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Reproductive Phenology of *Mangifera indica* L. and *Persea americana* Mill in Brazzaville (Republic of Congo)

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Abstract **Original Research Article**

Mangifera indica L. and *Persea americana* Mill are two species of fruit trees for food use. In Brazzaville, they seem to be the most representative and cover the whole city. The phenological study of these two species was carried out throughout the city of Brazzaville. The objective of the study is to improve the phenological knowledge of these species. The methods used are based on field surveys. The selected, marked and geolocated trees are monitored by the observation method for two years. The various results obtained show that flowering in *Mangifera indica* L. appears early in January. It evolves progressively and becomes visible in all sites during the dry season, between June and July, then decreases in August. The peak of flowering is observed in July with 100% of plants recorded. Fruiting starts in March, progresses gradually in terms of number of trees and reaches its peak between August and September with 80% of trees recorded. However, in *Persea americana* Mill, flowering starts early in March and progresses over time until it reaches its peak between July and August with 80% of trees recorded. Fruiting is observed from August onwards and lasts until December, January and February, during the rainy season. The evolution of these different phenophases shows phenological characteristics common to these trees, marked by phenological asynchrony, variation and interaction. These results highlight the effect of the seasons on the phenological evolution of the species studied.

Keywords: *Mangifera indica* L., *Persea americana* Mill, flowering, fruiting, rainfall, Brazzaville.

INTRODUCTION

For a long time, man has been interested in taking care of his fruit trees in the orchard, to find food (fruit) or a place for leisure and relaxation; but today with economic development, the fruit sector has taken another direction and is an important industrial interest in countries (Habouche and Salami, 2020).

Regarding fruits, several works have shown the importance of their consumption for the proper functioning of the human body. Thus, Brustel (2018), presents the nutritional characteristics of the mango which, according to her, is one of the richest fruits in provitamins A, vitamin C and vitamin B9 (folic acid) recommended in cases of anemia. In socio-economic terms, the mango is the 5th most produced fruit in the world with 39 million tons produced in 2010 according to the FAO (Food and agriculture organization) quoted by Dambreville, 2012. The avocado tree is mainly cultivated for food purposes. In addition, it has long been recognised as having many medicinal properties, such as deworming and fever control. Today, many countries cultivate this tree (Chloe, 2017).

Nowadays, many works on the phenology of fruit trees are reported throughout the world. However, for the city of Brazzaville, information on the phenology of fruit trees is not numerous, to our knowledge. It is in this context that the present study was conducted. It focuses on the phenology of *Mangifera indica* L. and *Persea americana* Mill two species of fruit trees for food use present throughout the city of Brazzaville. The objective of the study is to improve knowledge on the phenology of these two tree species.

MATERIALS AND METHODS

Study Environment

The study was carried out in the city of Brazzaville, the political capital of the Republic of Congo, located on the right bank of the Congo River and extending between 40 13' and 4018' South latitude and between 150 13' and 150 18' East longitude (Mbouba-Sonia, 2007). The sites selected for the study are the 9 districts of Brazzaville. The city's climate is of the low Congolese type. The average annual temperature is around 25°C, with a small thermal range of 5 to 6°C. March and April are the hottest months, while July and August are the coolest (Samba-Kimbata, 1978; Samba and Nganga, 2011). The average annual rainfall is 1,200 mm. Rainfall occurs from October to May, with a marked slowdown in January and February. The wettest months are generally March, April and November (Vennetier, 1977). The months of June to September are partly dry. The relative humidity is particularly high, always above 70%. An absolute minimum is noted in August and September and a relative minimum in February and March. The minimum varies between 50 and 60%; the maximums vary from 88% to 94%.

The Brazzaville area has four (4) types of soil: poorly developed soils, hydromorphic soils, podzolized soils and ferrallitic soils (Schwartz, 1987). In Brazzaville, there are soils formed on the Inkissi sandstone with a sandy-clay texture and soils formed on the heterogeneous alluvium of the Congo River and its tributaries, which are poor in organic matter (Nzila, 2001).

