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Leaf Gas Exchange Characters of *Musa* AB 'Ney Poovan' and *Musa* ABB (Pisang awak) Karpuravalli

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ABSTRACT

Ney Poovan (AB) and Karpuravalli (ABB) are indigenous and popular banana cultivars in south India for its unique taste, sweetness and flavour. Leaf gas exchange traits for these cultivars are important for better management practices. Diploid cv. Ney Poovan recorded higher photosynthesis (12.49 μ mol $m^{-2} s^{-1}$) than triploid cv. Karpuravalli (9.57μ mol $m^{-2} s^{-1}$) during vegetative stage. Ney Poovan has erect and narrow leaves compared to Karpuravalli (broad and droopy leaves) and helps in intercepting radiation effectively during morning hours. Stomatal conductance (gs) could demarcate physiologically efficient leaves in both the cultivars, as older and youngest leaves recorded lower stomatal conductance. The older leaves transpired on par with most active leaves with lower assimilation rate in both cultivars. The gas exchange parameters recorded higher in top 2-5 leaves, therefore these leaves can be used for any physiological and biochemical studies they reflect active physiological state of the leaves. Ney Poovan manifested early vigor by increased Pn, gs than Karpuravalli. Therefore, nutrient scheduling and management practice must be worked out separately for each cultivar; thereby we can exploit production potential of both cultivars.

Key words : Banana cultivars, Karpuravalli, Ney Poovan, Photosynthesis, Stomatal conductance, Transpiration.

Bananas are grown throughout the tropical and subtropical parts of the world. In India, it is grown in both tropics and sub-tropics environment. Present existing banana cultivars are originated from natural hybridization of *M. acuminata* (A) and *M.balbisiana* (B) and most of the cultivars are triploids and few are diploids (Simmonds and Shepherd 1955). Understanding the processes of growth and development is important to adapt or modify the management practices to increase productivity. For growth studies, net assimilation rates are difficult to measure in larger plants and the methods are destructive. Measurement of photosynthesis and associated parameters, however, provide information on the physiological activity of plants and factors influencing the crop cycle (Eckstein and Robinson, 1995; Turner 1995). Most of the gas exchange studies were undertaken in commercially important banana cultivars *i.e.* Cavendish group (AAA). Banana cultivars like Ney Poovan (AB) and Karpuravalli (ABB) are indigenous and popular in south India for its unique taste, sweetness and flavor. No or a little literatures are available on leaf gas exchange properties for these cultivars. Gathering information on these traits is important for improving management practices and to increase the productivity of these banana cultivars and profitability of marginal farmers. The present study was undertaken to characterize the gas exchange properties of these important indigenous banana cultivars in top six green leaves.

MATERIAL AND METHODS

The experiment was conducted at National Research Centre for Banana farm located at 10° 50' N latitude 74° 50' E longitude at 90 MSL during 2006-07. A diploid banana cultivar 'Ney Poovan' (AB) and a triploid 'Karpuravalli' ABB, differing in ploidy and genome constitution were used for this study. In an established plant crop (0.5 acre) for these cultivars, uniform sword suckers were selected allowed to grow with spacing of 2m x 2m. Cultural operations were carried out as per recommended cultivation practices. For studying gas exchange properties, four month old plants were chosen; when the plant height and circumference were in the range of 0.9m to 1.2m and 25 to 32 cm respectively and similar set of plants were chosen to repeat the experiment. Net CO_2 assimilation rates, transpiration rate and stomatal conductance of intact leaf blades of plant were measured using LCA 4 portable photosynthesis system of ADC, inc., Hoddeson and Hertfordshire, England. The LCA–4 analyzer is used in conjunction with Portable Leaf Chamber (PLC-4) that enabled measuring photosynthesis, transpiration simultaneously. The leaf area in the chamber was fixed at 6.25 cm^2. Field was irrigated 1-2 days before measurements to maintain it at field capacity to prevent any soil moisture stress. For each measurement six plants were selected having on an average of 7-8 green leaves. During measurement clipped leaf always angled towards sun for uniform lighting and maximum physiological efficiency. Exposure time was approximately 30-40 seconds until steady state was reached. Measurements were taken on clear day between 10 am to 11 am. Photosynthesis, transpiration and stomatal conductance were measured down the profile of plant from youngest completely unfolded leaf (no.1) to the old leaf (no.6). The leaf was classified into apical, middle and lower portions (P) and each portion has two sides(S), i.e. left and right sides of midrib (Fig. 1). The data were analysed using factorial completely randomized design with variables of cultivars, leaf number and positions with three replications (Table-1). Each replication comprised of five plants. To eliminate the border effect the observations, samples were taken leaving two plants from the border row. The data were analysed using IRRISTAT DOS version 3.0.

