

# Determination of growth stages and seedling structures associated with slow emergence of shea butter tree (*Vitellaria paradoxa* C. F. Gaertn.) seedlings.

F.D. Ugese<sup>1\*</sup>, K. P. Baiyeri<sup>2</sup> and B. N. Mbah<sup>2</sup>

<sup>1</sup>Department of Crop Production, University of Agriculture, PMB 2373, Makurdi, Nigeria

<sup>2</sup>Department of Crop Science, University of Nigeria, Nsukka, Nigeria

\* Author for correspondence e-mail: [f\\_ugese@yahoo.com](mailto:f_ugese@yahoo.com)

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## 1 SUMMARY

Growth of seedling structures of three accessions of *Vitellaria paradoxa* i.e. Makurdi, Jalingo and Kano, were investigated at Makurdi, Nigeria, in 2007. Ten (10) seeds per accession were planted in 7 litre plastic containers filled with weathered saw dust at the rate of one seed/container, with each seed representing a replicate. Weekly observations were made on the seeds for germination and growth of seedling structures. Results indicated that accessions differed with respect to days to appearance of swelling, length of radicle at which swelling appeared and shoot length above ground at the time of emergence. Percentage of seedlings that sprouted during the first week of observation differed in favour of Makurdi (80%) and Kano (60%) seeds, while seeds from Jalingo began sprouting after two weeks of planting. Seedling emergence spanned from 51-79 days. In general the accessions followed the pattern of germination and growth expected of *Vitellaria*. Time to formation of swelling and formation of shoot to its growth and emergence could account for the long time it takes for the seedling to emerge above ground. Efforts at hastening seedling emergence in this species should therefore focus on the above aspects.

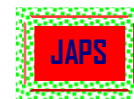
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## 2 INTRODUCTION

One of the important tree species in Africa is the shea butter tree (*Vitellaria paradoxa* C. F. Gaertn.) owing to its high potential in contributing to reduction of rural poverty, hunger and disease and enhancing environmental sustainability. The fruit pulp, which has excellent nutritional content (Ugese *et al.*, 2008a and b) is widely consumed among indigenous peoples of Africa (Maranz *et al.*, 2004) while among some ethnic groups, the flowers are made into fritters (ICRAF, 2000). Locally, the oil is used as a cooking fat while in Europe and Japan; it is used in chocolate manufacture (Umali and Nikiema, 2002). Caterpillars of *Cirina butyrospermi*, associated

with the species are eaten by some ethnic groups in Nigeria such as the Yoruba, Nupe and Tiv (Ande, 2004; Ugese *et al.*, 2005).

Shea butter is also used in production of cosmetics (Boffa *et al.*, 1996). The increasing popularity of the butter in cosmetics the world over is attributed to its skin protecting and rejuvenating properties (FAO, 2006). The tree confers stability on the land resource thereby curtailing degradation (Boffa *et al.*, 1996). This is achieved partly through improvement of soil structure by the slow decomposing leaf litter (Bayala *et al.*, 2005). Trade in shea tree products has been reported to improve the incomes and living standards of rural farm families and the



economies of exporting countries (Popoola and Tee, 2001).

However, some of the peculiar characteristics of the species under cultivation include its slow emergence speed (Joker 2000; Ugese *et al.*, 2007), slow growth rate (Jackson, 1968) and long gestation period (Awoleye, 1995). Germination in *V. paradoxa* is peculiar, and is said to be 'cryptogeal' as it does not fit exactly into the known patterns of hypogeal and epigeal germination. Jackson (1968) observed that germination starts with the cracking of the testa at the blunt end of the nut and the coming out of the false or apparent radicle. This structure, which is positively geotropic, attempts to curve beneath the nut before penetrating deeper into the soil. Subsequently, a swelling is formed about 5 - 7cm along its length. Above the swelling, a pink colored shoot with scale leaves emerges and grows upwards. The structure below the swelling,

which is the true root, continues its growth downwards. The time for the appearance of the shoot above ground when seeds are planted is long (Awoleye, 1995; Joker, 2000; Ugese *et al.*, 2005), even though it takes only a few days for the apparent radicle to emerge from the testa under favorable conditions (Jackson, 1968).

Unfortunately, information does not exist on the relative period of growth of seedling structures, which would be important in determining why the plumule takes long to appear above ground, hence developing solutions to this constraint (Ugese *et al.*, 2005). It was therefore considered necessary to follow the germination and emergence processes of shea seedlings to identify which stages or seedling structures are responsible for emergence delays. This understanding is critical in the efforts towards overcoming the characteristic slow speed of emergence of *Vitellaria* seedlings.