Originally, the Brazzaville region and its surroundings were covered by forests and savannahs (Mpassi, 2016). The forests have different aspects depending on the geomorphology. There are forests reduced to copses, groves of anthropogenic origin on the plateaus and forming forests along the edges of watercourses. The savannahs are marked by a group of grasses dominated by *Trachypogon spicatus* and shrubs of the Annonaceae family. Brazzaville is watered from north to south by various rivers: the Djiri, Tsiémé, Mikalou, Mfoa, Madoukoutsékélé, Djoué and Mfilou (Makany, 1976).

METHODS

Study Sites and Choice of Trees to be sampled

Nine (9) arrondissements in the city of Brazzaville were selected for the study. Each arrondissement constitutes a site as follows: site 1: Makélékélé; site 2: Bacongo; site 3: Poto-Poto; site 4: Moungali; site 5: Ouénzé; site 6: Talangaï; site 7: Mfilou-Ngamaba; site 8: Madibou and site 9: Djiri.

Thirty (30) fruit trees of each species are selected per site as a sample (Grouzis, 1991). Each tree is chosen according to its physical condition, health status, physiognomy, height and the greenness of its foliage.

Phenological Monitoring of Trees

The study of phenology is based on observation. The regularity of observations is a condition that can guarantee the quality of the results (Sidibou, 1991). Thus, for the present study, a sample of 30 individuals of all varieties per species was monitored in each district. This number seemed sufficient to constitute a representative sample for the study and to limit individual variability (Grouzis, 1991; Brustel, 2018).

The time interval between two successive observations is one (1) month for each species. The phenological monitoring was carried out by different passages in all the sites each month and for two years (2019 and 2020) and focused on the reproductive phenology. The phenophases selected were flowering and fruiting. These phenophases were monitored at the tree level. This makes it possible to estimate their evolution (Persello, 2019). In order to characterize the evolution of the phenophases, at each passage, flowers, ripe fruits, immature fruits, seeds, individuals in flower or in fruit were noted (Sabatier *et al.*, 1986). The rate of each phenophase is determined by the following formula:

% phenophase = number of trees in the relevant phase * 100/total number of trees at the site.

After obtaining the monitoring results, we compared the start of the phenological phases with the climatic and environmental data. This allows us to identify the factors related to the phenological cycle of the species studied (Yahi, 2021).

RESULTS

Phenology of the Studied Fruit Trees

Phenology of *Mangifera Indica* L. in 2019

Figure 1 shows the evolution of the flowering of *Mangifera indica* L. during the year 2019 in all sites. The analysis of this figure shows that the selected plants start to flower from January with a low percentage ranging from 13.33% to 46.66% of trees recorded and the phenomenon extends until September. Between March and May, the rate of flowering trees decreased significantly and in June, a large number of trees are found flowering again. In July, the peak of 100% of this phase is observed and after that, the rate of flowering trees decreases and is cancelled in September. Then in December flowering reappears early in both sites. There is therefore a seasonal effect on tree flowering. The dry season seems to be the period that favours flowering.

Figure 2 shows the evolution of *Mangifera indica* L. fruiting in 2019 in the sites selected for the study. From this figure it can be seen that in January and February, a few *Mangifera indica* L. plants are in the fruiting stage at the various sites, but at very low rates. From March to July, the phenomenon progressively gains a large number of plants and between August and September, fruiting is almost total and then decreases from October 2019. Fruiting is influenced by the season.

Fruiting seems to be more abundant at the end of the dry season.

Phenology of *Mangifera Indica* L. in 2020

The evolution of the flowering of *Mangifera indica* L. in 2020 is shown in figure 3. The observation of this figure shows that the flowering of the trees started in January in some sites, in proportions ranging from 20% to 66.66% of the trees recorded. From there we see a gradual evolution until July when the phenophase is almost full with the peak reaching 100% of individuals in site 7. Between August and September, a small number of *Mangifera indica* L. plants are in flower. The dry season seems favourable for flowering in 2020.

