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RESEARCH ARTICLE

PHENOLOGY OF *MYRIANTHUS ARBOREUS* (P. BEAUV) IN FIVE LOCALITIES OF CÔTE D'IVOIRE

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ABSTRACT

Myrianthus arboreus is an indigenous African species of socio-economic importance, widely distributed in the South Sudanese part of Côte d'Ivoire. A good knowledge of its phenology could contribute to its conservation and sustainable management in the context of climate change. The objective of this study was to analyze some phenophases of *Myrianthus arboreus* from the localities of Abengourou, Adzopé, Daloa, Diabo and Zouan Hounien in order to consider its possible domestication. For better knowledge of flowering and fruiting leading to fruit maturation, 150 individuals aged at least 5 years were observed during 2018 and 2019. The results revealed that individuals from Diabo and Abengourou flowers from January to February. Those of Daloa, Adzopé and Zouan Hounien flower from January to March. The flowering percentage of male individuals ranges from 53 to 90 %, and that of females is 100 %. The maturation of the male inflorescence of individuals from Abengourou and Diabo lasts 15 ± 2 days while in Adzopé, Daloa and Zouan Hounien lasts 19 ± 2 days. Fruit setting lasts 85 ± 4 days in individuals from Adzopé, Daloa and Zouan Hounien while it lasts 54 ± 4 days in those from Abengourou and Diabo. In individuals from Adzopé and Zouan Hounien, fruiting lasts 170 ± 9 days while it varies between 112 and 142 ± 9 days in those from Abengourou, Daloa and Diabo. Fruit ripening lasts 86 ± 5 days in individuals from Abengourou, Adzopé and Zouan Hounien, on the other hand, it lasts 57 ± 4 days in those from Daloa and Diabo. These data provide an overview of the period, duration of flowering and fruiting of *Myrianthus arboreus*, for any hybridization tests.

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INTRODUCTION

Myrianthus arboreus is a multi-use species of great socio-economic importance in West, East and Central Africa (Amata, 2010; Olonode et al., 2015; Manfo, 2018). It constitutes a substantial source of food and income for populations during the lean season (Agbeke, 2014; Ehilé et al., 2019). This plant produces leaves, fruits and seeds used in food, pharmacopoeia and crafts (Memvanga et al., 2015; Manfo, 2018; Katou et al., 2018). According to (Ehilé et al., 2019), young leaves of *M. arboreus* represent 11 % of spontaneous leafy vegetables consumed. The fruits, seeds and roots have therapeutic properties (Orwa et al., 2009; Apema et al., 2011; Omotayo & Borokini, 2012). The wood of *M. arboreus* is also used for making fences, making gourds and spatulas (Manfo, 2018). Apart from the occasional sale of fruits, the young leaves of this plant remain the main organ that interests consumers (N'dri et al., 2008). *M. arboreus* is a plant with high nutritional, medicinal and economic value. Nutritionally, young leaves and fruits are rich in amino acids, iron, mineral salts, proteins, water and phosphorus (Okafor, 2004; Kouamé et al., 2015). Medicinally, this plant is used to treat many diseases such as hypertension (Apema et al., 2011a), diabetes (Apema et al., 2011b), diarrhea (Okafor et al., 2004), malaria (Kipré et al., 2017), anemia (Amata, 2010) and malnutrition (Zoro et al., 2014). The particularity of this plant is that all its organs have very recognized (Tijani et al., 2022) and remarkable medicinal virtues.

On the economic level, young leaves are the subject of financial transactions on the markets (Kouamé & Gnahoua, 2008). Indeed, a bunch of leaves is sold at 50 F or 2300 FCFA per kilogram (Akaffou et al., 2019). Low seed germination and cutting rates are coupled with anthropogenic activities linked to the population explosion and the overexploitation of young leaves for food and commercial purposes. In addition to anthropogenic activity, climate change today constitutes an additional constraint and a significant threat to the sustainability of this plant in Africa and particularly in Côte d'Ivoire (FAO, 2017; Akaffou et al., 2018; 2019). Studies have been carried out at the biochemical and medicinal level (Omotayo & Borokini, 2012; Zoro et al., 2014) and also in the context of the regeneration of this species (Akaffou et al., 2018; 2019). However, very few studies have been carried out on the aspect of the reproductive biology of *M. arboreus* mainly at the phenology level. According to (Avaligbé et al., 2021), to promote plant genetic resources and implement the reforestation policy, it would be useful to make reliable data available to decision-makers which can guide conservation and valorization strategies for spontaneous plants, for example *M. arboreus*. The attention paid to *M. arboreus* is justified by the fact that efforts to promote the species have been underway in recent years in the country. We note the agromorphological characterization, the optimization of agromorphological parameters by cuttings and the influence of the sowing method on the appearance and survival rate of the cuttings after budding. This study intends to answer two main questions. What

