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INVESTIGATION OF PHENOLOGY IN FOUR COMMON VARIETIES OF MANGO (*Mangifera indica* L.) IN SOUTHEASTERN NIGERIA

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ABSTRACT

Phenological studies provide the knowledge of the patterns of plant growth and development and the influence of weather dynamics on vegetative and reproductive biology of plants. The leafing, flowering, and fruiting events of four common varieties of mango (*M. indica* v. *german*, *M. indica* v. *haden*, *M. indica* v. *enugu*, and *M. indica* v. *peter*) *were* observed weekly at three different stations in Oyi Local Government Area (L.G.A.), southeastern Nigeria from October, 2023 to October, 2024. Existing BBCH scale was used for data collection. Results revealed almost similar phenological trends in all the varieties. The vegetative and reproductive phenology in v. g*erman* and v. *haden* relatively advanced by approximately 1 week. Moreover, the results revealed a delay of approximately 9 days in the onset of growth in all the varieties in 2024 as against the year 2023. Fruiting initiation in the both episodes coincided with the dry periods of the year. However, Fruit maturity to ripeness in the second episode extended to early rainy period (April to May). The varieties recorded high average overall synchrony indices for flowering (v. *german*: 0.82; v. *haden*: 0.80; v. *igbo*: 0.79; v. *peter*: 0.80). The results of the present study have provided some information on aspects of the reproductive biology of mango, which could be useful in breeding and management purposes It is recommended that long-term phenology monitoring be conducted on mango in Oyi L.G.A. to provide long data series needed for establishing correlation between phenology and climatic factors for tracing the impact of climate change.
Key words: BBCH scale, climate change, mango varieties, phenology, synchrony,

1.0 INTRODUCTION

Phenology is often an overlooked aspect of plant ecology, and is yet to receive sufficient attention in the breeding and management of fruit trees. Phenology is the study of the relationship between climatic factors and periodic phenomena in organism (Igboabuchi *et al*., 2018). Plant phenology is a field of study that deals with the timing of the biological stages of plants and how they relate to environmental factors (Alsubhi and Alzahrani, 2024), Changes in the timing of phenophases of fruit trees are of great economic importance because they have direct impact on factors influencing final fruit yield (Kushwaha and Singh, 2005).

Agriculture and forestry sciences have applied phenological data for timing of agricultural work, selection of suitable crops and cultivars, and in conservation and management programmes. Knowledge of phenology and floral morphology are essential for conducting studies on breeding systems, particularly on pollination study (Igboabuchi *et al*., 2018). Therefore, reproductive phenological studies help in developing strategies to preserve genetic potential of rare species which are crucial for restoration programmes.

Mango came to Nigeria in the 20th century through itinerant merchants, missionaries, and colonialists, from where it has become an integral part of indigenous cropping systems (Aiyelaagbe, 2001; Nyishri, 2004). The mango tree produces a fruit with great diversity with respect to form, size, colour, and quality (Singh and Kushwaha, 2006). The four varieties of mango commonly found in Oyi Local Government Area (L.G.A.), Anambra, Nigeria are: *Mangifera indica* v. *german*, *Mangifera indica* v. *haden*, *Mangifera indica* v. *igbo*, and *Mangifera indica* v. *peter.* With the increasing demand for fruits in the southeastern Nigeria and the world at large, mango has become the major economic fruit for the indigenous people of Oyi L.G.A.

Phenological observations are some of the most sensitive data in identifying how plant species respond to regional climate changes (Echereme and Mbaekwe, 2015). Climate change will cause phenological mismatches, which will affect the flowering and fruiting at irregular times and make them susceptible to pests and diseases for longer duration (Mukhtiar *et al*., 2025). The occurrence of adverse climatic conditions can result in less uniform fruit quality and stage of maturity at harvest, posing further challenges for deliveries to markets and consumer satisfaction (Boudon *et al*., 2020).

Despite the well-known connection between phenology and climate change (IPCC, 2014), its relevance and implications for resource conservation and management, precise information is lacking on onset and end dates, the length of growing season, and the levels of synchronicity of phenological events of mango in Oyi L.G.A. Understanding the patterns of the seasonal chronologies in the growth and developmental stages in mango can be of immense benefit for planned management of orchards, and can be useful in alerting mango growers against environmental vagaries (Rajan *et al*., 2011) and the impacts of climate change. Against this backdrop, the present study aimed to investigate phenological patterns in four common varieties of mango in Oyi L.G.A., southeastern Nigeria. Specifically, the research was intended to (1) investigate, interpret, and document the temporal patterns of leafing, flowering, and fruiting events and (2) to quantify the levels of synchrony/asynchrony of leafing, flowering, and fruiting events.