Figure 4 shows the development of *Mangifera indica* L. fruiting in 2020 at all study sites. The analysis of this figure shows that fruiting appears in March and then progressively evolves until December 2020. Its plateau appears between August and September with rates varying between 80% and 93.33%. There is still a seasonal effect on fruiting of *Mangifera indica* L. in 2020.

Phenology of *Persea americana* Mill in 2019

Figure 5 shows the flowering pattern of *Persea americana* Mill in 2019. From this figure it can be seen that flowering of *Pesea americana* Mill occurs early from January at low rates. However, the flowering rate increases in April and continues until September 2019. In this time frame, full flowering occurs between June and September, with 80% of plants in flower. After September, the flowering rate gradually decreases to zero in December 2019. These results show that the dry season is favourable for the flowering of *Pesea americana* Mill.

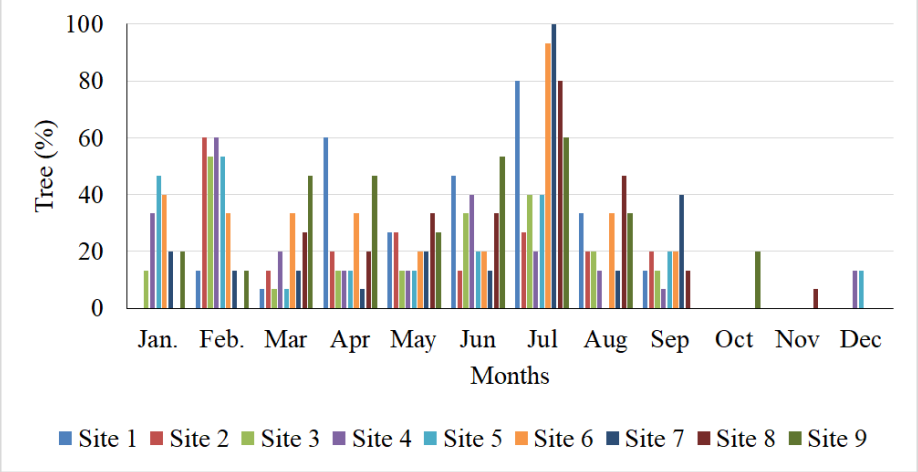

Figure 1: Evolution of flowering of *Mangifera indica* L. in 2019

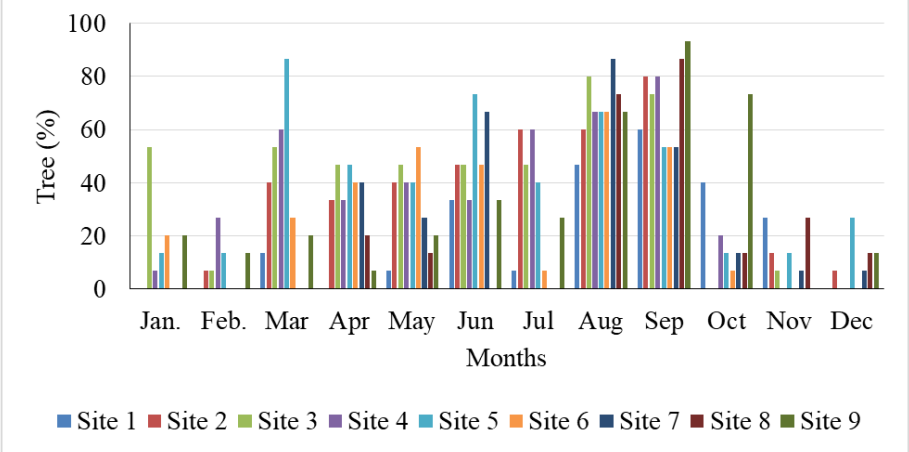

Figure 2: Evolution of fruiting of *Mangifera indica* L. in 2019

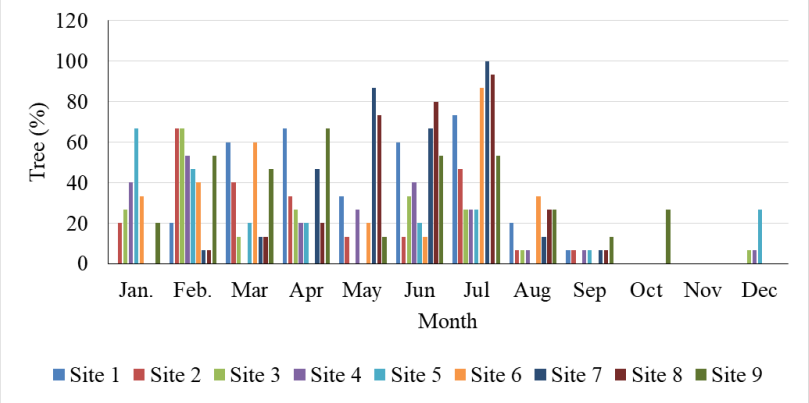

Figure 3: Flowering trend of *Mangifera indica* L. in 2020.

