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Research Paper

Phenological charts: A tool-kit in germplasm conservation and domestication of *Adansonia digitata* Lin in Nigeria

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Sound *ex-situ* conservation of parklands tree species will be appropriately complemented where detailed knowledge of the species phenological behaviours are available. Information of this type will not only provide knowledge about the plant growth, development and environment influence but also assists in the species genetic improvement. Range-wide phenological information of this type is scanty for *Adansonia digitata* in Nigeria. The study employed phenological review of literatures, voucher specimens examinations from a reputable herbarium in Nigeria (FHI) as well as phenological field observations for two consecutive years in the selected species range taken into consideration dry and raining season events. Data obtained were later related to their locations and their co-ordinates subsequently superimposed on the vegetation map of Nigeria, hence mapping the species into the different vegetation phytochoria or agro-ecological zones. Field phenological observations alongside with other sources of data obtained were synchronized over a 24-calendar months to produce phenological charts in the species. Findings indicated that flowering and fruiting regimes increased in a south-north direction of the species range with great overlaps. Flowering commenced late in the dry season extending northwards to the early rains (February-September) while fruiting was more of a early to mid raining season event (April-August). From the present study, future fruits collection programme should target (November–March) in the Lowland rain forest and Derived savannah range of the species and (June-September) in the Guinea and Sudan savannahs. The inconsistencies and overlaps observed in flowering and fruiting activities in the species could perhaps be attributed to global climate change and seasonality.

Key words: *Adansonia digitata*, phenological charts, domestication, *ex-situ* conservation

INTRODUCTION

The natural forest resources constitute an integral part of the rural economy providing food, income, medicinal materials as well as services to the rural and peri-urban population (FAO, 2005). African wealth of biological resources and forest genetic resources in particular are critical element in alleviating poverty, ensuring food security and developing new medicines (Van Wyke, 2008). They also possess immeasurable socio-cultural values and significance (Gillespie *et al*., 2004). Mgeni, (1991) opined that with the unique diversity of plant and animal life, tropical rain forest and savannah represent biological renewable resources of food, medicine and fuel

if well managed. Despite these potentials, developmental research attention is more recent in the non timber forest products (NTFPs) compared with their timber tree species counterparts (Oni, 2001). Deliberate research efforts became more pronounced following the recognition of their economic importance after the 5th meeting of the Panel of FAO Experts on Forest Genetic Resources Priority List (FAO, 2005). Within the natural forests and savannah ecosystems in Nigeria, abound several valuable non-timber resources of edible and highly nutritive plants whose fruits, leaves, stems, twigs, barks and roots are of high economic and medicinal values (Ugbogu and Odewo, 2004; Oni, 2010).

Adansonia digitata L otherwise known as Baobab, 'monkey bread tree', or 'upside down' tree belongs to the family Bombaceae (Bremer *et al*., 2003). It is locally called 'Kuka' in Hausa and ''Ose'' among the Yoruba speaking tribes in Nigeria (Keay, 1989). It is a deciduous tree native to Central Africa (Yazzie *et al*., 1994) from where it spread to other West African countries extending from Senegal to Sudan (Bosch *et al*., 2004) while occurrence has also been reported in the main highland of Madagascar (Diop *et al*., 2005). It has also been successfully introduced to South America (Sidibe and Williams, 2002). The species botany and biology had been adequately reported in literatures (Wickens, 1982, Bosch *et al*., 2004; Orwal *et al*., 2009). A deciduous tree with a large round canopy, swollen trunk of about 10-25m in height and diameter at breast height (DBH) often reaching 3-10m while sometimes giant individuals often attain 28m (Wickens, 1982). The bark is smooth and soft grayish-brown to purplish- grey, fibrous while the tree branches are normally ash-grey. The thick fibrous bark is remarkably fire resistant and this is one of it adaptive features in its savannah range (Orwal *et al*., 2009).