2.0 MATERIALS AND METHODS

2.1 Study Area

The study was carried out at three experimental stations in Oyi L.G.A., Anambra State, southeastern Nigeria (between latitude 5° 15' 0° to 5° 25° north and longitude 6° 13' 0° to 6.21° east; hsl: 98 to 120 m.). The local climate is classified as tropical humid, and is characterized by two seasons: rainy season (April to October) and dry season (November to March). Mean annual rainfall ranges from 1700 mm to 2100 mm, with the peaks (double maxima) coinciding with July and October (Usman *et al*., 2015). There is characteristic drop in rainfall in August, locally referred to as 'August break' lasting for about 2 weeks, although this has not been consistent in the area due to climate change. Temperature varies so little throughout the year. The maximum day temperature varies from 28.5 °C in September to 31.1 °C in March. Soil is stable, rich in minerals and has high clay content (Orjiako *et al*., 2012). Dry season is accompanied by a short period known as Harmattan. Harmattan is characterized by cold and dry wind with grey haze, which limits visibility and blocks the sun's rays leading to extreme dry weather. Mean monthly relative humidity is 80 % with the peak value occurring in July, while the least value in December.

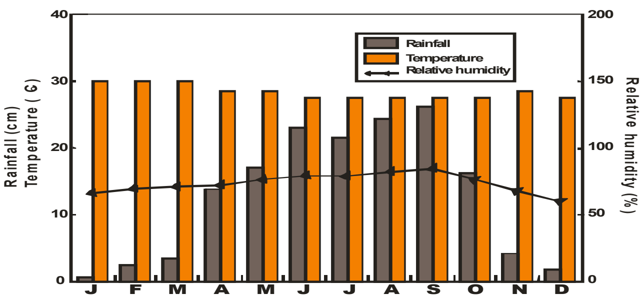

Figure 1: Long-Term Local Climatic Conditions in Oyi L.G.A., Anambra State

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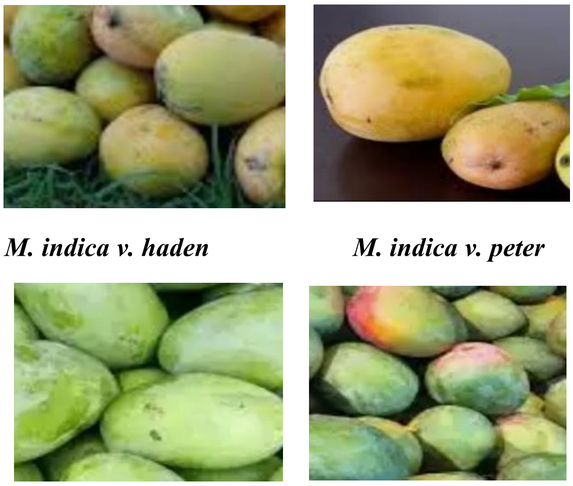

M. indica v. haden ***M. indica v. peter***

M. indica v. german ***M. indica v. igbo***

Plate 1: Mango varieties at BBCH 819 stage (first episode of ripening in February) and BBCH 829 stage (second episode of ripening in April) as observed in Oyi L.G.A., southeastern Nigeria.

2.2 Study Design

Mango orchards owned and managed by the indigenous people of Awkuzu, Umunya, and Nkwelle-Ezunaka in Oyi L.G.A. were selected for observation for changes in leafing, flowering, and fruiting phenophases. A total of 220 trees (minimum of 18 trees per cultivar per station) were randomly selected and tagged for the studies. Trees were selected if they appeared to be healthy, had canopies visible to the observer, and had signs of the previous year fruit production. In line with Sun (1996), on each selected individual, two major branches, one in each direction, were selected, marked, and observed at weekly intervals for 13 months (October 2023 to October, 2024). Observations were all ground-based. In line with (Meier, 2019), a phenophase was considered to be active in the station just when it was observed in at least 20% of the crown in a minimum of 25% of the sampled variety. Trees were considered to be in flushing leaves mode when the vegetative buds opened, revealing young pale leaves. Trees were counted as being in flowering mode when flower buds opened.

