 cm, 6 cm, 8 cm and 10 cm after they have been pre-treated mechanically. Data on germination, shoot height, leaf area index and number of leaves were collected six (6) weeks after sowing (WAS), 12 WAS, 18 WAS and 24 WAS. Results showed that the different planting depth influenced growth and development of Shea seedlings. The highest germination percentage was recorded at 2cm planting depths and highest seedlings height recorded at 6cm planting depth. Analysis of variance showed significant differences ($p > 0.05$) among the various treatments with respect to their effect on shoot height and leaf area index except number of leaves within the first and third weeks after sowing. It is inferred that Shea performs variably in different planting depths with regard to growth and development. It is therefore recommended that for higher germination of Shea seeds and maximum growth and development in Northern Ghana, planting should be done at 2- 6 cm depth.

***Corresponding Author:** Damian Tom-Dery ✉ tom_dery@yahoo.co.uk

Introduction

The Shea tree (*Vitellaria paradoxa* C.F. Gaertn.) belongs to the family Sapotaceae and is the only species in the genus Vitellaria (Henry *et al.*, 1983). Shea trees grow naturally throughout the Sudanian region centre of endemism from Senegal to the foothills of the Ethiopian highlands (White, 1993) covering a 5,000 km belt (Umali and Nikiema, 2002). In Ghana, the Shea tree virtually covers about two-thirds of the country's landmass mostly in the wild, however, trees on cultivated grounds in farms and around villages are often the finest (Abbiw, 1990). The majority of the Shea parklands in Ghana fall within the Guinea Savannah ecological zone, which is associated with total annual rainfall of about 1,000–1,300 mm/annum, while Sudan Savannah normally records precipitation below 1,000 mm/annum (MoFA, 2011).

Being a perennial woody species, abscission is an annual ritual and thereby thought to play a major role in nutrients recycling through the decay of its leaves and fine roots at the soil surface (De Bie *et al.*, 1998; Bayala *et al.*, 2006). However, the shea tree is highly valued by farmers, mostly because of its fat containing kernels which are sold both on local and international markets, thereby considerably contributing to wealth creation. The vegetable fat of shea nut is second in importance only to palm oil in Africa (Hall *et al.*, 1996). The products arising from the shea tree generates substantial income for women as it is traditionally seen as women business (Elias and Carney, 2007). The commercialization of shea products represents an important source of income at different parts of the community chain, from community levels, with rural children and women who gather and process nuts, to town dwellers as well as entire countries (Bonkoungou, 1992; Boffa *et al.*, 1996). Shea tree also provides fruits, medicine, construction materials, fuel wood and carving wood (Hall *et al.*, 1996). The ripe fruit from the tree is eaten by both man and livestock (ICRAF, 2000).

The numerous uses of the multipurpose shea tree have inspired efforts for its domestication (Leakey, 1999). The survival of Shea plants in the Shea growing areas of Northern Ghana still depend on natural regeneration. They have therefore retained characteristics typical of wild tree species and very little effort has been made to bring them under cultivation Bakang (1981). Though, the Shea tree grows under natural conditions, relying on nature alone does not meet the growing needs of the people of Northern Ghana and hence efforts should be made to domesticate and cultivate the Shea trees to supplement the natural sources. With respect to the above, there is the need to assess the potential of domesticating Shea tree in Northern part of Ghana in particular and the country at large. In order to establish Shea plantations it is necessary to plant using seedling. In nature Shea 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). Booth and Wickens (1988) reported that with fresh seeds, the germination rate can be over 90%.

Few studies have been conducted on germination and initial growth of Shea trees. Planting depth has been reported to be a key factor determining germination percentage (Tripathi and Bhatia, 1985) and initial seedling growth (Bhatia and Chawan, 1983). Ugese *et al.* (2007) reported insignificant difference in germination and initial growth using 2, 3, 4, 5 and 6 cm planting depth. However, Ugese *et al.* (2010) reported that with respect to seed size better germination percentage is achieved between planting depths of 2cm and 8 cm. The current study was therefore, intended to assess the effects of planting depth on the germination and initial stages of development of shea in Northern Ghana with specific objectives: (1) To determine the germination percentage with respect to different planting depths and (2) To assess the effects of planting depth on the initial growth and development of the seedlings.

