



Growth and Development of Leaf and Stalk at Various Growth Stages of Palmyrah Palm (*Borassus flabellifer* L.)

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Studies were conducted at Agricultural College and Research Institute, Killikulam, Tamil Nadu Agricultural University on the growth pattern of leaf and stalk in different stages of growth viz; seedling, juvenile, early juvenile and adult (male and female) and observation on rate of growth of leaf and stalk, time taken for completing the active growth of leaf & stalk and time taken for successive production of leaf in the five selected palms in each of the above four categories. The results showed that the rate of growth of leaf was maximum in adult female followed by adult male and was the least in the seedling stage. It was also observed that there was an increase in the rate of growth of leaf as the stage of growth of palm was advanced. Further, it was also noticed that the arresting of leaf growth in all stages of palm coincided with the initiation of stalk at leaf base. There was a gradual and steady reduction noticed in the mean number of days taken to complete the active growth of leaf as the advancement of growth stages of the palms, showing that adult stages of the palm was found to be active compared to the subsequent stages of growth. Similarly, a gradual reduction in the mean number of days taken for successive leaf production was noticed, as the growth stage of the palms advanced. The rate of growth of stalk was found to be faster and maximum in seedling stage followed by early juvenile, juvenile and adult stages. The rate of growth of stalk showed a linear and increasing trend coinciding with the developmental stages of the palm. The mean number of days required for completing the active growth of stalk during various stages showed a reverse trend to that of active leaf growth, since, the early stages of palms took less number of days to complete the active growth of stalk compared to the later or advanced stages. Both early juvenile and seedling stages were found to be active compared to the subsequent stages of growth.

Key words: Seedling, juvenile, early juvenile, adult, rate of leaf growth, active growth stage

Among the four sugar yielding palms viz., *Borassus flabellifer* (palmyrah), *Phoenix syvestris* (date) *Caryota urens* (sago) and *Cocos nucifera* (coconut), palmyrah palm ranks first in yielding sugar as well as other edible and non edible produces. Palmyrah being a remunerative tree crop of dry lands, is extensively grown from time immemorial all over India, especially in the coastal as well as in dry / sandy areas of Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, Madhya Pradesh, Chattisgarh, Orissa and Rajasthan (Chattopadhyay and Bose. 2006). The potentiality of this tree crop has been rightly felt, which is evident from the fact that innumerable products (both edible and non edible) are prepared from this poor man's palm. To be more precise, almost every part of the tree is commercially valued and the importance of palmyrah in Tamil Nadu can be understood from the designation assigned to this crop as 'State Tree' of Tamil Nadu from 1978 onwards.

Among the various products of palmyrah, the sweet sap or neera collected from the inflorescence is a major source of income from this tree and it replaces cane sugar in palmyrah growing tracts of Tamil Nadu, as a sweetening agent. The endosperm of immature seed nuts from young fruit, a delicacy during summer like that of tender coconut. Besides the tasty yellow fibres (mesocarp) of ripened fruit, a number of value added products can also be prepared from the matured fruits. One can have an edible sweet spongy haustorium (spent endosperm) and apocolon (tuber), on germination of the seed nuts from ripened fruits.

Palmyrah is also a source of fibre. Three types of fibres from petiole, from leaf base and from leaves are obtained. Mesocarp of the fruit also yields fibre. Several palmyrah fibre based industries are functioning in Tamil Nadu, Andhra Pradesh and West Bengal. Varieties of fancy and utility articles are also made from palm leaves, veins and roots. Palm leaves have been used to write scripts from time

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immemorial. Matured leaves are cured and used for thatching.

A tree with such a great significance and multi varied utility, has so far been given less research focus or attention by the scientific community and not much efforts have been taken especially to gather some basic and fundamental information viz; growth and development of leaf, stalk, root / apocolon, fruit, floral biology etc. For promoting the commercial exploitation of palmyrah palm, research needs are greatly required but only after understanding the nature of this tree through some basic studies such as growth and development etc., other managerial research strategies for future can be well formulated. One such area is on the growth and development of leaves and stalk and hence, the present study was undertaken with the due recognition for leaves and stalk, which form the basic raw material for many products

Materials and Methods

The palmyrah germplasm collection maintained under AICRP-Palms, Killikulam centre were utilized for recording the growth pattern of leaf and stalk in different growth stages. The trees with the following four stages of primary growth were selected for the study

Stage of growth	Year of planting of germplasm	Age of tree
Seedling stage	2006	1 year
Early juvenile stage	1997	10 years
Juvenile stage	1995	12 years
Adult stage (male & female)	1986	20-22 years

There were 10-12 palms in each of the first three categories of varying age group and out of these, 5 palms were randomly selected for conducting experiment on rate of growth of leaf and stalk in seedling, juvenile and early juvenile stages of palm. Growth of leaf right from leaf initiation to full opening was recorded at weekly basis in the five selected palms in each of the above three categories. The rate of growth of stalk was also recorded as and when it appeared at the leaf base. In the case of adult palm, two palms each in male and female with age group of 20-22 years were utilized for recording the same set of observation as done for above three growth stages. Observations on rate of leaf growth, days taken for completing active leaf growth, rate of successive production of leaf, rate of stalk growth and time taken for completing active stalk growth were recorded.

