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RESEARCH ARTICLE

VEGETATIVE PHENOLOGY OF DACYODES EDULIS (G. DON) H. J. LAM AND ELAEIS GUINEENSIS JACQ. IN BRAZZAVILLE (REPUBLIC OF CONGO)

Pierre MPASSI[1], Olendekah AMBOUA ISSENGUE[2-3], Amour Macelvi MATOUMOUENE[2-3], Joseph YOKA[2*], Yedjanlognon Faustin ASSONGBA[4] and Julien Gaudense DJEGO[4]

[1]Ecole Normale Supérieure, Université Marien Ngouabi, Brazzaville, Congo; [2]Laboratoire de Biodiversité, de Gestion des Ecosystèmes et de l'Environnement, Faculté des Sciences et Techniques, Université Marien Ngouabi, Brazzaville, Congo; [3]Ecole Nationale Supérieure d'Agronomie et de Foresterie, Université Marien Ngouabi, Brazzaville, Congo; [4]Laboratoire d'Ecologie Appliquée, Faculté des Sciences Agronomiques, Université d'Abomey-Calavi, Cotonou, Bénin

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ABSTRACT

In *Dacryodesedulis* (G; Don) H. J. Lam L and *Elaeis guineensis* Jacq. Are two fruit species used for food. In Brazzaville, they are among the most representative and cover the entire city. The phonological study of these two species was carried out throughout the city of Brazzaville. The aim of the study is to improve phenological knowledge of these species. The methods used are based on field surveys. The trees selected, marked and geolocated were monitored using the observation method for two years. The various results obtained show that in *Dacryodesedulis* (G. Don) H. J. Lam., defoliation is widespread on the trees between April (rainy period) and August (dry period). It peaked in June (dry period) with 53.33% of trees recorded. Leafing, on the other hand, is more noticeable than defoliation and starts in January (dry period), then progresses gradually. It becomes visible on the trees at all the sites during the rainy season, between March and June, then decreases in August. Its peak is reached between May and June, with 100% of trees counted. In the case of *Elaeis guineensis* Jacq. on the other hand, defoliation occurs between June and July (dry period). Leafing occurs throughout the year. The evolution of these different phenophases shows phonological characteristics common to these species, marked by phonological asynchronism, variation and interaction. These results highlight the effect of the seasons on the phonological development of the species studied.

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INTRODUCTION

Currently, with climate change leading to high social and environmental vulnerability, the use of plant species with high phonological plasticity such as *Dacryodesedulis* (G. Don) H. J. Lam and *Elaeis guineensis* Jacq. is one response to the difficultsoil and climate conditions to which few plants are adapted (Zango, 2016). Numerous studies have shown the importance of the plant organs of these trees for the well-being of the human population. Indeed, in addition to the economic aspect, the fruit sector remains the key sector for empirical knowledge in our traditions through the use of vegetative organs and secretion products. This is the case in traditional pharmacopoeia, where resin, roots, leaves and bark are used in numerous therapeuticrecipes to treat wounds, an aemia and dysentery, digestive tract disorders, toothache, earache and leprosy (Raponda-Walker and Sillans, 1961). *Dacryodesedulis* (G. Don) H. J. Lam. Is used not only as a decorative tree in front of and behind dwellings, but is also planted as a shade tree in cocoa and coffee plantations, where it contributes to the ecological balance of the environment (Sonwa *et al*., 2002). The safoutier is also used by local people to fix the soil in the terraces of their homes on sloping land. Each safoutier is part of the family's property or heritage. *Dacryodes edulis* wood can also be used for cabinet-making. It has the same wood quality as mahogany and is comparable to that of *Dacryodes buettneri* (Engl.) H. J. Lam. According to Kinkela *et al.* (2006), the value of cultivating *Dacryodesedulis* (G. Don) H.J. Lam lies in the nutritional value of its fruit, the edible pulp of which is rich in fatty acids and aminoacids. According to Kengué (2002), this fruit tree has long been exploited by people in Central Africa, mainly for its edible fruit. Poligui (2014), for his part, points out that this tree is likely to bring considerable revenue to the economies of Central African countries. After cooking, the pulp of these fruits can be transformed into an edible paste (safou butter) that keeps for two to three months after harvesting and is used in a variety of culinary recipes. Food and cosmetic coil can be extracted from the pulp and kernel of the safflower. *Elae is guineensis* Jacq. is not only a "tree" that produces nuts and palm wine, but also one that provide senormous high-quality goods and services to mankind through its various vegetative organs, and no one can ignore the use of the palm leaf in households and in the construction of traditional wellings. The palm tree is the world's leading oil seed crop in terms of production (Jacquemard *et al*., 2011). The development of oil palm cultivation has led to strong economic development and a significant reduction in rural poverty. Palm oil is also used in soap, cosmetics and lubricants. Around 1% of palm oil is used to produce biodiesel and crude or refined palm oil contains almost 100% lipids in the form mainly of triglycerides, made up of glycerol to which three fatty acids are attached. The proportion of fatty acids issaturated, with palmitic acid in the lead at around 50% (Cros, 2014). Given the multiple uses of these species, it seems essential to characterize their vegetation period in order to understand the behaviour of the vegetative phenology of these trees in order to determine the effects linked to the different ecological variables and plan their sustainable management in the face of climate change. Nowadays, many studies on the phenology of fruit trees are reported throughout the world. However, for the city of Brazzaville, information on the phenology of fruit trees, and more specifically, vegetative phenology, is not, to our knowledge, abundant. It was in this context that the present study was carried out, focusing on the vegetative phenology of *Dacryodesedulis* (G. Don) H. J. Lam and *Elaeis guineensis* Jacq, two fruit species for food use found throughout the city of Brazzaville. The aim of the study is to improve knowledge of the vegetative phenology of these two fruit species.

