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Phenological Study of Some Tree Species at Different Ages in Aswan, Egypt

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Abstract: ***Phenological studies for eight tree species, i.e. Azadirachta indica, Chrysophyllum oliviforme, Dalbergia sissoo, Inga edulis, Khaya senegalensis, Spathodea campanulata, Syzygium cuminii and Tamarindus indica grown at different ages during 2013/2014 and 2014/2015 years were conducted. These trees grown in Kom-Ombo, Tropical Farm, about 45 kilometers northern Aswan). In this study, 24 trees for each age (less than 10 and more than 25 years old) from these species were monitored at three different periods of each month of the year. Leaf initiation for the deciduous tree species began in late January, continued up to mid March, however leaf initiation for the sapling species was shortly before those of mature trees. Flowering continued in different woody species throughout the year. However, flower- initiation started from late January to late May for the mature trees, while it was from late January to mid May for sapling tree species. Among the studied woody species, sapling trees showed shortly prior flower activity compared to those of mature in the two studied years. However, in comparison to fruiting activity, woody species at the mature stage exhibited late fruiting activity than that of sapling one. In the tested species, sapling trees exhibited more germination percentage than for matures one.***

Keywords: Phenological studies, Leaf initiation, flower-initiation, woody species, mature trees

1. Introduction

Phenology is the study of relationship between climatic factors and periodic phenomena in organisms. Pattern of phenological events are variously used for characterization of vegetation type (Opler *et al.*, 1980). The study of plant phenology provides knowledge about the pattern of plant growth and development as well as the effects of environment and selective pressures on flowering and fruiting behavior (Zhang *et al.*, 2006). However, Singh and Kushwaha (2005a) suggested that climate change forced deviations in the length of growing period, and competition among species may change the resource use patterns in different species. Karmer (1997) concludes that differences in tree species phenological responses to temperature changes can have long-term consequences on their geographic distribution. He further suggests that phenology and climate relationship can also reveal the potential impacts of future climate changes. The initiation of growth in plants and changes in phenology are governed by various environmental factors and the influence of temperature and moisture has been studied by several workers (Dewald and Steiner, 1986). However, in temperate regions, where plant growth and development are mainly determined by temperature, some effects are already apparent. For example, especially strong temperature increases during winter and spring are causing phenophases such as first leaf and first bloom to start sooner in many temperate tree and shrub species (Cayan *et al*., 2001). Thus, spring phenology shows considerable promise as an indicator of the impact of global warming on the temperate biosphere (Badeck *et al.*, 2004).

Several workers were studied the phenological differences between life stages of tree species. For *Acer saccharum* and *Fagus grandifolia*, leaf expansion was earlier and leaf senescence was later for saplings than for conspecific canopy trees (Gill *et al.*, 1998). For *Acer mono*, leaf emergence was earlier in younger trees, whereas leaf senescence did not differ among trees of different ages (Seiwa, 1999a). For *Ulmus davidiana*, leaf emergence was earlier and leaf fall later in seedlings than in adults (Seiwa, 1999b). In each of these studies, differences in phenology resulted in greater leaf longevity for juveniles than for adults. Moreover, Augspurger and Bartlett (2003) stated that among life stages of *Gymnocladus dioicus*, saplings had the earliest bud break but prolonged expansion duration and thus the latest leaf expansion. These saplings also had the earliest senescence and shorter senescence duration, and thus shorter leaf longevity than other stages. Therefore, leaf phenology differed broadly both between life stages and within the juvenile life stage in this community.

An understanding of the phenological patterns in different geographical regions and of factors underlying these patterns is important and assist conservation scientists in predicting consequences of perturbations such as atypical climatic events or global warming (Tutin and Fernandez, 1993). On the other hand, the optimal time for flowering and fruiting is determined by biotic and abiotic (Petanidou *et al.*, 1995) factors, and a combination or interaction of both kinds of factors related to seed dispersal (Oliveira, 1998) and seed germination (Burtt, 1970). Recently, Khamis (2013) studied the phenological variations of three urban forest trees grown in Aswan and Alexandria and indicated that high temperature resulted in leaves completion beginning 3-5 weeks earlier and defoliation delayed 13-25 weeks later, as noticed in Aswan for the three genera. Also, max. and min. temperature and day length were well correlated with leaves flushing of both *Albizia lebbeck* and *Delonix regia* in Alexandria as well as, for *Cassia javanica* in Aswan.

