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ASSESSMENT OF NATURAL REGENERATION OF *VITELLARIA PARADOXA* C.F. GAERTN IN SAKI, OYO STATE, NIGERIA

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ABSTRACT

This study was aimed at assessing the natural regeneration of *Vitellaria paradoxa* at seedling stage *in order to accentuate its sustainable plantation establishment*. Two land-use types (cultivated and fallow lands) and five crown shapes (round, spindle, spherical, umbrella and intermediate) were evaluated for their effects on early growth of *Vitellaria* seedlings. Data were analyzed using descriptive statistics and ANOVA at 5% level of significance. The results revealed that cultivated land had a higher mean value in height (19.29 cm), number of leaves (6.26) and leaf area (33.38 cm^2). Land-use types and tree crown shape significantly influenced the level of carriage of the seeds by rodent pest animals with 2.6% seeds from the cultivated land while fallow land had 21.6%. For sustainable production of healthy seedlings, adequate land preparation and soil conditioning are very important for natural regeneration and early growth of the seedlings of *V. paradoxa*.

Keywords: Cultivated land, Fallow land, Natural Regeneration, Seedlings, *Vitellaria paradoxa*.

INTRODUCTION

Natural regeneration is the natural process by which plants replace themselves (Yang *et al*., 2014). It engenders forest restoration through seedlings establishment and coppicing, which results in high-quality forests with high biodiversity (Wang *et al*., 2008). It is reported that natural regeneration offers a cheaper alternative to active reforestation and has the potential to become the predominant way of restoring degraded tropical landscapes at large scale (Latawiec *et al.,* 2016). Ecological restoration offers benefits which include: reversal of biodiversity decline, the reestablishment of ecological processes, and enhancement of ecosystem services in disturbed or degraded lands throughout the world (Lamb, Erskine & Parrotta, 2005; Chazdon and Guariguata, 2016; Crouzeilles, Beyer, Mills, Grelle & Possingham 2016a; Latawiec *et al.*, 2016). *Successful regeneration of young forests following natural or anthropogenic alterations is the first principle of sustainable forest management. Regeneration practices, whether successful or not, can have substantial long-term effects on future stand dynamics, sustainable management options, and whether overall goals are achieved (Wagner et al., 2018).*

Vitellaria paradoxa (Shea butter tree) is a highly valued economic forest tree species which is indigenous to semi-arid and sub-humid savannas of Sub-Saharan Africa (Bonkoungou, 2004). In Africa, the area of distribution of this species tally with the area of Sudano-Sahelian climate. The species covers a geographical band from Eastern Senegal to North-Western Uganda. According to Rao, Verchot & Laarman (2007), it is a tropical tree species with multipurpose uses: ecological, socio-economic functions and helps to maintain soil conditions. Besides, the trees are used in agroforestry systems that play an important role in the adaptation to climatic change such as contribution to soil fertility. *It is reported that V. paradoxa provides sustainable means of livelihood for rural women (Bello-Bravo et al., 2015).* Almond obtained from the seed is usually processed into Shea butter and widely used in culinary cooking and strongly marketed into the sub-region and the world. This oil is also used in the manufacturing of cosmetics and pharmaceutical products. The wood of the Shea butter tree is used for charcoal, mortar and pestle, furniture and construction, and the latex for glue making (Lovett and Haq, 2000).

However, Shea tree as commonly known has been classified as a vulnerable species on the International Union for Conservation of Nature Red list due to high level of exploitation in the natural forests. It is also subject to the menace of all kinds especially related to its low natural regeneration, high demographic pressure and the current practices of bushfires. The other cause of the destruction of Shea trees is their invasion by parasites, epiphytes and fungi.

Shea tree in agroforestry parklands (also known as Shea Parklands) has received international attention since the 1950s when Shea tree products became recognized as important nutritional and economic resource (Bonkoungou, 1992). Traditionally, farmers across the Shea tree belt have developed land-use systems which ensured the sustainable use of the valuable Shea resources through parklands. Culturally, at the time of land clearing for agricultural production, some valuable trees like *V. paradoxa* are usually reserved and nurtured in the cropped field. In addition to Shea trees, other highly valued tree species preserved in parkland system include fruits trees such as *Parkia biglobosa*, *Tamarindus indica*, *Adansonia digitata* or the *Faidherbia albida* (Bonkoungou, 1998). Therefore, the parklands system forms an integral and often dominant part of the natural and agricultural landscapes in which the trees grow. Due to its economic importance, it is highly necessary to assess this important species for in-situ conservation and *possible sustainable plantation establishment*. Hence, the study is aimed at assessing the natural regeneration potential of this multipurpose tree species.

