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Phenological Study of *Irvingia gabonensis* (Aubry-Lecomte ex O' Rorke) Growing in Ihiala, Anambra State, South-East, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Phenology refers to periodic biological phenomena that are correlated with climatic conditions. Very little is known about the phenological pattern of most tropical fruit trees especially in the South-East, Nigeria. The aim of this study was to provide a phenological data and baseline information on the phenology of *Irvingia gabonensis* (Aubry-lecomte ex O'Rorke). The study was conducted with exotic species at Ihiala, South-East, Nigeria, a tropical climate. The initiation and completion of different phenophases of the tree, such as budding, leafing, flowering, fruiting and ripening were recorded at 2 weeks interval. The combination of the principal growth stages and the secondary growth stages produced 2-digit codes, were used to delineate the time-dependent phenophases. The results showed that changes in the prevailing seasons influenced the vegetative phenophases in *I. gabonensis*. There are splashes of rains even in the supposed dry months. Hence, bud formation, leafing and leaf fall phenophases were overlapping all through the seasons. Flowering phenophase peaked by March/April with the coming of the rains. Also fruiting and ripening peaked by June/July respectively (rainy season). Thus the study has revealed that the major seasons in the area (rainy and dry seasons) influence the various phenophases in *I. gabonensis*. The study has equally revealed the phenological data and base line information on the phenology of *I. gabonensis* which

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will in the future serve as correlation between phenology and climate change in the area. The study has revealed that the phenology of *I. gabonensis* may not be stable or resilient since it is influenced by these changing seasons, little wonder then a shift in phenology is recorded in this study.

Keywords: Phenology; Irvingia gabonensis; phenophases; climate; variability; flowering; plant responses.

1. INTRODUCTION

Phenology is the study of periodic events in biological life cycles and how these are influenced by seasonal and interannual variations in climate, as well as habitat factors (Such as elevation) [1]. Examples of phenological events include leaf unfolding, flowering of plants in spring, fruit ripening, color changing and leaf fall in autumn, appearance and departure of migratory birds, timing of animal breeding, etc. Global climate change has renewed the interest in the study of plant phenology, which is currently considered to be a multi-disciplinary science that unites biometeorology, ecology and evolutionary biology [2].

Furthermore, phenological studies constitute the basis for understanding the dynamics of resource availability for populations of many animal species in tropical forests [3] and are important tools for biodiversity monitoring, management and conservation [4]. Phenological data are among the most valuable indicators of ecological responses to climate change, as phenology is the natural aspect of simple observation that responds mostly to climate change at several levels [1]. Phenological studies in fruit trees are important for planned management of orchards and alerting fruit tree growers against environmental vagaries and for understanding the phenological impacts during the flowering phase and the subsequent effects on other phenological events [5].

Phenology has emerged as an important integrative measure to assess the impact of climate change on horticultural crops which is substantially sensitive to weather dynamic. Reports from phenological studies can be very useful to people in planning and management of fruits trees. It can also provide important insight into the biology of the plants concerned and their phenological patterns. Although phenological studies have increase in recent decades [6] and great advances have come from the use of remote-sensing technologies and other methods [7], we simply do not have any systematic phenological information for most areas of tropical rainforests.

There are still many gaps in our knowledge on base line information and phenological data on the plants especially fruit trees. This has made it possible for researchers to say in clear terms how the plants have been impacted in the face of our changing climate. Determination of the sequence in the seasonal appearance of phenophases in *Irvingia gabonesis* commonly called “wild mango” found in Ihiala, Anambra State, a tropical climate, is the specific aim of the study. The main objective of the study was to provide phenological data for *I. gabonensis* and provide baseline information on the phenology of this fruit tree.

2. MATERIALS AND METHODS

2.1 Study Area Characteristics

The study was carried out in Ihiala, Nigeria. Ihiala is in a tropical region with dry deciduous vegetation and experienced two seasons; raining season (March-October) with temperature ranging from 22.9^{0}C to about 30.2^{0}C and dry season (November- February) where temperature can reach 33.9^{0}C. Ihiala is a semi-urban area with enough fruit trees and is located in the south-eastern Nigeria between latitude 6^{0}10’0’’N and longitude 6^{0}46’0’E. The average daily minimum and maximum temperatures of Ihiala is 23^{0}C and 33^{0}C respectively. With mean annual rainfall of 1886.88mm (Enugu weather station, 2017).