Many previous studies were conducted on the phenology of the different tree species. Bangarwa and Singh (1994) on *Dalbergia sissoo* noticed that tree is leafless in December-January and flowering is influenced by temperature; it takes 7-

8 months from bud initiation to fully ripened pods. However, Falcao and Clement (2000) pointed out that study of the phenology of the *Inga edulis* species may help to plan fruit commercialization and plantation management. In their observations made in Amazonas, Brazil the majority flowering periods of plants were during March and May, followed by fruiting periods in April and June. Meanwhile, Swenson *et al*. (2008) on *Chrysophyllum oliviforme* recorded that the leaves are evergreen so they are present year round; these trees flower all year round in some places, such as Florida, and in other places they only flower between July and October, producing matured fruit in February. On the other hand, Rangaiah *et al.* (2004) on *Spathodea campanulata* revealed that it is an evergreen tree species. It blooms and fruits during the dry season. The fruit is a capsule and dehisces naturally when mature, releasing small, light and winged seeds into the ambient air. Seed dispersal takes place effectively by wind during dry season. *Azadirachta indica* A. Juss, neem in recent times has emerged as a tree of choice for afforestation projects and for meeting the fuel and timber needs under developed countries (Prasad, 1983).

Chrysophyllum oliviforme L. belongs to family Sapotaceae. It contributes to the aesthetics of the forests where it grows, helps protect the soil, and furnishes food and cover for wildlife. The wood, which has a specific gravity of 0.9, is hard, heavy, and strong. It is used for construction in Cuba (Little and Wadsworth, 1964). *Dalbergia sissoo* (Roxb.) belongs to family Fabaceae and recognized as an important multipurpose tree species. Its timber is used for making cabinets, veneers, bent wood articles like furniture, superior quality felloes for wheels, in gun carriage, in ordnance factories etc. *Inga edulis* Mart. is a tree legume in the family Fabaceae, native to tropical America, and widely used for its fruits, wood, shade, and more recently, as an agroforestry component. *Khaya senegalensis* (Desr.) A. Juss. is the most common species in the mahogany family (Meliaceae) in Egypt particularly in the South. It produced a valuable wood for carpentry, joinery, furniture, cabinet work, ship building and decorative veneer. It is suitable for construction, flooring, interior trim, vehicle bodies, railway sleepers and pulpwood (Arbonnier, 2004).

Spathodea campanulata Beauv, belongs to family Bignoniaceae and known as African tulip-tree or Indian cedar (locally known as Espatodea in Guamuhaya) was introduced for ornamental purposes due to its attractive scarlet flowers. *Syzygium cuminii* L., belongs to family Myrtaceae. It is a fast-growing tree, which provides excellent firewood and charcoal. Wood is durable in water, resistant to termites and used for construction, boat building and furniture (FAO, 1982). *Tamarindus indica* L. belongs to family Fabaceae, is an important woody perennial tree species that is found throughout the tropics for its beauty as an ornamental, adaptability to variable climatic and edaphic conditions and fruit production (El-Siddig *et al*., 1999). Tamarind timber consists of hard, dark red heartwood and softer yellowish sapwood. So, the present study was carried out over a two-year period (2013/2014 - 2014/2015) to evaluate the phenology for the previous tree species, growing in Kom-Ombo, Aswan, southern Egypt at different ages to understand the differences in leaf, flower, seed germination and fruit phenology exist between saplings and conspecific mature trees, based on observations of the seasons.

2. Materials and Methods

Study Site

Phenological observations of 48 trees represent the two ages; less than 10 and more than 25 years from the eight species (3 trees for each species) have been carried out on the Tropical Farm of Kom-Ombo; 45 km Northern Aswan city. The present paper is aimed at the results of monitoring phenological phenomena of these trees in 2013/2014 and 2014/2015 seasons. Aswan is city of Upper Egypt (N 24°05' E 32°53'); it is a very dry and sunny place with no rain whatsoever, making it one of the driest places on earth.