Materials and methods

Study area

The study was conducted at the Faculty of Renewable Natural Resources nursery site at UDS Nyankpala campus. Nyankpala is located within the Guinea Savanna zone of West Africa with latitude 9^0 25 N and longitude 0^0 58 W at an altitude of 183 m above sea level (SARI, 1997). The area has a unimodal rainfall pattern with an annual rainfall of 1034.4 mm (SARI, 2004) distributed uniformly from April to late November. Temperature ranges from 22^0 C during the rainy season and reaches a maximum of 34 C during the dry season.

Fig. 1. Photograph of shea seedlings.

Experimental design and procedure

Seeds of Shea were obtained from pikoro – Paga in the Upper East Region. The seeds were treated mechanically by removing the husk and sown in poly bags containing soil and labeled. The Complete Randomized Design (CRD) was used for this study using five treatments defined by the different planting depths of 2 cm, 6 cm, 4 cm, 8 cm and 10 cm. Each treatment was replicated twenty times.

All the poly bags were watered regularly; starting from the first day of sowing, at one day interval throughout the experimental period. Seedling emergence was monitored for the first four weeks (4 WAS). At the end of the 6th week (6WAS) twenty – five (25) seedlings were randomly selected and relabeled as 2A- 2K, 4A – 4E, 6A – 6E, 8A – 8E, 10A – 10E for easy identification and data collection for another eighteen weeks. Parameters considered were shoot height, number of leaves, and leave area index. The leave area index was calculated using the equation 1 below Sexena and Singh (1965);

LAI= 0.75 x L x B.....(1)

Where LAI is leave area index, 0.75 is a constant, L is length of leaf and B is breadth of leaf. Data collected on shoot height, number of leaves and leave area index were subjected to analysis of variance test (ANOVA) using GEN-STAT software, while treatment means were separated using Least Significant Difference (LSD) at 5% probability level.

Results

Determination of germination percentage of Shea seed

The results of Shea seeds planted at different planting depths are shown in Table 1. At the end of the study, Shea seeds sown at 2 cm depth recorded the highest germination percentage (65%) with 10 cm planting depth being the least (30%). The mean germination percentage recorded was 53%.

Plant house

Seedlings (Shoot) height

Result showed that there was no significant difference between treatments 2 cm and 4 cm at 6, 12, 18 and 24 WAS. However, the analysis of variance showed significant difference (p> 0.05), between treatments 6, 8, and 10 cm at 6, 12, 18 and 24 WAS (Table 2). At the end of the study, the highest mean seedling height recorded was at 6 cm planting depth of 4.66cm and the least being 8 cm (3.14 cm). Separation using LSD showed that planting depth of 6 cm had an effect on seedling height which was significantly greater than that of 2 cm, 4 cm, 8 cm and 10 cm (Table 2).

Number of leaves

The result showed no significant difference (p> 0.05) between planting depths: 2 cm, 4cm, 6cm, 8cm and 10cm at 6WAS and 18WAS at LSD 0.813 and 0.6188 respectively. Fig.1 shows a photograph of seedlings with 2-4 leaves 6 WAS. However, at 12WAS the analysis of variance showed significant difference (p

>0.05) among all treatments except 6cm at LSD 0.5597. There was also significant difference between 8cm and 10cm at 24WAS at LSD 0.813 (Table 3).

Table 1. Germination percentage of Shea seeds at different planting depths.

TREATMENT (cm)	NO. OF SEED SOWN	NO. GERMINATED	GERMINATION PERCENTAGE (%)
2	20	13	65
4	20	12	60
6	20	12	60
8	20	10	50
10	20	6	30

Table 2. Mean height of *Vitellaria paradoxa* seedlings as influenced by different planting depths at 6, 12, 18 and 24 weeks after sowing (WAS).