MATERIALS AND METHODS

Study environment: The study was carried out in the city of Brazzaville (Republic of Congo), which is located on the right bank of the Congo River in Central Africa and lies between 40 6' and 40 23' south latitude and between 150 5' and 150 25' east longitude (SOCB, 2021 and Matoumouene Goma, 2022). The sites selected for the study comprise 9 districts of Brazzaville. The city has a low land Congolese climate. The average annual temperature is around 25°C, with a small temperature range of 5 to 6°C. March and April are the hot test months, while July and August are the coolest (Samba-Kimbata, 1978; Samba and Nganga, 2011). Average annual rain fall is 1400 mm, with rains falling from October to May, with a markeds low down between January and February. The wettest months are generally March, April and November. The months from June to September are partly dry. Relative humidity is particularly high, always over 70%. An absolute minimum is recorded in August and September, and a relative minimum in February and March. The minimum varies between 50% and 60%; the maximums range from 88% to 94%. The study area has four (4) types of soil: soils with little erosion, hydromorphic soils, podzolised soils and ferrallitic soils. In addition, there are soils formed on the In kiss is and stone with a sandy-clay texture and soils formed on the heterogeneousalluvium of the Congo River and it stributaries, which are poor in organic matter (Schwartz, 1987). Originally, the Brazzaville region and its surroundings were covered by forest and savannah. The forestsvary in appearancede pending on the geomorphology. There are forests reduced to copses, groves of anthropogenicorigin on the plateaux and forming forests on the edges of water courses. The savannahs are characterised by a group of grasses dominated by *Trachypogonspicatus* (L.F.) Kuntze and shrubs of the Annonaceae family (Mpassi, 2016). Brazzaville is watered from north to south by variousrivers: the Djiri, the Tsiémé, the Mikalou, the Mfoa, the Madoukoutsékélé, the Djoué and the Mfilou (Makany, 1976).

METHODS

Study sites and choice of trees to besampled: The city of Brazzaville has nine (9) arrondissements. Each arrondissement constitutes a site and is divided 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. For this study, a sample of 30 fruit trees per species, of all varieties, was monitored in each district. This number is sufficient to constitute a representative sample for the study and to limit individual variability (Grouzis, 1991; Brustel, 2018). Each tree was selected at random, according to its physical condition, health, physiognomy, height and the greenness of its foliage (Brustel, 2018).

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). The time interval between two successive observations is one (1) month for these two species. Phenological monitoring was carried out on a monthly basis at all sites for two years (2019 and 2020) and focused on vegetative phenology. The phenophases selected were defoliation and leafing. These phenophases were monitored at tree level. This makes it possible to estimate their evolution (Persello, 2018). In order to characterise the evolution of the phenophases, leaf fall or yellowing and leaf renewal or budburst were noted at each passage (Sabatier and Puig, 1986). The rate of each phenophase was determined by the following formula:

$$P\ (\%) = \frac{n \times 100}{N}$$

Where P = phenophaserate; n = number of trees in the phase in question; N = total number of trees on the site. Once the monitoring results had been obtained, the start of the phenological phases was compared with the climatic and environmental data. This made it possible to identify the factors linked to the phenological cycle of the species studied (Yahi, 2021).