Phenological Observations

The species composition of trees of less than 10-years (saplings) and more than 25- years old for the same species (mature trees), their Famillies and habits are shown in Table (1) as follows: *Azadirachta indica* A.Juss, *Chrysophyllum oliviforme* L., *Dalbergia sissoo* Roxb., *Inga edulis* Mart., *Khaya senegalensis* Desr., *Spathodea campanulata* Beauv, *Syzygium cuminii* L.and *Tamarindus indica* L. Phenological observations were made at three different periods of each month of the year for both the saplings and mature trees of the studied species on the leaf- initiation, leaf-full initiation and leaf- fall initiation (only for the deciduous species) as well as flower- initiation, flower-full initiation, flower end, fruit-initiation, fruit-mature, fruit- dehiscence and fruit drop (for all species) from January 2013 to January 2015. However, for the phenological phases three different periods of each month were taken: first, mid and late. For example, the period from 1st April to 10th April (first April); April 11th to 20th April (Mid April) and 21st April to 30th April (late April). However, in each tree species, three trees from sapling and mature one were selected for observation. Behavioral patterns of plant species for developed of leaves were described following Kikim and Yadava (2001).

Flowering was considered to be the occurrence of open flowers. The occurrence of fruit-initiation was considered to be between flower disappearance and fruit appearance. Fruit was considered to be mature when fully developed green fruits displayed a change of color and/or texture between successive observations. In those plant species without apparent change in mature fruit, the full development of seeds was examined. Data recorded during the 2-yr period was pooled for the leaf production, flowering and fruiting and then the monthly presence of each phonological phase was established for each plant species. In addition, the mean date (week of the year) of the phenological observations for the studied trees was calculated as indicator of the length of growing season.

Germination Study

Seeds were collected from all species for germination studies. Three replicate seeds of each species for both sapling and mature trees were planted in petri dishes (10 cm in diameter). Number of germinated seeds, counted every 4 days till

germination became constant for each plant and seed germination percentage was calculated; then the range and average of germination percentages were recorded.

3. Results

Leaf Phenology

Leaf initiation for the deciduous tree species i.e *Azadirachta indica, Dalbergia sissoo, Inga edulis* and *Tamarindus indica* started in late January, continued up to mid March as indicated in Table (2). Evergreen species (*Chrysophyllum oliviforme, Khaya senegalensis, Spathodea campanulata* and *Syzygium cuminii*) exchange their leaves at different periods throughout the year. However, leaf initiation for the sapling species was shortly before those of mature trees. In the deciduous tree species, the observations indicated that these species started to complete leaf development by mid. February and late March for mature trees while, from first February to mid. March for saplings. Among the studied woody species, saplings showed shortly prior leaf-flushing activity compared to those of mature trees in the two years. On the other hand, the onset of leaf fall initiation is different in various woody species; leaf-fall initiation for the mature tree species was from late November to late January, while it was from first December to late January for the saplings.

Flowering Activity

Flowering continued in different woody species throughout the year (Table 3). However, flower- initiation started from late January to late May for the mature trees, while it was from late January to mid May for sapling tree species during 2013/2014 and 2014/2015 seasons. One peak period of flowering was distinguished in the month of March when *Azadirachta indica, Dalbergia sissoo, Khaya senegalensis, Spathodea campanulata* and *Syzygium cuminii* exhibited flower initiation in response to the mature trees. The flower initiation in *Tamarindus indica* was delayed and begins in the late May and mid. May for the mature and sapling trees, respectively during the two studied years. Regarding to flower full initiation, woody species started from mid February to mid June for mature trees and from first February to late May for the saplings of the same trees during both seasons. Among the studied woody species, sapling trees showed shortly prior flower activity compared to those of mature in the two studied seasons. On the other hand, *Dalbergia sissoo* species end their flowering early at the month of April period, occasionally with a long extension into the month of September (*Tamarindus indica*). Also, sapling tree species end their flowering stage shortly before that of mature trees in most cases during both seasons.

Fruiting Activity

The initiation period of fruits was February -June for the sapling and mature tree species. However, in comparison to fruiting activity, woody species at the mature stage exhibited late fruiting activity than that of sapling one (Table 4). Among the deciduous and evergreen woody species, sapling trees showed shortly prior fruit maturation compared to those of mature trees in the two studied seasons. In the studied species, only *I. edulis, K. senegalensis* and *S. campanulata* their fruit dehiscence is completed between late April- first July period. On the other hand, some species i.e. *D. sissoo, I. edulis, S. campanulata* and *T. indica* have a lengthy period of fruit retention or not dropped, while the other tree species were dropped their fruits from mid June to mid July.

