RESEARCH PAPER

Physiological and biochemical changes during moisture stress in banana

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Present investigation was carried out to study the physiological and biochemical changes during moisture stress by identifying two contrasting genotypes from earliar studies *i.e. M. acuminata*. ssp *burmaniceoides* commonly recognised as 'Calcutta-4' belonging to AA genomic group and 'Bee hee kela' belonging to BB genomic group were used. The per cent reduction in photosynthetic rate (P_N) between control and stressed plants was 45.28 (%) for 'Calcutta-4' and 36.01(%) for 'Bee hee kela', Transpiration rate (E) was 30.24 (%) for 'Calcutta-4' and 22.36 (%) for 'Bee hee kela' and Stomatal conductance (gs) was 60.30 (%) for Calcutta-4 and 56.10 (%) for 'Bee hee kela', indicating BB genotypes are tolerant to water deficit conditions. Leaf water potential (Ø) was higher in 'Bee hee kela' (BB) both in watered (-0.913 MPa) and under stress (-1.518 MPa) situations when compared with 'Calcutta-4' (AA) control (-1.35 Mpa) and stressed (-1.824 MPa) plants. Malondialdehyde content was estimated to be high in 'Calcutta-4' than that of 'Bee hee kela' indicating higher degree of membrane damage in Calcutta-4. The two antioxidant enzymes namely Super oxide dismutase (SOD) and Catalase activities were found to be higher in Bee hee kela stressed samples than 'Calcutta-4' indicating better oxidative damage withstanding capacity. 'Bee hee kela' (BB) showed higher Ø, gs, and antioxidant enzyme (SOD and Catalase) activities. 'Bee hee kela' genotype is more drought tolerant than 'Calcutta-4'. Identified drought tolerant genotype can be further used as a donor for drought tolerance.

Key words **:** Banana, Drought, Photosynthesis, Melondialdehyde, Antioxidants

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INTRODUCTION

Bananas and plantains are important sources of carbohydrate for the millions of people worldwide. Globally banana (*Musa* sp.) is fourth most important commodity after rice, wheat and corn and is produced in tropical and sub tropical regions of developing economies, grown across 130 countries in an area of 8.25 mha with a production of 97.38 million tonnes (NHB Database, 2006). India leads in global banana production. The other important banana growing countries are Brazil, Philippines Indonesia, China, Ecudor, Cameroon, Mexico, Columbia and Coasta Rica. The important banana growing states of India are Maharashtra, Andhra Pradesh, Assam, Bihar, Gujarat, Karnataka, Kerala, Tamil Nadu, West Bengal and Orissa.

Drought stress induces a range of physiological and biochemical responses in plants. These responses include stomatal closure, repression of cell growth and photosynthesis and activation of respiration. An assortment of genes with diverse functions are induced or repressed by these stresses (Bartels and Sunkar, 2005).

The increasing demand for water for domestic and industrial needs has led to limited availability of good quality water for agriculture. Growing crops under such water limiting conditions is a great challenge for the scientists. Hence, understanding the response of the crops to moisture limiting conditions and using this knowledge for growing crops successfully is very much essential. Banana crop bearing a mesophyte is very sensitive to water stress conditions, most of its cultivation is under irrigation and understanding the changes in banana genotypes response to water deficit conditions is very important. Keeping above points in view, the present investigation was carried out with the objective to study the physiological and biochemical changes due to moisture stress in banana.

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RESEARCH METHODOLOGY

The experiment was conducted with two contrasting genotypes involving three replications of banana genotypes *viz., M. acuminata*. ssp *burmaniceoides* commonly recognised as Calcutta-4 (AA Genomic group) and Bee hee kela (BB Genomic group) for drought tolerance during 2008, at banana field, Indian Institute of horticultural research, Hessaraghatta, Bangalore-89. Two treatments were imposed *i.e.*, control and stress. Irrigation was with held 120 DAP (days after planting) for a period of twelve days for stress treatment and control plants were regularly watered. The following observations were recorded, gas exchange parameters *viz*., photosynthesis rate (P_N), transpiration rate (E) and stomatal conductance (gs) were measured from the third fully expanded leaf using portable photosynthetic system infra red gas analyser (IRGA) (Model-LCA-3) ADC Company. All observations were recorded during bright sunlight hours (10AM-12 Noon). Leaf water potential (Ψ) was measured with psychrometer HR 33T (Wescor, USA) in the mode "dew point" equipped with sample chamber C-68 and C-79. Biochemical analysis like, estimation of lipid peroxidation of membranes was done by quantifying melondialdehyde content (Draper and Hadly, 1990). Estimation of the activities of antioxidative enzymes *viz.,* catalase and sodium oxide dismutase (SOD) (Zhanyuan and Willium, 1994) was done.