RESULTS

Phenology of the fruit treesstudied: *Phenology of Dacryodesedulis (G. Don) H. J. Lam. in 2019.* Figure 1 shows the development of leaf removal of *Dacryodesedulis* (G. Don) H. J. Lam. over the course of 2019 at all the sites. Analysis of this figure shows that this species drops leave sir regularly from March (rainy period) to August (dry period), in some sites at low rates (06, 66% to 25%) and the peak of 40% of this phenophaseis observed in June (dry period). In September (dry period), leaf fall diminished and then disappeared. Between November and December (rainy period), it reappeared early at two different sites.

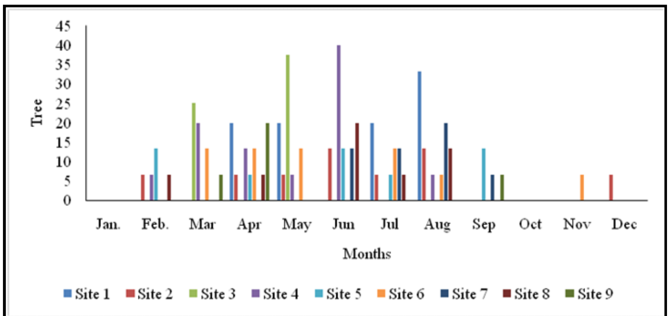

Figure 1. Evolution of defoliation of *Dacryodesedulis* (G. Don) H. J. Lam., in 2019

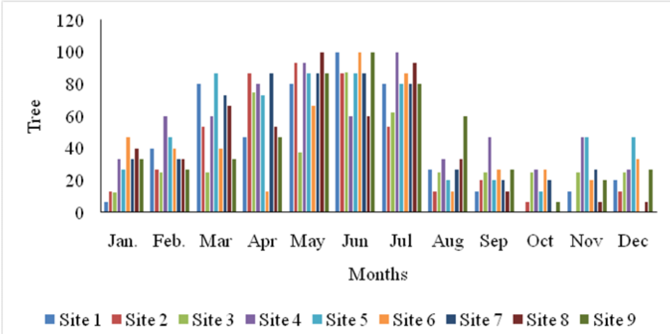

Figure 2. Evolution of foliation of *Dacryodesedulis* (G. Don) H. J. Lam., in 2019

Figure 2 shows the foliage development of *Dacryodesedulis* (G. Don) H.J. Lam. in 2019 at the sites studied. Observation of this figure shows that leafing starts in January (dry period) at all sites at low rates. From March (rainy period) to July (dry period), this phenophase gradually spreads to a large number of plants and then becomes wide spread across the sites. The peak was between May (rainy period) and July (dry period), when 100% of plants were counted. Between August (dry period) and December (rainy period), foliage declines considerably, with rates varying between 06.66% and 46.66%. Leafing seems to be influenced by the season, as it is more abundant in the rainy season.

Vegetative phenology of Dacryodesedulis (G. Don) H.J. Lam. in 2020

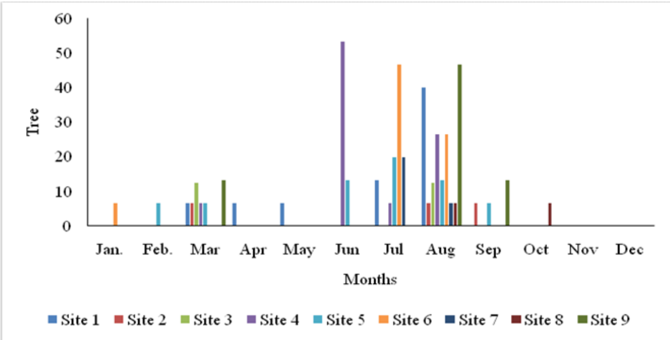

Figure 3. Evolution of defoliation of *Dacryodesedulis*(G. Don) H. J. Lam., in 2020

Figure 4 shows the foliage development of *Dacryodesedulis* (G. Don) H.J. Lam. in 2020. Analysis of this figure shows that leafing begins in January and then progresses gradually until July 2020. It reaches a plateau between April and June at rates of up to 100%. Between August and December 2020, the percentage of trees in leaf decreases from 06.66% to 46.66%. This figure shows that this phenophaseis more abundant during the rainy season. There is therefore a seasonal effect on the foliage of Dacryodesedulis (G. Don) H.J. Lam.