are the percentage and flowering period as well as the duration of maturation of the inflorescence of male individuals of *M. arboreus* in Côte d'Ivoire? What are the percentage and period of flowering, duration of fruit setting, fruiting and maturation of the fruit of female individuals of *M. arboreus* in Côte d'Ivoire?

The general objective of this study is to analyze some phenophases of *Myrianthus arboreus* from the localities of Abengourou, Adzopé, Daloa, Diabo and Zouan Hounien. Specifically, this involves: (i) determining the percentage and period of flowering as well as the duration of maturation of the inflorescence of male individuals of the species and (ii) evaluating the percentage and period of flowering, the durations of fruit setting, fruiting and maturation of the fruit of female individuals.

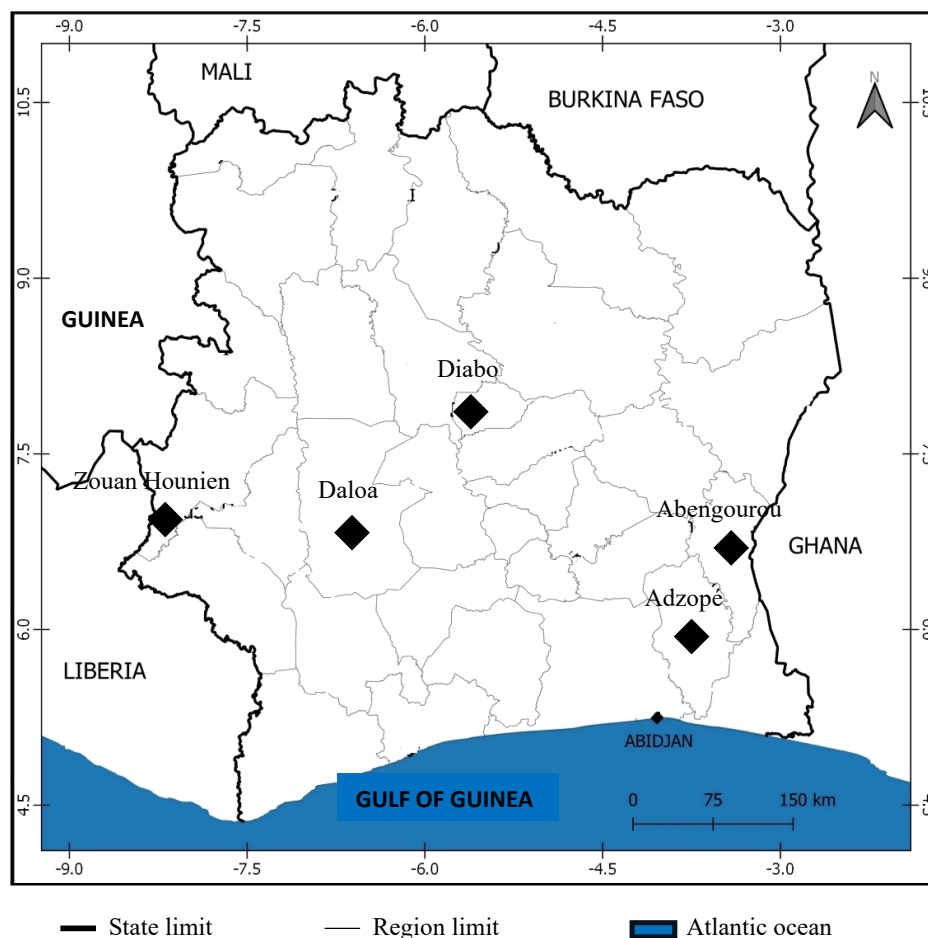
MATERIAL AND METHODS

Collection areas and plant material: Data collection was carried out in Côte d'Ivoire in five very distinct localities (Abengourou, Adzopé, Daloa, Diabo and Zouan Hounien) covering different climatic zones (Figure 1). The vegetation of these localities, consisting largely of forest, has disappeared in favor of fallow land and orchards. Rainfall varies between 1000 and 2200 mm of water per year with an average monthly temperature of 27 °C. Average humidity varies between 71 and 84 %. The soil is generally of the ferrallitic type (Aka, 2010). These localities have distinct characteristics in terms of climate and soil (Table I). In total, 150 randomly selected individuals aged at least 5 years, including 30 per locality, were observed. These individuals chosen in the same locality are at least 200 m apart from each other and have already produced fruit at least once before the start of phenological monitoring.