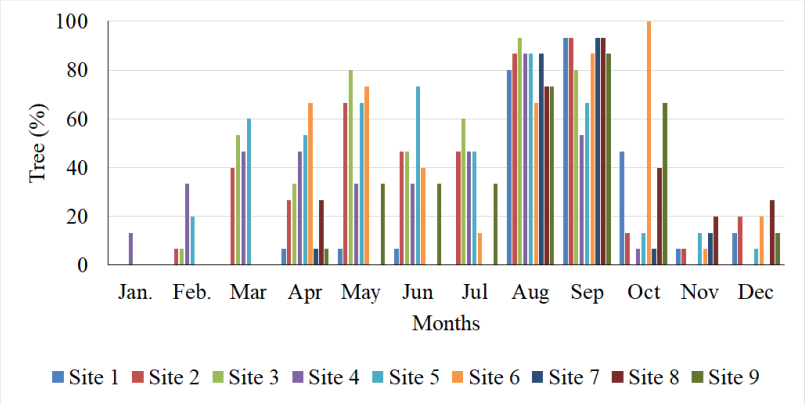

Figure 4: Evolution of *Mangifera indica* L. fruiting in 2020

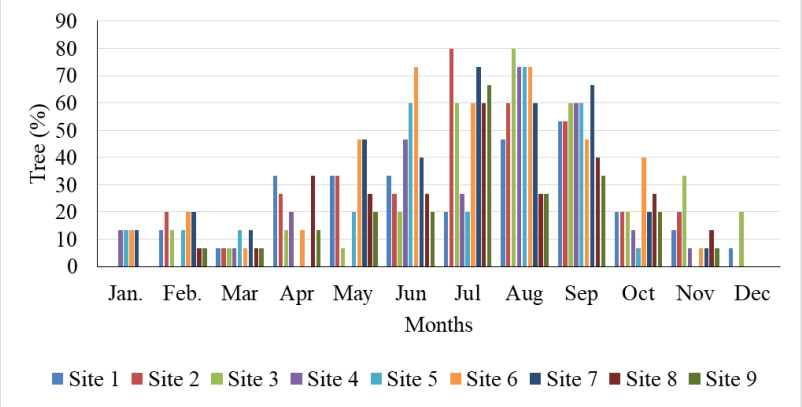

Figure 5: Flowering trend of *Persea americana* Mill in 2019

Figure 6 shows the fruiting trend of *Persea americana* Mill in 2019. The analysis of this figure shows that *Persea americana* Mill fructifies between January and February on the one hand and between August and December on the other. During these periods, fruiting is widespread in all sites. However, between March and July, some plants fruit at different sites at low rates. The rainy season seems to be favourable for fruiting of *Persea americana Mill*.

Phenology of *Persea americana* Mill in 2020

The evolution of the flowering of *Persea americana* Mill in 2020 is shown in figure 7. Examination of this figure shows that the plants of *Persea americana* Mill begin to flower in March and the phenomenon continues until October 2020. However, flowering is early between January and February when a few plants show flowers in three or four sites, and then late, between November and December 2020. These results show that in 2020, the dry season seems to be the most favourable period for *Persea americana* Mill to flower.