MATERIALS AND METHODS

The study area

The study was carried out on *Vitellaria* parkland located at Saki in the Southern Guinea Savanna ecological zone of Oyo State, Nigeria. It is on latitude 8°36′N and 8°40′N and longitude 3°16′E and 3°19′E of the Greenwich meridian. It has a population size of 388,225 at 2006 census (NPC, 2006). The climate in the area is characterized by both rainy and dry seasons. The rainy season starts between April and October while dry season between November and February. The average annual temperature in the district is 27°C and temperatures range from 17°C to 35°C (Wikipedia, 2019).

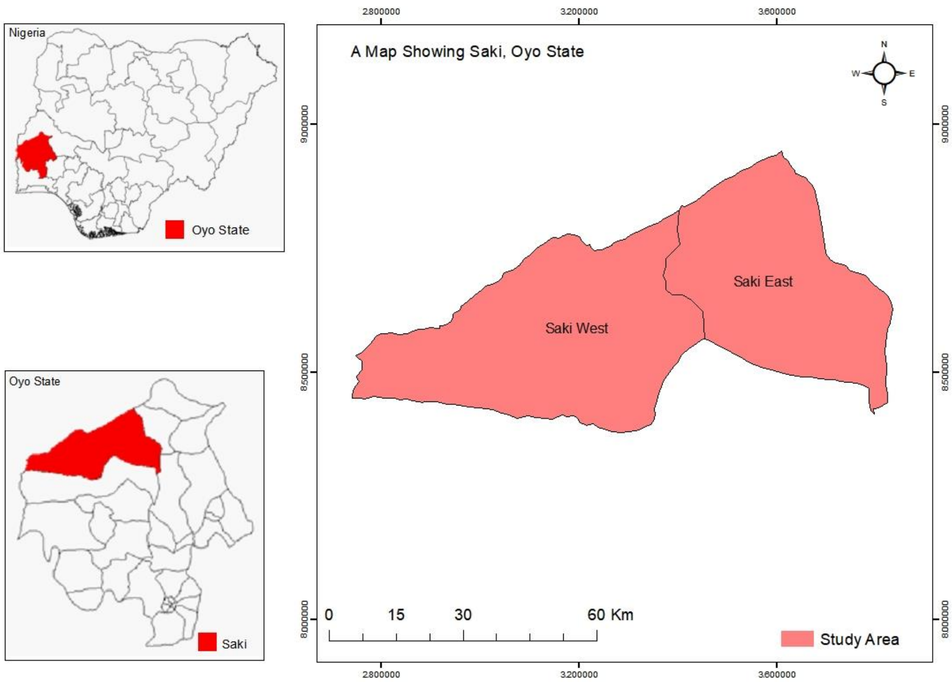

Figure 1: Map of the Study Area

Experimental Procedure

The experiment was purposively carried out at *Vitellaria* parkland that had at least five major crown shapes with eighteen to twenty-five (18-25) mature mother trees. A population consisting of eighteen (18) mother trees were chosen while ten healthy trees with high fruiting ability were identified and further classified based on crown shapes (round, spindle, spherical, umbrella and intermediate) and selected for natural regeneration monitoring. The fruit production of the trees selected based on five identified crown shapes was bought from farmers for that particular fruiting season thus ensuring adequate security of the areas. On the floor of five trees selected for each of the five crown shapes where active farming activities exist, a square dimension of 5x5 m round the stems of *Vitellaria* trees was scrapped of litters, fruits, seeds and undergrowth before lightly tilled. The same five crown shapes were also identified on fallow land and a similar area of 5x5 m on the floor around the stem of each was only demarcated. Fruits fall was monitored on the forest floor of the two groups for a week and thereafter one hundred (100) fruits per tree were tagged by putting labelled stand beside the identified fruits sampled. Pulp decomposition, organisms involved in the decomposition and rodent pests in the areas were monitored every week and recorded for six (6) weeks. After germination, ten (10) developing seedlings under each crown of the selected *V. paradoxa* mother trees were monitored for early developmental studies. The experiment was laid in Randomized Complete Block Design (RCBD) where there are two land-use types (cultivated and fallow lands) constituting the Block and five crown shapes (round, spindle, spherical, umbrella and intermediate) constituting the Treatments.