RESEARCH FINDINGS AND ANALYSIS

The experiments were conducted at IIHR fruit crops field by planting two contrasting genotypes Calcutta-4 (AA) and Bee hee kela (BB) in two structures built by cement bricks having three replications based on leaf water retention capacity and $\Delta^{13}C$ analysis of present and earlier experimental results. For one structure irrigation was with held 120 days after planting for a period of twelve days for stress treatment and other structure was maintained at 100 per cent field capacity. The present investigation carried out on the behaviour of banana to water stress that helps to understand a few physiological, biochemical aspects during irrigated and water deficit conditions. The results obtained in this study are presented below.

The observations recorded on photosynthesis rates under well watered and water stressed conditions showed significant variations. Average photosynthetic rates of irrigated and stressed plants of Calcutta-4 genotype showed to be 8.76 ± 0.41 and 4.75 ± 0.87 μ mol m^{-2} sec^{-1}, respectively, and values for Bee hee kela (BB) under well watered and stressed conditions showed 12.03 ±1.67 and 7.70 ± 0.6 μ mol m^{-2} sec^{-1}, respectively (Table 1). Under water stressed conditions the genotype Culcutta-4 (AA) showed high per cent reduction in photosynthetic rate (45.77 per cent) when compared with the genotype Bee hee kela (BB) (36.01 per cent) (Fig. 1a). Above findings are contradictory to the findings of Bananuka *et al.* (1999). Present results on photosynthesis rates of two genotypes, indicates Bee hee kela (BB) can maintain high photosynthesis rate even under water stressed environments when compared with Calcutta-4 (AA), it may be due to lower sensitivity of stomatal conductance and net photosynthesis to leaf to air vapour pressure difference of cultivars containing more B genomes than that of A genomes, is consistent with the view that the B genome contributes to drought tolerance in *Musa* sp. (Thomas *et al*., 1998).

Data on transpiration rates of two genotypes Bee hee kela and Calcutta-4 under irrigated and water stressed conditions exhibited differences, the genotype Bee hee kela (BB) exhibited transpiration rates of 12.30 ± 0.35 m mol m^{-2} sec^{-1} and 9.55 ± 0.15 m mol m^{-2} sec^{-1}, under irrigated and water stressed conditions, respectively. The genotype Calcutta-4 noticed transpiration rates of 11.97 ± 0.13 m mol m^{-2} sec^{-1} and 8.35 ± 0.15 m mol m^{-2} sec^{-1} under irrigated and water stressed conditions, respectively (Table 1). Per cent reduction in transpiration rate was occurred in both the genotypes but it was high for Calcutta-4 (30.24 per cent) indicating its susceptibility to water deficit conditions but the genotype Bee hee kela (22.36 per cent) showed less per cent reduction in transpiration rate(Fig. 1b) indicating its tolerance to water limiting conditions. These results are in agreement with the findings of Bananuka *et al.* (1999) in banana.

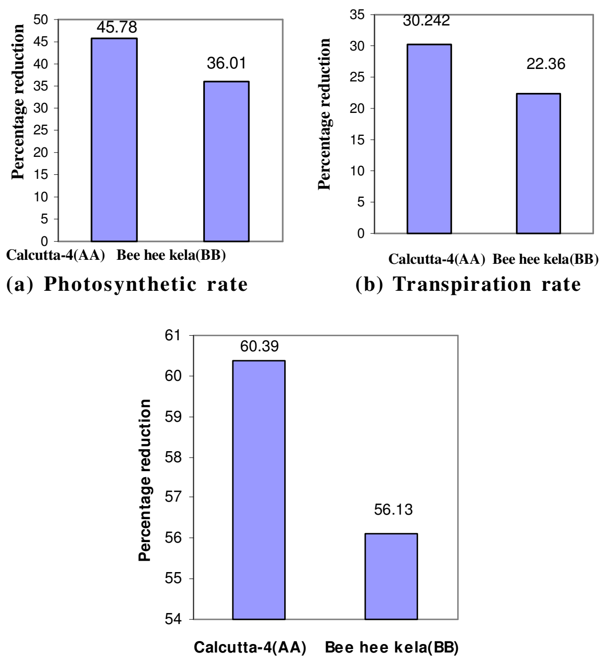
Effect of water stress showed significant changes in the stomatal conductance of both the banana genotypes. The stomatal conductance of the genotype Calcutta-4 under well watered and water stressed conditions was shown to be 866 ± 18.87 m mol m^{-2} sec^{-1} and 343 ± 49.1 m mol m^{-2} sec^{-1}, respectively. The genotype Bee hee kela recorded stomatal conductance of 1060 ± 180 m mol m^{-2} sec^{-1} and 465 ± 5 m mol m^{-2} sec^{-1} under

Table 1 : Gas exchange characteristics in two banana genotypes under well watered and stress conditions

