International Journal of Agriculture and Environmental Research

ISSN: 2455-6939

Volume:04, Issue:03 "May-June 2018"

EFFECTS OF DENSITY AND PHENOLOGY ON FECUNDITY IN *Vitellaria paradoxa* C.F. Gaertn.

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ABSTRACT

Fecundity, measured as the degree of fruitfulness was assessed by determining the effects of tree density and phenology on fruits in *Vitellaria* population at the permanent site of University of Ilorin. A total of thirty (30) trees were randomly selected from two distinct locations, tagged and used for this study. The locations include a dense and a sparse areas. From each selected tree, flowering and leafing phenological events as well as fruiting patterns were observed and recorded. Number of flower buds per inflorescence, percentage anthesis, and number of fruits per inflorescence were taken. Fruits and seeds quantitative characteristics were recorded at the end of the fruiting season. The data taken were analyzed using SPSS. Results indicated that *Vitellaria* fruits from December to February with peak in April. Three flowering timings- early, mid and late- were observed with significant difference ($p \leq 0.05$) with respect to fruits dimensions. Early flowering trees produced highest number of fruits/inflorescence (5.6), fruit weight (37.2cm), length (4.9cm) and diameter (4.1cm). Flower and leaf phenology interactions significantly affected fruits set in *Vitellaria*. Trees that produced flowers before shedding their leaves have the highest number of fruits, while those that flowered and shed leaves synchronously have the least number of fruits. Furthermore, trees in sparse areas produce higher average number of fruits/inflorescence (8) compared to those in dense areas (3). This indicated that *Vitellaria* trees found in sparse areas fruit better than those at dense areas.

Keywords: Density, fecundity, phenology, variation, *Vitellaria paradoxa*

1.0 INTRODUCTION

The Shea-butter tree, *Vitellaria paradoxa* Gaertn, is a major component of woody flora of the Sudan and Guinea Savannah vegetational zones of sub-Saharan Africa (Lovett and Haq, 2000). It is indigenous to sub-Saharan Africa, and generally only found in semi-arid to arid areas north of

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the humid forest zone (IPGR, 2006). The species' range from an almost unbroken belt approximately 5,000km long by 500km wide from Senegal to Uganda (IPGR, 2006).

Shea tree is an important economic crop because of the heavy demand for its butter in the international market mainly as a substitute for cocoa butter in the production of chocolate (Chidiogo *et al*., 2013). Shea butter is the most important product of shea trees and is extracted from the dried kernels. Its oil is widely utilized locally for domestic purposes, as skin moisturizer and as an illuminant (Lovett and Haq, 2000). The shea tree therefore, has a potential for economic development especially in rural areas (Chidiogo *et al*., 2013; Okullo *et al*., 2003). In addition, it helps in carbon sequestration and maintenance of soil conditions (Sanogo *et al*., 2016, Luedeling and Neufeldt, 2012).

In Nigeria, shea trees occur naturally in the wild and thrive almost exclusively in the North and grow especially better in opened field with low tree densities (Odebiy *et al*., 2004; Djossa *et al*., 2008). In general, trees do not usually yield fruit until they are 20 years old, and do not reach full maturity until they are 45 years old. However, once productive, they will continue to bear fruits up to their 200th year (Fleury, 2000).

Vitellaria shed their leaves mostly at the beginning of dry season and flower during their period of leaflessness (Burkill, 2000). Flowers develop in the axils of scale leaves, at the extremities of dormant twigs, from buds formed 2 years previously. Inflorescence is dense fascicle 5-7.5 cm in diameter at the end of a flowering twig, each usually containing 30-100 flowers. Fruits are produced from May to September depending on the altitude in groups of six to eight each carrying one to two nuts (Burkill, 2000), and sometimes, up to three nuts per fruits (Sale and Morakinyo, 2017).

Vitellaria fecundity have been described as complex and unpredictable (Aleza *et al.*, 2018) and its fruits production as cyclical (Delolme, 1947; Bourlet, 1950). The results of several studies suggest that decrease in the local densities of a given species affects the mating patterns and reproductive success of tropical trees by reducing pollinator activity, pollen deposition and out crossing levels. The flower synchrony of trees has also been proposed as an additional factor in controlling fruit set and regulating levels of out crossing, particularly in disturbed habitats (Fuchs *et al*., 2003). Romain *et al*., (2011) observed increase in shea productivity from regions with high tree densities to less dense areas. Other factors include genetic variations (Sale and Morakinyo, 2017; Aleza *et al*., 2018; Boffa, 1996; Ruyssen, 1957; Desmarest, 1958; tree diameters (Boffa, 1996; Kelly and Senou, 2017; Lompo *et al*., 2018), amount of rainfall and other climatic factors (Soro *et al*., 2012; Maranze and Wiesma, 2003; Sanou *et al*., 2006) and local interspecific interaction between shea trees and other components of ecosystems (Aleza *et al*., 2018).