A set of 24 seeds in four replicates from each mother tree used above were potted into 16 x 14 x 12 cm poly pots filled with 5cm depth topsoil on the forest floor. The potted seeds were placed under the mother trees in the four cardinal directions (North, South, East and West) and left to natural watering through rainfall. This was compared with the topsoil medium used in the nursery and the growth on the forest floor. Development of pseudo-radicle elongation and epicotyl initiation were monitored weekly using the destructive method.

DATA ANALYSIS

The data obtained from this study were analyzed using descriptive statistics and Analysis of Variance. Means found to be significant were separated by the Duncan Multiple Range Test (DMRT) at 5% level of probability.

RESULTS

Germination percentage

Land-use types significantly affected the germination of *V. paradoxa* ($p \leq 0.05$) while tree crown shape did not (Table 1). High germination percentages were recorded for cultivated land-use type under various crown shapes with the highest mean germination percentage of 90.4%, while 41.4% was recorded in the fallow land (Table 2). Tree canopy shapes were not significantly different from one another (Table 1). From all the tagged seeds, only 2.6% seeds were carried away by pests like insects (crickets) and some other small animals like squirrels and giant rats from the cultivated land while 21.6% were carried away from fallow land.

Table 1: ANOVA for germination and tree canopy shapes of *V. paradoxa*

Variables	SV	Df	MS	F-cal	p - Level
Germination	Tree crown shape (TCS)	4	67.10	0.926^{ns}	0.529
	Land-use type (LT)	1	6002.50	96.61*	0.000
	Error	4	62.13		
Tree canopy shape	Tree crown shape (TCS)	4	27.60	11.04*	0.000
	Land-use type (LT)	1	902.5	361.00*	0.000
	Error	4	2.5		

Note: * Significant at 5% probability level; ns = not significant

Total seedling height (cm)

There were significant differences ($p \leq 0.05$) in the height of *V. paradoxa* wildings grown on cultivated and fallow lands (Table 3). However, there were no significant differences ($p \leq 0.05$) in the height due to difference in tree canopy nor were there significant interactions at $p \leq 0.05$ among the tree crown shapes. The highest mean height (19.29 cm) was recorded on cultivated land while fallow land type had 9.41 cm (Table 2).

Shoot diameter (mm)

There was a significant difference ($p \leq 0.05$) for both land-use type and canopy shapes (Table 3). The mean shoot diameter of wildlings under spherical, umbrella and spindle (1.13 mm, 1.11 mm and 1.09 mm) canopy shapes were not significantly different ($p \leq 0.05$) from each other but they were significantly different ($p \leq 0.05$) from the round (1.19 mm); this was also significantly different ($p \leq 0.05$) from the intermediate shape with the highest mean of 1.30 mm (Tables 2).

Leaf production

Land-use types, as well as tree canopy shapes, had significant ($p \leq 0.05$) influence on leaf production of *V. paradoxa* wildlings (Tables 3). However, follow-up test showed differences in the mean number of leaves from cultivated and fallowed land-use types; as well as tree canopy shapes. The highest mean number of leaves (6.26) was recorded from cultivated land which was almost twice (3.56) produced on fallowed land. Also, among the tree canopy shapes, spherical and umbrella crown shapes were not significantly different ($p \leq 0.05$) from each other. The highest mean number of leaves for the two was 5.32 each. These were followed by the spindle (4.84) which was significantly different ($p \leq 0.05$) from round and intermediate crown shapes with 4.43 and 4.66 respectively (Table 2).

Table 2: Mean germination and early growth of *V. paradoxa* seeds under different tree crown shapes and land-use types

Variables	% Germination	Height (cm)	Diameter (mm)	Leaf Production.	Leaf area (m^2)
Land-Use type					
Cultivated	90.40^{b}	19.29^{b}	1.54^{b}	6.26^{b}	33.38^{b}
Fallowed	41.40^{a}	9.41^{a}	0.79^{a}	3.56^{a}	23.87^{a}
Tree Crown Shape					
Round	11.50^{a}	11.03^{ns}	1.19^{b}	4.43^{a}	30.36^{c}
Spindle	9.00^{a}	$11. 04^{ns}$	1.09^{a}	4.84^{ab}	28.22^{b}
Spherical	13.00^{a}	11.10^{ns}	1.13^{a}	5.32^{b}	25.38^{a}
Umbrella	18.00^{b}	11.00^{ns}	1.11^{a}	5.32^{b}	31.25^{c}
Intermediate	9.00^{a}	11.01^{ns}	1.30^{c}	4.66^{a}	27.91^{b}