RESULTS AND DISCUSSION

The ploidy level of banana affects phenotype and expression of several morphological traits of banana (Monet and Charpentier, 1965). Most of the cultivated bananas are diploid and triploid genome, which are derivative of *Musa acuminata* and *Musa balbisiana.* Diploid banana have more erect and acute angled postured leaves, while triploid leaves are drooping. Although much research has been carried out on leaf morphology, little or no attempt has been made to relate leaf morphology to photosynthetic efficiency (Gowen, 1995). The present results revealed that Ney Poovan (AB), a diploid banana recorded significantly higher photosynthesis (12.49 μ mol m^{-2} s^{-1}) than Karpuravalli (9.57 μ mol m^{-2} s^{-1}) a triploid genome cultivar (Table 2).

In both cultivars the photosynthesis was recorded higher in 2-5 leaves compared to first leaf and sixth leaves. The most efficient leaves on a banana plant growing vegetatively are leaves two to five down the profile (Kallarackal et al*.,* 1990; Eckstein and Robinson 1995). For standardized physiological measuring techniques, any of these leaves can thus be chosen. The youngest first leaf is still in a sink growth stage, because stomata on its surface are not fully operational and assimilates are imported rather than manufactured. From this table it is very clear that 2 to 5 leaves from top are very active. The sixth leaf recorded slight decrease in photosynthesis compared to its young leaves except first leaf. Therefore taking care of first 2-5 leaves without damage by pest and diseases, leaf tearing and cutting leaves is crucial for normal plant growth and development. There was no much differences in photosynthesis exist between different portions (P) and sides (S), i.e. apical, middle and lower portions of left and right sides of midrib of leaves in both cultivars (Table 2). But it is more convenient to take middle portion of leaves for physiological studies.

Both Ney Poovan and Karpuravalli did not significantly differ in stomatal conductance (0.220 and 0.145 mol m^{-2} s^{-1}, respectively). However, right side (R) of apical portion stomatal conductance of Ney Poovan recorded significantly higher than Karpuravalli (Table 3). Compared to photosynthesis, the stomatal conductance demarcated young leaves and old leaves, where lower conductances were recorded. The stomatal conductance of leaves manifest its efficiency of physiological functions. This may be considered as one of the trait to identify the best functional leaves. In transpiration, cv. Ney Poovan recorded significantly higher (5.75 mmol m^{-2} s^{-1}) than Karpuravalli (4.395 mol m^{-2} s^{-1}). This was more pronounced in, however, in left side of leaves in Ney Poovan than Karpuravalli (Table 4). The significance of transpiration is exhaustion of soil water for drymatter production. The significance

Fig 1. Banana leaf portions used for observation.