Baobab is a long-lived multipurpose tree with several economic values and its economic importance had been widely reported (Von-Maydell, 1990; Gebauer *et al*., 2002). The leaves are used as vegetable in soup while the flowers are sometimes eaten raw. The seed when roasted is used as soup thickener in place of groundnut (Tukur, 2010) and it also provides traditional flour which is very rich in vitamin B and protein (Von-maydell, 1990). The fruit pulp from the seeds provides a refreshing drink when dissolved in water or milk (Tukur, 2010) while the spongy nature of the stem bark allows it store water which is often taken during the heat period by both adults and children. The fiber from the inner bark of the stem is long (90-120cm) and is used for making rugs, mats and ropes (Sidibe and Williams, 2002). In fact all parts of the tree had been reported to have one economic importance or the other (Gebaur *et al*., 2002). Despite these numerous potentials and economic importance, there is increasing threats to the remaining germplasm range-wide especially in the savannah parklands largely due to poor deliberate planting efforts, reduced natural regeneration, habitat destruction, grazing, climate change and increasing desertification (Olajide, 2003; Bada and Popoola, 2005, Nikiema, 2005). Bosch *et al*. (2004) opined that dry season, bush burning, seed diseases are among other threats facing the remaining population of the species. It was also indicated that mother trees are diminishing in the species range due to elephant activities causing mortality of 1-4% annually (Bosch *et al*., 2004). Development of appropriate conservation and management programme for the remaining germplasm require not only detailed knowledge of the current population structure, natural regeneration pattern but also information on the species reproductive biology or phenology (Oni *et al.,* 2014). Opler *et al*. (1984) and Zhang *et al*. (2006) indicated that the pattern of phenological events are variously used for characterization of vegetation types which also assists in the pattern of plant growth, development, effects of environment and selection on flowering and fruiting behaviours.

Progress made in the field of forest tree species phenology had been very inspiring (Hall *et al*., 1996, 1997, Sun *et al*., 1996; Singh and Kushwaha, 2005, Oni *et al*., 2014). However much information on phenological attributes of parklands tree species are still required compared with their rainforest counterparts. Pettet (1977) and Oni (1997) reported that tropical plant tree species are characterized by precocious flowering, while for many, onset of flowering increased with latitudes (Oni *et al*., 2014). Hall *et al*. (1996) and (1997) provided information in that regard for *Vitellaria paradoxa and Parkia biglobosa* in their range in West Africa. In Nigeria, onset of flowering in *Kigelia africana and Khaya senegalensis* also increased in a south-north direction (Oni *et al*., 2014). Such synthesized detailed information is scanty for *A. digitata,* in most parts of its range in Nigeria. The paucity of this information will hinder sustainable fruits collection programme and will subsequently affect its domestication and *ex-situ* conservation synergy in the species and this currently justifies the present study. The study collated and harnessed phenological information in selected species range to provide additional information in the sustainable management of the species.

MATERIALS AND METHOD

Review of literatures were carried out for *A. digitata* range-wide in Nigeria based on all accessible records either in cited literatures or from herbarium voucher specimens (Forestry Research Institute of Nigeria, Ibadan (FHI). The review covered the species range from the lowland rain forest where it occurs as a component of secondary forest as well as in the Derived savannah where it occurs as invasive species. In Guinea and Sudan savannahs it is endemic and a component of the various vegetation phytochoria including wooded

Table 1. The bio-physical characteristics of the sites mentioned in literatures and Herbarium voucher specimens for *A. digitata* in relation to their agro-ecological zones in Nigeria .