Results and Discussion

Rate of growth of leaf in seedling, early juvenile, juvenile and adult (Male and Female) stages of palmyrah palm

The measurement of length of leaf during the period from August to December at weekly intervals

was recorded right from initiation to cessation of growth and the data were used for calculating the rate of growth of leaf (cm/day) in seedling, early juvenile, juvenile and adult stages and the results are presented below.

The rate of growth of leaf (cm/day) in seedling stage was calculated for the period from August 2007 to December 2007 and the data are presented in Table 1. The rate of growth of leaf in seedling stage was prominent from first week of August up to fourth week of December. The mean rate of growth of leaf

Table 1. Rate of linear growth of leaf (cm / day) in seedlings stage at weekly intervals in palmyrah palm

Stage	Aug., 2007	Sep., 2007	Oct., 2007	Nov., 2007	Dec., 2007
Stage 1	0.40	0.23	0.23	0.15	0.06
Stage 2	0.67	0.40	0.35	0.44	0.06
Stage 3	0.92	0.43	0.33	0.27	0.05
Stage 4	0.33	0.48	0.41	0.16	0.06
Mean	0.58	0.39	0.33	0.26	0.06
SEd	0.08	0.08	0.10	0.11	0.02
CD (0.05)	0.17	0.18	0.23	0.25	0.04

Observation recorded at weekly basis

was highest (0.58 cm/day) during the month of August followed by September (0.39 cm/day). The minimum mean rate of growth was recorded during the month of December (0.06 cm/day). However, the rate of growth of leaf was found to be significant during the month of August only. The rate of growth of leaf (cm/day) in early juvenile stage was maximum (0.92 cm/day) during stage 4 of September, while, it was minimum (0.19 cm/day) during stage 1 of October and the mean rate of growth pooled over stages ranged from 0.10 cm / day (October) to 0.68 cm / day (September) (Table 2).

Table 2. Rate of linear growth of leaf (cm / day) in early juvenile stage at weekly interval in palmyrah palm

Stage	Aug., 2007	Sep., 2007	Oct., 2007
Stage 1	0.55	0.43	0.19
Stage 2	0.57	0.67	0.23
Stage 3	0.38	0.68	0.00
Stage 4	0.56	0.92	0.00
Mean	0.51	0.68	0.10
SEd	0.12	0.12	0.17
CD (0.05)	0.27	0.26	0.37

Observation recorded at weekly basis

During juvenile stage, the rate of growth of leaf (cm/day) was almost equal and steady during both the months of observation and the mean was 0.72 and 0.70 cm /day during August and September respectively (Table 3). The mean rate of growth of leaf was the maximum (2.02 cm/day) during August

Table 3. Rate of linear growth of leaf (cm / day) in juvenile stage at weekly interval in palmyrah palm

Stage	August, 2007	September, 2007
Stage 1	0.58	1.05
Stage 2	0.71	1.01
Stage 3	0.64	0.88
Stage 4	0.94	0.55
Stage 5	-	0.00
Mean	0.72	0.70
SEd	0.19	0.27

Observation recorded at weekly basis

and during September it was 1.26 cm/day in adult male (Table 4). During both the months of observation a highly significant rate of growth of leaf

Table 4. Rate of linear growth of leaf (cm / day) in adult (Male palm) at weekly interval in palmyrah palm

Stage	August, 2007	September, 2007
Stage 1	1.84	3.31
Stage 2	1.79	0.96
Stage 3	0.89	0.79
Stage 4	2.97	0.00
Stage 5	2.59	-
Mean	2.02	1.26
SEd	0.21	0.32
CD (0.05)	0.46	0.71

Observation recorded at weekly basis

was observed. The rate of linear growth of leaf (cm/day) in adult female palm was calculated during the active growth period and the results are presented in Table.5. The rate of growth of leaf (cm/day) in

Table 5. Rate of linear growth of leaf (cm / day) in adult (Female palm) at weekly interval in palmyrah palm

Stage	August, 2007	September, 2007
Stage 1	1.77	2.45
Stage 2	1.31	1.35
Stage 3	1.40	1.80
Stage 4	2.40	2.09
Mean	1.72	1.92
SEd	0.40	0.42
CD (0.05)	0.88	0.93

Observation recorded at weekly basis

adult stage of female palm was more or less equal during both the months of observation and the mean rate of growth of leaf in adult female palm recorded during the month of September and August was 1.92 and 1.72 cm /day respectively.