Conduct study: The study was carried out from January 2018 to December 2019. This study was carried out over two years in order to confirm the trend of the plant's phenophases. Thus, phenological monitoring was carried out during these two years taking into account the conditions suggested by (Frankie *et al.*, 1974) according to which: 1) a relatively undisturbed station, sheltered from pressures likely to lead to a modification of the population structure; 2) a large number of people, able to represent the population considered in order to establish variations within the populations of the species and 3) phenological monitoring over several years in order to establish the periodicity of the different phases. The parameters determined focused on female and male individuals. On female individuals, the parameters determined concerned the percentage and period of flowering, the duration of fruit setting, fruiting and maturation of the fruit. On male individuals, these parameters concerned the percentage and period of flowering as well as the duration of maturation of the inflorescence.

Flowering period and percentage of male and female individuals: According to (Maalouf *et al.*, 2011), the flowering period of a species corresponds to the period during which more than 50 % of the individuals in the population flower. An individual has flowered when more than 50 % of its flower buds open. The flowering percentage expresses the proportion of flowering individuals out of all the individuals evaluated.

Duration of maturation of male inflorescence: The duration of maturation of the male inflorescence corresponds to the time which elapses between the immature inflorescence and the mature inflorescence. Individuals chosen by locality were regularly monitored at three-day intervals. Ropes were used to mark the branches carrying the inflorescences and then observed over time.



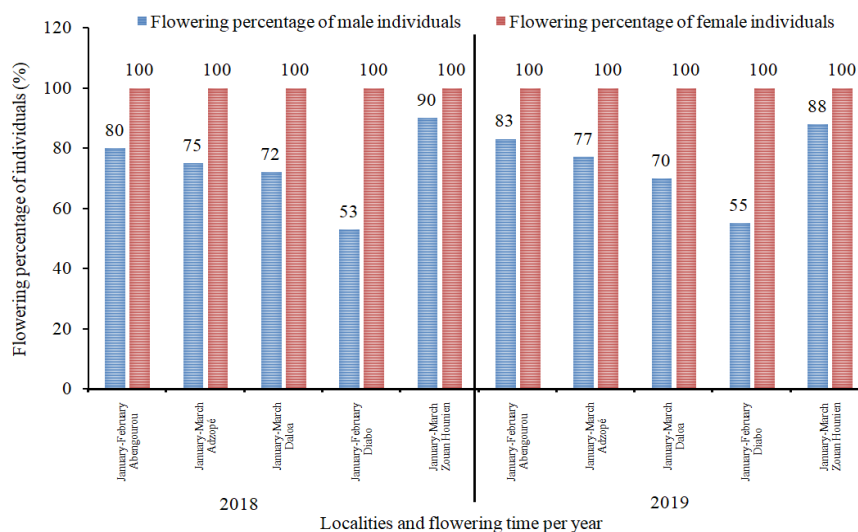
Abengourou (6°49'47" North ; 3°29'47" West) ; Adzopé (6°06'25" North ; 3°51'36" West) ; Daloa (6°54'28" North ; 6°26'25" West) ; Diabo (7°47'00" North ; 5°11'00" West) and Zouan Hounien (6°55'00" North ; 8°13'00" West) (Yao *et al.*, 2012).