Mean date (week of the year) of the phenological observations:

All species displayed phenological differences between the mean date (week of the year) but differed in the extent to which they displayed differences in initiation or completion of phenological events (Tables 5 and 6). Generally, saplings (less than 10 years) tended to have earlier in the leaf, flower and fruit observations than mature individuals (more than 25 years). Among life stages of most studied species**,** its saplings trees completed leaf, flower and fruit characteristics earlier than mature trees by means of about 1 to 2 weeks. For *Khaya senegalensis*, dates of flower initiation and full initiation as well as fruit parameters were earlier for sapling individuals than for mature ones by about 2-3 weeks while, they end their flower in the first season at the same date.

Germination behavior:

The range and average of germination percentages of the sapling and mature for the tested species were shown in Table (7). The most increasing of germination percentages occurred with sapling trees compared to that of mature ones for all species. In this respect, the highest value was obtained in *Khaya senegalensis*, followed by *Syzygium cuminii*. Conversely, the lowest value of germination percentage was recorded from *Spathodea campanulata*

4. Discussion

In this phenological study, all species displayed differences between life stages in some aspect of their leaf, flower fruit phenology as well as germination percentage. Species varied in which phenological event differed and whether spring or autumnal phenology differed more. Most importantly, leaf, flower and fruit events were earlier for sapling trees than for mature trees. Similarly, Seiwa (1999*a*, 1999*b*); Augspurger and Bartlett (2003) found that seedlings of two temperate deciduous species had greater leaf longevity than conspecific adults. In contrast, Lei and Lechowicz (1990) found that *Acer saccharum* juveniles are more similar to conspecific adults in their leaf physiology and morphology than to congeneric understory species. Previous studies of deciduous tree species have demonstrated that juveniles gain a substantial amount of annual carbon (Gill *et al.*, 1998) and growth (Seiwa, 1998) prior to leaf emergence of mature species. Harrington *et al.* (1989) found that early leaf emergence was more important than late senescence for carbon gain in four shrubs in a deciduous forest. However, low temperatures in both early spring and late fall limited photosynthetic rates.

The tropical dry deciduous forest exhibited considerable diversity in leaf initiation, leaf fall, flowering and fruiting activity. In our study, leaf initiation peak for the deciduous trees in February, may be attributed to hot months of the year

in the spring of Aswan. This may be attributed to the triggering effect of the rising temperature (Yadav and Yadav, 2008) and increase in length of photoperiod's .Borchert and Rivera (2001) also suggested that in dry summer season, the vegetative buds of spring flushing stem succulent species are in a state of endo-induced dormancy induced and terminated by declining and increasing photoperiod, respectively. The role of photoperiod has been confirmed by Rivera *et al.* (2002) who reported that spring flushing in tropical semi-deciduous trees is induced by an increase in photoperiod of 30 minutes or less. In the present study, leaf-initiation in most species was regulated by length of photoperiod.

The leaf fall was concentrated in cool and dry winter months i.e. from late November to late January. Prasad and Hegde (1986); Augspurger and Bartlett (2003) observed a similar pattern of leaf-fall in tropical deciduous forests in the South India. The results are also in conformity with Singh and Singh (1992) who reported that initiation of leaf fall coincides with the onset of the post-monsoon low temperature dry period and can be a mechanism maintaining turgidity of shoots. However, Borchert *et al.* (2002) suggested that in Argentina leaf shedding of several species is probably caused by a combination of increasing leaf age and declining photoperiod rather than increasing drought. As majority of species produced flowers during leaf-less phase, which favours wind pollination as well as floral display to attract pollinators (Singh and Singh, 1992). Flowering and leaf flushing seems to be related to moisture, temperature and day length, which is in conformity with observations made by other workers (Murali and Sukumar, 1994). Wright (1991) suggested that changes in moisture availability may affect other physical factors, such as nitrogen mineralization, and the possibility that seasonal flushes of phosphorus from decaying litter synchronize with plant activity cannot be discounted. The studied woody trees produced flowers shortly after leaf fall in January in response to increased moisture content of leafless branches either from the water stored in stem or obtained from the water table. Borchert (1994) also suggested that the stored water buffers the impact of seasonal drought and enables flowering and flushing during the dry season.

