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Phenological Study of Dacryodes edulis (Local Pear) growing in Ihiala, Anambra State, South-East, Nigeria

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ABSTRACT

Phenology is the study of periodic events in biological life cycles and how they are influenced by climate and habitat factors. The phenological patterns of most tropical fruit trees especially in the South-East, Nigeria are quite scanty. This study is aimed at determining the sequence in the seasonal appearance of phenophases in Dacryodes edulis (G.don), to obtain and document its phenological data and provide baseline information on its phenology, to evaluate the effects of seasons on the appearance of its phenophases; and to determine how stable or resilient the phenophases of the species has been in the face of changing climate. The study was conducted with perennial fruit tree species in Ihiala, Southeast, Nigeria, with a tropical climate. The timing of the beginning and ending of the following tree phenophases of the tree budding, leafing, flowering, fruiting and ripening were observed and recorded at 2 weekly basis for three years. The resulting 2-digit code from combining principal growth stages and the secondary growth stages were used to interpret the time-dependent phenophases. The results revealed that Flowering in D. edulis occurred more towards rainy season while ripening occurred more during rainy season. This suggests that seasons in the area influence the reproductive phenophases in D. edulis and hence, not likely to have a stable phenology. The phenological data and baseline information on D. edulis was equally revealed by the study. This will serve as a yardstick for measuring changes in phenology for the species in the future.

Keywords: *Phenology, Dacryodes edulis, phenophases, climate variability, plant response.*

INTRODUCTION

Plant phenology, the timing of plants' life cycle transitional events, plays an important role in tracking climate change, diagnosing agricultural management practices and investigating, ecosystem processes (3,8, 16).

Plant phenology has been proposed as an indicator of climate difference and global change by the European Environmental Agency and the Inter-governmental panel on climate change (10).

Phenology has proven to be a multi-disciplinary science encompassing ecology, evolutionary biology and biometerecology (24). Also, the study of phenology have paved way for more understanding of resource availability and management for populations of many animal species in tropical ecosystems (2) and also indispensable in conservation, biodiversity monitoring and management (12).

Since 1990, phenology has been one of the most active disciplines to evaluate the effects of climate change on ecosystems (17). Ecological responses to climate has been deduced through phenological data gotten by simple observation as this responds to climate variability at different levels (14). Many authors have reported changes in responses of organisms to current climate change (17, 14). The phenological changes are complex and subject to species, locations and seasons (16).

Depending on these factors, plant phenology may respond to changes in temperature, precipitation, snow melt or day length and plants may respond to cues differently in different seasons (7).

In spite of more studies on phenology over the last few decades (12), and the use of advanced technologies and other methods (1), there is still paucity of phenological data for most tropical fruit tree species. This has made it impossible for researchers to say in clear terms how the plants have been impacted in the face of our changing climate. The study is aimed at determining the seasonal appearance of phenophases in *Dacryodes edulis,* commonly called 'local pear' found in Ihiala, Anambra State, Southeast, Nigeria, a tropical climate is the specific aim of the study. The main objectives of the study was to obtain and document phenological data and baseline information for *D. edulis*; evaluate the effects of seasons on the appearance of the phenophases and determine how stable or resilient the phenophases of the species have been in the face of changing climate.

MATERIALS AND METHODS

Study Area Characteristics

The study was carried out at Ihiala, Nigeria. Ihiala is in a tropical region with dry deciduous vegetation and experiences two seasons- raining season (March-October) with temperatures ranging from 29.0^0 to about 34.0^{0}C and the dry season November- February) where temperature can reach 37.9^{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'o''N and longitude 6^{0}46'o'E.

The average daily minimum and maximum temperatures of Ihiala is 22^{0}C and 37^{0}C respectively, with mean annual rainfall of 281.94mm (Weather spark.com, Anambra, Nigeria, 2022).

Data Collection

Samples: - Twenty (20) perennial tree samples (same species) of *Dacryodes edulis* (G.don) which have been actively flowering and fruiting over the years were ear-marked for the study at Afam village, Ihiala. Owners of the trees were informed to avoid acts of disruption like cutting down the tree. The timing of the initiation and completion of the following phenophases-budding, leafing, flowering, fruiting and ripening were observed and recorded for all the (20) sample trees species for (3) cycles/years at 2 weeks interval.

This study was carried out for 3 years.

First cycle/year observation lasted from August, 2018- July, 2019.

Second cycle/year observation lasted from August, 2019-July 2020

Third Cycle/years observation lasted from January, 2022-December, 2022.