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Information about the pattern of, and the factors affecting fruiting and overall fecundity of shea in a given population is scanty (Akpona *et al*., 2015; Aleza, 2018; Kelly and Senou, 2017; Boffa *et al*., 1996). However, this information such as fruits and nuts quality and quantity characteristics is prerequisite to shea conservation, propagation and breeding programmes. Selection should primarily be based on the qualitative and quantitative characteristics of fruits produced by varieties, and the regularity of fruits production. This would ensure that the yield of nuts, a character of interest to both the farmers and industries, is not compromised (Okolo *et al*., 2009). Consequently, this study aimed at determining the effects of tree size, local densities and phenological events on fecundity of shea trees.

2.0 MATERIALS AND METHODS

2.1 Study Area

The study was conducted at the University of Ilorin, Nigeria, Ilorin lies between latitude 8°30´N and longitude 4° 33´E/ latitude 8.500°N and 4.550°E.

2.2 Methods

Studies on fecundity in *V. paradoxa* is undertaken in the population to determine the effects of trees density and flowering and leaf phenology on fruits set of this important species. A total of thirty (30) trees were randomly selected from two distinct locations, tagged and used for this study. The locations include a dense area (forested sites), in which the tree stands are found in close and continuous canopy formation with their conspecies and other tree species; and sparse area (school premises), in which trees are widely spread. From each selected tree, eight (8) branches, two from each of the cardinal directions were selected, tagged and used in the research. From each branch, flowering and leafing phenological events as well as fruiting pattern were observed from October 2014 to July 2015. Number of flower buds per inflorescence, number of flowers that open, number of immature fruits and percentage of mature fruits relative to the number of immature fruits were taken. Because flowering in *Vitellaria* is erratic, observations and enumerations were done weekly throughout the fruiting period to capture and record all the phonological events. Fruits and seeds quantitative characteristics were recorded at the end of the fruiting season.

2.3 Data analysis

The data collected were subjected to two sample t-test to compare between the two locations, ANOVA was used to compare between the flowing timings observed. These analyses were performed using SPSS version 20, and the results were presented in table and charts using means and percentages.

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3.0 RESULTS

3.1 Monthly percentage of Vitellaria fruits set

First set of fruits in *Vitellaria* appeared towards the end of December and continuous until early January in the sparse area, whereas in the dense area, the first set of fruits delayed until early February (Fig 1). In both cases, the first batch of fruits got aborted before maturity. Trees in sparse areas produced higher number of fruits in February, March and April. But the reverse of this trend took place in May and June.