### 3 MATERIALS AND METHODS

**3.1 Shea seed collection and planting:** Shea fruits were collected from Makurdi, Jalingo and Kano in 2007. Pertinent geographic information about these locations as contained in previous reports (Ugese *et al.*, 2010) indicates that Makurdi, Jalingo and Kano belong to the southern guinea savanna, northern guinea savanna and the sudan savanna zones respectively. The fruits were depulped to obtain the seeds or nuts. The seeds were planted on July 30, 2007 in growth medium comprising of weathered sawdust placed in 7 litre plastic containers. Seeds were planted 4cm deep with their more flattened side facing downwards and completely covered. Ten seeds of each seed source or accession were planted, with each seed in a pot standing for a replicate. The experiment was a completely randomized design (CRD). Pots were arranged under a shade at the Teaching and Research Farm of the University of Agriculture, Makurdi.

**3.2 Data recording and analysis:** Weekly observations were made on the seeds by carefully

removing them to record the extent of growth. After each observation, the seeds were carefully placed back and covered.

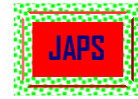
Generally, observations were made on sprouting of seeds, days to appearance of swelling, shoot and emergence of seedling above ground, length of false radicle at formation of swelling, length to swelling, length of shoot above ground at emergence, total shoot length and root length at emergence. The last three parameters were taken at emergence of the seedling at which data taking was terminated, since the major interest was on growth of seedling from sowing to emergence only. Days from shoot formation to its emergence were estimated as the difference between when seedlings emerged above ground and when swelling was noticed.

Data were subjected to analysis of variance using GENSTAT Discovery edition 3, Release 7.2DE (GENSTAT, 2007) while means were separated using F-LSD.

### 4 RESULTS

Events from seed sowing to seedling emergence are presented in Fig 1. Results indicated significant

variation of the accessions with respect to days to appearance of swelling, length of radicle at which



swelling appeared and the length of shoot above ground at the time of emergence. Other parameters did not differ significantly (Table 1). It was observed at the first week of observation that 80 and 60%, respectively, of seeds of Makurdi and Kano origins had sprouted. However, with the Jalingo seeds the earliest evidence of sprouting was after two weeks of sowing. Sprouting in this case denotes the emergence of the false radicle from the testa at the acute angled end of the scar (Fig 1).

As shown in Table 1, swelling was noticed after 23 days for the seeds from Makurdi, 40 days for the seeds from Jalingo and 33 days for those from Kano. Conversely, the accession from Makurdi had the longest days from shoot formation to its emergence. Thus in the final analysis, days to

emergence across the three accessions were non-significant even though the seeds from Makurdi showed a tendency to emerge earlier than the others.

Length of radicle, along which the swelling formed, varied from 12.4 to 15.7 cm. Days to seedling emergence also varied non-significantly from 57 to 64. Length of radicle to swelling measured at seedling emergence was from 5.0 (Jalingo) to 7cm (Kano). Similarly, total length of shoot at seedling emergence was from 6.7 to 7.3 cm, while the portion of shoot above ground varied from a high of 2.3 cm (Makurdi) to a low of 1.3 cm (Kano). Length of root (including false radicle) when seedling emergence was recorded spanned from 24.4 to 30.8 cm.

**Table 1:** Comparison of growth and number of days taken to attain different stages of growth of seedling structures of shea (*Vitellaria* sp.) seeds of accessions from in Nigeria.

Accession	DSN*	LFRSN	DTE	LTS	TSLE	SAGE	RLE	DSFE
<b>Makurdi</b>	23.0	12.4	57.0	6.3	6.7	2.3	30.8	34.0
<b>Jalingo</b>	39.8	14.4	63.6	5.0	7.3	1.9	24.4	23.8
<b>Kano</b>	32.8	15.7	62.2	7.0	6.9	1.3	28.8	27.4
<b>Mean</b>	31.9	14.2	60.9	6.1	7.0	1.8	28.0	28.4
<b>LSD (0.05)</b>	8.8	NS	NS	0.9	NS	0.6	NS	9.8
<b>CV (%)</b>	24.5	17.6	16.0	13.6	18.4	29.9	5.7	30.6

\* - DSN – Days at which swelling was noticed; LFRSN – Length of false radicle when swelling was noticed; DTE – Days to seedling emergence; LTS – Length (of radicle) at which swelling forms; TSLE – Total shoot length at emergence; SAGE – Shoot above ground at emergence; RLE – Root length at emergence; DSFE – Days from shoot formation to its emergence; NS – No significant difference

Table 2 summarizes the days to first and last emergence of seedlings and the associated percentage emergence. Incidentally, first seedling emergence occurred 51 days after sowing across all accessions. However, while 50% of Makurdi

seedlings emerged at that date, only 20 and 10% emerged for Kano and Jalingo accessions, respectively. Similarly, days to last seedling emergence were 79 with 10% of seedlings emerging in all the accessions.