2.3 Data Collection

The existing BBCH (Biologische Bundesantalt, Bundessortenamt and Chemische Industrie) scale method of Augspurger (1983) was modified on the basis of the data generated from mango in the present study. Six (6) out of the 10 principal growth stages of the trees under studies were arranged chronologically according to their appearance in the course of the annual cycle, for data collection. The 6 principal growth stages were: bud development (both for leafing and flowering), leaf development, inflorescence emergence,

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flowering, fruit development, and fruit maturity denoted by the integers 0, 1, 5, 6, 7, and 8, respectively. The secondary stages were numbered 0 to 9 that described the percentage growth values in the principal growth stages, in the course of the year. The integer 0 denoted the beginning of a phenophase, while 9 denoted the end of a phenophase. Mesostages (1 to n) were introduced between the principal and the secondary stages to describe the number of episodes of phenological activity in the annual cycle. Thus, a 3-digit code, BBCH-xyz defined a phenophase for leafing, flowering, and fruiting events, where x, y, and z are integers representing the principal growth stage, the mesostage, and the secondary growth stage, respectively. In code BBCH610, for example, 0 depicted the beginning of flowering, 1 for first flowering episode in the year, and 6 for the principal growth stage for flowering, BBCH619 defined the end of flowering in the first flowering cycle. In the phenological leaf flushing phase, BBCH125, for example, 1 stood the principal growth stage for leaf development, 2 for second leafing cycle of the year, and secondary growth stage 5 in this case stood for 50% of the leaves unfolded.

2.4 Analysis of Phenological Data

Phenological data were summarized by recording occasions separately and for the three stations combined. Phenological calendars of mango varieties were prepared and studied for the interpretation of the overall results. Peaks were used to refer to the months in which the number of individuals observed in a particular phenophase reached a maximum. Synchronization of phenological events was estimated using the method of Davenport (1997) synchrony index. Thus, synchrony index $\mathcal{X}_i$ method of Davenport (1997) was modified considering all individuals within and among varieties. Thus, intrastation synchrony index $\mathcal{X}_i$ was calculated as the ratio of individuals' mean duration of a particular phenophase to the overall duration of the phase. Thus,

$$\mathcal{X}_i = \frac{1}{f_i} \sum_{i=1}^{n} t_i \cdot \frac{1}{T_p}$$

Where $\mathcal{X}_i$ = synchrony index, t_i = individual's duration in days for a phenophase, f_i = total number of individuals for a phenophase, and T_p = overall duration in days of a phenophase. To calculate the inter-station *synchrony* (i.e. the average overall synchrony), the sum of the intrastation synchrony indices was divided by 3.

3.0 RESULTS AND DISCUSSIONS

Leafing Phenology

The results of the leafing events in four varieties of mango in Oyi L.G.A. in 2023 and initiation of growth in 2024 are as presented in Tables 1a and b.

Table 1a: Description and Timing of Leafing Events in Four Varieties of Mango in Oyi L.G.A. in 2023

BBCH Code	Description	Timing of Phenophases				
Principal growth stage	*Vegetative bud*		**H**	**I**	**P**	
01:	*development*	**G**	1	2	2	Oct.
010	Beginning of bud dev.	1	2	3	3	Oct.
019	End of bud break	2				
Principal growth stage	*Leaf development*					
11:	First leaves separated	2	2	3	3	Dec.
110	Leaf at 10% of its full	3	3	4	4	Dec.
111	size	3	3	4	4	Dec.
115	Leaf at 50% of its full	1	1	2	2	Jan.
119	size					
	Leaf flushing ended					
Principal growth stage	*Vegetative bud*					
02:	*development*	2	2	3	3	Jan.
020	Beginning of bud dev.	3	3	4	4	Jan.
029	End of bud break					
Principal growth stage	*Leaf development*					
12:	First leaves separated	3	3	4	4	Jan.
120	Leaf at 10% of its full	3	3	4	4	Feb.
121	size	3	3	4	4	Feb.
125	Leaf at 50% of its full	3	3	4	4	Feb.
129	size					
	Leaf flushing ended					

G:: German; H:Haden; I: Igbo; P: Peter.
1: First week; 2: Second week; 3: Third week; 4: Fourth week
Jan.: January; **Feb.:** February; **Mar.:** March; **Apr.:** April; **May:** May; **Jun.:** June; **Jul.:** July;
Aug.: August; **Sep.:** September; **Oct.:** October; **Nov.:** November; **Dec.:** December.