Genotype	Treatments	P_N (μ mol m^{-2} sec^{-1})	E (m mol m^{-2} sec^{-1})	Gs (m mol m^{-2} sec^{-1})	Ψ (Mpa)
Calcutta-4	Well watered	8.76	11.97	866	-1.35
(AA)	Water stressed	4.75	8.35	343	-1.824
Bee hee kela	Well watered	12.03	12.3	1060	-0.913
(BB)	Water stressed	7.70	9.55	465	-1.518

P_N : Net photosynthetic rate, E: Transpiration rate, Gs: Stomatal conductance, Ψ: Leaf water potential.

well watered and water stressed conditions, respectively (Table 1). Per cent reduction in stomatal conductance (gs) after twelve days stress was recorded high for the genotype Calcutta-4 (60.39 per cent) genome when compared with Bee hee kela (56.13 per cent) (Fig. 1c).The similar kind of results were observed by Bananuka *et al.* (1999) in banana. Stomatal conductance of stressed plants was lower when compared with control plants and the stomatal conductance of BB genomic group (Bee hee kela) was higher than AA genomic group and this was correlating with the $\Delta^{13}C$ of BB genotypes this is fine and it was expected and it proves the drought tolerance capacity of BB genomic group is better than AA genomic group.



(a) Photosynthetic rate (b) Transpiration rate (c) Stomatal conductance

Fig. 1 : Per cent reduction in gas exchange characteristics of banana genotypes due to water stress

In the present study genotype Bee hee kela (BB) recorded water potentials of -0.930 (MPa) and -1.518 (MPa) under irrigated and water stressed conditions, respectively and for genotype calcutta-4 recorded water potentials of -1.350 (MPa) and -1.824 (MPa) under irrigated and water stressed conditions, respectively (Table 1). Calcutta-4 (AA) showed lower leaf water potential compared to Bee hee kela under water stress conditions, indicating that Bee hee kela has got capacity to maintain higher water potential even under water stress conditions and these results are on far with the findings of Kallarackal *et al*. (1990).

In the present study an attempt was made to quantify the malondialdehyde content, activity of super oxide dismutase and catalase enzymes in two genotypes of banana under water stressed condition. As OD change at 532nm increases the malondialdehyde content also gets increases, in Calcutta-4 OD change at 532 nm was 0.2431 and 0.4540 for watered and stressed leaf samples, respectively. In Bee hee kela it was 0.1983 and 0.3436 under watered and stressed conditions. In Culcutta-4 OD change between watered and stressed plants was 0.2109 but in Bee hee kela it was 0.1453, indicating that membrane damage was high in Calcutta-4 than Bee hee kela.

The data on the activity of SOD in two genotypes of banana showed that, under water stressed condition the enzyme activity was high in Bee hee kela (30.593 U g^{-1} FW) when compared with Calcutta-4 (22.945 U g^{-1} FW). The activity of SOD between control and stressed plants was compared, there was an increase of more than two fold in Bee hee kela (BB) as compared to less than 1.5 fold in Calcutta-4 (AA). The results obtained on the activity of catalase showed that, there was more than two fold increase in the activity between control and stressed plants of both Calcutta-4 and Bee hee kela but this was recorded higher activity (2.7772 U g^{-1} FW) than that of Calcutta-4 (0.6666 U g^{-1} FW) under water stressed conditions (Table 2). The results from this investigation on MAD content, activities of SOD and catalase enzymes during drought in watered and stress situations can be correlated with the findings of Fazeli *et al.* (2007), Ratnayaka *et al.* (2003) and Upadhyaya and Panda (2004). The malondialdehyde content was found to be high in case of Calcutta-4 (AA) than that of Bee hee kela (BB) suggesting that, BB genotypes are better protected from oxidative damage under drought stress than AA genotypes. The activities of super oxide dismutase and catalase were found to be more under water deficit conditions than well watered conditions in both the genotypes but the activity in Bee hee kela (BB) was high under drought when compared with the Calcutta-4 (AA), indicating presence of good defense mechanism in Bee hee kela (BB), this also

Table 2 : The activity of catalase and super oxide dismutase in banana genotypes under well watered and stressed conditions

Genotype	Genomic group	Treatments	Catalase activity (U g^{-1} FW)	SOD activity (U g^{-1} FW)
Calcutta-4	AA	Well watered	0.3201	16.252
		Water stressed	0.6666	22.945
Bee hee kela	BB	Well watered	1.2222	13.384
		Water stressed	2.7772	30.593

maintained better leaf water potential under stress also had low malondialdehyde content under stress. All these parameters indicate Bee hee kela can withstand water stress better than Calcutta-4 (AA).

The results obtained with the physiological and biochemical studies are significant. As per the literature available BB genome has got better drought tolerant capacity than that of AA genome accordingly in our study the BB genotype (Bee hee kela) was found to have better mechanisms to cope with the drought situation than the AA genotype (Calcutta-4).

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