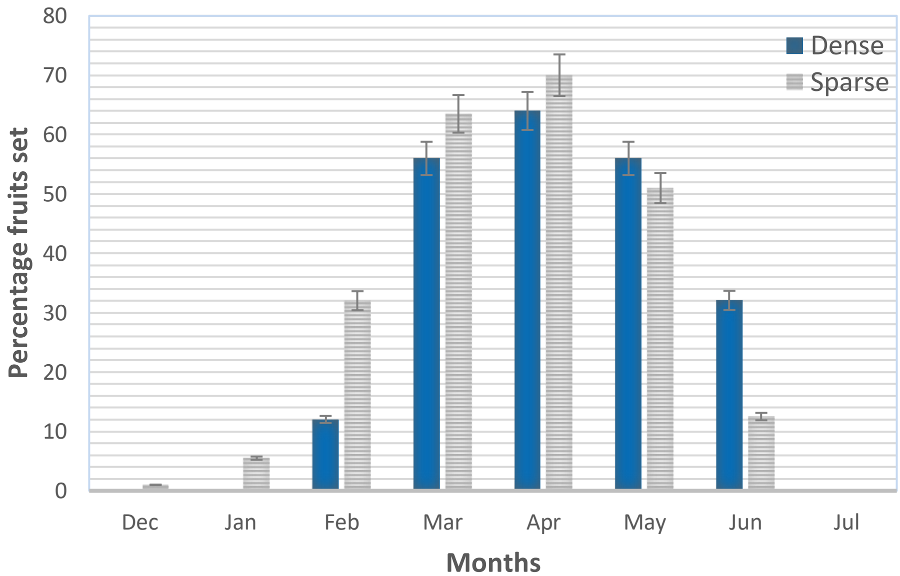

Figure 1: Monthly variation in percentage fruits set in the study area

3.2 Effect of flowering timing on fecundity

Some trees produced flower and fruits earlier, some late, but majority of the trees flower and fruit sometimes between the two extremes. Variation was observed amongst the trees on the basis of their flowering and fruiting timing. Analysis of variance showed significant difference ($P \leq 0.05$) between the three flowering times observed with respect to fruits weight, length and diameter, but there was no significant difference ($P > 0.05$), between the groups with respect to fruit number (Table 1).

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Table 1: variation in fruits quantitative characteristics with respect to time of flowering

Flowering timing	Fruit characteristics			
	Number of fruits	**Fruit weight**	**Fruit length**	**Fruit diameter**
Early flowering	5.6200±3.48[a]	37.1680±3.82[a]	4.9400±0.58[a]	4.0560±0.09[a]
Mid flowering	3.4960±2.12[a]	27.1500±3.61[b]	4.1320±0.25[b]	3.6560±0.24[b]
Late flowering	4.8380±1.73[a]	24.4820±4.46[b]	4.3260±0.47[b]	3.4400±0.32[b]

3.3 Effect of flower/leaf phenology interaction on fecundity

Both flowers and leaves in *Vitellaria* emerged from terminal buds, which lead to their competition for space. Flowering and leafing phenological events interacted in such a way that the old leaves got shed when flowers are emerging, and new leaves re-emerged when fruits are setting. Being on the same terminal shoot, sometime, old leaves would drop together with the flowers that borne on their axil. In some cases, the new leaves would emerge and replace the flowers/fruits on the terminal shoots. These interactions led to trade-off between the characters (leaves and flowers/fruits) at the expense of flowers and/ or fruits. Some trees shed most of their leaves before flowering, some started flowering first before leaf shed and others shed leaves and produce flowers at the same time. On these bases, three categories of phenological interactions were observed:

i. Leaf shed before flower
ii. Flower before leaf shed, and
iii. Flower and leaf shed together

Analysis of variance showed significant variation ($P \leq 0.05$) in these groups with respect to both number of flowers per inflorescence and number of fruits per inflorescence (fig. 4).

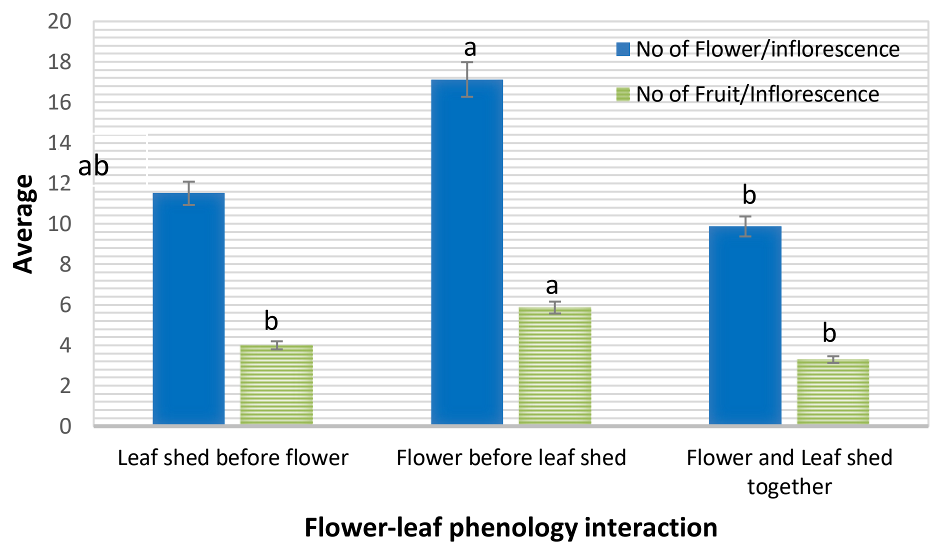

Figure 2: variation in flower and fruits production with respect to flower-leaf phenology interaction

3.4 Effect of tree density on fruitfulness in *Vitellaria paradoxa*

Figures 3a bellow shows differences in the average fruits length and diameter across the two locations. Higher length of fruits were recorded in dense areas, whereas fruit diameter was higher in sparse areas. Number of fruits was significantly higher in sparse areas than dense areas (fig. 3b).