Figure 8 shows the evolution of fruiting of *Persea americana* Mill in 2020. It can be seen from this figure that fruiting of *Persea americana* Mill takes place between January and February on the one hand and between June and December 2020 on the other. Overall,

the rainy season seems to be the most favourable period for fruiting *Persea americana* Mill.

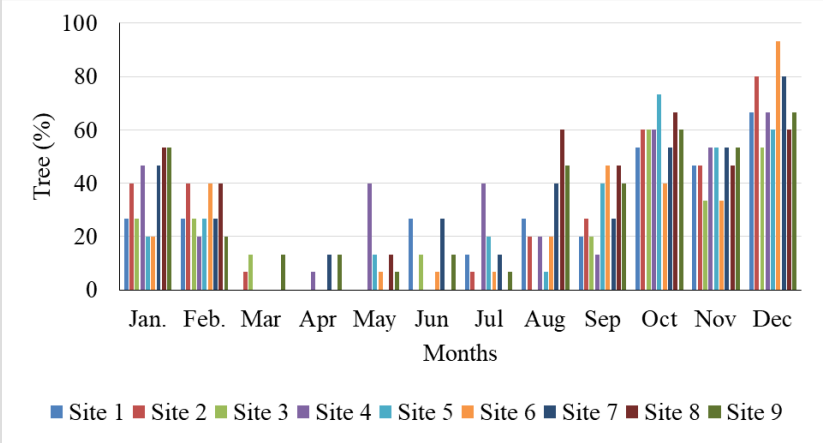

Figure 6: Fruiting trend of *Persea americana* Mill in 2019

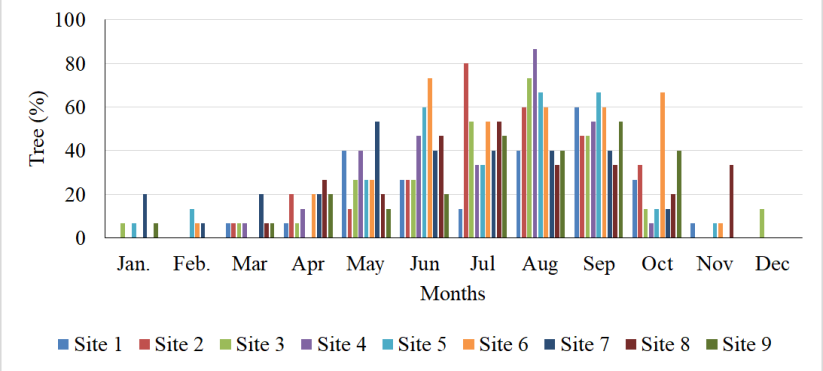

Figure 7: Flowering trend of *Persea Americana* Mill in 2020

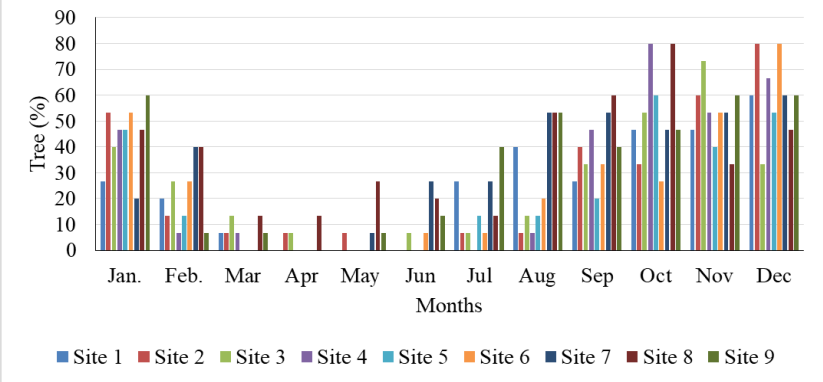

Figure 8: Development of fruiting bodies of *Persea americana* Mill in 2020

DISCUSSION

Phenological Evolution of the Trees Studied

The results of the present study show that in *Mangifera indica* L. and *Persea americana* Mill flowering is progressive and reaches its peak in the dry season. The season effect is therefore evident in the flowering of trees of these two species in Brazzaville. Full flowering occurs at all sites between May and July, with a peak in July of 93.33% for *Mangifera indica* L. Between May and September, flowering becomes progressively more important at all sites and reaches its peak between July and September for *Persea americana* Mill. After September, a considerable drop in flowering is observed, giving way to fruiting. On the whole, flowering is a phenophase spread over a number of months. Poligui (2014) makes the same observation about the spread of safoutier flowering in Gabon.