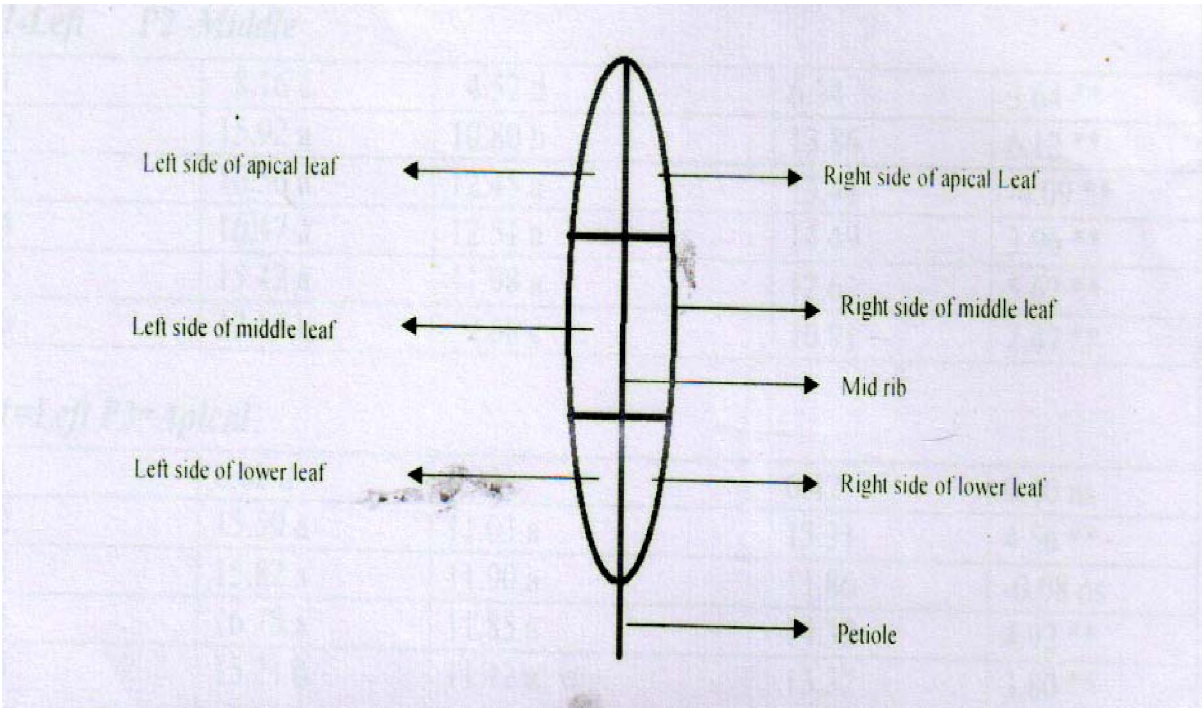

Table 1. The levels of variables for gas exchange studies in banana.

S.No.	Factors	Level
1.	Cultivars	Ney Poovan, (AB) and Karpuravalli (ABB)
2.	Treatments (T)	
	T1 - Side (S)	Left (L) , Right (R)
	T2 - Position (P)	Lower (L), Middle (M), Apical (A)
	T3 - Leaf Number (L)	1, 2, 3, 4, 5, 6
3.	Replications	Three

of the present finding was in cv. Ney Poovan; the lower leaves (sixth leaf from top) transpired more on par with young active leaves (2-5. But the contribution toward photosynthesis by these older leaves was significantly lesser (Table 2) than leaves of two to five.

The present investigation concludes that, to study physiological function of banana leaves from top to down 2-5 fully opened leaves can be used. The angle of insertion is very important for crop productivity as this governs the exposure of the leaves to sunlight and hence the more even distribution of light through the plant cover enabling more efficient photosynthetic activity at the mid and lower levels of the plant (Cayon 1992). Owing to erect and narrow leaves of Ney Poovan radiation interception and photosynthesis was higher in Ney Poovan than Karpuravalli. Therefore, Ney Poovan could be explored as suitable intercrop under coconut plantation crop.

Table 2. Photosynthesis (μ mol m^{-2} s^{-1}) of diploid and triploid banana varieties in different leaves of different portions at 120 days after planting (DAP).