2.3 Data Analysis

The Biologische Bundesantalt and Chemische industries (BBCH) scale method of (11). (1993) in which the principal growth phases of the tree under study was sequentially arranged according to their natural appearance in the course of the year. In this method, the entire developmental cycles of the fruit tree was subdivided into ten (10) clearly recognizable and distinguishable long-lasting phenological phases, that is, the principal growth phases, thus;

- Budding.
- Leafing
- Tillering
- Shoot development
- Development of harvestable vegetative plant parts or vegetatively propagated organs
- Development of Inflorescence
- Flowering
- Fruiting
- Ripening
- Senescence/beginning of dormancy.
- 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.

The following are the principal growth stages

S/N STAGES DESCRIPTION

1. Budding
2. Leafing
3. Tillering
4. Shoot development
5. Development of harvestable Vegetative plant parts
6. Development of Inflorescent
7. Flowering
8. Fruiting
9. Ripening
10. Senescence, beginning of dormancy

BBCH Scale (11)

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.

2 digit codes, BBCHXY, which resulted from the integration of the principal and secondary growth stages were used to define the phenophases overtime. 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 BBCH85, that is 8 is the principal growth stage for ripening secondary growth stage 5 in this case, stands for 50% of the fruits have ripened. Also, code BBCH10 depicts the beginning of leaf development, while BBCH19 is for the end 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.

The researcher was interested in the species since it thrives in Nigeria especially in the region under study, where it is widely cultivated for its edible fruits. It was selected based on its easy-to-observe crown architecture and accessibility to its location in the region.

Photographs of different phenophases of the fruit tree was taken for proper identification. Also climate/ weather averages in Ihiala were collected to integrate with the records.

RESULTS AND DISCUSSION

The results on the phenological studies of *Dacryodes edulis* (G.Don) growing in Ihiala showing the timing of their different phenophases (Bud formation, leaf development, flowering, fruit development and ripening) during the study period (August, 2018-July, 2019; August, 2019-July, 2020; August, 2021-July, 2022).

That is, 3-seasons, are shown in Tables below.

Table 1: Phenophases of Dacryodes edulis (G.Don) Lam

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	–	BBCH05	–	BBCH07	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	BBCH04
Leaf development	BBCH142	–	–	–	BBCH188	–	–		–	BBCH922	–	–	BBCH96	–	–	–	–	–	–	–	–	–	–	–
Flowering	*	*	*	*	*	*	*	*	*	*	–	BBCH62	–	–	BBCH64	–	BBCH68	–	–	*	*	*	*	*
Fruit development	–	–	*	*	*	*	*	*	*	*	*	*	–	BBCH72	–	–	–	BBCH74	BBCH76	–	–	–	–	BBCH78
Ripening	BBCH88	–	–	–	–	–	–	*	*	*	*	*	*	*	* –	*	*	–	BBCH82	–	BBCH84	BBCH85	–	BBCH86
Senescence																								

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

The dash (-) represents gradual development of the phenophase.

Significant increase in bud formation was observed between 3rd and 4th week of July (BBCH04) through 3rd and 4th week of September (BBCH07). 80% of the leaves developed by 1st and 2nd week of October (BBCH18). By ending December, 20% of the leaves has fallen (BBCH92) and 60% has fallen by 1st and 2nd week in February (Table 1).

Flowering commenced by 3rd and 4th week in January (20%) (BBCH62) and by 1st and 2nd week of April (BBCH68) 80% flowering was achieved. Fruiting occurred 20% by 3rd and 4th week of February (BBCH72) and 3rd and 4th week of July, 80% fruiting has occurred (BBCH78) (Table 1). 20% ripening occurred in 1st and 2nd week in May (BBCH82) and continued till 1st and 2nd week August when about 80% of fruits has ripened (BBCH88) (Table 1).

Table 2: Phenophases of Dacryodes edulis (G. Don) Lam

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	_	BBCH06	_	_	BBCH07	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	BBCH02
Leaf development	BBCH112	_	_	_	BBCH148	_	BBCH96 _	BBCH16	_		_	_		_	_	_	_	_	_	_	_	BBCH92 _B	_	_
Flowering	*	*	*	*	*	*	*	*	*	*	_	BBCH62	_	_	BBCH64	_	BBCH68	_	_	*	*	*	*	*
Fruit development	BBCH79 _B	_	_	_	_	*	*	*	*	*	*	*	_	BBCH72	_	_	_	BBCH74	BBCH76	_	_	_	_	BBCH78
Ripening	BBCH88	_	_	BBCH89	_	_	*	*	*	*	*	*	*	*	* _	*	*	_	BBCH82	_	BBCH84	BBCH85	_	BBCH86
Senescence																								

Note: *The asterisks (*) in the table denote the absence of observed phenophases.*
Note: *The dash (-) represents gradual development of the phenophase.*