TREATMENT	6 WAS (cm)	12 WAS (cm	18 WAS (cm)	24 WAS (cm)
2	$2.2.0^{a}$	3.08^{a}	3.46^{a}	3.94^{a}
4	2.22^{a}	3.00^{a}	3.26^{a}	3.80^{a}
6	3.12^{bc}	3.72^{bc}	4.24^{ab}	4.66^{bc}
8	1.46^{bcd}	2.20^{bcd}	2.80^{ab}	3.14^{bd}
10	2.60^{ab}	2.66^{ab}	3.00^{ab}	3.50^{ad}
LSD	(0.6236)	(0.5915)	(0.778)	(0.665)

Means with the same superscript are not significantly different.

Table 3. Mean number of leaves of *Vitellaria paradoxa* seedlings as influenced by various planting depths at 6, 12, 18 and 24 weeks after sowing (WAS).

TREATMENT	6WAS	12WAS	18WAS	24WAS
2	2.40^{a}	3.80^{b}	3.40^{a}	4.20^{a}
4	1.80^{a}	3.20^{b}	2.80^{a}	3.80^{a}
6	2.20^{a}	3.60^{a}	3.40^{a}	4.20^{a}
8	2.00^{a}	3.20^{b}	3.40^{a}	3.00^{b}
10	2.80^{ab}	3.00^{bc}	3.00^{a}	4.60^{ac}
LSD (0.813)	(0.5597)	(0.6188)	(0.813)	

Means with the same superscript are not significantly different.

Table 4. Mean Leaf Area Index of *Vitellaria paradoxa* seedlings as influenced by various planting depths at 6, 12, 18 and 24 weeks after sowing (WAS).

TREATMENT	6WAS (cm^2)	12WAS (cm^2)	18WAS (cm^2)	24WAS (cm^2)
2	3.18^{a}	7.22^{a}	8.20^{a}	9.44^{b}
4	4.00^{a}	9.42^{a}	9.30^{a}	10.54^{b}
6	4.60^{b}	11.72^{bc}	14.06^{bc}	12.94^{bc}
8	1.70^{bcd}	3.36^{acd}	7.48^{acd}	7.88^{b}
10	2.52^{acd}	8.06^{acd}	10.10^{bde}	9.58^{acde}
LSD	(0.914)	(1.087)	(1.087)	(0.5320)

Means with the same superscript are not significantly different.

Leaf area index

There was no significant difference between treatments 2cm and 4cm at 6, 12, and 18 WAS but experienced significant difference at 24WAS. However, there was significant difference among treatments 6cm, 8cm and 10 cm at 6, 12, 18 and 24WAS using LSD. At the end of the experiment, planting depth of 6cm recorded the highest leaf area index of (12.94cm^2) with the least being 8cm (7.88cm^2) as shown on Table 4. Leaf Area Index experienced significant difference ($p>0.05$).

Discussion

Germination percentage of Shea seeds

The first evidence of germination is the emergence of the radical (Yayock *et al.,* 1988). The result showed high germination percentage of a mean of 53% (Table 1) and can be attributed to the fresh state of seeds collected and nursed three days after. The fresh seeds may posses the required amount of moisture needed for germination. Ruyssen (1957) recommended that for high percentage germination, seeds should be sown as soon as possible preferably within the first week of collection. Yidana (1990) also reported that germination percentage vary widely (10%-90%) depending on several factors such as ripeness, types of trees and genetic factors.

The low germination percentage 30% may also be attributed to the deeper nature of the 8cm and 10cm planting depths which may lack sufficient oxygen for germination and not also conducive for Shea seed germination. This confirms the recommendation of Nikiema and Umali (2007) that Shea seeds are best planted at depths of 1 – 5cm for there is available moisture, oxygen and favorable temperature for germination at that range. Though Ugese *et al.* (2007) reported germination percentage to vary insignificantly across depths of 2 – 6cm, a follow up research inferred that in respect of seed size, shea seeds could be sown at depths ranging from 2 – 8 cm (Ugese *et al*., 2010), thus larger seeds being able to germinate from deeper depths due to higher food reserves (Schmdt, 2000).