The phenological evolution of the trees studied shows that flowering occurs when the vegetative buds transform into the reproductive state and give rise to floral buds. It is thus a transformation of the vegetative meristems that become prefloral, leading to floral induction with the formation of the primordium of the

perianth and sexual parts (Heller *et al.,* 2000). As June approaches, there is a variation in temperature, resulting in a drop in temperature and even a cessation of rainfall. These moments announce the presence of the dry season. In the life cycle of trees, the drop in temperature and rainfall generates water stress in many trees and leads to a halt in vegetative growth, which in turn leads to the induction of flowering. Low temperatures therefore stimulate flowering (Brustel, 2018).

According to Osama (2018) water stress is caused by insufficient water availability which affects many physiological functions especially growth and photosynthesis. It has constraining effects on growth and primary metabolite levels depending on its duration, intensity and occurrence during plant development. Secondly, a too low temperature (whose optimum of functioning is around 20°C to 25°C) decreases photosynthesis and plant growth. Tahir *et al.,* (2003) report that water stress inhibits shoot initiation through its direct impact on cell division and elongation.

According to Sandrine (2009), it is cool temperatures that induce reproductive shoots or lead to the development of shoots in the reproductive system. In *Mangifera indica* L., the site of production of the floral stimulus is located in the leaves. When exposed to cool inductive temperatures, these leaves synthesise the stimulus which migrates to the buds via the phloem and induces flowering, she continues.

Fruiting follows flowering on all trees of both species studied and on all sites. In *Mangifera indica* L., full fruiting occurs between August and September in sites with high percentages of trees. In *Persea americana* Mill fruiting starts in May at very low rates until August. Full fruiting is clearly visible between January and February and then between September and December in all sites. Overall, the rainy season seems to be more favourable for fruiting. However, Dambreville (2012) points out that fruit development depends on both endogenous and exogenous factors. We believe that rainfall is the main exogenous factor influencing fruiting. In this respect, Vogel *et al.,* 2005 point out that many plants in tropical regions where it is always warm but there is a dry season, only start growing when there is sufficient moisture. In these regions, they argue, the timing of growth is determined by the rate of rainfall and not the temperature.

The low rate of flowering and fruiting observed at certain times of the year could be due to the sudden fall of flowers and fruits. This can be explained by an excess of nitrogen content in the plant or in the soil, by the phenomenon of trophic competition between vegetative growth and flowering, but also by fruiting, which take place simultaneously (Dambreville, 2012). The wind can also intervene in the fall of inflorescences through its mechanical action with the rigorous swinging of flowering branches. This result in the low rate of flowering or fruiting recorded in the different sites during certain periods.

Phenological Variability

During the observations made at all the sites of the present study, it was found that the rate of a phenophase (flowering or fruiting) at tree level is variable from one site to another, and for the same site from one species to another. Thus, for example, flowering occurs fully between June and July in *Mangifera indica* L., whereas the same phenophase occurs fully between March and June in *Persea americana* Mill. Variation can also be observed in individuals of the same species over time. This can be explained by the fact that on the same tree or from one tree to another, meristematic activity is not identical for all buds and this difference in activity can be the cause of variability in flowering (Kulkami, 2002 in Sarron, 2019). This leads to phenological asynchrony and alternation (Dambreville, 2012). The asynchrony manifests itself not only at the inter-tree level but also at the intra-tree level and particularly at the level of the carpenter (main branch) and subcarpenter or secondary branch of the tree. The main consequence is that flowering or fruiting is variable over time and fruit ripening will not be uniform (Yeshitela *et al.,* 2005 in Sarron (2019). In this respect, Guira, (1997) states that in phenological variability; all the different phenophases do not appear regularly either at the level of a single tree or at the level of a single stand.