The abstract of rate linear of growth of leaf (cm/day) recorded during seedling; early juvenile, juvenile and adult stages pooled over different months are presented in Table 6. From the data collected in

Table 6. Rate of growth of leaf in various stages (cm / day) in palmyrah palm

Month	Stage				
	Seedling	Early Juvenile	Juvenile	Adult Male	Adult Female
	Leaf (cm/day)	Leaf (cm/day)	Leaf (cm/day)	Leaf (cm/day)	Leaf (cm/day)
August, 2007	0.58	0.51	0.72	2.02	1.72
September, 2007	0.39	0.68	0.70	1.26	1.92
October, 2007	0.33	0.10	-	-	-
November, 2007	0.26	-	-	-	-
December, 2007	0.06	-	-	-	-
January, 2008	-	-	-	-	-
February, 2008	-	-	-	-	-
March, 2008	-	-	-	-	-
Mean	0.32	0.43	0.71	1.64	1.82

various stages of growth, it is evident that the rate of growth of leaf was maximum in adult female (1.82 cm/day) followed by adult male (1.64 cm/day) and was the least in the seedling stage (0.32 cm/day). It was also observed that there was an increase in the rate of growth of leaf as the stage of growth of palm was advanced. In general, the rate of growth of leaf gradually increased as the advancement of period of growth irrespective of various stages of growth. Further, it was also noticed that the arresting of leaf growth in all stages of palm coincided with the initiation of stalk at leaf base. This finding is in accordance with the report of Ramadasan and Jacob Mathew (1987) who opined that in coconut, the length of a leaf depended on age of the palm, and the leaves of seedlings had lesser rate of linear growth than those of healthy mature palms. Satyabalan (1993) also found that the seedlings produced comparatively lesser number of leaves in the early stages and the periodicity of leaf production became steady in adult stage. Patel (1938) also reported that the number of leaves present on the crowns of coconut trees at any one time varied according to the age of the palm and the rate of production was found fast as the tree grew in age.

Number of days to taken to complete active growth of leaf

The abstract of rate of growth of leaf (cm/day) recorded during seedling, early juvenile, juvenile and adult stages and the number of days taken, to complete active growth of leaf are presented in Table.7. The results showed that among the different stages, adult male took the minimum number of days (63 days) to complete the active period of growth, followed by juvenile (70 days).

There was gradual and steady reduction noticed in the mean number of days taken to complete the active growth of leaf as the advancement of growth stages of the palms, showing that adult stages of the palm was found to be active compared to the subsequent stages of growth. Among the male and female palm the male palm was found to be more active since it took the least mean number of days

Table 7. Rate of growth of leaf in different stages and number of days taken for completing active growth of leaf in palmyrah palm

Stages of growth	Rate of leaf growth (cm / day)	No. of days of active growth of leaf
Seedling (2005)	0.32	175.0
Early Juvenile (1997)	0.43	84.0
Juvenile (1995)	0.71	70.0
Adult - Male	1.64	63.0
Adult – Female	1.82	77.0

(63.0 days) compared to the female (77.0 days). The seedling stage took the maximum period of 175 days to complete the active leaf growth, followed by

Table 8. Number of days taken for successive production of leaves in various stages in palmyrah palm

Stages	Mean number of days taken for successive leaf production
Early juvenile stage	43.97
Juvenile stage	28.77
Adult (male)	23.25
Adult (female)	24.25

early juvenile stage (84.0 days). In coconut, Mandal (2000) reported that the top leaflets took four to five months to completely emerge out of the sheath.

Number of days taken for successive production of leaf

Sankaralingam (1999) reported that the palmyrah palm was topped by a crown of 20-30 large leaves. Davis and Johnson (1987) also found

Table 9. Rate of linear growth of Stalk (cm / day) in seedlings stage at weekly interval in palmyrah palm

Stage	December 2007	January 2008	February 2008	March 2008	April 2008
Stage 1	0.01	0.03	0.05	0.04	0.01
Stage 2	0.01	0.03	0.03	0.04	0.01
Stage 3	0.03	0.04	0.03	0.03	0.00
Stage 4	0.03	0.06	0.02	0.03	0.00
Mean	0.02	0.04	0.03	0.03	0.00
SEd	0.01	0.01	0.01	0.01	0.01
CD (0.05)	0.02	0.03	0.02	0.02	0.02

Observation recorded at weekly basis

The rate of linear growth of stalk (cm/day) in seedling stage was calculated and the results are presented in Table 9. The rate of growth of stalk (cm/day) in seedling stage was prominent from first week of December up to second week of April. The mean rate of growth of stalk was the highest (0.04 cm/day) during the month of January followed by February; March (0.03 cm/day).

that a normal palmyrah crown contained 30-40 palmate leaves and the tree produced about one leaf per month.