Table 1b: Initiation of Leafing Events in Four Common Varieties of Mango in Oyi L.G.A. in 2024

BBCH Code	Description	Timing of Phenophases				
Principal growth	*Vegetative bud*		**H**	**I**	**P**	
stage 01:	*development*	G	2	3	3	Jan.
010	Beginning of bud					
	dev.	2				

In 2023, the first leafing episode (mesostage 1) started after bud break in the first week October (BBCH019) in v. *german* and v. *haden*, while in v. *igbo* and v. *peter*, bud break occurred in the second week of October (Table 1a), all coinciding with the late rains. However, in 2024, bud breaking delayed for approximately 1 week in all the varieties (Table 1b). In the third week of December, about 10% of the final leaves size developed (BBCH110) in v. *german* and v. *haden*, while fourth week of December in v. *igbo* and v. *peter*. Leaf flushing proceeded from December and ended in first January (BBCH119) (Table 1a). The next episode of vegetative growth (mesostage 2) resumed in the second week of January (BBCH120) in v. *german* and v. *haden*, while in v. *igbo* and *v. peter*, resumption of vegetative growth occurred in the third week of January. Flushing peaked in the third week of January and ended in the third week of January (BBCH129) (Table 1a). For v. *german* and v. *haden*, flushing peaked and ended in the fourth week of January. The multiple phenocycles observed in the present studies is not incompatible with Anderson *et al*. (2005) that a healthy mango shoot completes four to five flushing episodes per year. Two or more peaks in flushing and flowering are possible in the tropics because the

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sun passes overhead twice each year, influencing insolation rates and weather patterns (Borchert, 1994). During leafing, there was no marked leaf drop among the leaves, thus transition between the young flushing leaves and the old ones was never marked with leaflessness, even during the peak of drought (February-March). The absence of marked transition between flushing and leaf drop may be as a result of the trees' high water storage capacity and cambial activity during the dry periods. Borchert (1994) has suggested that the stored water buffers the impact of seasonal drought and enables flushing and flowering during the dry season. In agreement with this, Singh and Kushwaha (2006) described mango tree as having alternately arranged evergreen or nearly evergreen leaves. It was observed that about 10% of v. *igbo* and v. *peter* and 6 % of v. *german* and v. *haden* never followed the above patterns. Leaf flushing in these trees started in the second week of January in v. *german* and v. *haden* and in the third week of January for v. *igbo* and v. *peter*, coinciding with the second (mesophas2) major episode of growth in the year.

Flowering Phenology

The results of flowering of flowering events in four varieties of mango in Oyi L.G.A. in 2023 and initiation of growth in 2024 are as presented in Tables 2a and b

Table 2a: Description and Timing of Flowering Events in Four Common Varieties of Mango in Oyi L.G.A. in 2023

BBCH Code	Description	Timing of Phenophases				
Principal	*Inflorescence*	G	H	I	P	
growth stage	*emergence*	1	1	2	2	Oct
51:	Flower bud dev.	3	3	4	4	Oct
510	began	2	2	2	3	Nov
515	50% of					
519	inflorescence dev.					
	Inflorescence dev.					
	ended					
Principal	*Flowering*					
growth stage	First flower opened	1	1	2	2	Dec
61:	50% of flowers	3	3	4	4	Dec
610	opened	1	1	2	3	Jan
615	End of flowering					
619						
Principal	*Inflorescence*					
growth stage	*emergence*	2	2	3	3	Jan
52:	Flower bud dev.	3	3	4	4	Jan
520	began	2	2	3	3	Feb
525	50% of					
529	inflorescence dev.					
	Inflorescence dev.					
	ended					
Principal	*Flowering*					
growth stage	First flowers	2	2	3	3	Jan
62:	opened	3	3	4	4	Feb
620	50% of flowers	3	3	4	4	Feb
625	opened					
629	End of flowering					