Agro-ecological zones	Location	Latitude (ºN)	Longitude (ºE)	Altitude (m)	Annual Rainfall (mm)	Rainfall pattern
Rain forest	Ibadan (Unibadan)	7°,26'	3°, 54'	228	1230	Bi-modal
	Ibadan (IITA area)	7°, 27'	3^0, 55'	228	1230	
	Oyo– Ogbomoso axis	7°, 32'	3°, 44'	235	1165	
	Olokemeji.	7°, 25	3°, 32'	240	1232	
	Ibadan-Abeokuta road axis	7°, 08'	4°, 33'	225	1130	
Derived savanna	Iseyin-Saki axis	7°, 58'	3°, 36'	230	1100	Bi-modal
	Ogbomoso	8° , 09'	4°, 15'	235	1100	
	Ilorin	8°, 11'	5°, 21'	308	1256	
	Kabba	7°, 50'	6° , 05'	460	1510	
	Makurdi	7°, 41'	8°, 37'	114	1377	
	Lokoja					
Guinea savanna	Kotangora	10° , 24'	5° , 29'	400	1222	Mono-modal
	Kaduna	10°, 36'	7°, 27'	645	1300	
	Zaria	36° 10'	8° , 32'	407	832	
	Wukari	8 38'	11 08'	168	920	
Sudan savanna	Kano	12^0 , 03'	8°, 32'	172	832	Mono-modal
	Katsina	13°,	7° 41'	138	686	
	Sokoto	13° 04'	05°, 10'	372	737	

Source: Agboola (1979) and Field work (2014).

Table 2. Cited Herbarium voucher specimens in Forestry Research Institute of Nigeria Herbarium (FHI).

Herbarium voucher specimen number	Location	Phenological status of tree at the time of collection	(Year and months) of collection
11006	Eruwa	Fruiting	Jan, 2014
109612	Unibadan campus	Fruiting Flowering	October, 2012
106415	Ibadan (IITA) area)		June, 2002
107766	Igbaja (Kwara state)	Fruiting	August, 2007
7837	Zaria	Fruiting	June, 2014
89479	Igboora	Flowering	February, 1979

Source: FRIN Herbarium (FHI) (2015).

savannah and the savannah parklands where it is selectively protected (Oni, 1997). All observed voucher specimens from (FHI) herbarium were recorded for their locations (towns), time of the year when they were collected as well as their morphological and reproductive status. All available information with respect to flowering and fruiting periods (months of the year) for all the cited and observed specimens were later related to their locations and their co-ordinates determined from the Atlas map of Nigeria (Agboola,1979). The coordinates for all these locations were subsequently superimposed on a vegetation map of Nigeria. This arrangement was used for mapping *A. digitata* into the different vegetation phytochoria or agro-ecological zones in Nigeria. (Table1). This was followed by field observations in selected locations of the species range for four consecutive seasons covering both raining and dry seasons. The flowering and fruiting regimes were then synchronized over a 24-calendar month, taken into consideration both dry and raining seasons' records.

The flowering and fruiting seasons were related to their specific locations based on the already determined coordinates and were subsequently used to develop phenological charts for the species. Information obtained from the different locations in literatures, herbarium voucher specimens and field observations were used to produce the bio-physical characteristics for the species (Table 1).

Records for all cited herbarium voucher specimens were as indicated (Table 2). The phenological charts based on flowering and fruiting and records were as depicted (Figures I and 2) in the result section.