2.2 Data Collection

The BBCH (Biologische Bundesantalt and Chemische industries) scale method of Meier *et al.* [8] in which the principal growth phases of the trees under study were arranged chronologically according to their appearance in the course of the year or all phases from one plant were grouped in one line, following their natural developments was used.

The entire developmental cycles of the selected fruit trees were subdivided into ten (10) clearly recognizable and distinguishable long-lasting phenological phases, that is, the principal growth phases, thus; germination. Sprouting/bud development; leaf development; formation of side shoots/tillering; stem elongation/shoot development; development of harvestable vegetative plant parts or vegetatively propagated organs; inflorescence emergence; flowering, development of fruit; ripening or maturity of fruit and seed; senescence. Ordinal numbers 0 to 9 was used to describe the principal growth stages in ascending order.

However, not all the principal growth stages were observed, as attention was on leaf development, flowering, development of fruit, fruit ripening.

Since the principal growth stages cannot be sufficiently used to define exactly the stages in the developmental cycles before senescence, the secondary growth stages were introduced. They are the intermediate values between 0 and 9. These values, however, were expressed as percentage values in this study.

The principal growth stages and the secondary growth stages resulted in 2 digit codes, BBCHXY, which defined the phenophases over time. The first ordinal number X denotes the principal growth stage while the second ordinal number Y denotes the percentage of the development in the secondary stages. For example, the phenological leaf fall or leaf fall phenophase was defined with BBCH95.

That is 9 is the principal growth stage for senescence secondary growth stage 5 in this case stands for 50% of the leaves have fallen. Also, code BBCH10 depicts the beginning of leaf development.

The observer made use of visual observation in observing opening of flower buds and petals, colour changes and changes in size and number in the principal growth stages for the phenophases.

The researcher ensured uniform conditions by observing the trees at 1.00pm. This was to ensure optimum sensitivity for colours for the eyes. Also, at this time, the sun is high and behind the observer. The frequency of observation was two weeks interval starting from the month of September, 2018 to August, 2019.

3. RESULTS

Table 1. Presents the percentage occurrence of the phenophases of *Irvingia gabonensis* (Aubry-Lecomte ex O'Rorke).

The dash (-) represents gradual development of the phenophase. Steady and gradual bud formation was observed across months observed although 1st and 2nd week of September (BBCH04) through 3rd and 4th week November (BBCH07) (Table 1) recorded a little increase in bud formation.

Leaf development was equally steady and gradual, although 1st and 2nd week of October (BBCH14) through 1st and 2nd week December recorded slight increase in leaf formation. 20% of the leaves fell off by 3rd and 4th week of December through 3rd and 4th week January when up to 60% of the leaves fell off (Table 1). Flowering started by 3rd and 4th week of January (20%) through 3rd and 4th week of April when about 70% of the flowers has emerged (BBCH67) (Table 1). Late phase flowering started by 3rd and 4th week in May through 3rd and 4th week in June (BBCH62) when about 20% of the flowers were produced but desiccated within a short time.

Fruit development occurred early March through early July when about 80% of the fruits have developed (BBCH78).

Ripening commenced by the 3rd and 4th week in May (BBCH82) when about 20% of the fruits has ripened. Ripening continued till 3rd and 4th week of July when about 90% of the fruits has ripened (BBCH89) (Table 1).

4. DISCUSSION

The phenological studies of the *Irvingia gabonensis* found at Ihiala, Anambra State, South-East, Nigeria, a tropical climate revealed high phenological diversity for the principal growth stages (Budding, Leafing, flowering, fruiting and ripening) in the tree observed from August 2018 to July, 2019.

The study revealed that the studied fruit tree showed cyclical and seasonal appearance of the phenophases observed in the course of the year. This supports Singh and Kushwala [9] assertion that plant vegetative and reproductive growth and development shows rhythmic appearances over time.