**Table 2:** Range in days from sowing to emergence of *Vitellaria* sp. seedlings.

Accession	First emergence (Days)	Last emergence (Days)
Makurdi	51 (50)*	79 (10)
Jalingo	51 (10)	79 (10)
Kano	51 (20)	79 (10)

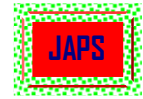
\* - Values in parentheses indicate percentage of seedlings that emerged on the specified days.

## 5 DISCUSSION

Germination and seedling emergence of *Vitellaria* seeds as observed in this study followed the sequence of events reported by Jackson (1968). This includes sprouting of the false radicle, formation of swelling along its length, splitting of the swelling and the attendant appearance of the pink-coloured

shoot that grows upwards and continuation of growth of the true root below the swelling.

Findings agree with those of Jackson (1968) that when the false radicle is growing the swelling forms 5-7cm along its length. Length to swelling in this study was 5, 6.3 and 7cm for Jalingo, Makurdi and



Kano accessions, respectively. Observation by the above author (Jackson, 1968) that the root is normally 7 - 8 cm long when the swelling begins to form was a little out of tune with our findings. Root length measured at swelling formation in the present study showed a range of 12.4 to 15.7cm. The observed disparity could be attributed to differences in seed origin or the higher number of seeds used in the present study.

Appearance of split from where the shoot emerges and grows to the soil surface is one of the events in the germination and emergence process of *Vitellaria*. It was not captured separately from swelling formation in the present work. This is because for most seedlings appearance of swelling and split occurred on the same observation date. This implies that these events take place in short succession to each other or even concurrently. According to Jackson (1968) the root first grows to a reasonable length before the shoot emerges. This was found to be true in this study. At the time the shoot was visible above the surface (with an above ground length of 1.3- 2.3cm), the root had already reached 24-31cm deep. This represents an average length over the shoot above ground of 15 times

The Makurdi accession had higher percentage of seedlings emerging on the first day of emergence. The accession however did not record significantly earlier days to emergence. It was however observed that the last batch of seeds to emerge at 79 days after sowing across accessions (Table 2) did not form the split on the swelling on time. Reasons for the delay in formation of split seem obscure at present but obviously contributed to the long time it took some seedlings to emerge above ground. This is capable of introducing wide disparities in days to seedling emergence even of the same seed lot.

It appeared quite interesting that even though sprouting of seeds from Jalingo lagged behind the others by about two weeks, this was not the case with days to emergence. Here, the accession lagged 7days behind the one from Makurdi and only one

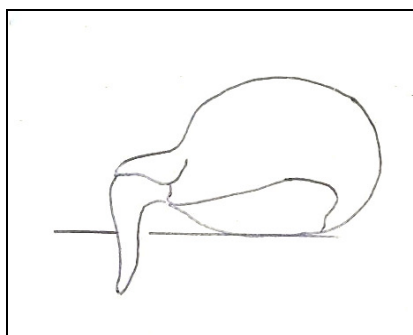
day behind seeds from Kano. From the estimate of days of shoot formation to its emergence, even though the accession took longer to develop the swelling (39days), it took comparatively shorter for its shoot to form and grow (23.8days). This behaviour could be linked to the larger size of Jalingo seeds which are considered to have more food reserves for the growing shoot compared to the smaller seeds from other locations, an opinion that seems to be supported by more recent findings of a positive (but non-significant) correlation between seed size and seed fat content (Ugese, 2009). The opinion that food reserves may be of more critical importance to seedling survival in *Vitellaria* has already been expressed (Ugese *et al*, 2007). Seedlings in this study were found to emerge first at 51 and last at 79 days from sowing. Ugese *et al* (2007) reported that a group of nuts emerged first after 45 days and last in 88 days after sowing.