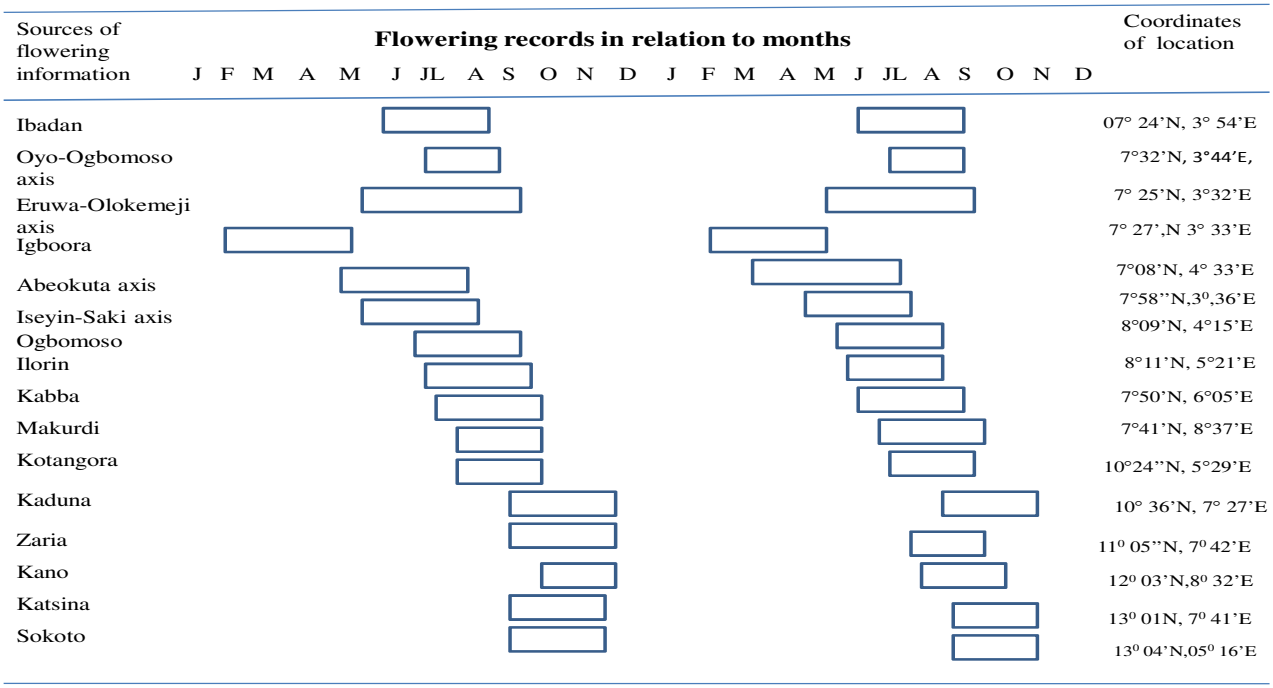

Figure 1. Flowering records in *Adansonia digitata* in its range in Nigeria.

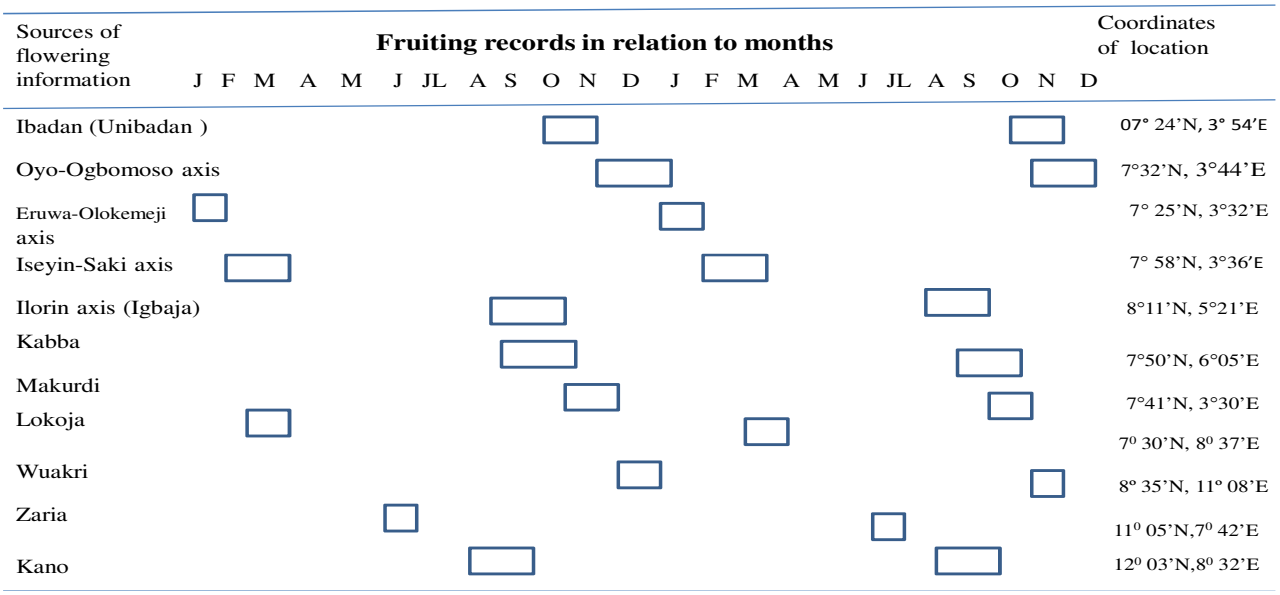

Figure 2. Fruiting records of Adansonia digitata in its range in Nigeria.

