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Research Article

Report of Irregular Flowering by Some Mango Trees in Awka: Possible Link with Climate Change, Implications for Food Security and Breed Selection

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Abstract

Serious concern has been expressed of the likelihood that climate change will aggravate in the future and its possible escalating impact on society, including diminishing agricultural yields. Mango is widely known to be vulnerable to changes in climate variables. This study aimed to add to our understanding of climate change by observing patterns of irregular flowering and fruiting by some mongo trees in Awka, Nigeria. It was found, among others, that short spells of dryness occurring during the rainy seasons disrupted the usual pattern of flowering and fruiting, and exerted a 'miscarriage effect' on the mango trees that reduced subsequent yields, even the yields of the usual fruiting seasons. The implications, among others, are that late-flowering / late-fruiting varieties of mango trees appear to be more resistant to the vagaries of climate change. They appear also to record narrower gaps between expected yield and actual yield. Hence, they appear to present better potentials for food security and breed selection in order to promote resilience against possible worsening effect of climate change in future. More research is needed to establish this observed notion of 'miscarriage effect', as well as establish comparison between early- and late-flowering / fruiting varieties. Similar research and emerging knowledge may be replicated for other trees and crops.

Keywords

Breed Selection, Climate Change, Food Security, Mango Phenology, Miscarriage-effect, Resilient Variety

1. Introduction

Climate change has become an established global phenomenon, affecting all regions in diverse ways and varying intensity [1]. It is expected that with time, climate change will escalate, and so will its impact [2, 3]. It becomes imperative, therefore, that we continue to intensify our study of climate change to gain improved understanding of the phenomenon, and to apply knowledge gained to develop evidence-led actions to build community resilience. Mango tree phenology has been known to be highly sensitive to climatic variables, hence modest changes in these variables significantly affect its activities including flowering, fruiting, maturing, yield, quality and taste [4, 5]. The objective of this study, therefore, is to contribute to climate study and climate knowledge by examining the possible effect of climate change on the patterns of flowering and fruiting of some mango tree varieties in Awka, Anambra State, Nigeria.

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2. Method

Simple observation was made on four un-common mango tree varieties, standing adjacent to each other within the same premises (located at coordinates 6.213°N and 7.075°E) in the Agu-Awka district of Awka, Anambra State. The observation spanned the period between April 2023 and April 2024 for patterns of flowering, fruiting and yield. Starting from the entry to the premises, the trees were referenced as A, B, C and D, given that the actual varieties of the mango trees could not be precisely identified and matched with mango tree varieties common in the area. This is to avoid the error of inaccurate identification. Simple observations made were noted.

3. Result/Observations

3.1. Observations

Whereas the usual period of flowering for mango trees in Anambra State is during the dry season / harmattan spanning December to February:

1) The observed mango trees flowered various times within the usual rainy season spanning April - October. Tree A flowered three times; Trees B and C flowered twice; while Tree C flowered once.
2) When rain falls, raindrops beat out most of the flowers, preventing them from developing (setting) into fruits. Only very few fruits eventually developed and matured.
3) During subsequent usual flowering season (December - February), the trees flowered and fruited, but at levels that were scanty compared to previous years.
4) At some points in time, three different stages of development simultaneously existed on the same tree: new flowers blooming; young fruits of 4 - 6 weeks, and matured fruits awaiting ripening.

