IJTA © Serials Publications

National Academy of Agricultural Science (NAAS) Rating : 3. 03

Physiomorphological and Biochemical Screening of Banana Cultivars for Drought Tolerance

*Resmi L. and *Ashalatha S. Nair

ABSTRACT: *Bananas and plantains (*Musa *spp.) are fruit crops having great socio economic significance as it serve as staple food for many millions of people across the humid tropics and source of income for many household. However, in many banana growing regions rainfall is not sufficient or not evenly distributed throughout the year. Rainfall is often supplemented with irrigation in some commercial plantations which is not feasible for small household farmers. Water is one of the most limiting abiotic stress factors in banana production. Therefore the present study aimed to screen five banana cultivars for their suitability to grown under water deficit conditions.*

Key Words: *Banana, Drought tolerance,* Musa, *RWC*

A large scale loss of plant production occur when abiotic stresses happen in planting season under different agricultural production systems, which may result in 70% reduction of the potential yields of crop plants. In the growth and developmental periods, crop would suffer seasonal floods and drought, temperature extremes or salinity all the year round. It has been estimated that moisture or drought stress is the most adverse crop environmental stress, accounting for over 70% of potential agriculture yield losses worldwide [1]. Drought is brought about by a shortage of rain or by a large variation in the amount of rainfall, and is the major abiotic stress limiting crop productivity worldwide [2]. Improvement and expanded adoption of crops suited to growth with limited water resources on marginal lands is critical to ensuring food security, given the limited arable land and population growth, further compounded by the effects of climate change. Plant tolerance to drought stress is a complex trait with several interacting layers of molecular and physiological responses. Depending on the plant growth stages, drought stress influences morphology, anatomy, physiology and biochemistry of plants. Drought stress responses and tolerance genes have been well characterized in a number of plant species, lending insight into the general pathways involved and potential tolerance mechanisms and genes in other species [3]. Plant resistance to drought stress can be achieved through escape (e.g. early flowering time in drier environments), avoidance (e.g. transpiration control by stomata and development of extensive root systems), phenotypic flexibility, water conservation in tissues, antioxidant defences, plant growth regulation by hormones and osmotic adjustment. Drought stress induces accumulation of metabolites and drought-related proteins [4]. Bananas and plantains (*Musa* spp.) are fruit crops having great socio economic significance as it serve as staple food for many millions of people across the humid tropics and source of income for many household. Because banana has shallow roots and a permanent green canopy, it is especially sensitive to conditions that lead to water deficit [5]. A better understanding of the mechanisms employed by banana plants to tolerate abiotic stresses will be helpful for increasing crop production and quality of this economically valuable fruit. Therefore, the present investigation was carried out with an objective to identify drought tolerant cultivars by means of morphological, physiological and biochemical evaluation.

Five banana cultivars viz., *Amrit sagar* (*Musa* AAA group), *Njalipoovan* (*Musa* AB group), *Nendran* (*Musa* AAB group), *Monthan* (*Musa* ABB group) and *Boothibale* (*Musa* ABB group) were selected as experimental samples for the present study. One

* Department of Botany, University of Kerala, Kariavattom, Thiruvananthapuram, Kerala, India

month old tissue culture plantlets of the cultivars were purchased from Model Floriculture and Biotechnology Centre, Kazhakkuttom, Thiruvananthapuram which were further maintained in green house conditions at Department of Botany, University of Kerala, Kariavattom. Plantlets were well watered and maintained for three months and then transferred to 20-L plastic grow bags (filled with 20 kg of sterilized soil (soil: sand: cow dung at 4: 2: 1 (v/v/v) respectively) in glass house conditions with an average temperature of 35^o Celsius for inducing drought stress. For the analysis of physiomorphological drought responses, four month old plantlets in plastic grow bags were grown in a randomized complete block design (RCBD) replicated three times. To identify the effect of water stress on physiomorpholgy, plants were exposed to water stress by reducing soil moisture content (SMC). Before the application of treatments, all plants were watered with 1 L of water every 2 days until 60 days after planting (DAP). After 60 DAP, plants in the stress treatment were subjected to gradual drought stress conditions for a total of 50 days by withholding water. During the water stress treatment period, morphological drought-stress-related traits were measured, including: number of leaves, length and breadth of leaves and plant height. Leaf length was defined as the distance from the tip of the leaf to the petiole. Leaf width was measured as the widest region across the lamina perpendicular to the length. Physiological traits were selected on the basis of plant water relations including leaf relative water content (RWC) and Initial water content (IWC). These measurements were collected from three plants per genotype from each replication for each treatment after first, fourth and seventh weeks of drought stress. Total chlorophyll content in leaf-tissue was determined through dimethylsulfoxide (DMSO) method [6]. Leaf tissue (100 mg) was placed in culture tubes (15 mL) containing DMSO (4 mL) and incubated in a water bath (65 °C for 12 h). Absorbance of the extract was read at 645 and 663 nm in the spectrophotometer and total-chlorophyll content was calculated. Total chlorophyll (mg g^{-1} fresh weight) = $[(20.2 \times OD645) + (8.02 \times OD663)] \times V/(1000 \times W)$, where 'V' is the volume of extract and 'W' is the weight of tissue in g.