RESULTS AND DISCUSSION

The phenological trends observed for *A. digitata* in the selected species range in Nigeria presented an inspiring picture typical of most savannah parklands fruit tree species. It was observed that onset of flowering and flowering activities increased in a south-north direction of the species range. In Ghana, Hall *et al*. (1996, 1997) observed similar trends for *V. paradoxa* and for *P. biglobosa* in Nigeria. In the present study, flowering

information were obtained in a total of 17 different locations range-wide (Figure 1) while fruiting records were obtained in 1l different locations (Figure 2). Range-wide, onset of flowering ranged from February-September in a south-north direction (Figure 1). Bosch *et al.* (2004) reported that onset of flowering primarily occurs before the onset of rains in the lowland rainforest range and Derived savannah. Nakar *et al*. (2014) reported similar findings in India for this species where maximum flowering was observed between April-May. In the lowland rain forest range of the species, flowering was most conspicuous between late (April-August) (Figure 1).

Herbarium voucher specimen records also indicated flowering in June (FHI 106415l) in the rain forest range of the species. In the Derived savannah range, early flowering was observed in February (Eruwa-Olokemeji axis) (FHI 89479) which coincided with late dry season however flowering was more pronounced between (May-August) coinciding with the raining season period (Figure 1). Further north of its range (Iseyin-Saki axis), flowering was very conspicuous from late August-September why in Ilorin axis (Derived savanna) it was most visible in August though tends to fairly overlap with fruit initiation. In Kontagora axis of the species range, flowering was recorded between July-August, however accurate information on when exactly flowering commenced remained inconclusive. At the northern limit of the Derived savannah, (Mokwa axis and Lokoja) flowering was more conspicuous between August-September. This finding was in tandem with what was reported for *Khaya sengelensis* and *Vitellaria paradoxa* both of which are typical savannah parklands species (Oni *et al*., 2014).

In most locations within the Guinea savanna range of the species, flowering was more conspicuous in September though tends to extend to October ahead of fruits initiation.

In the Guinea and Sudan savannahs range of the species, flowering onset tends to coincide with the early rains (April -June) however extending to end of rains (September-October). These findings agreed with what was reported for *P. biglobosa* and *V.paradoxa* in that range (Oni *et al*., 2001, Oni *et al*., 2014) respectively. Sidibe and Williams (2002) made similar observations in Burkina Faso for *A. digitata.* Northwards of the species range, more individual stems were observed flowering from July to October which was in line with what was reported for the species in Burkina Faso (Nikiema, 2005). In Katsina-Ala–Wukari axis (Benue–Taraba states), belonging to the Guinea savannah range, few individuals were observed in flowers in mid September while in Wukari town (Taraba state) flowering was also recorded in April.

This was in agreement with what was reported for the species in a similar range in Burkina Faso and dry lands in India (Nikiema, 2005, Nakar *et al*., 2014). Like several savanna species *A. digitata* had very varying flowering and fruiting regimes in some parts of its range while in some locations flowering was not steady and could not be properly synchronized with seasonal variations. In most of the species range, where it was conspicuous, mono-modal type of rainfall is the most frequent and in these locations flowering coincides with early rains (May-June, FHI 7837). Within these regions, rainfall commences from late April-May and continues till mid October. Dry season commence from late October-November till the following year March-April.