Significant increase in bud formation was observed between 3rd and 4th week of July (BBCH02) through 1st and 2nd week of November (BBCH07). 80% of the leaves developed by 1st and 2nd week of October (BBCH18). By ending week December, 20% of the leaves has fallen (BBCH92), and 60% has fallen by 1st and 2nd week in February (BBCH96) table (2). Flowering commended by 3rd and 4th week in January (20%) (BBCH62) and by 1st and 2nd week of April (BBCH68) 80% flowering was achieved.
Fruiting occurred 20% by ending of February (BBCH72) and by ending July, 80% fruiting has occurred (BBCH78). 20% Ripening occurred in 3rd and 4th week in May (BBCH82) and continued till ending September when about 90% of fruits has ripened (BBCH89) (Table 2).

Table 3: Phenophases of Dacryodes edulis (G. Don) Lam

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	_	BBCH08	_	BBCH09	_	_		_	_	_	_	_	_	_	_	_	_	_	_	_	BBCH05	_	_	BBCH06
Leaf development	BBCH162	_	_	_	BBCH18	_	_		_	BBCH92	_	_	BBCH96	_	_	_	_	_	_	_	_	_	_	BBCH15
Flowering	*	*	*	*	*	*	*	*	*	*	BBCH62	BBCH64	_	_	BBCH68	_	BBCH69	_	_	*	*	*	*	*
Fruit development	_	BBCH79 B	_	_	_	_	*	*	*	*	*	*	BBCH72	BBCH75	_	_	_	BBCH76		_	_	BBCH78	_	_
Ripening	BBCH88	BBCH89	_	_	_	_	*	*	*	*	*	*	*	*	* _	*	*	_	BBCH82	_	BBCH84	BBCH85	_	BBCH86
Senescence																								

Note: *The asterisks (*) in the table denote the absence of observed phenophases.*
Note: *The dash (-) represents gradual development of the phenophase*

Bud formation, leaf development and leaf fall are gradual and steady in *Dacryodes edulis*. However, increased bud formation was observed between early June (BBCH05) and latter September (BBCH09) (Table 3). Also, increased leaf development was observed between ending July and early October (BBCH18) (table 3). Bud formation, leaf development and leaf fall were overlapping. Flowering commenced early January (BBCH62) through early April (BBCH69).

Fruiting occurred from early February (BBCH72) through ending August (BBCH79). Ripening occurred 20% by early May (BBCH82) and continued through ending August when about 90% of fruits has ripened (BBCH89) (Table 3).

DICUSSIONS

***Dacryodes edulis* (Tables 1, 2, 3)-** The study revealed that the studied fruit trees showed vegetative and reproductive phenophases following in quick succession. This supports (19) assertion that plant vegetative and reproductive growth and development shows rhythmic appearances over time. 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 (July - November) which decays with the coming rains in March, against peak flowering time of April in *D.edulis*. According to (21) the period of vegetative phenology strongly determines the flowering period. In woody species, phenological events are interdependent (20). Flowering in *D.edulis* occurred more during dry season (January - April), fruiting occurred more towards rainy (February – July) while ripening occurred more during rainy season (May-August/September). This suggests that seasons in the area influence the reproductive phenophases in *D.edulis*. Changing seasons influence the appearance of phenophases in *Delonix regia* (6); also in *Irvingia gabonensis* (14)

The fruiting and ripening time in *Dacryodes edulis* may have lagged by 2-4 weeks comparing the three (3) seasons of this report and also with the reports of (24) that recorded July as peak ripening period. Phenological shifts are ubiquitous phenomenon and can be interpreted as a sensitive indicator of the ecological impacts of climate change (21). Reproductive stages of fruit trees are most susceptible to climate change with implication on quantity and quality of the fruits produced (18). 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 cause poor pollen production, pollen desiccation and consequently poor food production or yield (1, 9). The result implied that *D.edulis* trees flower and fruit once in a year, also that mature ripe fruits drop from the trees from May to August/September. Seeds for propagation therefore, can be collected within May and September. The study equally revealed high level of synchronization in the appearance of phenophases in *D.edulis*. There is virtually no isolated initiation and completion of any phenophases by individual trees.

CONCLUSION

This study has revealed the phenological data for *D. edulis* for the region and where similar climatic conditions prevail. It could be of great help in knowing the timing of different phenophases in *D. edulis* for people who wish to plan their orchards. The phenological data and pattern revealed by this study will serve as a valuable indicator of ecological responses to climate change in the area as well as be of great help for comparison over long duration of time to see if there will be further change in the phenological patterns of *D. edulis*.

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