In the present investigation morphological traits including number of leaves, length and breadth of leaves and plant height were measured during the water stress treatment period. The number of leaves was found to be significantly reduced during the seventh week of water deficit stress in all the cultivars. However, *Monthan* (ABB) and *Njalipoovan*(AB) were more tolerant to drought when compared to others in terms of number of leaves (Fig 1). *Amritsagar* (AAA) was found to be highly susceptible to water deficit stress in terms of length and breadth of leaves (Fig. 2 & 3). Water deficit stress decreases the leaf area which results in the decreases in the shoot length in many crops. Shoot length reduction is occurring due to the lower turgor pressure in the water stress conditions. The capacity to sustain plant function under stress is generally taken as a statement of tolerance in that function to stress. Physiological traits based on plant water relations viz., leaf relative water content (RWC) and Initial water content (IWC) were measured during drought stress treatment. Percentage of initial water content in the leaves was found to be increased in *Monthan* and *Boothibale* during the period of drought stress while in *Nendran* it was decreased significantly (Fig 4). *Amritsagar* and *Nendran* were found to be highly susceptible to water deficit stress in terms of relative water content percentage (Fig 5). Leaf RWC is of the best growth indices revealing the stress intensity [7]. Plants having higher yields under drought stress should have high RWC. It has been reported that high relative water content is a mechanism of drought resistance rather than drought escape and it is believed that high relative water content is the result of higher osmotic regulation of tissue with lower elasticity [8]. Plant water status, rather than plant function, controls crop performance under drought. Therefore, those genotypes that can maintain higher Leaf water Potential, and RWC are drought resistant simply because of their superior internal water status. Estimation of chlorophyll pigment in the leaves after ten days of water deficit stress also showed highest content in the leaves of *Monthan* in terms of chl_a, chl_b and total chlorophyll followed by *Boothibale* (Fig 6). Chlorophyll content is an indication of stress tolerance capacity of plants and its high value means that the stress did not have much effect on chlorophyll content of tolerant plants [9].