Fruiting in *A. digitata* was majorly a dry season event in the Lowland and Derived savannah range of the species commencing from late October –February (Figure 2). Moving northwards of its range (Guinea and Sudan) savannahs, fruiting tends to coincides with early rains (April-May) and continues northwards becoming more conspicuous in the middle of the rains (June-July) and extending to September-October (Figure 2). In Zaria, Guinea savanna (FHI 7837- Zaria) fruiting was recorded in June coinciding with early rains in the zone while in Taraba state (Wukari) also in Guinea savannah fruiting was recorded in (October- November) (Figure 2). In Kano however (Sudan savannah), fruiting was observed between (July-September).

Diverse opinions exist on fruiting pattern in the species due to seasonality as well as fruit resilience typical of several savanna parklands species with many of them retaining parts of their previous year fruits till the following flowering season. Fruiting in the species had been indicated to last for up to 5 -8 months and hence previous year fruits are often at the beginning of a new flowering year, thus making flowering and fruiting seasons cumbersome to synchronize (Bosch *et al*., 2004). *P. biglobosa* also sometimes demonstrates similar behavior (Oni, 2001) while precocious flowering had also been reported for few savannah parklands species (Pettet, 1997; Oni *et al*., 2014).

Conclusion

The study on phenological behaviors generally provides information and knowledge about the pattern of plant growth and development, effect of environment and selection on flowering and fruiting in woody tree species (Zhang *et al*., 2006). Phenological studies of this nature addressing threatened and poorly conserved indigenous multipurpose fruit tree of diverse and extensive economic importance deserves sustained research intervention as presently elucidated. Findings from the present study demonstrated that flowering is majorly a dry season occurrence though overlapping into the early rains. Fruiting however, was typical of early rains though sometimes overlapping with the early dry season of the following year. Future fruits collection programme should therefore target (October–March) in the Lowland rain forest and Derived savannah range and (June- September)

in the Guinea and Sudan savannahs. The inconsistencies observed in flowering and fruiting activities in the species could probably be attributed to precocious flowering and perhaps global climate change.

AUTHORS' DECLARATION

We declare that this study is an original research by our research team and we agree to publish it in the journal.

REFERENCES

Agboola SA (1979). An Agricultural Atlas of Nigeria. New York: Oxford University Press Ltd.

Bada SO, Popoola L (2005). Sustainable Forest Resources Development in Nigeria, *Proceedings* of *30th Annual Conference of Forestry Association of Nigeria*eds. (Eds. Popoola, L, P. Mfon and P.I Oni) 38-48.

Bremer B, Chase MW, Reveal JL (2003). An update of the Angiosperm phylogeny Group classification for the orders and families of flowering plants APG II. *Botanical Journal of the Linnaean Society,* 141: 399-436.

Bosch CH, Sje K, Asafa BA (2004). *Adansonia digitata* L. from Grubben, G.T.H., and Denton OA (Editors) PROTA, Wageningen, Netherlands.

Diop AG, Sakho M Clase M, Reynes M (2005). *Le baobab* Africain (*Adansonia digitata) Principales Caracterististques et Utilisations* Fruits: 61: 55-69.

Food and Agriculture Organization (2005). Global Forest Resources Assessment 2005, FAO Forestry Paper 147, FAO Rome.

Gebaur K, El-Saddiq P, Ebert G (2002). Babob (*Adansonia digitata*): A review on Multipurpose Tree with promising future in the Sudan pp. 129.

Gillespie TW, Brock J, Wright CW (2004). Prospects of quantifying structure, Floristic compositions and species richness of Tropical Forests. *International Journal of Remote Sensing* 25(14) 70-77.

Hall JB, Danielle PA, Tomlinson Helen F, Osei-Amaning E, Julia RH (1996). *Vitellaria paradoxa*: A Monograph. School of Agricultural and Forest Sciences, Publication. No 8 University of Wales, Bangor pp. 105

Hall JB, Tomlinson HF, Oni PI, Aebisher D, Marlene B, Aebisher DP (1997). *Parkia biglobosa* (Jacq.) Benth A Monograph. School of Agricultural and Forest Sciences, Gwynedd LL57, 2UW, Bangor United Kingdom. 107pp

Keay RWJ (1989). *Trees of Nigeria*, Oxford: Clarendon Press. Pp. 476.