Chart 1. The following are the principal growth stages

S/N	STAGES	DESCRIPTION
1.	0	Germination/bud development
2.	1	Leaf development
3.	2	Formation of side shoots
4.	3	Stem elongation
5.	4	Development of harvestable vegetative plant parts
6.	5	Inflorescent emergency
7.	6	Flowering
8.	7	Development of fruit
9.	8	Ripening or maturity of fruit and seed
10.	9	Senescence, beginning of dormancy

BBCH Scale Meier et al. [8]

Table 1. Phenophases of *Irvingia gabonensis*

Time Period	MONTHS OBSERVED																							
	AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER		JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE		JULY	
	1-2wks	3-4wks	1-2wks	3-4wks	1-2wks	3-4wks	1-2wks	3-4wks	1-2wks	3-4wks	1-2wks	3-4wks	1-2wks	3-4wks	1-2wks	3-4wks	1-2wks	3-4wks	1-2wks	3-4wks	1-2wks	3-4wks	1-2wks	3-4wks
Principal growth stage																								
Bud formation	–	–	BBCH04	–	–	–	–	BBCH07	–		–	–	–	–	–	–	–	–	–	–	–	–	–	–
Leaf development	–	–	–	–	BBCH12	–	BBCH14	–	–	BBCH91	–	BBCH96	–	–	–	–	–	–	–	–	–	–	–	–
Flowering	*	*	*	*	*	*	*	*	*	*	*	BBCH62	–	BBCH64	–	BBCH66	–	BBCH67	–	BBCH60	–	BBCH62	*	*
Ripening	–	–	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	BBCH82	–	BBCH84	–	BBCH89
Senescence																								

Note: *the asterisks (*) in the table denote the absence of observed phenophases*

Bud formation, leaf development and leaf fall phenophases were overlapping without the tree being leafless at any period, that is, semi deciduous. This vegetative phase occur before the tree's reproductive phase: Flowering and fruiting. The reproductive phenophases require more nutrients which is coincidentally provided by a mulching mat of fallen leaves (December-February) which decays with the coming rains in March against peak flowering time of April in *I. gabonensis*. According to Walter *et al*. [10] the timing of vegetative phenology strongly determines the flowering period and thus flowering at least depends indirectly on leaf development. Phenological events are not wholly independent in woody species and flowering may be partly or wholly dependent on leafing activity [11].

Flowering reaches peak by April in *I. gabonensis* with the coming of the rains. Later phase flowers that appeared May/June desiccated showing that heavier rains do not favour flowering in *I. gabonensis*. Some degree of seasonality is often recorded for vegetative and reproductive phenophases in tropical forests at the community level, and the regulation of seasonality has been linked to oscillations in air temperature, photoperiod and precipitation [12,13].

The fruiting and ripening time in *Irvingia gabonensis* may have advanced by 2-4 weeks comparing with the reports of Anegbeh *et al*. [14] which recorded peak ripening period of 3rd week of August, as against peak ripening time of ending July in this study. Reproductive stages of fruit trees are most susceptible to climate change with implication on quantity and quality of fruits produced [15]. Shifts (leading or lagging) in timing of the phenophases of these fruit trees especially flowering and fruiting, causes disruption of the pollen-pollinator relationship, also shifts into period of higher temperature causes poor pollen production, pollen desiccation and consequently poor food production or yield [16,17].

The result implied that *I. gabonensis* trees flower and fruit once in a year, also that mature ripe fruits drop from the trees from May to July. Seeds for propagation therefore can be collected within May and July.