The fruiting activity was completely absent from November to January except for *Dalbergia sissoo* indicating that it continues for 9 months during the annual cycle which is in conformity with the observations made in the dry tropical forest of Varanasi (Singh and Singh, 1992). In several species initiation of fruit ripening begins in post-monsoon period and continues up to the end of cool and dry winter period that may be due to the difference in fruit maturation activity of different species as reported for sub-tropical forests in north-eastern India (Kikim and Yadava, 2001). Thus fruit dehiscence of tree species coincides with the onset of monsoon to allow optimal germination (Singh and Kushwaha, 2006).

Table 1: The selected plant species investigated for phenological behaviours during 2013/2014 and 2014/2015 in Aswan, Egypt

No.	Taxa for selected plants	Families	Habit
1	*Azadirachta indica* A.Juss	Meliaceae	Tree
2	*Chrysophyllum oliviforme* L.	Sapotaceae	Tree
3	*Dalbergia sissoo* Roxb.	Fabaceae	Tree
4	*Inga edulis* Mart.	Fabaceae	Tree
5	*Khaya senegalensis* Desr.	Meliaceae	Tree
6	*Spathodea campanulata* Beauv.	Bignoniaceae	Shrub
7	*Syzygium cuminii* L.	Myrtaceae	Tree
8	*Tamarindus indica* L.	Fabaceae	Tree

Table 2: Leaf-initiation, leaf-full initiation and leaf-fall initiation in both saplings and mature deciduous tree species grown in Aswan during 2013/2014 and 2014/2015 seasons.

Tree species	2013/2014					
	Mature trees (more than 25 years old)			Saplings (less than 10 years old)		
	Leaf- initiation	Leaf-full initiation	Leaf- fall initiation	Leaf- initiation	Leaf-full initiation	Leaf- fall initiation
Azadirachta indica	Late Feb	Mid Mar	First Jan	Mid Feb	First Mar	First Jan
Dalbergia sissoo	Late Feb	Mid Mar	Late Jan	Mid Feb	Late Feb	Late Jan
Inga edulis	Mid. Feb	Late Feb	First Dec	First Feb	Mid Feb	Mid Dec
Tamarindus indica	First Feb	Mid Feb	First Dec	Late Jan	First Feb	Mid Dec
Tree species	2014/2015					
	Mature trees (more than 25 years old)			Saplings (less than 10 years old)		
	Leaf- initiation	Leaf-full initiation	Leaf- fall initiation	Leaf- initiation	Leaf-full initiation	Leaf- fall initiation
Azadirachta indica	Mid Mar	Late Mar	Mid Jan	First Mar	Mid Mar	Late Jan
Dalbergia sissoo	First Mar	Mid Mar	Late Jan	Late Feb	First Mar	First Jan
Inga edulis	Mid Feb	First Mar	Late Nov	First Feb	Mid Feb	First Dec
Tamarindus indica	Mid Feb	Late Feb	First Dec	Late Jan	First Feb	First Dec

Table 3: Flower-initiation, flower-full initiation and flower end in both saplings and mature tree species grown in Aswan during 2013/2014 and 2014/2015 seasons.

Tree species	2013/2014					
	Mature trees (more than 25 years old)			Saplings (less than 10 years old)		
	Flower - initiation	Flower -full initiation	Flower-end	Flower - initiation	Flower -full initiation	Flower-end
Azadirachta indica	Late Mar	First Apr	Mid May	Mid Mar	First Apr	First May
Chrysophyllum oliviforme	Late Jan	Mid Feb	Late Apr	Late Jan	First Feb	Mid Apr
Dalbergia sissoo	Mid Mar	First Apr	Late Apr	Mid Feb	Late Feb	First Apr
Inga edulis	Mid Feb	First Mar	Mid May	Mid Feb	Late Feb	Late Apr
Khaya senegalensis	First Mar	Mid Mar	First Jul	Mid Feb	Late Feb	First Jul
Spathodea campanulata	Mid Mar	Late Mar	Mid Jun	First Mar	Mid Mar	Mid Jun
Syzygium cuminii	Mid Mar	Mid Apr	Mid May	Mid Mar	First Apr	Late Apr
Tamarindus indica	Late May	Mid Jun	Mid Sep	Mid May	Late May	Late Sep
Tree species	2014/2015					
	Mature trees (more than 25 years old)			Saplings (less than 10 years old)		
	Flower - initiation	Flower -full initiation	Flower end	Flower - initiation	Flower -full initiation	Flower end
Azadirachta indica	Late Mar	First Apr	Late May	Mid Mar	Late Mar	Mid May
Chrysophyllum oliviforme	Mid Feb	First Mar	First May	First Feb	Mid Feb	Late Apr
Dalbergia sissoo	Mid Mar	Late Mar	Mid Apr	First Mar	Mid Mar	First Apr
Inga edulis	First Mar	Mid Mar	First May	Mid Feb	Mid Feb	First May
Khaya senegalensis	Mid Mar	Mid Mar	First Aug	Mid Feb	Late Feb	Mid Jul
Spathodea campanulata	Mid Mar	Late Mar	Late Jun	Late Feb	First Mar	Mid Jun
Syzygium cuminii	Mid Mar	First Apr	First May	First Mar	Late Mar	Late Apr
Tamarindus indica	Late May	Mid Jun	Late Sep	Mid May	Late May	Mid Sep