Seedling (shoot) height

It was observed that, Shea seedlings growth was slow after germination. Yayock *et al.* (1988) reported that when the Shea seed germinates it sends down a long tap root before producing any leaves. This germination strategy may have developed as a surviving mechanism. Seedlings attained a mean height of 2.3cm within the first six weeks after sowing but subsequent growth after the sixth week was slow reaching a mean height of 3.8cm after the twenty – fourth week. Frimpong and Adomako (1986) demonstrated that about 74% of the dry matter of seedlings is found in their roots, indicating that shoot development is suppressed in the early stages of Shea seedling growth. The result also showed that 6cm, 4cm and 2cm supported initial growth rate (height) of 4.7 cm, 3.8cm and 3.9 cm respectively as compared to 8 cm and 10 cm which recorded a growth rate (height) of 3.1cm and 3.5 cm respectively after a period of twenty-four weeks and the former can be attributed to the fact that 2 cm, 4 cm and 6 cm not being too deep and contain sufficient oxygen and conducive temperature to support fast growth.

Leaf area index and number of leaves

There was significant difference ($p> 0.05$) on leaf area index as affected by various planting depths. Planting depth of 6 cm recorded the highest leaf area index (12.9cm^2) and 8cm recorded the lowest (7.9cm^2) (Table 3).

The Shea seedlings germinated easily reaching 2- 4 leaves with a mean of 2 leaves (Table 3) within the first six weeks after sowing. However, subsequent growth after the sixth week was a bit fast reaching 2-8 leaves with a mean of 4 leaves (Table 3) after the twenty-fourth week. This conforms to Yidana (1994) and Frimpong *et al.* (1990) who stated that generally the seeds in the Shea fruits germinate easily, reaching 2 – 4 well developed leaf stage within six weeks (38-40 days).

The research indicated that crop growth and development which translates into plant height was significant as demonstrated by the various planting

depths. However, the study revealed that 2, 4 and 6 cm planting depth produced optimum conditions for germination of Shea seeds and growth and development of Shea seedlings. Based on the above conclusions it is recommend that for higher germination of Shea seeds and maximum growth and development in Northern Ghana, Planting should be done at 2 – 6 cm depth.

References

Abbiw D.1990. The Useful plants of Ghana. Intermediate Technology Publications/Royal Botanic Gardens, London/Kew. 337.

Bakang JEA. 1981. Shea nut (*Butyrospermum Parki* G. Don) Kotschy) in Northern Ghana. A review BSc. Dissertation, Crop Science Dept. University of Ghana, Legon. 60.

Bayala J, Balesdent J, Marol C, Zapata F, Teklehaimanot Z and Ouedraogo SJ. 2006. Relative contribution of trees and crops to soil carbon content in a parkland system in Burkina Faso using variations in natural ^{13}C abundance. Nutrient Cycling in Agroecosystem **76**, 193-201.

Bhatia RK and Chawan DD. 1983. Effect of sowing depths on growth performance in Senna. Indian Forester **109**, 212-215.

Boffa JM, Yameogo G, Nikiemoa P and Jaonda JB. 1996. What is the future for the shea tree. Agroforestry Today. 202 .

Bonkoungou EG. 1992. Sociocultural and economic functions of *Acacia albida* in West Africa. *In:* Vandenbeldt R.J., ed. The West African semi-arid tropics: proceedings of a workshop, 22-26 April 1991, Niamey, Niger. Nairobi: International Centre for Research in Agroforestry, 1-6.

Booth FEM and Wickens GE. 1988. Non-timber uses of selected arid zone trees and shrubs in Africa. FAO – conservation-Guide **19**, 1-176.