3.2. Interpretation of Observations

1) Since full bloom/flowering of mango in the region is dependent on the climatic conditions of dry season and onset of harmattan (December - February), irregular flowering and fruiting observed during the rainy season (April - October) were induced by 'short spells of dryness' interspersed within the rainy season arising from vagaries accompanying climate change.
2) During the rainy season, raindrops beat out most flowers and prevented them from forming fruits because the flowers are not adapted to withstand the impact of raindrops and accompanying winds.
3) Furthermore, the duration of the short spells of dryness may not have been long enough to provide adequate climatic impetus and pollinator-activities needed to permit the formation of fruits from flowers.
4) Reduced intensity and quantity of flowering, fruiting and yield observed during subsequent usual/normal flowering/fruiting seasons may be due to reduced productive capacity arising from a possible 'miscarriage effect' imposed by the previously 'aborted' irregular flowering and irregular fruiting exercises.
5) Early-fruiting varieties of mango trees, being comparatively more sensitive to onset of dry season, are more affected by the series of dry spells during the rainy season. Accordingly, they will exhibit the highest number of irregular flowering and fruiting sessions in the year and should be affected more by the 'miscarriage effect' induced by irregular flowering and fruiting sessions. Conversely, late-fruiting varieties of mango trees require more pronounced dryness/harmattan conditions to flower and fruit. Hence, they are comparatively less affected by short dry spells during the rainy season. Accordingly, they will exhibit less number of irregular flowering and fruiting sessions and less affected by the said 'miscarriage-effect'.
6) The gap between potential yield and actual yield is likely to be more pronounced among early-fruiting varieties than late-fruiting varieties.

4. Discussion

4.1. Increasing Diversity of Mango Varieties and Challenge of Accurate Identification

With proven evidence of originating about 6,000 years ago in the Indo-Burma-Malay region [6] and now being cultivated in more than 89 countries in both tropical and sub-tropical climates, the mango tree has demonstrated very great resilience and diversity in its varieties. Nutrada [7] reports of more than 1000 varieties of mango while Napili Farmers Market (NFM) [8] reports of over 2000 varieties. These varieties vary in texture, flavor, and appearance; and vary also in colour from green, orange, yellow and red with accompanying hues and spot in some cases. They vary in size from a few ounces to four pounds.[7, 8] It is noteworthy that over time, and still continuing, new varieties and strains of mango have continued to emerge, not only from deliberate cross-breeding but also spontaneously. Sauco *et al* [9] report of the emergence of spontaneous tetraploids from diploid parent mango trees as confirmed by flow cytometry and chromosome count analyses in their studies in Canary Island. Hence, the accurate identification of a mango variety in a region where it is not common may present a challenge.

Ngutor [10], FrutPlanet [11] and Kitchen Butterfly [12] provide insights into the mango varieties prevalent in Nigeria and Anambra State, as well as their distinguishing characteristics including Julie, German (Opioro), Ogbomosho, Cherry, Kerosene, Cotonou, Benue, John-Peter, Paparanda, Lalaba, Hindi, Dausha, Broken, Mummy, Ambrose and Jama.

The observed mango tree labelled 'A' resembles a blend of

John-Peter and Julie varieties. Its big size and shape resemble John-Peter but the flesh resembles the sweet fiberless premium quality of the Julie variety. The observed tree variety labelled 'B' resembles the Cherry and more closely the Igbo Mango/Ofaneze because of its highly fibrous flesh. However, the skin colour is yellowish with slight patches or hues of light grey. The observed tree labelled 'C' resembles a typical German (Opioro) in shape but the size is almost 50% bigger, the skin has a slightly yellowish-green tinge. The skin is also softer and thinner than the German (Opioro). The observed tree labelled 'D' closely resembles the Kerosene variety. However, its kerosene taste/flavor is faint, its flesh is not fibrous, and the skin of the ripened fruit retains more of its green than pale peach.

The Agu-Awka area where the observed mango trees are located is close to a natural water-course draining the adjoining neighbourhood. The soil is more of clayey sand that hardens during the dry season and easily puddles during the rainy season, hence susceptible to water-logging. Inappropriate construction in the area has adversely blocked natural waterways aggravating water-logging in the area. Hence, crops and trees in the area are greatly impacted. Moreover, it could not be confirmed from the occupiers of the premises whether the trees germinated spontaneously, or were planted as selected seedlings. Hence, the possible impact of the peculiar environment on the tree varieties observed in this study could not be ascertained. Hence, peculiar environment could not be relied upon as likely reason for the slight differences in fruit features between the four observed trees and common varieties they resemble. Owing to the above limitations, this study safely decided to label the observed trees as A, B, C and D, instead of assigning variety names that may prove inaccurate.