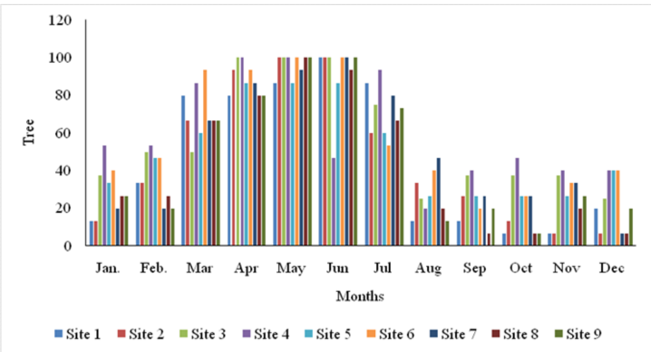

Figure 4. Evolution of foliation of *Dacryodesedulis* (G. Don) H. J. Lam., in 2020

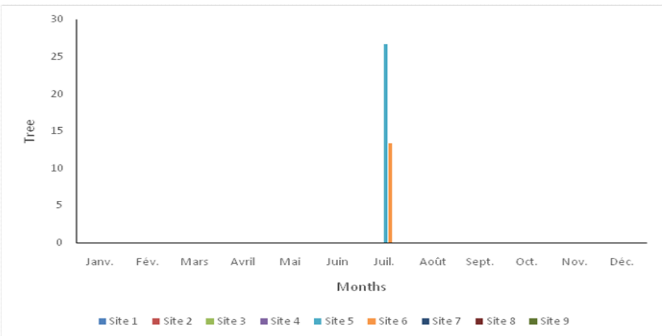

Figure 5. Evolution of defoliation of *Elaeis guineensis* Jacq., in 2019

Phenology of Elaeis guineensis Jacq. in 2019: Figure 5 shows the development of leaf shedding in *Elaeis guineensis* Jacq. in 2019.Observation of this figure shows that this phenophaseonlyoccurs in July at two sites at low rates, ranging from 13.33% to 26.66% of plants recorded. Figure 6 shows the leafing trend in *Elaeis guineensis* Jacq. in 2019. Analysis of this figure shows that leafing in *Elaeis guineensis* Jacq. Occurs regularly throughout the year at all the sites, at variable frequencies and continuously.

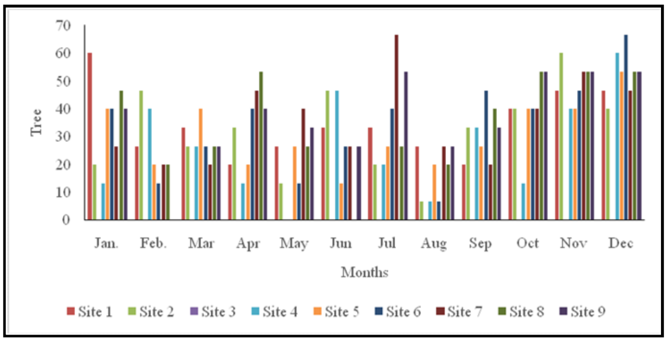

Figure 6. Evolution of foliation of *Elaeis guineensis* Jacq., in 2019

Vegetative phenology of Elaeis guineensis Jacq. in 2020: Figure 7 shows the development of leaf shedding in *Elaeis guineensis* Jacq. in 2020. Examination of this figure shows that this phenophase occursir regularly at the sites and is only observed in July. However, a few signs of defoliation were observed in May at two sites, and at very low rates. These results show that, in 2020, the dry season appears to be the most favourable period for defoliation in Elaeis guineensis Jacq.

