WHAT IMPARTS DROUGHT TOLERANCE IN COCONUT?

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Coconut is a perennial tree crop which thrives well in the tropical region. Since the crop is mainly grown under rainfed conditions, especially in Kerala, the palm is exposed to both soil and atmospheric droughts that prevail during summer months, from February to May. Early cessation of south west monsoon, negligible rainfall during north-east monsoon and failure of summer showers all contribute to prolonged drought with detrimental impact on coconut (Ramadasan *et al.*, 1991; Rao, 1986).

Extensive investigations carried out for over a decade at CPCRI Kasaragod dealt with the physiological response of West Coast Tall (WCT) palms to rainfed conditions in comparison with irrigation levels (Rajagopal *et al.*, 1989), impact of weather factors on stress parameters in WCT and Chandra Sankara [Chowghat Orange Dwarf (COD) x WCT] (Kasturi Bai *et al.*, 1988), progressive stress development in WCT palms between post-monsoon to summer months (Shivashankar *et al.*, 1991) and response of WCT, WCT x COD and Chandra Sankara to moisture stress in sandy loam and laterite soils (Voleti, 1993). Through the rapid screening methods developed (Rajagopal *et al*, 1988), coconut palms comprising of talls, dwarfs and hybrids, could be categorised for their degree of tolerance to drought (Rajagopal, *et al.* 1990). The significant relationship between the physiological parameters and nut yield has been elucidated (Rajagopal *et al.*, 1992), thereby indicating the validity and usefulness of the screening methods for drought tolerance in coconut.

Later studies revealed the mechanism of drought tolerance through biochemical characteristics operating in coconut palms when exposed to moisture stress conditions (Kasturi Bai, 1993., Chempakam *et al.*, 1993). The present paper aims at answering the following questions:

(i) How does coconut palm manage to withstand moisture stress under field condition?

(ii) Which of the varieties/hybrids possess the desirable characters of stress tolerance?

For any plant to withstand the adverse effects of moisture stress, it must regulate its water balance in the tissues. This is achieved through effective stomatal regulation to check the transpirational loss of water from the leaf surfaces. Once the transpiration rate is minimized under stress conditions, the internal tissue water (leaf water potential) remains high leading to maintenance of turgidity in the leaves. This is what was precisely shown by Rajagopal *et al* (1990) who had observed that during March, with the prevalence of high evaporative demand in the atmosphere, some of the coconut genotypes transpired less and maintained turgidity, thus qualifying to be designated as drought tolerance.

The turgor of the cell can also be maintained through osmotic adjustment (Munns, 1988). Adaptation of crop plants to water stress by osmotic adjustment has been reviewed by Morgan (1984). In this process, an active accumulation of organic solutes occurs in tissues subjected to stress, thus leading to decrease in osmotic pressure of the cells. This permits the tissue turgor to remain more positive. In coconut, higher accumulation of sugars and free amino acids was observed in drought tolerant palms, than the susceptible types, which reflected on the relatively low osmotic potential in the former (-1.16 MPa) than in the latter (-1.03 MPa) (Kasturi Bai,1993). This resulted in the maintenance of significantly higher turgidity (turgor potential 0.23 MPa) in drought tolerant than in drought susceptible (0.09 MPa) palms.

The third mechanism by which the plant adapts itself to withstand drought is through deposition of wax on the leaf surface, called epicuticular wax (ECW). This is also referred to as glaucousness, reported extensively in sorghum (Blum, 1975). Besides checking the water loss from leaf surface, wax also plays a key role in reflecting back the heat load on the leaf, thus minimizing the thermal damage to tissues. The work in the author's laboratory clearly established the role of ECW in coconut under stress conditions (Rajagopal *et al.*, 1990; Kurup *et al*, 1993).

To sum up, the answer to the first question emerges from a complex mechanism of water relations, which culminates in the maintenance of turgidity, as clearly shown in coconut cultivars/hybrids. Table 1 depicts the parameters which impart drought tolerance in coconut. It is evident that those palms which show high stomatal resistance, low transpiration rate, high leaf water potential, low osmotic potential, high turgor potential and high wax content, when subjected to moisture stress are qualified to be considered as drought tolerant.

The answer to the second question pertaining to the identification of promising varieties/hybrids could be found from the ranking given to adult palms of 23 cultivars/hybrids screened for drought tolerance which revealed that WCT, FMS, Fiji, Java giant, Chandrakalpa (Laccadive Ordinary - LO) among the talls and Laksha Ganga [LO x Ganga Bondam(GB)], Chandra Laksha (LO x COD), WCT x WCT and WCT x COD among the hybrids are tolerant to moisture stress by virtue of possessing the above mentioned desirable traits (Rajagopal *et al.*, 1990). Out of these, the hybrids LO x COD and LO x GB also proved to be good yielders under drought conditions (Bhaskara Rao *et al.* 1991). Conversely, the dwarfs like COD, Malayan Yellow Dwarfs (MYD), Malayan Orange Dwarf (MOD) and GB and the hybrid COD x WCT (particularly under sandy loam) are classified as drought susceptible, as they could not maintain turgidity under stress conditions due to ineffective stomatal regulation, less osmotic adjustment and low wax deposition. Further evidences on the drought tolerant nature of certain genotypes were obtained through biochemical characterization (Chempakam *et al.* 1993). For instance, maintenance of turgidity reflected on membrane integrity in tolerant palms, whereas in the susceptible ones membrane damage was apparent, as indicated by leakage of solutes from the tissues (Table.1) Conseqently the lipid peroxidation, which is a measure of extent of membrane damage was more in susceptible than in tolerant palms. The activity of related enzymes supported the above trend between the palms of two groups.

Having elucidated the factors that impart drought tolerance and identified the genotypes, the next logical step would be to develop the crosses with suitable parents and test the tolerance at seedling stage itself. The genetics and plant breeding section had already made several crosses, the seedlings of which are being screened for drought tolerance. The indications from the data of three consecutive years are that the crosses CGD x WCT, MYD x WCT, MYD x Java possess seedling tolerance to moisture stress conditions (Anonymous 1994).

Table. 1. Parameters that impart drought tolerance in coconut (Values recorded during stress period - February/March)

Parameter	Tolerant	Susceptible
Stomatal resistance (Sec.cm^{-1})	High (>7.0)	Low (<3.0)
Transpiration rate (µg. cm^{-2} s^{-1})	Low (<2.5)	High (>5.0)
Leaf Water potential (MPa)	High (>-0.95)	Low (<-1.0)
Osmotic potential (MPa)	Low (<-1.16)	High (>-1.09)
Turgor potential (MPa)	High (>0.23)	Low (>0.1)
Soluble sugars (mg. g^{-1} dwt)	High (>15.1)	Low (<14.6)
Free amino acid (mg. g^{-1} dwt)	High (>0.53)	Low (<0.48)
Epicuticular wax content (µg. cm^{-2})	High (>95)	Low (<75)
Electrolyte leakage (%)	Low (<32)	High (>40)

To conclude, the drought research in coconut not only resulted in the development of screening methods based on the factors that impart tolerance and identification of promising drought tolerant varieties/hybrids but more so in the breeding strategies to produce crosses suitable for cultivation under water - limited situations.

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