



## Physio-chemical changes in coconut leaf at different maturity stages

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Coconut (*Cocos nucifera* L.), a perennial plantation tree crop with a single apical growth point, puts forth leaves in succession which forms regular whorls. In adult palms annually 12 to 14 leaves are produced and the number of leaves on the crown in a standing crop varies from 20-40 depending upon the variety, nutrition and environmental factors. However the leaves contributing to the production of spadices are only 12-14 (Menon and Pandalai, 1958). Senescence is the final stage in the life span of a leaf and leads to death / abscission. In coconut, progressive senescence is seen by which the oldest leaf shed first which takes nearly 2 to 2½ years from primordial initiation. Extensive reports are available on physiological and biochemical changes during leaf maturity /senescence of crop plants (Leopold, 1980; Thompson *et al.*, 1998). In coconut variations in leaf water potential (Voleti *et al.*, 1993) as well as variation in photosynthetic characteristics (Naresh Kumar and Kasturi Bai, 2009) among leaves of different maturity stages are reported. Ramadasan and Jacob Mathew (1987) reported that once the leaf is fully unfolded there is no change in leaf area and dry weight. However no reports are available on the biochemical changes especially in the enzyme activities scavenging the reactive oxygen species produced during the leaf maturity/senescence.

A study was conducted in CPCRI, Kasaragod during 2009 to understand physiological and biochemical changes occurring in coconut leaf of different physiological maturity. Fifteen years old West Coast Tall (WCT) cultivar of growing under rainfed conditions was the material for the studies. Leaves of different maturity stages starting from spindle (non chlorophyllous youngest leaf), first (fully unfolded), 6<sup>th</sup>, 11<sup>th</sup>, 14<sup>th</sup> and 20<sup>th</sup> were destructively sampled from five palms for the observation each palm treated as single replication. The observations were carried out during the month of September just after the cessation of monsoon i.e., non-stress condition where soil and atmospheric parameters are congenial for coconut

growth (Kasturi Bai *et al.*, 1988). Soil moisture content on dry weight basis ranged between 7.2 and 10 %. Physiological parameters *viz.*, net photosynthetic rate ( $P_N$ ) and stomatal conductance ( $g_s$ ) were recorded using Infrared gas analyzer (ADC, LCA-4, UK.) as per method standardized by Rajagopal *et al.* (2000) and total chlorophyll content was estimated by the method of Arnon (1949). Physiological parameters were recorded only in the leaves with chlorophyll (i.e., 1<sup>st</sup> to 20<sup>th</sup> leaf). Bio chemical parameters *viz.*, lipid peroxidation- LP (Heath and Packer, 1968) and related enzyme activities *viz.*, super oxide dismutase-SOD (Beauchamp and Fridovich, 1971) and peroxidase- POD (Kar and Mishra, 1976), were estimated as per the standard procedures with slight modifications as suited to coconut (Chempakam *et al.*, 1993). The data was statistically analyzed using SPSS (Version10.0) 1999 package.

The results (Table 1) revealed significant variation in net photosynthetic rate ( $P_N$ ) with leaf maturity. Just after the leaf expansion, there is an increase in  $P_N$  rate to the tune of 38 % and remained relatively steady until a decline (50 %) by 20<sup>th</sup> leaf stage. Stomatal conductance ( $g_s$ ) on the other hand remained more or less steady up to the 14<sup>th</sup> leaf stage and reduced significantly by 20<sup>th</sup> leaf stage. Total chlorophyll content also showed an increase from 1<sup>st</sup> leaf to 14<sup>th</sup> leaf and decreased by 20<sup>th</sup> leaf. Attainment of maximum  $P_N$  capacity at or prior to full