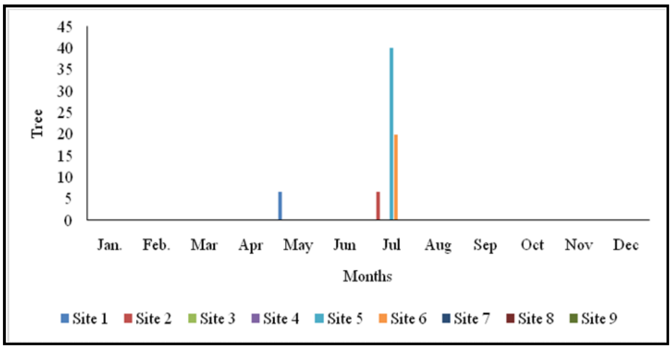

Figure 7. Evolution of defoliation of *Elaeis guineensis* Jacq., in 2020

Figure 8 shows the foliage development of *Elaeis guineensis* Jacq. in 2020. Examination of this figure shows that leafing occurs continuously throughout the year. It is observed at all the sites with varying frequencies.

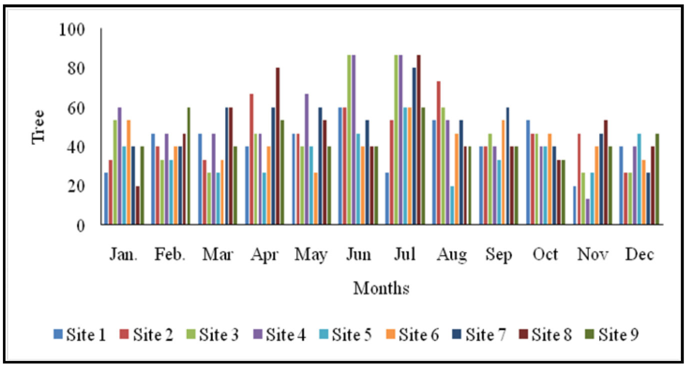

Figure 8. Evolution of foliation of *Elaeis guineensis* Jacq., in2020

DISCUSSION

Phenological evolution of the two species studied

The results of the present study show that in *Dacryodesedulis* (G. Don) H. J. Lam. And *Elaeis guineensis* Jacq., defoliation occursir regularly across sites, peaking in most cases during the dry season. There is therefore a clear seasonal effect on the leaf-out of trees of these two species in Brazzaville. Full leaf-out occurred at all sites between June and July, peaking in June at 53.33% for *Dacryodesedulis* (G. Don) H. J. Lam, and after July, there was a considerable drop in defoliation until December. In *Elaeis guineensis* Jacq. on the other hand, full leaf-out was not observed until July, after which phenophase was no longer observed. De-leafing is nothing other than the phenomenon of abscission, marked by the fall of leaves due to the rupture of the petiole or the yellowing of the leaves, which become deciduous. For these perennial plants with evergreen leaves, it also represents an adaptation to the bad season, the renewal of the photosynthetic apparatus and the elimination of waste (Heller *et al.*, 2000). *Dacryodesedulis* (G. Don) H. J. Lam., gradually takes hold in the sites from January onwards. It begins to become wide spread in the sites from March onwards, peaking between May and July at a rate of 100% of total numbers during the rainy season. After that, leafing decreases considerably until December. So there is a seasonal effect on foliage. In *Elaeis guineensis* Jacq. foliage is annual. However, it appears to be more important in June and July, with a maximum of 80% of plants recorded in 2020. Leafingis a time when meristem activity is very intense and is marked by phenomena of cell division that establish the tissues of future organs (Coste, 1988). These phenomenatake place rhythmically and result in the architecture of the tree. Edelin (1984) indicates that during this period of organogenesis, the meristemputs in place a set of organs in an outline state, constituting the morphogenesis unit and the growth unit corresponding to a portion of the axis which develops during a given elongation phase.

In *Dacryodesedulis* (G. Don) H. J. Lam., vegetative growth begins in January and lasts until July, with full growth visible from March to July. In *Elaeis guineensis* Jacq, on the other hand, this grow this not fully distinguish able, especially with defoliation, because of the long lifespan of the leaf, which is estimated at four (4) years (Jacquemard *et al.,* 2011). These results can also be explained by the fact that the owners of the trees sampled regularly maintain these *Elaeis guineensis* Jacq. stands by stripping the leaf petioles, and the foliage of these trees is always green. By observing the periods of foliage formation in *Dacryodesedulis* (G. Don) H. J. Lam., we can see that this species grows most during the rainy season, when rainfall and temperature are high. This is when mineral elements are mobilised, particularlynitrogen, which is more active, a factor that promotes plant growth. For example, Kuster et al. (2017) report that a warm, wet season favours vegetative growth, and then an increase in temperature leads to the increasing mobilisation of nutrients, particularly nitrogen from organic matter. Nitrogenis more mobile than phosphorus, potassium and calcium. Nitrogen is the most important element in arboriculture, as it is involved in vegetative growth and development. Heller *et al.* (2000) state that a dietrich in nitrogen favours vegetative development to the detriment of the reproductive system, in which case the C/N ratio is low.