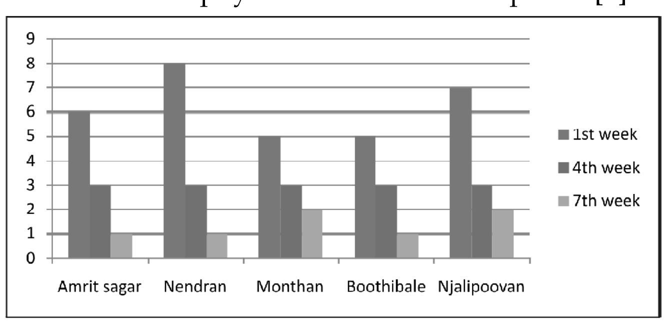

Figure 1: Number of leaves during drought stress

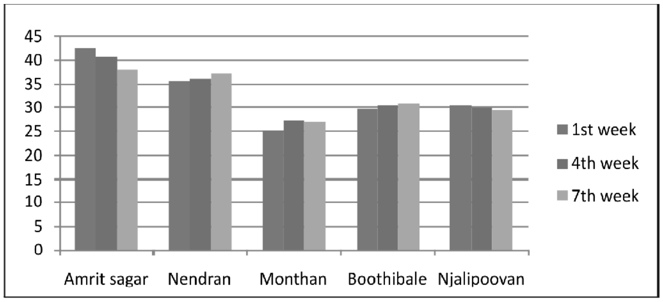

Figure 2: Length of leaves (cm) during drought stress

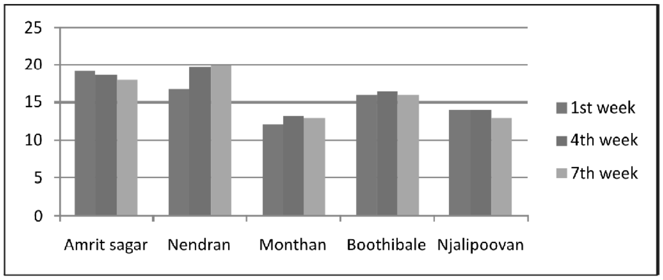

Figure 3: Breadth of leaves (cm) during drought stress

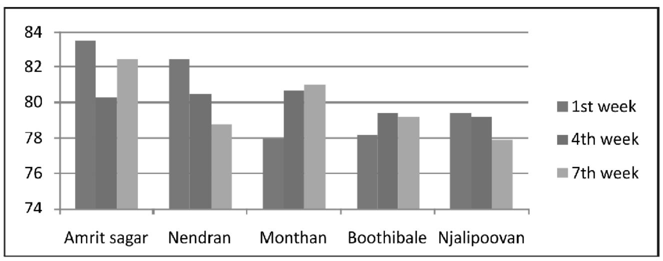

Figure 4: Initial Water Content in the leaves during drought stress

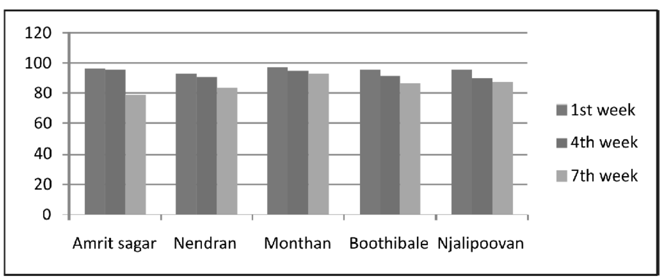

Figure 5: Relative Water Content in the leaves during drought stress

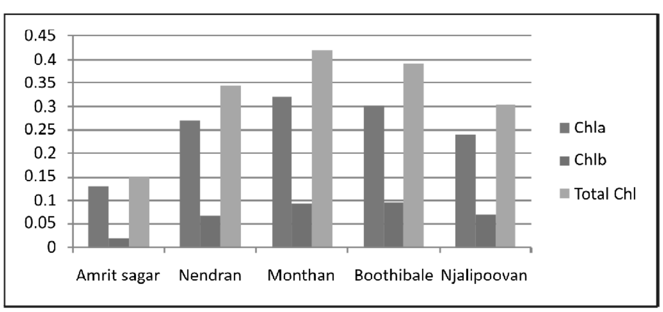

Figure 6: Amount of chlorophyll (mg/g leaf tissuse) after 10 days of stress

Present study observed that *Musa* ABB group cultivar Monthan is highly tolerant towards water deficit stress, while Musa acuminata cultivar Amritsagar is highly susceptible to water deficit stress. Hence present study recommends Monthan as a suitable variety which can be nurtured under water less conditions.

ACKNOWLEDGEMENT

First author acknowledges University Grants Commission, New Delhi for granting post doctoral fellowship under UGC Research Award scheme 2012-14.

REFERENCES

Boyer J. S. (1982), Plant productivity and environment. *Science* 218**:** 443–448.

Saini H. S., Westgate M. E. (2000), Reproductive development in grain crops during drought. Advances in Agronomy 68**,** 59–96.

Farooq M., Wahid A., Kobayashi N., Fujita D., Basra SMA (2009), Plant drought stress: effects, mechanisms and management. *Agronomy for Sustainable Development* 29: 185-212.

Ramachandra Reddy, A., Chaitanya, K.V., Vivekanandan, M., (2004), Drought-induced responses of photosynthesis and antioxidant metabolism in higher plants. *J. Plant Physiol.* 161, 1189–1202.

Sreedharan S., Shekhawat U. K., Ganapathi T. R. (2013), Transgenic banana plants overexpressing a native plasma membrane aquaporin MusaPIP1;2 display high tolerance levels to different abiotic stresses. *Plant Biotechnol J* 11: 942–952.

Hiscox J. D., Israelstam, G. F. (1979), A method for the extraction of chlorophyll from leaf tissue without maceration. *Canadian Journal of Botany* 57: 1332-1334.

Alizadeh, A. (2002), Can Predict the Drought and or Deal with it? 2002. Agricultural Dry and Drought. Ministry of Jihad-e-Agriculture. Issue 6.

Ritchie, S. W., H. T. Nguyan and A. S. Holaday. (1990), Leaf water content and gas exchange parameters of two wheat genotypes differing in drought resistance. *Crop Sci.* 30: 105-111.

Mohan M. M., Narayanan S. L. and Ibrahim S. M. (2000), Chlorophyll stability index (CSI): Its impact on salt tolerance in rice. *Int. Rice. Res. Notes*, 25: 38-39.