Alternation is defined as the behaviour of a tree or branch that does not produce regularly from year to year or a year of low production follows another year of high yield (Dambreville, 2012; Sarron, 2019). Alternation can occur at the level of a tree but also on a single branch of a tree and Sarron (2019) adds that a tree that is very busy one year will have reduced vegetative and reproductive development the following year. Spatio-temporal influences between growths units lead to a shift in the appearance of flushes on the tree. This results in the observation of several particular phenological stages in the same tree.

From their phenological characteristics we can see that the species studied belong to the category of species with discontinuous and irregular flowering and fruiting. In these trees, production takes place without a fixed periodicity. In addition, there is a synchronism between climatic and biological seasonality. In fact, flowering in *Mangifera indica* L and *Persea americana* Mill. reaches its peak in the long dry season (June, July, August and September), while fruiting reaches its peak in the rainy season (October, November, December, January and February, even March). The season effect is therefore noticeable on flowering and fruiting. Studies on the phenology of these two sampled species would therefore be recommended in the dry season, for flowering, and in the rainy season, for fruiting.

CONCLUSION

This study showed that the flowering and fruiting rates of *Mangifera indica* L. and *Persea americana* Mill are globally higher in the dry and rainy seasons respectively in Brazzaville. Rainfall therefore seems to be the climatic parameter that influences the reproductive phenology of the trees of these two species during the two years of observations. There is variability in flowering and fruiting between trees of the same species on the same site, between trees of different species on the same site, and between trees of the same species and of different species on different sites during a year. The results of the present study could serve as a basis for further work on reproductive phenology and contribute to decision-making on the sustainable management of fruit trees in Brazzaville.