During this growth, the branches or stems grow from the apical or lateral buds before the vegetative rest. This grow this not synchronous throughout the plant or from one tree to another. This rhythmic and gradual nature means that the new foliage can be installed through the sequential budburst of the new leafy axes by the meristems, there by modifying the tree's architecture (Sandrine, 2009). Kéngué (1990) reports that the growth of the safoutier or Dacryodesedulis (G. Don) H. J. Lam. isrhythmic, occurring in successive waves during which organs such as leaves, buds and internodes are formed. A wave of growth lasts about two months and is dividedinto five stages: bud break (ten days), internode elongation (8 days), leaf growth (10 days), leaf maturation (10 days) and vegetative rest (21 days). Kengué (2002) also points out that on the same safoutier tree, twigs in a well-defined area of the crown can have a totally different phonological behavior from another area. One area maybe in full vegetative growth, while another is completely dormant. In some cases, part of the crown is in flower or fruit, while the rest is either resting or in vegetative growth. This is known as erraticism. Erraticism means asynchronism, which isobserved at canopy level and marked by the existence of two or three phenophases on the branches or foliage. This is what marks the asynchronous character of perennial species in tropical regions where the growth and development of the branch are independent of the rest of the tree and increases the phenomena of production heterogeneity on the scale of the tree (Sarron, 2019). This asynchronous process occurs simultaneously throughout the rainy season, which is marked by high temperatures and heavy rainfall. Tree leafing rates at this time of years ome times exceed 80% at most sites. Later on, this rate gradually decreases with the arrival of the dry season, marked by a reduction in rainfall, leading to water stress, which is at the origin of the reproductive period and its intensification.

Phenological variability: During the observations made at the sites, it was found that the rate of phenophase (defoliation or foliage) in the tree canopy varies from one site to another and, within the same site, from one tree to another and then from one species to another. For example, in Dacryodesedulis (G. Don) H. J. Lam., defoliation occurs in full in June and July, whereas in Dacryodesedulis (G. Don) H. J. Lam. Defoliation occurs in July. J. Lam., while the same phenophase occurs irregularly in July in Elaeis guineensis Jacq. Variation can also be observed between 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 plant growth and development (Sarron, 2019). This leads to asynchrony and phenological alternation (Dambreville, 2012). Asynchronismoccurs not only at inter-tree level but also at intra-tree level, particularly at the level of the main branch and the secondary branch. Guira (1997) states that in phonological variability, all the different phenophases do not appear regularly, either within a single tree or within a single stand. In terms of their phonological characteristics, the species studied belong to the category of species with discontinuous and irregular growth. Their growth and development take place without a fixed periodicity. In addition, Dacryodesedulis (G. Don) H. J. Lam. Leafing in Dacryodesedulis (G. Don) H. J. Lam. Reaches its peak in the rainy season (from March to May), where as leaf fall peaks in the dry season (June, July and August). There is therefore a noticeable seasonal effect on leaf shedding and leaf set in Dacryodesedulis (G. Don) H. J. Lam. According to Núñez-Eliséa *et al.* (1996), vegetative phenology depends on warm temperatures (25°C or more) and high rainfall. It is also stimulated by a vegetative promoter (VP) synthesised in the leaves of young shoots, which inhibits flowering (Nuñez-Elisea and Davenport, 1995). This VP promoter is potentially a gibberellin and seems to decrease with the age of the shoots. Flowering will then be affected by this promoteruntil the growth units and leaves are mature and no longer produce this VP promoter (Davenport, 2007).

CONCLUSION

This study has shownthat the leaf-out and leaf-in rates of *Dacryodesedulis* (G. Don) H. J. Lam. J. Lam. and *Elaeis guineensis* Jacq. are generally higher during the rainy season in Brazzaville. Rain fall therefore seems to be the climatic parameter that influences the vegetative phenology of these two species during the two years of observations. De-leafing and leafing are variable 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 in the course of a year. The results of this study could serve as a basis for further work on vegetative phenology and contribute to decision-making on the sustainable management of fruit trees in Brazzaville.

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