Coull GC. 1928. Distribution and yields of Shea butter nut trees in the Northern territories. Yearbook of the Gold Coast, Deparment of Agriculture **1927**. 130- 137.

De Bie S, Ketner P, Paasse M & Geerling C. 1998. Woody plant phenology in the West Africa savanna. J. Biogeography **25**, 883-900.

Elias M and Carney J. 2007. African Shea butter: a feminized subsidy from nature. Africa **77 (1)**.

Frimpong EB and Adomako D. 1986. Sheanut; Germination and mineral nutrition studies. Annual Rep. Cocoa Res. Inst. Ghana. 1985/86. 98-100.

Frimpong EB, Dwapanyin AO, Boafo JN and Essah EA. 1990. Metabolism of germinating shea. Annual Rep., Cocoa Res. Inst. Ghana, 1989/90 .152.

Hall JB, Aebischor DP, Tomlinson HF, Osei-Amaning E and Hindle JR. 1996. *vitellaria paradoxa* : A monograph, School of Agriculture and Forest Sciences Publication No. **8** University of Wales, Bangor. 105.

Henry AN, Chithra V and Nair NC. 1983. Vitellaria vs Butyrospermum (Sapotaceae). Taxon **32**, 286.

ICRAF. 2000. International Centre for Research in Agroforestry. Agroforestree Database 2000.

Jackson G. 1968. Notes on West African Vegetation-III: the seedling morphology of *Butyrospermum paradoxum*. J. West Afr. Sci. Assoc **13,** 215-222.

Leakey RRB. 1999. Potential for novel food products from agroforestry trees: A review. Food Chem **66,** 1-14.

Ministry of Food and Agriculture, MoFA. 2011. Policy for the Development of the Perennial Crops Sub-Sector in Ghana; Final Report. 46.

Nikiema A and Umali BE. 2007. *Vitellaria paradoxa* C.F. Gaertn, [Internet) Record from protabase. Van der Vossen, H.A.M. &Mkamilo, G.s. (Editors). PROTA (Plant Resource of Tropical Africa/Ressources vegetales de I'Afrique tropicale), Wageningen, Netherlands. <http: //database. Prota.org/search.htm>

Ruyssen B. 1957. Le karate au Soudan. Agronomic tropicale 12(2):143-172 and (3): 279-307.

SARI. 1997. Soil survey. Savanna Agricultural Research Institute, Nyankpala. 9-22.

SARI. 2004. Annual Report for the year 2004. Savanna Agricultural Research Institute, Nyankpala. 8-9.

Sexena MC and Singh Y. 1965. A note on area estimation of intact maize leaves. India J. Agron **10(4),** 437-439.

Schmdt L. 2000**.** Guide to Handling of Tropical and Subtropical Forest Seed. Danida Forest Seed Centre, Krogerupvej 21, Denmark. 511.

Tripathi JP, Bajpai SP. 1985. Effect of depth of sowing on germination of kardan (*Anogeissus pendula*) seeds. Indian Forester **111,** 167-169.

Ugese FD, Ojo AA and Adedzwa DK. 2007**.** Effect of sowing depth and seed size on emergence and seedling growth of seeds of shea butter tree (*Vitellaria paradoxa*). Nig. J. Bot **20,** 93-102.

Ugese FD, Baiyeri KP and Mbah BN. 2010. Effect of sowing depth and mulch application on emergence and growth of shea butter tree seedlings (*Vitellaria paradoxa* C. F. Gaertn.). African Journal of Biotechnology **9 (10),** 1443-1449.

Umali BE and Nikiema A. 2002. *Vitellaria paradoxa* C. F. Gaertn. Record from Protabase. Oyen LPA and Lemmens RHMJ (Editors). PROTA, Wageningen, the Netherlands.

Yayock JY, Lombin G and Owonub JJ. 1988. Crop Science and production in warm climates-shea butter. 150.

Yidana JA. 1994. Pollination in shea trees. Cocoa Research Institute, Ghana Annual Report 1992/93.