4.2. Increasing Impact of Climate Change on Mango Phenology: Implications for Food Security

The increasing negative impact of climate change on mango phenology, fruit yield, fruit quality and their implications for food security have been sufficiently observed, and appropriate concerns have been expressed. Back in 2016, Makhmale *et al* [13] observed that:

"Climate-related changes have already brought widespread changes in flowering and fruiting patterns of mango. This is adversely affecting fruit production in some areas".

As at 2020, some Governments had instituted expert committee studies with illuminating elaborate reports [14] on climate change impact on the induction of flowering in mangoes. As at 2022, mainstream media, print and electronic, have supported campaigns to expand public awareness on the subject of climate change impact on mangoes [15]. More recently, Halder *et al* [16] provided a comprehensive review of literature on the subject in its broader dimension, covering from climate change disruption of traditional phonological patterns, through pollination, fruit development, to harvest.

How do these developments impact food security? According to Nutrada [7], mango is an excellent source of vitamins E and C, potassium, iron, niacin and beta carotene. According to NFM [8], mangoes are richly endowed with antioxidants such as quercetin, catechins and mangiferins which combat oxidative stress among other health benefits. They submit further that "a ¾ cup serving of mango provides 50% of your daily vitamin C needs, supporting immune function and skin health". In some societies, mango is so cherished and eaten, not just as mere fruit, but as fruit-food taken as full breakfast or dinner especially by adults. Some communities incorporate mangoes in traditional meals and celebrations. For certain communities in Africa, mango is so intimately embraced, such that they are used for the prevention and treatment of some ailments [17]. Accordingly, mango is regarded as one of the world's most popular fruits, consumed and cultivated.

Ngutor [18] provides an illuminating illustration of the key position of mango in global food security. He submits that:

1) mango is the second most grown fruit globally;
2) that in the 27 years from 1990 to 2017, global demand for mango rose at an estimated annual growth of 10 percent;
3) that mango is grown in commercial quantities in more than 90 countries;
4) that an estimated global export of about 1.7 million metric tons in 2017 catered for needs of other areas;
5) and, that Nigeria produced 917,617 metric tons of mango to emerge as Africa's number one highest producer and world's 10th largest producer.

He further listed some of the highest producer nations to include India (18.8 million metric tons); China (4.8 million metric tons); Thailand (3.4 million metric tons), Mexico (2.2 million metric tons), and Pakistan (1.6 million metric tons).

For a more recent update on mango production, World Population Review (WPR) [19] provides a 2026 data with India leading about 100 other countries with a 26.2 million metric tons output. However, the data combines output production for mangoes, guavas and mangosteens. A more reliable update is provided by Altaf [20] whereof the global total output was put at more than 54 million metric tons. However, individual country data were provided only for the 10 leading producer nations, from India (25.0 million metric tons) at number one position to Nigeria (1.0 million metric tons) at the tenth position.

The mango pricing chart published by FrutPlanet [11] provides us with an insight into how changes in availability of mango affects unit price in Nigeria. During peak seasons (mid-April - mid-July) when supply is maximal, mango sells at between N200 - N400 per kilogram depending on location. During 'transition' seasons (late March - mid April) and 'late season' (June - July), prices increase to N300 - N500 and N400 - N600 per kilogram, respectively. However, during 'off-seasons' (August - January), prices jump to N800 and above per kilogram. This reflects a 100 - 400% increase compared to peak season prices. This provides a glimpse of the extent to which climate change induced reduction in mango yields and supply can escalate prices and place mangos out of the reach of low- and middle-income earners, thereby reducing their nutritional intake.

The preceding data and information indicate a large scale global production of mango and equally heavy global consumption of mango, discounting losses arising from post-harvest and the supply chain. To the extent that climate change threatens global mango flowering, fruiting and yield, food security is equally threatened, whether at global, country or community levels.

4.3. Increasing Impact of Climate Change on Mango Phenology: Implications for Breed Selection

Yadav and Singh [6] inform us that the earliest attempt on breed selection was introduced by the Portuguese in the 15^{th} century to clone superior mono-embryonic trees in India. They submit further that the most popular mango varieties in India at present including Dashehari and Alphonso are actually breed selections made as far back as 1542-1605 AD during the reign of Akbar and subsequently multiplied through vegetative propagation for several hundred years.