Table 1b: Initiation of Flowering Events in Four Common Varieties of Mango in Oyi L.G.A. in 2024

BBCH Code	Description	Timing of Phenophases				
Principal	*Inflorescence*		H	I	P	
growth stage	*emergence*	G	2	3	3	Oct.
51:	Flower bud dev.					
510	began	2				

Reproductive phenology in all the varieties started with flower bud development, which started in the first week of October (BBCH510) (Table 2) in v. *german* and v. *haden*, while in v. *igbo* and v. *peter*, reproduction started in the second week of October. However, in 2024, the first episode of flower bud development along the year delayed by approximately 1 week (Table 2b) as bud development in v. *german* and v. *haden* started in the second week of October, whereas in v. *igbo* and v. *peter,* bud development started in the third week of October.

Inflorescence extension in the first episode (mesostage 1) ended (BBCH519) in the second week of November, second week of November for all varieties excepting v. *peter* that recorded end of inflorescence extension in the third week. Flower opening followed inflorescence extension in the first week of December (BBCH610) in v. *german* and v. *haden*, and by third week of December, about 50% (BBCH615) of flowers per inflorescence had opened (Table 2a). Flowering peaked in the third week of December and ended in the first week of January for the mesostage 1 in v. *germany* and v. *haden* (Table 2). For v. *igbo* and v. *peter*, opening of flowers occurred in the second and third week, respectively. Flowering peaked and ended in the first week of January in both v. *german* and v. *haden*, second week of January in v. *igbo* and third week in v. *peter*. Flowering peaked synchronously in all the varieties. For mesostage 2, flowering in v. *german* and v. *haden* started with inflorescence extension after bud break in the second week of January (BBCH629) (Table 2). Flower opening in v. *german* and v. *haden* started in the second week of February, and by third week of February, about 50% of flowers per inflorescence had opened (BBCH625). Flowering peaked and ended in all the varieties (BBCH629) in the fourth week of February, however, v. *german* and v. *haden* stopped flowering a week earlier. The multiple episodes of phenology recorded in the present studies is in compatibility with (Anderson *et al*., 2005) who reported that growth of the mango trees is usually given by cycles with short repetitions throughout the year and it is dependent on the variety, climatic conditions and management. Flowering time is a crucial event in the lifetime of angiosperms that has critical impacts on plant fitness (Luzuriaga *et al*., 2023). From the findings of the present study, water deficit favours flowering, as the onset and maintenance periods of flowering coincided with the periods of diminishing rain and drought, respectively. Water stress has been reported to favour flowering in mango. (Rajan *et al*., 2017) have reported that moist and humid atmosphere washes pollen and encourages insect pests and diseases, and also interferes with the activity of pollinators. Authors have reported on the impact of air temperature on the flowering in mango (Sukhvibul *et al*., 2000; Khalifa and Ababatta, 2023). Mango growth, development, and flowering are all generally influenced by temperature, which is best between 27 to C and 33 ° C. Pollen is harmed by temperatures below 10 ° C and over 33 ° C, which is one potential cause of low fruit set seen in several commercial types (Khalifa and Ababatta, 2023). The maximum day temperature at Oyi L.G.A. varies from 28.5 to C in September to 31.1 ° C in March, and temperature rarely exceeds 32 ° C. These conditions could likely be optimum for flowering success in mango in the area; a prerequisite for successful mango production is the absence of rain during the flowering period. The delay in flowering in 2021 could be credibly linked to climate change impact.

Flowering proceeded synchronously with leaf flushing in both episodes, with number of flowers produced noticeably higher in the first episode among trees. The majority of the trees from the four varieties produced flowers in the both episodes. However, approximately10 % of the trees from each of the varieties observed failed to undergo the two major episodes of phenology. First flowering in these trees coincided with flowering in the second episode, which occurred in February.

Fruiting phenology

The results of the fruiting phenophases of four mango varieties in Oyi L.G.A. are as presented in Table 3.