Ugese *et al*. (2005) had subjected the testa of shea seeds to various treatments to see how this could improve germination. This was based upon Jackson's (1968) claim that intact testa could impose some level of dormancy on the seed. Results obtained however did not show significant reduction in number of days to seedling emergence, and led to the conclusion that the long time it took the plumule to emerge above ground could be traced to other factors apart from the seed coat. This has been confirmed by the present study suggesting that efforts at improving seedling emergence in this species should not be targeted primarily at the testa. Evidence obtained in this study strongly suggest that time to formation of swelling, formation of shoot to its growth and emergence, and in some cases, the splitting up of the swelling to pave the way for shoot formation could be key factors contributing to the long time it takes the shoot to emerge above the ground in this important species. Therefore efforts at overcoming emergence delays in this species should focus on the identified structures or stages.

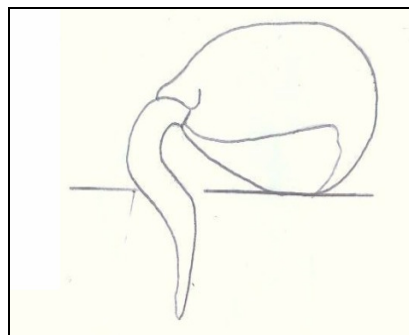
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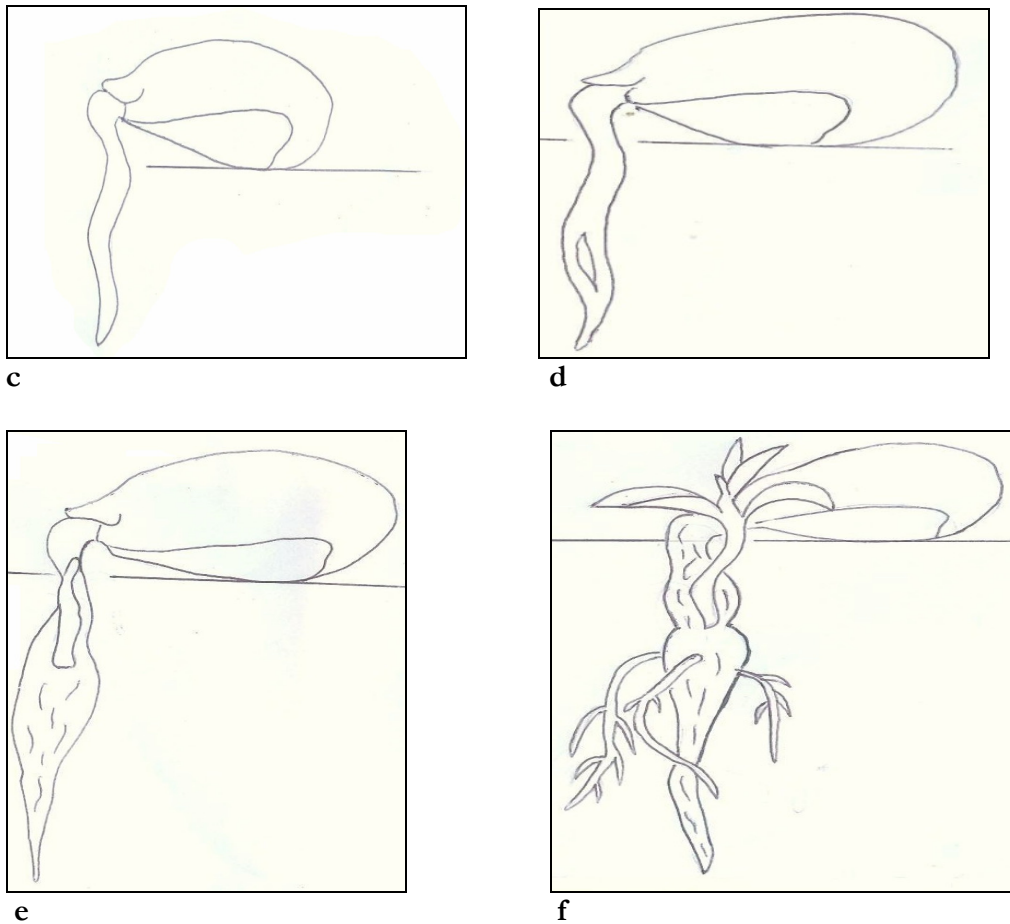


a



b





**Figure 1:** *Vitellaria* seedlings showing various stages of growth of structures: **a.** Seed just sprouted; **b.** Pseudo-radicle curving slightly beneath the seed before proceeding; **c.** seedling with well developed root showing swelling; **d.** Seedling with slit on the swollen portion; **e.** Seedling with shoot arising from swelling; **f.** Emerged seedling with young leaves.