Figure 1. Collection areas

Table I. Characteristics of collection areas (Soro, 2011; SODEXAM, 1991 to 2020)

Collection sites	Contact details	Climate	Vegetation	Tav (°C)	Rav (mm/an)	Hav (%)	Soil type
Abengourou	6°43'47''N ; 3°29'47''W	Tropical wet and dry	Cocoa tree orchard	27.4	1000-1900	82	Ferralitic soil
Adzopé	6°06'25''N ; 3°51'36''W	Humid subequatorial	Fallow	26.7	1200-2200	84	Ferralitic soil
Daloa	6°54'28''N ; 6°26'25''W	Tropical wet and dry	Sacred Forest	26.2	1100-2000	76.83	Ferralitic soil
Diabo	7°47'00''N ; 5°11'00''W	Tropical humid savannah	Cashew orchard	27	1000-1900	71.83	Ferruginous soil
Zouan Hounien	6°55'00''N ; 8°13'00''W	Tropical wet and dry	Cocoa tree orchard	25.9	1600-2000	77.75	Ferralitic soil

Tav : average temperature ; Rav : average rainfall ; Hav : average relative humidity

Figure 2. Fruit setting of *Myrianthus arboreus*Figure 3. Period and percentage of flowering of male and female individuals of *Myrianthus arboreus* depending on the collection area

Duration of fruit setting, fruiting and fruit maturation of female individuals: The duration of fruit set indicates the time that elapses between the fertilized flower and its transformation into immature fruit (Figure 2). Fruiting time is the time between the fertilized flower and its transformation into mature fruit. The duration of fruit ripening corresponds to the time that elapses between the immature fruit and its transformation into mature fruit. Individuals chosen by locality were regularly monitored at three-day intervals. Ropes were used to mark the branches carrying the inflorescences and then observed over time.

Statistical analysis of data: The different parameters determined were subjected to an analysis of variance (ANOVA) with one classification criterion.

The source of variation was the collection area. The Smallest Significant Difference (PPDS) test at the 5 % threshold made it possible to compare the averages of the different collection zones. All statistical analyzes were carried out using Statistica version 7.1 software (StatSoft, 2005).

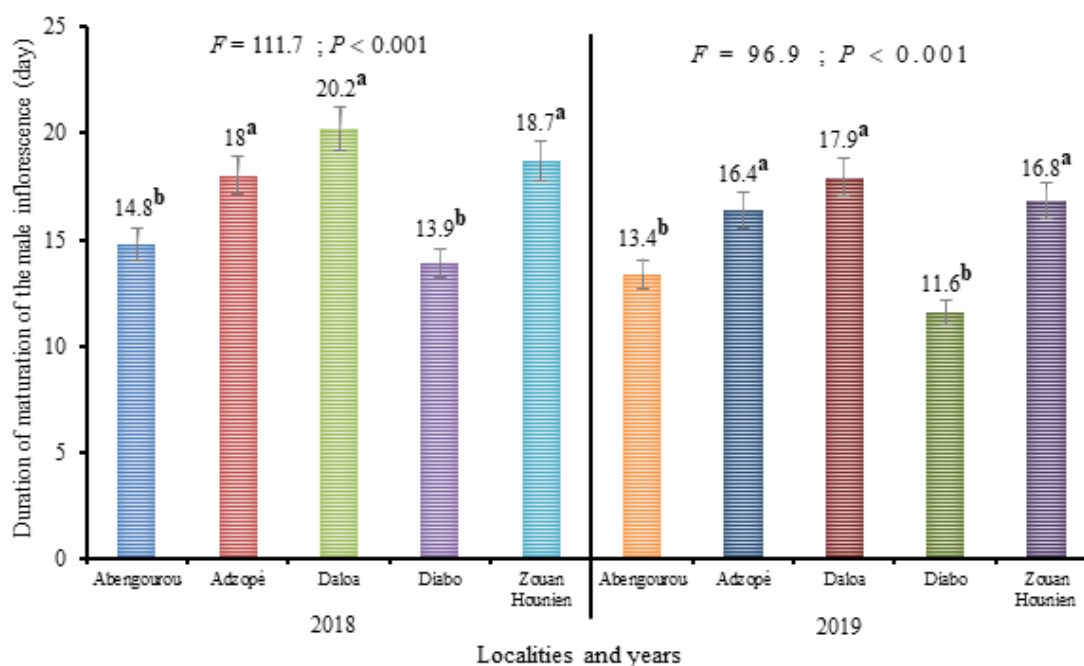
RESULTS

Flowering period and percentage of *M. arboreus*: The production of male and female flowers occurs simultaneously in *M. arboreus*. The results revealed that, in male *M. arboreus* individuals, flowering time and percentage varied depending on the ecological zone (Figure 3). Diabo and Abengourou individuals flower from