REFERENCES

- Brustel, L. (2018). Evaluation de l'effet de pratiques culturales (paillage/ enherbement du sol/ récolte prophylactique précoce) en vergers de Manguier (*Mangifera indica* L.) sur la régulation des bioagresseurs de la floraison et de la fructification. Les cas de la Cecidomyie des fleurs (*Procontarinia mangiferae*) et des mouches des fruits (*Diptere tephritidae*). Mémoire d'Ingénieur CIRAD, 51 p.
- Chloé, M. (2017). Contribution à l'étude phytochimique des espèces *Leea guineensis*, *Persea americana* et *Litchi chinensis* en vue de valorisations cosmétiques. Mémoire de Master. Université de Liège, 84 p.
- Dambreville, A. (2012). Croissance et développement du manguier (*Mangifera indica* L.) in natura : approche expérimentale et modélisation de l'influence d'un facteur exogène, la température et de facteurs endogènes architecturaux. Thèse de Doctorat, Université de Montpellier II, France, 181 p.
- Goguey, T. (1995). Approche architecturale des mécanismes de la croissance aérienne et de la floraison du manguier. Thèse, Université de Montpellier II, Montpellier, 264 p.
- Grouzis, M. (1991). Phénologie des arbres et arbustes en zones arides et sémi-arides. Groupe d'études de l'arbre. Paris, France, p 145-153.
- Guira, M. (1997). Etude de la phénologie et de la variabilité de quelques caractères chez le karité, *Butyrospermum paradoxum* subsp *partii* (G. Don) Hepper (Sapotaceae) dans les champs et les jeunes jachères dans la moitié ouest de Burkina Faso. Thèse de Doctorat de troisième cycle, Université de Ouagadougou, Ouagadougou, 191 p.
- Habouche, K., & Salmi, C. (2020). Diversité biologique de l'arboriculture fruitière dans la région de Msila. Mémoire de Master académique, Université Mohamed Boudiaf- Msila, République Algérienne Démocratique et Populaire, 93 p.
- Heller, R., Esnault, R., & Lance, C. (2000). Physiologie Végétale 2. Développement. Cours 1er cycle/ licence- CAPES- Agrégation. 6e édition DUNOD, Paris, 365 p.
- Makany, L. (1976). Végétation des Plateaux Téké (Congo). Collection. Travaux, Université de Brazzaville, Congo, 301 p.
- Mbouba, S. D. (2007). Importance et aspects biogéographiques de la flore ligneuse allochtone à Brazzaville. Mémoire de CAPES, Université Marien NGOUABI, République du Congo. 72 p.
- Mpassi, V. L. (2016). Caractérisation morphologique des sols maraichers au site du jardin Municipal de Brazzaville. Mémoire de Master, ENSAF. Université Marien NGOUABI, Républiqque du Congo. 53 p.
- Nzila, J. D. D. (2001). Les sols du Congo et les problèmes d'aménagement, Fascicule. Cours de pédologie, Université Marien NGOUABI, (E.N.S.) D.S.N., Brazzaville, 69 p.
- Osama, A. N. (2018). Effet des conditions environnementales sur les caractéristiques morpho-physiologiques et la teneur en métabolites secondaires chez *Inula montana* : une plante de la médecine traditionnelle Provençale. Thèse de Doctorat, Université d'Avignon, France, 179 p.
- Persello, S. (2019). Réponse du manguier, *Mangifera indica* L., à la taille : caractérisation et intégration dans un modèle structure-fonction des effets de la taille sur la croissance végétative et la reproduction. Thèse de Doctorat, Université de Montpellier, Montpellier, 174 p.
- Sabatier, D., & Puig, H. (1986). Phénologie et saisonnalité de la floraison et de la fructification en forêt dence guyanaise. Tnstitut de Botanique, Montpellier. Laboratoire de Botanique tropicale. Extait de Mémoires du Muséum National d'Histoire Naturelle, tome 132. Vertébrés et forêts tropicales humides d'Afrique et d'Amérique, Paris, éditions du Muséum, p 173-184.
- Samba, G., & Nganga, D. (2011). Rainfall variability in Congo-Brazzaville: 1932-2007. *International Journal of Climatology, 32, 854-873. http://dx.doi.org/10.1002/joc.2311*
- Samba-Kimbata, M. J. (1978). Le climat Bas congolais. *Thèse de doctorat, Université de Dijon, Dijon*, 278 p.
- Sandrine, C. (2009). Cartographie de la biomasse sèche structurale et des sucres de reserve du manguier et leurs évolutions au cours du cycle phénologique. Mémoire de Master Bioingénieur des Sciences Agronomiques. *Faculté Universitaire des Sciences Agronmiques de Gembloux, Belgique*, 100 p.
- Sarron, J. (2019). Estimation spatialisée des rendements d'une culture perenne en Afrique de l'Ouest : cas du manguier au Sénégal. Thèse de Doctorat, Montpellier SUPAGRO, France, 259 p.
- Schwartz, D. (1987). Les sols des environs de Brazzaville et leur utilisation. ORSTOM, Pointe-Noire, Congo, 17 p.

- Sididou, S. (1991). Phénologie. Méthodes d'Etudes. Centre National de Sémences Forestières Ouagadougou, Burkina Faso. Rapport d'accueil au laboratoire d'Ecologie, ORSTOM- Dakar. 24 p.
- Tahir, F. M., Ibrahim, M., & Hamid, K. (2003). Effet of drought stress on vegetative and reproductive behaviour of mango (*Mangifera indica* L.) *Asian Journal of plant Sciences*, 2, 116-118.
- Vennetier, P. (1977). Atlas de la République Populaire du Congo. Edition Jeune Afrique, Paris, France, 64 p.
- Vogel, J., Mairet, A. J., Lucerne, Brugger, R., Jaberg, G., & Soleure. (2005). Phénologie. Un projet scolaire d'étude de l'influence des saisons sur les cycles biologiques. Globe suisse, 1ere édition, 51 p.
- Yahi, I. (2021). Suivi phénologique de quelques variétés des Rosacées fruitières dans la ferme pilote Oued Athemania-Mila. Mémoire de Master. Université des Frères Mentouri Constantine I. République Algérienne Démocratique et Populaire, 75 p.