**Table 1.** Physio-chemical changes in coconut leaf at different maturity stages (Mean for 5 palms)

Parameters /leaf no.	Pn rate ( $\mu\text{mol m}^{-2}\text{s}^{-1}$ )	gs ( $\text{mol m}^{-2}\text{s}^{-1}$ ) (mg.g <sup>-1</sup> f.wt)	Total chlorophyll content
1st	4.62	0.20	0.74
6th	6.37	0.21	1.61
11th	6.10	0.21	1.99
14th	6.08	0.23	1.91
20th	3.26	0.13	1.81
CD (P=0.05)	0.41	0.01	0.31

leaf expansion has been observed in cashew (Balasimha, 1991). Flore and Lakso (1989) related the ontogenic decline in leaf  $P_N$  to the declining sink demand for assimilates. However, in coconut since each leaf axil subtends a bunch of different maturity stage, the sink demand is always higher. Recently Naresh Kumar and Kasturi Bai (2009) observed significant variation in photosynthetic characteristics in different shapes of coconut canopy as well as between leaves of different maturity stages under irrigated and rainfed conditions. In silverbrich, Oleksyn *et al.* (2000) observed decrease in photosynthetic rate after the leaves are fully developed but the rate of decline was found to vary due to growth habit or growth environment.

It has been suggested that with the decrease in photosynthetic rate the photosynthetic electron flux to  $O_2$  will increase, resulting in the increased production of reactive oxygen species which include superoxide radicals, hydrogen peroxide, hydroxyl radicals etc. and are extremely damaging to cell wall lipids, proteins and pigments unless they are rapidly scavenged within the chloroplasts by the activities of antioxidative enzymes (Asada, 2006). In aerobic cells, the enzyme SOD protects cells by converting the superoxide radicals to hydrogen peroxide while catalase and peroxidase convert hydrogen peroxide to water and molecular oxygen. But during maturity/senescence, the balance between production and elimination will get disturbed. The observations in coconut revealed a rapid increase in the lipid peroxidation from spindle leaf to the first leaf and thereafter steady increase (Fig. 1). Simultaneously with the increase in lipid peroxidation, there was decrease in the enzyme activities *viz.*, SOD and POD. Increased lipid peroxidation and decline in anti oxidant enzyme activities have been reported as the possible cause of leaf senescence in different plants by various workers (Dhindsa *et al.*, 1981; Hurng and Kao, 1994; Prochazkova *et al.*, 2001). Negative correlation between anti oxidant enzyme

activities and lipid peroxidation has been reported in coconut by Chempakam *et al.* (1993). The negative correlation observed between SOD and LP in the present study (Fig. 2) corroborate with the above finding. In the present observation high SOD activity was observed in the spindle leaf and showed decrease with the maturity of the leaf. On the other hand, POD activity decreased from spindle to 11<sup>th</sup> leaf and increased with leaf maturity. POD has been implicated in plant senescence by virtue of its ability to oxidize 3-indole acetic acid (Parish, 1968). Higher increase in the activity of this enzyme during development and senescence has been reported in *Cajanus* (Mukherjee, 2003) thus corroborating with our observation in coconut. Variations in individual anti oxidative enzyme activities have been reported by various workers (Kanawaza *et al.*, 2000; Shrivalli and Khanna-Chopra, 2001). Chlorophyll degradation due to lipid peroxidation is known to occur (Heath and Packer, 1968) and the decline in chlorophyll content in coconut with leaf maturity can be attributed to the lipid peroxidation in the chloroplast membranes.