5. CONCLUSION

This study has revealed the phenological data for *I. gabonensis* for the region and where similar climatic conditions prevail. It could be of great help in knowing the timing of different phenophases in *I. gabonensis* for people who wish to plan their orchards. The study has equally provided baseline information on the phenology of *I. gabonensis*. It has provided important insights into the biology of *I. gabonensis* and revealed the phenological pattern. The study has revealed that major seasons in the area (rainy and dry seasons) influence the various vegetative and reproductive phenophases in *I. gabonensis*. The study has revealed that the phenology of *I. gabonensis* may not be stable since it is influenced by these changing seasons, little wonder then a shift in phenology is recorded in this study. This study would also be of great help for comparison over long duration of time, for example, to see if there is further change in the phenological patterns of the same plant species in the next 10 or more years. Such comparative study could not be possible at this time since sufficient relevant literature is not available for the region.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Pau S, Wolkovich EM, Coook BL, Davies TJ, Kraft NJB, Bolmgren K, Batancourt JL and Cleland E. Predicting phenology by integrating ecology, evolution and climate science. Global Change Biology. 2011; 11(7):33-36.
2. Wolkovich EM, Cook BI and Davids TJ. Progress towards and interdisplinary science of plant phenology; building Predictions across space, time and species diversity. New Phytol 2014; 201:1156 – 1162.
3. Bullock SH, Solis-Magallance JA. Phenology of Canopy Trees of a Tropical deciduous forest in Mexico. Biotropica 1990;22:22-35.
4. Morellato LPC, Alberton B, Alvarado ST, Borges B, Buisson E, Camargo MGG, Cancian LF, Carstensen DW, Escobar DFE, Leite PTP et al. Linking plant phenology to conservation biology. Biological conservation. 2016;195:60-72.
5. Chuine I, Yiou P, Viovy N, Seguin B, Daux V and Le Ladurie E. Back to the middle ages? Grape harvest dates and temperature variations in France since 1370. Nature. 2004;432:289-290.
6. Morellato LPC, Camargo MGG and Gressler EA. Review of plant phenology in South and Central America. In Phenology: An integrative Environmental Science, Schwartz, M.D.; Ed.; Springer: Dordrecht, The Netherlands, 2013;91-113.

7. Chmielewski EM, Heider S, Moryson S and Bruns E. International Phenological Observation Networks. Concept of IPG and GPM. In Phenology. An integrative Environmental Science; Springer; Dordrecht, The Netherlands, 2013;137-153.
8. Meier N, Bachmann L, Buhtz E, Hach H, Klose R, Marlander B and Weber E. Phanologische Enttwicklungsstadien der Beta Ruben (*Beta vulgaris* L.) Coddierung und Bschreibung nach der erweiterten BBCH-ska la mit Abbildungen, Nachrichtenbl. Deut; 1993.
9. Singh KP and Kushwaha CP. Diversity of flowering and fruiting phenology of trees in a tropical deciduous forest in India. Annals of Botany, 2006;97(2):265-276.
10. Walther GR, Post E, Convey P, Menzel A, Parmesan C, Beebee TJC, Fronmentin JM, Hoegh-Guldber O, Bairlein F. Ecological responses to recent climate change. Nature, 2002; 416:389-395
11. Van Schaik CP, Terborgh JW, Wright J. The phenology of tropical forests; adaptive significance and consequences for crop producers. Annual Review of Ecology and Systematic. 1993;21:353-372
12. Borchert R, Renner SS, Calle Z, Navarrete D, Tye A, Gautier L, Spichiger R, Von Hilderbrand P. Photoperiodic induction of synchronous flowering near the equator. Nature. 2005;433(633):627-629.
13. Morellato IPC, Talora DC, Takahasi A, Bencke CC, Romera EC and Ziparro,VB. Phenology of atlantic rain forest trees; A comparative study. Biotropica. 2000; 2:811-823.
14. Anegbe PO, Usoro C, Okafor V, Tchoundjien Z, Leakey RRB, Schreckenbery K. Agroforest systems. Kluwer Academic Publishers. 2003; 58:213-218.
15. Ramos C, Introgholo DS, Thompson RB. Global Change challenges for horticultural systems. In: Araus, J.L, Slafer, G.A., editors crop stress management and Global climate change. CAB International. 2011.
16. Bhriguvanshi SR. Impact of climate change on mango and tropical fruits. In: Singh, H.P Singh, J.P, Lal, S.S, Westrille Publishing House, New Delhi, India. 2010; 224.
17. Gorisamo A, Clen Jing M, Chapyang W. Citizen science: linking the recent rapid advances of plant flowering in canada with climate variability". Scientific Reports. 2013;3(1): 2239.

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