Mgeni ASM (1991). A more efficient estate: Natural forest or plantation. In Pyatt. N and T. Williams (eds). Tropical Forestry: third world priorities versus Western Concerns, 43-58.

Nakar RNN, Jadeja BA, Dhaduk H (2014). Phenological studies of two Bombaceae members from Girnar Forest Reserve, Junagadh, Gyarat, India. *Indian Forester*, 140 (1): 59-64.

Olajide O (2003). Steps toward Sustainable Natural Forest Management for Non-Timber Forest Products in Nigeria *Proceedings* of *29th Annual Conference of Forestry Association of Nigeria* (eds. Popoola, L; Abu and Oni, P.I) 303-308.

Nikiema A (2005). Agroforestry parklands species diversity: Uses and Management in semi-arid West Africa (Burkina Faso), An unpublished Ph.D Thesis, Wageningen University, Wageningen. Pp. 102.

Oni PI, Hall JB, Ladipo DO (1997). The ecology of a key African multipurpose tree species; *Parkia biglobosa* (Jacq,) Benth: the current state of knowledge.) *Nigerian Journal of Ecology* Vol. 1: 59-77.

Oni PI (2001). Breeding systems in *Parkia biglobosa* (Jacq.) Benth: an indigenous fruit resource in Nigeria. *Journal of Tropical Resources*. 17(1):1-9.

Oni PI (2010). Ethno-botanical survey of fallow plot for medicinal plants diversity in Idena, Ijebu Ode. South Western Nigeria. *Journal of Medicinal Plants Research,*3. (10) 45-52.

Oni PI, Jimoh SO, Adebisi LA (2014). Management of indigenous medicinal plants using phenological information. *Journal of Medicinal Plants Research,* 8: (16): 619-631.

Opler PA, Frankie GW, Baker HG (1984). Comparative phenological studies of tree-lets and shrub species in Tropical wet and dry forests in the lowland of Costal Rica. *Journal of Ecology*, 68: 167-188.

Orwal C, Mutua A, Kindt R, Jammadass R, Simon A (2009). Agroforestry Publications of FAO. *World Agroforestry* 3: 90.

Pettet A (1977). Seasonal changes in nectar feeding by birds at Zaria, Nigeria. *The Ibis* 119: 291-30.

Sidibe M, Williams JT (2002). Baobab *Adansonia digitata* in International Centre for Underutilized crops, Southampton University, U.K

Singh KP, Kushwaha CP (2005). Emerging paradigms of tree phenology in dry Tropics, *Current Science,* 89: 964-975.

Sun C, Kaplin BA, Kristensen KA, Muyallgoga V (1996). Tree phenology in Tropical Montane forest in Rwanda, *Biotropica*, 28: 668-681.

Tukur R (2010). An assessment of the Access, use and management of Trees and shrubs in the semi urban fringes of Dustin-ma Area of Katisna state. An unpublished M.Sc Thesis. Department of Geography Bayero Univesity, Kano. Pp. 110.

Ugbogu OA, Odewo P (2004). Some medicinal plants in the Traditional medicare of Nigeria *J. For. Res. Manage* 1: (1& 2): 29-34.

Van Wyke BE, (2008). A broad review of commercially important South African medicinal plants. *Journal of Ethno-pharmacology* 199 (3): 342-355.

Von-Maydell HJ (1990): *Trees and Shrubs of the Sahel*, Their characteristics and Uses. Weakershein Verlag Josef Magraf Scientific Books

Wickens GE(1982). The Baobab; Africa's upside-down tree. Kew Bulletin

Yazzie D, VanderJagt DJ Patuszyn A, Okolo A, Glew H (1994). The Amino acid and Minerals content of Baobab *(Adansonia* digitata) leaves. *Journal of Food Composition and Analysis* 7: 180-193.

Zhang G, Song O, Yang D (2006). Phenology of *Ficus racemosa* in Xishungbana, Southwest China, *Biotropic*a, 38: 334-34.