Table 3: Description and Timing of Fruiting Events in Four Common Varieties of Mango in Oyi L.G.A. in 2023

BBCH Code	Description	Timing of Phenophases				
Principal	*Fruit development*	G	H	I	P	
growth stage	Beginning of	2	2	3	3	Jan
71:	fruiting	1	1	2	3	Feb
710	Fruit at 30% of its	2	2	3	3	Feb
713	final size	3	3	4	4	Feb
715	Fruit at 50% of its					
719	final size					
	Fruit fully					
	developed					
Principal	*Fruit maturity*					
growth stage	Beginning of	3	3	4	4	Feb
81:	ripening	3	3	4	4	Feb
810	Fruit ripe for					
819	consumption					
Principal	*Fruit development*					
growth stage	Beginning of	3	3	4	4	Feb
72:	fruiting	3	3	4	4	Feb
720	Fruit at 30% of its	3	3	4	4	Mar
723	final size	3	3	4	4	Mar
725	Fruit at 50% of its					
729	final size					
	Fruit fully					
	developed					
Principal	*Fruit maturity*					
growth stage	Beginning of	1	1	3	3	Apr
82:	ripening	1	1	2	2	May
810	Fruit ripe for					
829	consumption					

The first episode of fruiting events (BBCH 710) in the year started in the second week of January in v. *german* and v. *haden* after the end of flowering (BBCH619) in the second week of January (Table 3), and by the second week of February, 50% (BBCH715) of the final size of fruits had developed (Table 3). However, a delay of approximately 8 days was recorded for flowering in v. *igbo* and v. *peter* in February. Fruiting reached peak in the third week of February in all the varieties, and by this time 80% of the fruits had attained the final harvestable size. Fruiting development ended after reaching harvestable size (BBCH719) in third week of February for the mesostage 1 (Table 3), however, fruiting ended in the fourth week of February in v. *igbo* and v. *peter*. By the end of February, fruits in all the varieties were fully developed and ripe for consumption (BBCH819) (Figures 1 a – d)

For mesostage 2, fruit development in v. *german* and v. *haden* started in the third week of February when about 10% of the final size (BBCH721) of fruits developed. Fruiting in mesostage 2 started in the last week of February in v. *igbo* and v. *peter*. By the third week of February, 30%t of the final size (BBCH723) of fruits had already developed. Fifty per cent (BBCH725) of the final size developed in the third week of March in v. *german* and v. *haden*, while it was in the final week of March for v. *igbo* and v. *peter* (Table 3). Fruit development to the final harvestable size ended in the third week of March in v. *german* and v. *haden*, whereas for v. *igbo* and v. *peter* it was in the fourth week of March. Ripening in v. *german* (Figure1c.) and v. *haden* (Figure 1a) started from first week of April and ended in the first week of May. For v. *igbo* (Figure 1d.) and v. *pete* (Figure 1d), ripening started in the third week of April in and ended in the second week of May. The second fruiting episode extended to May, coinciding with the early rainy season. An average estimated delay of 1 month was recorded for fruiting duration (i.e. duration between fruits initiation to ripening) among the varieties in the second episode relative to the first episode. This delay may be attributed to the early significant rains from April to May after prolonged period of drought. Studies have reported on the unfavourable impact of rainfall on mango production (Rajan *et al*., 2011). Rajan *et al*. (2011) observed that an increase in precipitation during fruit growth and development may delay the number of days taken to maturity and fruits lose their attractive appearance if exposed to several rains during fruit growth and development periods.

The study also recorded varying average number of fruits produced per individual tree between the two distinct episodes in all the varieties, with the first episode recording relatively higher production. This is not incompatible with (Singh and Kushwaha, 2005) who observed that older and more mature flushes accumulate sufficient reserves of carbohydrates to attain physiological maturity required for fruit development than the relatively new flushes. The temporal separation of resource use needed for the accumulation of carbohydrate reserves for the next flowering and fruiting was never expected. Therefore, the marked reduction in fruit production observed in each of the varieties in the second episode would be the plausible explanation. This is not incompatible with Singh (2006) that flowering time and time lag between the

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onset of leaf flushing and flowering affect the degree of separation of resource use for vegetative and reproductive events within trees. Various physiologically active sites or sinks (e.g. leaf buds and leaves, flower buds and flowers, and fruits) may compete for water, nutrients, and metabolites, and such internal competition may lead to the partitioning in time of plant functions like leafing and fruiting.

Phenological Synchrony and Ecological Significance

The results of the synchrony indices of leafing, flowering, and fruiting events of four cultivars of mango are as presented in table 4.