The days taken for successive production of leaf from the date of leaf emergence of first leaf to the subsequent /successive leaf produced was worked out in the selected five palms of varying stages of growth viz., early juvenile, juvenile and adult stages and the abstract of mean number of days taken for successive production of leaves are presented in Table 8. The mean ranged from 23.25 days (adult male) to 43.97 days (early juvenile stage). Generally, a gradual reduction in the mean number of days taken for successive leaf production was noticed, as the growth stage of the palms advanced. Among the male and female palm the male took comparatively less mean number of days (23.25) than the female (24.25). Similar reports were made by Menon and Pandali (1958) who opined that, the rate of production of leaves was low in young coconut palms. Satyabalan (1993) reported that the periodicity of leaf production was fast in young seedlings but become steady in adult stage of coconut. Patel (1938) also reported that as the tree grew in age the rate of production fastly increased, then became more or less steady and declined in old age. Mandal, (2000) reported that the interval between the opening of two successive leaves in coconut was influenced by genetical make up, soil fertility and seasonal conditions

Rate of growth of stalk in seedling, early juvenile, juvenile and adult (Male and Female) stages of palmyrah palm

The measurement of length of stalk at weekly intervals was recorded and the data were used for calculating the rate of growth of stalk (cm/day) in seedling, early juvenile, juvenile and adult stages and the results are presented below.

The rate of growth in early juvenile stage was maximum (1.03 cm/day) during stage 3 of October, while, it was minimum (0.01 cm/day) during stage 2&3 of January. The mean rate of growth of stalk ranged from 0.04 cm /day (January) to 0.92 cm/day (October). Among the four months of observation the rate of growth of stalk was found to be significant during the month of October (Table 10).

Table 10. Rate of linear growth of Stalk (cm / day) in early juvenile stage at weekly interval in palmyrah palm

Stage	Oct, 2007	Nov 2007	Dec 2008	Jan 2008
Stage 1	0.92	0.68	0.31	0.13
Stage 2	0.92	0.59	0.11	0.01
Stage 3	1.03	0.87	0.13	0.01
Stage 4	0.81	0.67	0.10	0.00
Mean	0.92	0.70	0.16	0.04
SEd	0.21	0.26	0.08	0.04
CD (0.05)	0.46	0.58	0.17	0.09

Observation recorded at weekly basis

In juvenile stage, the rate of growth was maximum during stage 3 of September and it decreased gradually reaching the minimum value during December. The mean rate of growth of stalk significant during the months of September, October and November was 0.81, 0.91 and 0.16 cm / day respectively (Table 11).

Table 11. Rate of linear growth of stalk (cm / day) in juvenile stage at weekly interval in palmyrah palm

Stage	Sep, 2007	Oct 2007	Nov 2007	Dec 2007
Stage 1	0.37	0.76	0.30	0.10
Stage 2	0.84	1.13	0.10	0.17
Stage 3	1.13	0.99	0.13	0.01
Stage 4	0.89	0.76	0.13	0.13
Mean	0.81	0.91	0.16	0.10
SEd	0.23	0.10	0.05	0.10
CD (0.05)	0.50	0.22	0.11	0.23

Observation recorded at weekly basis

In adult male stage, an active period of growth of stalk was exhibited from first week during October up to second week during March and thereafter arresting of growth of stalk in the selected plant. The mean rate of growth of stalk (2.95 cm/day) was observed during the month of October and during November it was 1.90 cm/day. During October and November months of observation a significant rate of growth of stalk was observed (Table 12).