Table 4: Fruit-initiation, fruit-mature, fruit-dehiscence and fruit drop in both saplings and mature tree species grown in Aswan during 2013/2014 and 2014/2015 seasons.

Tree species	2013/2014							
	Mature trees (more than 25 years old)				Saplings (less than 10 years old)			
	Fruit - initiation	Fruit-mature	Fruit-dehiscence	Fruit-drop	Fruit - initiation	Fruit-mature	Fruit-dehiscence	Fruit drop
Azadirachta indica	Mid Apr	Mid Jun	-----	First Jul	Late Mar	First Jun	-----	Mid Jun
Chrysophyllum oliviforme	Mid Feb	First Jul	-----	Mid Jul	First Feb	Late Jun	-----	First Jul
Dalbergia sissoo	First Apr	First Dec	------	-----	Late Feb	Late Nov	------	-----
Inga edulis	First Mar	First May	Late May	-----	Late Feb	Late Apr	Late Apr	-----
Khaya senegalensis	Mid Mar	Late Jun	First Jul	Mid Jul	Late Feb	First Jun	Mid Jun	Mid Jun
Spathodea campanulata	First Apr	Late Jun	First Jul	-----	Mid Mar	Mid Jun	Late Jun	-----
Syzygium cuminii	Late Apr	Mid Jun	----	Late Jun	First Apr	Mid Jun	----	Mid Jun
Tamarindus indica	Mid Jun	Mid Feb	----	----	Late May	Mid Feb	----	----
Tree species	2014/2015							
	Mature trees (more than 25 years old)				Saplings (less than 10 years old)			
	Fruit -	Fruit-	Fruit-	Fruit-	Fruit -	Fruit-	Fruit-	Fruit-

	initiation	mature	dehiscence	drop	initiation	mature	dehiscence	drop
Azadirachta indica	First Apr	Late Jun	----	First Jul	Mid Mar	Mid Jun	----	Late Jun
Chrysophyllum oliviforme	First Mar	First Jul	-----	Mid Jul	Mid Feb	Late Jun	----	First Jul
Dalbergia sissoo	Late Mar	First Dec	-----	----	Mid Mar	Late Nov	----	------
Inga edulis	Mid Mar	First May	Mid May	----	Mid Feb	Late Apr	First May	------
Khaya senegalensis	Mid Mar	Late Jun	First Jul	Mid Jul	Late Feb	Late Jun	First Jul	First Jul
Spathodea campanulata	Late Mar	First Jul	First Jul	-----	First Mar	Late Jun	First Jul	-----
Syzygium cuminii	First Apr	Late Jun	------	First Jul	Mid Mar	Mid Jun	-----	Mid Jun
Tamarindus indica	Mid Jun	Mid Feb	-----	-----	Late May	Mid Feb	-----	----

Table 5: Mean date (week of the year) of the phenological observations for mature and saplings trees grown in Aswan during 2013/2014 season.