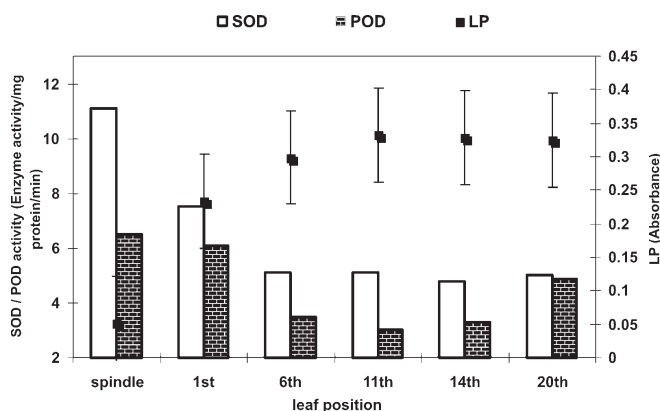


Fig.1. Changes in SOD, POD and LP during leaf maturity stages

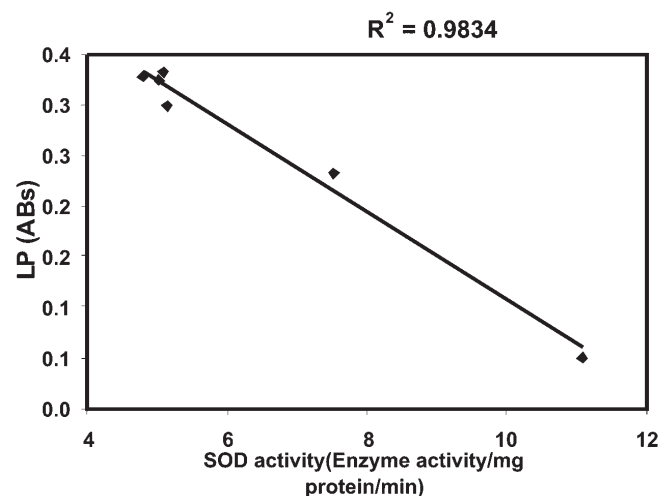


Fig.2. Correlation between SOD and lipid peroxidation (LP) in coconut (Each point represents mean of five observations)

From the foregoing it can be concluded that in coconut physio- chemical changes take place with leaf maturity. Naresh Kumar and Kasturi Bai (2009) reported decrease in photosynthetic rates beyond 10<sup>th</sup> month leaf maturity even after providing radiation at saturating levels. In a source limited crop like coconut (Naresh Kumar and Kasturi Bai, 2009) during adverse climatic conditions, vegetative growth gets priority over reproductive growth which will affect dry matter production and yield. This is mainly because increase in LAI will shade the lower leaves making them parasitic to other leaves. Actually the main purpose of leaf senescence is to enable nutrient recycling from the aging leaves to the developing tissues. This catabolic process

requires energy and as suggested by Oleksyn *et al.* (2000) this may be provided by the ATP generated by the senescent leaves via respiration. It is estimated that in perennial plantation crop, 75 % of the photosynthate are lost through respiration which otherwise would have been diverted for economic produce (Corley, 1983). This implies that proper management of leaves in the crown is highly crucial for optimizing the productivity of coconut palm.