In the current era of scientific advances in genetic engineering, Bura *et al* [21] inform us that success in the development of genetic markers has reduced errors and uncertainties in mango hybridization. Hence, commendable milestones have been achieved in developing new mango cultivars with improved qualities in many fronts including prolific fruit bearing, precosity, dwarfness, shelf life, resistance to diseases and pests, etc. Many other successes in mango hybridization initiatives have been reported by Binta, Manga & Mustapha [22].

Pinto, Ramos and Junqueira [23] report successes in mango hybridization works since 1983 at Cerrados Agricultural Research Center (CPAC) in Brasilia, Brazil, whereof 1,339 hybrid selections had been achieved. Nutrada [7] reports that the popular Honey Gold and Keitt varieties of mango are actually hybrids specifically developed for long shelf life and to withstand long storage in ships, making the varieties preferred export stocks.

The plasticity and resilience exhibited by the mango tree on its own, the wide diversity of varieties growing across tropical and sub-tropical regions, the documented emergence of spontaneous varieties, the ease of vegetative propagation, and the successes already achieved in hybridization currently place us in a good position to determine the pattern and direction of mango breeding now and in the future. Bura *et al* [12] inform us further that mango (Mangifera indica) shares grafting and pollination compatibilities with several other species within the Mangifera genus. This implies that these other species can serve as possible rootstocks or sources from which to borrow novel genetic traits for breeding mangoes. What is required at present, as Ahmed *et al* [24] rightly suggest, is to be more robust in our cultivar selection to deliberately improve the resilience of mangos to manage vulnerabilities to climate change.

As Halder *et al* [16] suggest also:

“Future research should focus on cultivar-specific responses and adaptation measures to ensure the resilience of mango cultivation in the face of climate change”.

Accordingly, this study enjoins further research to focus on its interim findings and possible interpretations, more especially on:

1) the thesis of ‘miscarriage effect.’ In brief, this notion of ‘miscarriage effect’ proposes that irregular flowering and fruiting sessions draw energy, nutrients and time resources on the mango tree thereby reducing its subsequent yields even during normal fruiting season; and
2) the proposal that late-flowering varieties, *ceteris paribus*, may present higher potentials for adaption to climate change in comparison with early-flowering varieties.

For agencies and governments embarking of tree restoration programs involving mango seedlings such as the Anambra State tree economy revival program [25], more attention needs to be paid to prioritizing distribution of seedlings of mango varieties that hold promise to comparatively resist harsh and negative impacts of aggravated climate change in the future.

It is noteworthy, also, that the findings of this study, including future researches, as they apply to mango may apply to other sister-species of the Mangifera genus, as well as to other trees and crops, considering that climate change is all embracing in its impact.

5. Conclusion

Strong evidence exists that mango phenology is highly susceptible to climate change. Irregular flowering and irregular fruiting observed in this study are attributable to short dry spells during the rainy season. The short dry spells, in turn, are products of climate change. Decrease in yield observed during subsequent fruiting seasons is likely due to a ‘miscarriage effect’ imposed on the mango tree by previous irregular flowering and irregular fruiting which had depleted energy and nutrients from the tree.

6. Recommendation

More research is needed to establish in detail the patterns of relationship between changes in climate variables and changes in mango performance including yields. Special attention should be paid to the notion of ‘miscarriage effect’ of irregular flowering and irregular fruiting on mango tree varieties, as well as the potentials for greater resistance to climate change which late-flowering varieties present. Emerging knowledge will be of immense benefit in prioritizing breed selection for mango varieties, and in turn, in promoting food security for our future. Similar research and emerging knowledge may also be replicable for other trees and crops for the overall benefit of society.

Abbreviations

AD	*Anno Domini (after the Year of Our Lord)*
CPAC	Cerrados Agricultural Research Center
NFM	Napili Farmers Market
WAT	West African Time
WPR	World Population Review

Author Contributions

Obiano Emmanuel Chukwuma: Conceptualization, Investigation, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing

Conflicts of Interest

The author declares no competing interest.

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