Table 12. Rate of linear growth of stalk (cm / day) in adult (Male palm) at weekly interval in palmyrah palm

Stage	Oct., 2007	Nov., 2007	Dec., 2007	Jan., 2008	Feb., 2008	Mar., 2008
Stage 1	3.13	2.29	0.70	0.26	0.44	0.04
Stage 2	2.80	2.26	0.70	0.36	0.46	0.04
Stage 3	2.79	1.68	0.54	0.29	0.35	0.00
Stage 4	3.09	1.36	0.48	0.28	0.16	0.00
Mean	2.95	1.90	0.61	0.30	0.35	0.02
SEd	0.26	0.30	0.14	0.04	0.08	0.04
CD (0.05)	0.57	0.65	0.31	0.09	0.19	0.09

Observation recorded at weekly basis

Among the various months, the mean rate of growth of stalk in adult female was the maximum (2.59 cm/day) during October followed by November 1.71cm/day) and during March it was the least (0.13cm/day). During October and November months of observation a significant rate of growth of stalk was observed (Table 13).

Table 13. Rate of linear growth of stalk (cm / day) in adult (Female palm) at weekly interval in palmyrah palm

Stage	Oct., 2007	Nov., 2007	Dec., 2007	Jan., 2007	Feb., 2007	Mar., 2007
Stage 1	2.64	1.93	0.43	0.43	0.37	0.53
Stage 2	2.87	1.73	0.61	0.48	0.35	0.00
Stage 3	2.49	1.51	0.38	0.38	0.40	0.00
Stage 4	2.34	1.68	0.64	0.36	0.36	0.00
Mean	2.59	1.71	0.52	0.41	0.37	0.13
SEd	0.67	0.29	0.16	0.58	0.08	0.15
CD (0.05)	1.46	0.64	0.36	0.12	0.17	0.34

Observation recorded at weekly basis

The abstract of rate of linear growth of stalk (cm/day) recorded during seedling, early juvenile, juvenile and adult phase pooled over different months are presented in Table 14. The results showed that the rate of growth of stalk was found to be minimum in seedling stage (0.02 cm/day) followed by early juvenile (0.46 cm/day) juvenile (0.50 cm/day) and

Table 14. Rate of growth of stalk in various stages (cm / day) in palmyrah palm

Month	Stages				
	Seedling	Early Juvenile	Juvenile	Adult Male	Adult Female
	Stalk (cm/day)	Stalk (cm/day)	Stalk (cm/day)	Stalk (cm/day)	Stalk (cm/day)
August, 2007	-	-	-	-	-
September, 2007	-	-	0.81	-	-
October, 2007	—	0.92	0.91	2.95	2.59
November, 2007	—	0.70	0.16	1.90	1.71
December, 2007	0.02	0.16	0.10	0.61	0.52
January, 2008	0.04	0.04	-	0.30	0.41
February, 2008	0.03	-	-	0.35	0.37
March, 2008	0.03	—	-	0.02	0.13
April, 2008	0.00	-	-	-	-
Mean	0.02	0.46	0.50	1.02	0.96

adult stages (1.02 and 0.96 cm/day, male and female respectively). The rate of growth of stalk showed a linear and increasing trend coinciding with the developmental stages of the palm. Various petiole length had been reported in observation with different accession of palmyrah and it increased with the age of the trees under experiment (Anon 2004 and 2005). Periasamy (1965) reported that in *Borassus*, the apex of the petiole resumed only a limited amount of growth in length after an initial cessation of elongation.

Number of days to taken to complete active growth of stalk

The abstract on the mean number of days required completing the active growth of stalk during seedling, early juvenile, juvenile and adult stages are presented in Table.15. The results showed a reverse trend to that of active leaf growth, since, the early stages of palms took less number of days to complete the active growth of stalk compared to the later or advanced stages. The mean number of days

Table 15. Rate of growth of stalk in different stages and number of days taken for completing active growth of stalk in palmyrah palm

Stage of growth	Rate of stalk growth (cm / day)	No. of days taken for completing active growth of stalk
Seedling (2005)	0.02	161.0
Early Juvenile (1997)	0.46	149.0
Juvenile (1995)	0.50	205.0
Adult - Male	1.02	189.0
Adult – Female	0.96	182.0

taken for completing the active growth of stalk was minimum in early juvenile(149 days), followed by seedling stage(161 days), showing that both early juvenile and seedling stages were found to be active compared to the subsequent stages of growth. Among the male and female palms, the female palm was found to be more active since, it took the least mean number of days (182.0 days) compared to the male (189.0 days) to complete the active growth of stalk.

Conclusion

Study on the growth pattern of leaf and stalk at various phases of growth indicated that the rate of growth of leaf and stalk gradually increased as the advancement of period of growth irrespective of various stages of growth. The seedling phase took the maximum number of days to complete the active

growth of leaf followed by early juvenile, juvenile, adult (female and male) phase. An opposite and reverse trend in stalk growth as compared to the growth of leaves was noticed and among the different phases. The number of days taken for successive production of both leaf and stalk was comparatively less in the male and female adult phases, followed by juvenile and early juvenile phases.

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