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### References

- Arnon, D.I. 1949. Copper enzymes in isolated chloroplasts, polyphenol oxidase in *Beta vulgaris*. *Plant Physiol.* **24**:1-15.
- Asada, K. 2006. Production and scavenging of reactive oxygen species in chloroplasts and their functions. *Plant Physiol.* **141**:391-396.
- Balasimha, D. 1991. Photosynthetic characteristics of cashew trees. *Photosynthetica* **25**(3): 419-423.
- Beauchamp, C. O. and I. Fridovich. 1971. Superoxide dismutase: Improved assay and an assay applicable to acrylamide gels. *Anal. Biochem.* **44**: 276-287.
- Chempakam, B., Kasturi Bai, K.V. and Rajagopal, V. 1993. Lipid peroxidation and associated enzyme activities in relation to screening for drought tolerance in coconut (*Cocos nucifera* L.). *Plant Physiol and Biochem.* **20**: 5-10.
- Corley, R.H.V. 1983. Potential productivity of tropical perennial crops. *Expl. Agric.* **19**: 217-237.
- Dhindsa, R.A., Plumb-Dhindsa, P. and Thorpe, T.A. 1981. Leaf senescence: correlated with increased permeability and lipid peroxidation, and decreased levels of superoxide dismutase and catalase, *J. Exp. Bot.* **126**: 93-101.
- Flore, J. A. and Lakso, A. N. 1989. Environmental and physiological regulation of photosynthesis in fruit crops. *Hort. Rev.* **11**: 111-157.
- Heath, R.L. and Packer, L. 1968. Photoperoxidation in isolated chloroplasts. I. Kinetics and stoichiometry of fatty acid peroxidation. *Arch. Biochem. Biophys.* **125**: 189-198.
- Hurng, W.P. and Kao, C.H. 1994. Lipid peroxidation and antioxidative enzymes in senescing tobacco leaves during post flooding. *Plant Sci.* **96**: 41-44.
- Kanawaza, S. Sano, S., Koshiha, T. and Ushimaru, T. 2000. Changes in antioxidative enzymes in cucumber cotyledons during natural senescence: comparison with those during dark-induced senescence. *Physiol. Plant.* **109**: 211-216.
- Kar, M. and Mishra, D. 1976. Catalase, peroxidase and poly phenol oxidase activities during rice leaf senescence. *Plant Physiol.* **57**:315-319.
- Kasturi Bai, K.V., Voleti, S.R. and Rajagopal, V. 1988. Water relations of coconut palms as influenced by environmental variables. *Agri..Forest.Meteorol.* **43**: 193-199.
- Leopold, A.C. 1980. Aging and senescence in plant development. pp.1-12. In: *Senescence in plants*. (Ed) Thimann, K.V., CRC Press, Boca Raton.
- Menon, K.P.V. and Pandalai, K.M. 1958. *The Coconut Palm*. A monograph. pp. 293-303. The times of India Press, Bombay.
- Mukherjee, D. 2003. Physiological changes I leaves, flowers and pods during development and senescence in *Cajanus cajan* L. *J. Indian Bot. Soc.* **82**: 78-84.
- Naresh Kumar, S. and Kasturi Bai, K.V. 2009. Photosynthetic characters in different shapes of coconut canopy under irrigated and rainfed conditions. *Indian J. Plant Physiol.* **14**(3):215-223.
- Oleksyn, J., Zytowskiak, R., Reich, P.B, Tjoelker, M.G and Karolewski, P. 2000. Ontogenetic patterns of leaf CO<sub>2</sub> exchange, morphology and chemistry in *Betula pendula* trees. *Trees* **14**:271-281.
- Parish, R. W. 1968. Studies on senescing tobacco leaf disks with special reference to peroxidase. 1. The effects of cutting and of inhibition of nucleic acid and protein synthesis. *Planta* **82**: 1-13.
- Prochazkova, D., Sairam, R.K., Srivastava, G.C. and Singh, D.V. 2001. Oxidative stress and antioxidant activity as the basis of senescence in maize leaves. *Plant Science* **161**: 765-771.
- Rajagopal, V., Naresh Kumar, S., Kasturi Bai, K. V. and Laxman, R.H. 2000. Day time fluctuations in juvenile coconut palms grown under rainfed and irrigated conditions. *J. Plant. Biol.* **27**(1): 27-32.
- Ramadasan, A. and Jacob Mathew. 1987. Leaf area and dry matter production in adult coconut palms. *J. Plantn. Crops* **15**: 59-63.
- Shrivalli, B. and Khanna-Chopra, R. 2001. Induction of new isoforms of superoxide dismutase and catalase enzymes in the flag leaves of wheat during monocarpic senescence. *Biochem. Biophys. Res. Commun.* **288**:1037-1042.
- Thompson, J.E., Froese, C.D., Madey, E., Smith, M.D. and Hong, Y. 1998. Lipid metabolism during plant senescence. *Prog Lipid Res.* **37**:119-141
- Voleti, S.R., Kasturi Bai, K.V. and Rajagopal, V. 1993. Water potential in the leaves of coconut (*Cocos nucifera*,L.) under rainfed and irrigated conditions. pp. 243-245. In: *Advances in Coconut Research and Development*. (Eds) Nair, M. K., H. H. Khan, P. Gopalasundaram, E.V. V. Bhaskara Rao., Oxford & IBH publishing Co Pvt. Ltd. New Delhi.

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