Mature trees(more than 25 years old)								
Phonological event/species	***Az. indica***	***Chr. oliviforme***	***D. sissoo***	***Inga edulis***	***Kh. senegalensis***	***Sp. campanulata***	***Sy. cuminii***	***T. indica***
Leaf- initiation	9	----	9	7	-----	----	-----	6
Leaf-full initiation	11	----	11	9	-----	-----	----	8
Leaf- fall initiation	2	-----	5	49	----	-----	-----	49
Flower - initiation	13	5	11	7	10	11	12	22
Flower -full initiation	15	8	14	10	11	13	16	24
Flower- end	20	17	17	20	27	24	20	40
Fruit - initiation	16	7	14	10	11	14	17	24
Fruit- mature	25	28	49	18	25	26	25	8
Fruit- dehiscence	-----	----	------	22	27	27	----	-----
Fruit- drop	27	29	-------	-----	29	-----	26	-----
Saplings(less than 10 years old)								
Phonological event/ Species	***Az. indica***	***Chr. oliviforme***	***D. sissoo***	***Inga edulis***	***Kh. senegalensis***	***Sp. campanulata***	***Sy. cuminii***	***T. indica***
Leaf- initiation	8	-----	7	6	------	-----	-----	5
Leaf-full initiation	10	------	8	7	-----	-----	-----	6
Leaf- fall initiation	1	-----	5	50	------	-----	-----	51
Flower - initiation	12	5	8	7	7	10	11	20
Flower -full initiation	14	6	9	9	9	11	14	22
Flower end	19	16	14	17	27	24	18	39
Fruit - initiation	13	6	9	9	9	11	14	22
Fruit- mature	24	26	48	17	23	24	24	7
Fruit- dehiscence	-------	----	-----	17	24	26	------	----
Fruit- drop	25	27	-----	------	24	-----	25	-----

Table 6: Mean date (week of the year) of the phenological observations for mature and saplings trees grown in Aswan during 2014/2015 season.

Mature trees (more than 25 years old)								
Phonological event/ Species	*Az. indica*	*Chr. oliviforme*	*D. sissoo*	*Inga edulis*	*Kh. senegalensis*	*Sp. campanulata*	*Sy. cuminii*	*T. indica*
Leaf- initiation	11	-----	10	7	-----	-----	-----	7
Leaf-full initiation	13	-----	12	10	-----	-----	-----	9
Leaf- fall initiation	3	-----	5	48	-----	-----	-----	49
Flower - initiation	13	8	11	10	11	11	12	22
Flower -full initiation	14	10	13	11	11	13	15	24
Flower-end	21	19	16	18	32	26	19	39
Fruit - initiation	14	10	13	11	11	13	15	24
Fruit- mature	26	28	49	18	26	27	26	7
Fruit- dehiscence	-----	----	-------	20	27	28	-----	----
Fruit-drop	27	29	------	-----	28	-----	27	-----
Saplings(less than 10 years old)								
Phonological event/ Species	*Az. indica*	*Chr. oliviforme*	*D. sissoo*	*Inga edulis*	*Kh. senegalensis*	*Sp. campanulata*	*Sy. cuminii*	*T. indica*
Leaf- initiation	10	----	9	6	-----	------	-----	5
Leaf-full initiation	11	-----	10	7	-----	-----	-----	6

Leaf- fall initiation	4	-----	5	49	-----	-----	-----	50
Flower - initiation	11	6	10	7	7	9	10	20
Flower -full initiation	13	7	11	7	9	10	13	21
Flower-end	20	17	15	18	28	24	17	38
Fruit - initiation	12	7	11	7	9	10	12	22
Fruit- mature	25	26	48	17	26	26	24	7
Fruit- dehiscence	-----	----	-----	19	27	27	-----	-----
Fruit-drop	26	27	-----	-----	28	-----	25	-----

Table 7: Range and average of germination percentages for saplings and mature tree species during 2014/2015 season in Aswan

Tree species	*Germination % for saplings*		*Germination % for mature trees*	
	Range	*Average*	*Range*	*Average*
Azadirachta indica	51.23- 63.17	54.27	38.47- 56.23	40.25
Chrysophyllum oliviforme	55.47- 70.35	60.55	51. 33- 66.17	56.23
Dalbergia sissoo	85.55- 93.36	90.23	81.32- 88.33	85.23
Inga edulis	51.34- 71.33	65.17	36.55- 65.15	55.18
Khaya senegalensis	95.45- 100	98.14	94.23- 99.11	96.17
Spathodea campanulata	33.17- 51.27	45.33	24.18- 45.47	40.56
Syzygium cuminii	96.47- 100	99.15	85.33- 97.23	94.17
Tamarindus indica	65.33- 81.17	71.33	45.45- 74.55	65.45

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