January to February (early flowering). Those of Daloa, Adzopé and Zouan Hounien flower from January to March (late flowering). The flowering percentage of male individuals varies from 53 % to 90 % and that of females is 100 %.

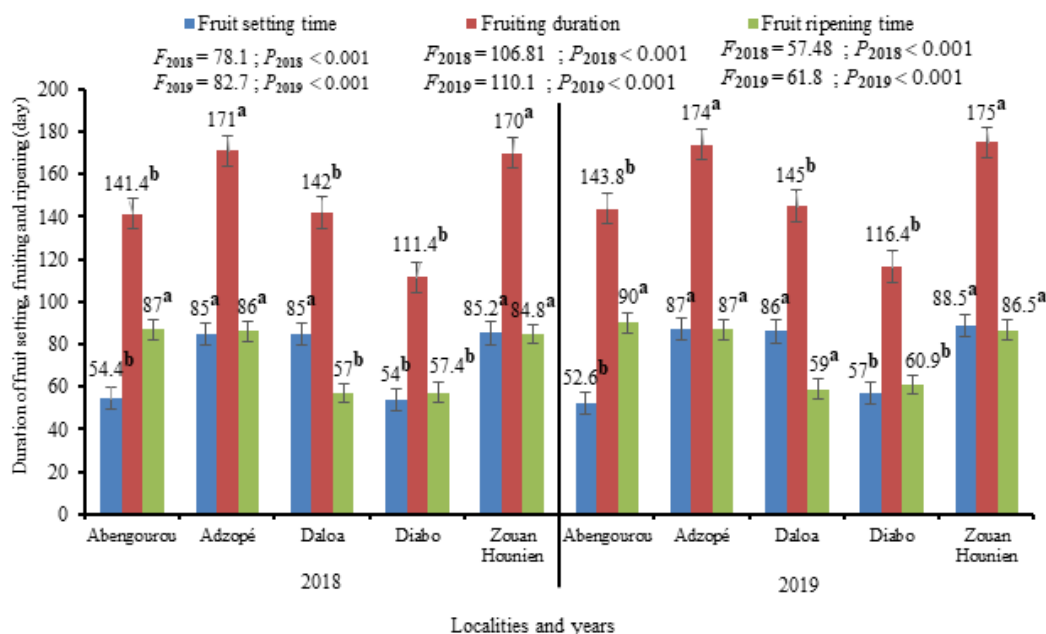
Maturation time of male inflorescence of *M. arboreus*: The duration of maturation of the male inflorescence varies depending on the locality. Indeed, the maturation of the male inflorescence is early in the individuals from Abengourou and Diabo and lasts 15 ± 2 days while it is late in those from Adzopé, Daloa and Zouan Hounien and lasts 19 ± 2 days (Figure 4).

Duration of fruit setting, fruiting and maturation of *M. arboreus*: The results revealed that the durations of fruit setting, fruiting and maturation of female *M. arboreus* individuals vary depending on the area (Figure 5). Indeed, fruit setting lasts 85 ± 4 days in individuals from Adzopé, Daloa and Zouan Hounien (late fruit setting) while it lasts 54 ± 4 days in those from Abengourou and Diabo (early fruit setting). In individuals from Adzopé and Zouan Hounien, fruiting lasts 170 ± 9 days (late fruiting) while it varies between 112 and 142 ± 9 days in those from Abengourou, Daloa and Diabo (early fruiting).



F : value of the statistic associated with the Fisher test ; p : probability value associated with the Fisher test.
Means indexed by the same letter are statistically identical following the test for the smallest significant difference at the 5 % probability level.