Similarly, figure 3b shows significant difference ($p \leq 0.05$) in the weight of fruits and seeds across the two locations in favour of sparse areas.

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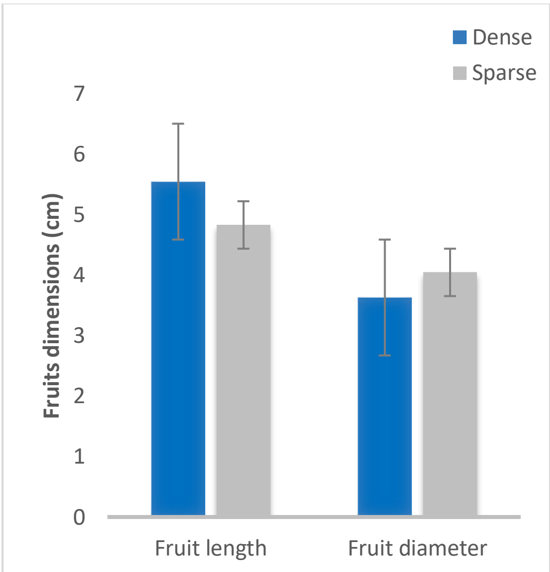

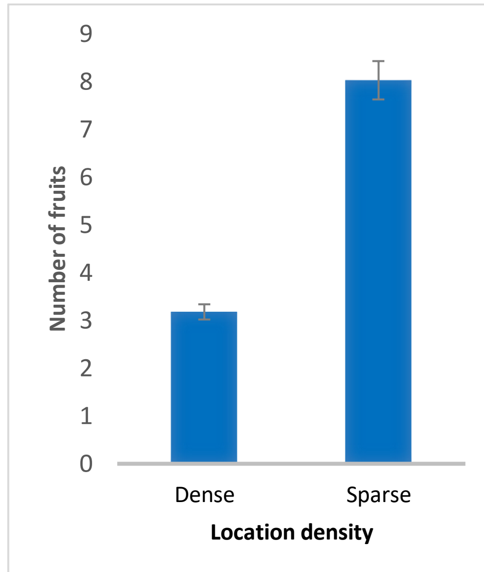

Fig. 3: (a) Differences in fruits diameter across locations (b) Difference in number of fruits across locations

4.0 DISCUSSION

The degree of fruitfulness differed in *Vitellaria* population with respect to phenological events and tree density. Trees in sparse areas produce fruits earlier than those in the dense area. This is probably due to the fact that trees in sparse area have access to enough light required to start flowering.

The three categories of fruiting timing observed might be due to genetic variations among individuals of *Vitellaria* population. This agrees with findings of Sale and Morakinyo, (2017); Aleza et al. (2018) and Trees that start fruiting earlier had better fruits characteristics. This is because they had ample time to nurture their fruits than those that start fruiting late. Another reason might be because they did not compete with others on pollinators.

The effects of flowering and leafing phenology interactions is due to the fact that both flowers and leaves are borne on the same terminal/apical shoot in *Vitellaria*. In some trees, new leaves emerged immediately after flower anthesis and displaced the flowers/fruits occupying the same position, which caused a serious tradeoff at the expense of flowers and/or fruits. This "phenology conflict" might be due to unstable and irregular climatic rhythms which might trigger the two events at the same time. This is perhaps the reason for unpredictability of shea fecundity (Aleza *et al.*, 2018).

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Trees in less dense areas produced fruits with better characteristics than those found in dense areas. The reduction in fruits characteristics may be due competition for space, air, light, water and nutrients. This agrees with findings of Romain *et al*., (2011) that fruiting in shea increase from Guinea to Sudan savannah.

5.0 CONCLUSION

Fecundity in *Vitellaria* is affected by many factors which include genetic, physiological, and environmental. In this study, the effects of phenological events, a physiological response and density, environmental factor, on fecundity was investigated. The results indicated that the type of phenology exhibited by a particular *Vitellaria* tree would determine its reproductive success. Trees that have longer fruiting period produce better fruits in terms of number and quality. In addition, trees that shed their leaves first, then produce flowers and fruits before new leaves emerge have better chance of having more fruits than those that have overlapped flowering and leafing phenological events. Furthermore, trees found in sparse areas have better fruits than those in dense areas. This information on the effect of phenology and density on fecundity is important in selecting *Vitellaria* varieties for breeding or regeneration programs and stocking densities in plantation establishment respectively.

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