Note: Means with the same letters are not significantly different from each other at $p \leq 0.05$

Leaf area (cm^2)

Land-use types (cultivated and fallowed), tree canopy shapes (round, spherical, spindle, umbrella and intermediate) and their interactions had significant differences ($p \leq 0.05$) on the leaf areas of *V. paradoxa* wildlings at 5% probability level (Table 3); and the follow-up tests showed differences in their means (Table 2). The mean leaf area (33.38 cm^2) produced on cultivated land-use type was higher than 23.87 cm^2 from fallow land. In terms of canopy shape, umbrella canopy had the highest value for leaf area of 31.25 cm^2, followed by the round canopy (30.36 cm^2) while spherical crown type had the least with 25.38 cm^2. Interaction of cultivated land-use type and umbrella canopy shape gave the highest mean value for leaf area (40.46 cm^2). This was followed by cultivated land-use and round canopy shape (34.12 cm^2).

Table 3: Analysis of variance for the effects of crown shape and land type on growth of *V. paradoxa* seedlings

Variables	df	MS	f-value	P-level
Height (cm)				
LT	1	14639.20	353.67*	0.000
TCS	4	16.16	0.39^{ns}	0.816
Error	4	41.39		
Shoot diameter				
LT	1	85.972	1811.621*	0.000
TCS	4	0.831	17.511*	0.000
Error	4	0.047		
Leaf Production				
LT	1	1090.80	213.07*	0.000
TCS	4	19.019	3.715*	0.005
Error	4	5.12		
Leaf area				
LT	1	13539.40	225.98*	0.000
TCS	4	632.26	10.553*	0.000
Error	4	59.91		

*Significantly different at $p \leq 0.05$, ns = not significant, LT = Land-use type and TCS = Tree crown shape

DISCUSSION

According to Pritchard *et al.* (2004), large seeds can be highly attractive to vertebrate seed predators. These might have provided the selective force for mass fruiting events, which led to predator satiation as in dipterocarp species (Curran and Webb, 2000). From this study, results showed that many seeds were lost to insects and rodents pests before they could germinate and this may be the reason why lower germination was recorded under fallow condition. This result agrees with the report of Mendi-Anjah (2005) when she investigated the effect of site location on seedling survival in *Ricinodendron hendelotii*. Cropping land produced more vigorous seedlings of *R. heudelotii*. Annighofer *et al*. (2015) also observed an increase in growth of *Quercusrobur L.* seedlings raised under clear cut and shelterwood systems. The report of Boydak (2004) which recommended the regeneration method in shelterwood, clear-cutting and strip cutting for *Pinus brutia* also agrees with the present study. The results obtained from this study also corroborate Byakagaba *et al.* (2011) who found a significant difference in the growth of *V. paradoxa* under different land-use types in Uganda with fallow land significantly different and also confirmed by Djossa *et al.* (2008a) who observed that a significant variation in the seedlings of *V. paradoxa* under different land use pattern with cultivated land use having poor growth. Comparison of growth on the forest floor with polythene pots showed that containerization limits the quantity of air moisture and nutrient availability to the growing seedlings. Therefore, the growing medium that will support tree growth of *V. paradoxa* seedlings must have sustained an appropriate blend of moisture, nutrient holding capacity and porosity to ensure adequate air circulation. This agrees with Kumah (2011) who reported that the physical composition of growing media have a profound effect on the supply of water and air to the growing plant and on the wetting properties of dried out media.

CONCLUSION

Land-use types significantly affected the *in-situ* germination and early growth of the species. Tilling could have encouraged the germination and seedling growth of the species by loosening the soil and thereby providing a suitable soil environment for seed germination and root growth. The fact that many seeds were lost to insects and rodents pests before they could germinate may also explain why lower germination was recorded under fallow condition. Comparison of growth on the forest floor with polythene pots showed that containerization limits the quantity of air moisture and nutrient availability to the growing seedlings. *For sustainable early growth of V. paradoxa seedlings, the growing media* must possess an appropriate blend of moisture, nutrient holding capacity and porosity to ensure adequate air circulation. Therefore, it can be concluded that adequate land preparation and soil conditioning are very important for natural regeneration and early growth of the seedlings of *V. paradoxa*.

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