Figure 4. Maturation time of male inflorescence of *Myrianthus arboreus* depending on the collection area



F : value of the statistic associated with the Fisher test ; p : probability value associated with the Fisher test.

Figure 5. Duration of fruit setting, fruit maturation and fruiting of *Myrianthus arboreus* depending on the survey area

Individuals from Abengourou, Adzopé and Zouan Hounien have fruit maturation lasting 86 ± 5 days (late ripening), however, it lasts 57 ± 4 days in those from Daloa and Diabo (early ripening).

DISCUSSION

Flowering time and fruiting duration of *M. arboreus*: In all localities, flowering of *M. arboreus* individuals begins in January and extends over two to three months (January to March). This result would be due to the dry season which would influence the flowering of individuals. This observation is observed in the majority of species existing in tropical Africa such as *Xylopia parviflora*, *Voacanga africana*, *Dacryodes edulis* (Eyog *et al.*, 2006). Indeed, the work of (Akaffou, 2013) on the coffee tree in Côte d'Ivoire showed that the period of induction of flower buds on plants corresponds to the dry season. However, our results contrast with those of (Arbonnier, 2009) and (Dao, 2012). Indeed, these authors revealed that the flowering of *Piliostigma reticulatum* begins in July after the start of the rainy season in the Sudano-Sahelian zone and not in the dry season. Furthermore, flowering is late in some localities and early in others. According to (Okafor, 2004), the genotypic variability of plants could have different genes and would be responsible for this difference in flowering. Environmental variability would also influence the flowering of these plants (Eyog *et al.*, 2006). According to (Linden, 2019), in flowering plants, variation in photoperiod is the environmental signal with the most widespread influence on flowering time. The photoperiod determining flowering time could be the basis of *M. arboreus* flowering. This is how the results of the work of (Nelson *et al.*, 2010) showed that plants respond depending on day length. (Hoong-Ye & Yeang, 2013) also revealed that plants could be classified according to photoperiod, namely long-day flowering plants whose light period is greater than a threshold and short-day flowering plants, whose day length is less than this threshold. According to (Iboukoun *et al.*, 2021), in general, not all plants enter the same phenological phases (flowering and fruiting) at the same time. Several plants including *Ziziphus lotus* (L.) Lam. in Tunisia (Zouaoui *et al.*, 2014) and *Acacia tortillis* sub sp. *raddiana* (Savi) Brenan in Senegal (Diallo *et al.*, 2016) have similar phenological variations. The variability of phenophases between zones would be linked to the conquest of the plant's environment, to the availability of water in the soil and to altitude (Mahamane *et al.*, 2007 ; Jaouadi *et al.*, 2012 ; Zouaoui *et al.*, 2014). In short, these variations in the phenophases of the species could be linked to local environmental conditions (Wolkovich *et al.*, 2014).

Ripening time of *M. arboreus*: In *M. arboreus*, fruit ripening varies between zones and takes two to three months. The genotypic variability of individuals coupled with their environment would justify these results because (Hecketsweiler, 1992) and (Harris, 1996) proved that the fruits of the species *Irvingia gabonensis* from Gabon take four months to ripen while the fruits of that of Cameroon take six months. These results were confirmed by the work of (Guira, 1989) on shea which showed that the ripening of shea fruits is staggered and occurs between the months of June and August.

CONCLUSION

The present study highlights some phenophases such as flowering and fruiting leading to the maturation of the fruits of individuals of *Myrianthus arboreus* from the localities of Abengourou, Adzopé, Daloa, Diabo and Zouan Hounien. In the male of *Myrianthus arboreus*, the maturation of inflorescence of the individuals can be late or early. Whether male or female, flowering of individuals can be late or early. In females, fruit setting, fruiting and maturation of the fruit of individuals can be late or early. These results provide a clear overview of the flowering and fruiting periods of this plant which is essential in the implementation of the crossing strategy and even an important step for its domestication. Taking these results into account in development policies would help to guarantee the conservation and

sustainable use of *Myrianthus arboreus* in Côte d'Ivoire. Given the socio-economic importance of the species, agronomic and forestry research institutions should implement good cultural practices and promote new vegetative propagation techniques such as grafting, layering and cuttings.

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