Table 4: The Inter-Station Synchrony Indices for Leafing, Flowering, and Fruiting Events in Four Varieties of Mango in Oyi L.G.A. in 2023

	v. German			*v. Haden*			*v. Igbo*			*v. Peter*		
Station	**LF**	**FL**	**FR**	**LF**	**FL**	**FR**	**LF**	**FL**	**FR**	**LF**	**FL**	**FR**
A	0.87	0.84	0.86	0.79	0.80	0.76	0.78	0.78	0.81	0.79	0.82	0.83
U	0.88	0.85	0.86	0.88	0.83	0.84	0.80	0.81	0.82	0.82	0.83	0.81
N	0.79	0.78	0.83	0.77	0.76	0.76	0.82	0.79	0.79	0.75	0.75	0.78
Overall	0.85	0.82	0.85	0.81	0.80	0.79	0.80	0.79	0.81	0.79	0.80	0.81

LF: leafing**; FL**: flowering; **FR:** fruiting.
A: Awkuzu**; U**: Umunya**; N:** Nkwelle- Ezunaka. Values are mean of stations: Value of X_1 below 0.50 indicated low synchrony; 0.79 to 0.82 indicated medium; and 0.83 to 0.99 indicated a high synchrony (see Augspurger, 1983).

The surveyed varieties showed medium to high synchrony in leafing, flowering, and fruiting events. The average overall synchrony indices (i.e. values from the three stations combined) in flowering events were 0.82, 0.80, 0.79.and 0.80 for *germany*, *haden*, *igbo,* and *peter,* respectively (Table 4). Among the varieties, *v. german* recorded the greatest average overall synchrony indices in leafing, flowering, and fruiting with the indices of 0.85, 0.82 and 0.85, respectively (Table 4). Considering the stations, Nkwelle-Ezunaka recorded relatively lower flowering synchrony indices for all the varieties, scoring 0.78, 0.76 and 0.79 and 0.75 on *german*, *haden*, *igbo* and *peter*, respectively (Table 4). The degree of flowering and fruiting synchronization is believed to have ecological and evolutionary relevance at several scales (Freitas and Bolmgren, 2008) Studies have reported the adaptive significance of synchrony of phenological events among individuals of a species (Wang *et al*., 2016; Fisogni *et al*., 2022). The high synchrony indices (low asynchrony) of flowering events among the varieties of mango as observed in Oyi L.G.A. (Table 4) may have contributed to the reproductive success of mango in the area, and this may have been achieved through efficient cross pollination among the synchronously flowering individuals. This is in conformity with Domínguez and Dirzo (1995) that synchronous individuals within the population should have a higher fitness than plants that flower out of synchrony, because of an increase in number of visiting pollinators, higher rates of pollen donated deposition, greater opportunities to find mates, a higher potential for out-crossing and/or larger number of seeds that escape predation. It is expected that synchronous individuals within the population should have a higher fitness than plants flowering out of synchrony, because of an increase in number of visits by pollinators, higher rates of pollen donation-deposition, greater opportunities to find mates, and higher potential for outcrossing, and/or larger number of seeds that escape predation Moreover, this synchronous phenology may serve as deterrent to predators and frugivores. This is because synchrony creates abundance of fruits, which swamps the predators and frugivores in high fruits episodes along the year. The relatively low synchrony of phenological events recorded for Nkwelle-Ezunaka may be attributed to the hilly and undulating topography of the area, which may directly affect moisture status of the soil or indirectly affect the stem water status at varying degrees among individual trees. This is not incompatible with Alsubhi and Alzahrani (2024) as they highlighted that phenology is not affected by climate alone, but can also be affected by soil, terrains, and topography.

4.0 CONCLUSIONS

Common varieties of mango growing in Oyi L.G.A. exhibit almost similar phenological trends. In this area, the common varieties of mango show two distinct episodes of vegetative and reproductive growths that occur both in the dry and in the rainy season, along the year. Mango is available in commercial quantities in Oyi L.G.A. in February and April–May. The high synchronization of flowering and fruiting of mango in Oyi L.G.A. suggests high and uniform productivity of mango, and this will make pest management, labour scheduling, and harvesting much more predictable and cost-effective. Multiannual phenological monitoring of mango in Oyi L.G.A. is hereby recommended to provide long data series needed for establishing correlation between phenology and local climatic variables for tracing the impact of climate change in the future

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