Leaf Number (N)	Variety (V)			
	Neypoovan(AB)	Karpuravalli (ABB)	N-Mean	Diff
S1- Left P1- Lower				
L1	7.58 c	3.64 c	5.61	3.94 **
L2	15.42 a	10.07 a	12.75	5.35 **
L3	15.41 a	9.76 a	12.59	5.64 **
L4	16.34 a	9.67 a	12.01	8.67 **
L5	15.61 a	8.55 b	12.58	6.06 **
L6	13.99 b	3.90 c	8.95	10.09 **
S1-Left P2 -Middle				
L1	8.16 c	4.52 d	6.34	3.64 **
L2	15.92 a	10.80 b	13.86	6.12 **
L3	16.56 a	12.45 a	13.41	-4.09 **
L4	16.47 a	12.51 a	14.49	3.96 **
L5	15.42 a	11.98 a	12.61	5.62 **
L6	12.14 b	9.68 c	10.91	2.47 **
S1=Left P3=Apical				
L1	6.62 d	6.22 c	6.42	0.40 ns
L2	15.59 a	11.03 a	13.31	4.56 **
L3	15.82 a	11.90 a	11.86	-0.08 ns
L4	16.78 a	11.85 a	14.32	4.92 **
L5	15.21 b	11.42 a	13.32	3.80 **
L6	12.65 c	10.09 b	11.37	2.55 **
S2=Right P1=Lower				
L1	6.43 c	0.74 d	3.59	5.69 **
L2	14.72 a	11.16 b	12.94	3.56 **
L3	14.92 a	12.85 a	10.89	0.07 ns
L4	14.62 a	12.66 a	13.64	1.96 **
L5	14.25 a	10.95 b	11.65	5.20 **
L6	12.16 b	8.38 c	10.27	3.78 **
S2=Right P2=Middle				
L1	7.22 c	1.91 c	4.56	5.31 **
L2	12.24 a	11.14 a	111.69	1.10 ns
L3	12.36 a	11.89 a	12.13	-1.53 *
L4	12.27 a	11.36 a	10.82	-3.10 **
L5	12.83 a	12.63 a	9.23	7.20 **
L6	10.59 b	8.52 b	13.05	-4.93 **
S2=Right P3=Apical				
L1	8.07 c	4.10 c	6.09	3.98 **
L2	11.85 a	11.31 b	11.58	0.54 ns
L3	11.72 a	12.65 a	12.18	-0.93 ns
L4	11.81 a	12.93 a	12.37	-1.13 ns
L5	11.92 a	10.81 b	13.37	5.12 **
L6	10.24 b	10.55 b	10.40	-0.31 ns
V-Mean	12.49	9.57	11.03	2.92

** = significant at 1% level, * = significant at 5% level ns = not significant

In a column under each P x S, means followed by a common level are not significantly different at the 5% level by DMRT.

Comparison	S.E.D.	LSD (5%)	LSD (1%)
N x P x S x V means	0.65	1.28	1.70

Table 3. Stomatal Conductance (mol m^{-2} s^{-1}) in different leaves of diploid and triploid banana varieties in different portion of left and right side of mid rib at 120 days after planting (DAP).

Leaf Number (N)	Variety (V)			
	Ney poovan (AB)	Karpuravalli (ABB)	N-Mean	Diff
S1=Left P1=Lower				
L1	0.08 b	0.03 c	0.055	0.050 ns
L2	0.26 a	0.11 a	0.185	0.150 *
L3	0.24 a	0.16a	0.200	0.080 ns
L4	0.26 a	0.11 a	0.180	0.150 *
L5	0.24 a	0.16 a	0.200	0.08 ns
L6	0.05 c	0.06 b	0.055	-0.01 ns
S1=Left P2=Middle				
L1	0.14 b	0.06 b	0.100	0.08 ns
L2	0.23 a	0.16 a	0.195	0.07 ns
L3	0.26 a	0.17 a	0.215	0.09 ns
L4	0.29 a	0.16 a	0.225	0.13 ns
L5	0.26 a	0.09 b	0.175	0.17 **
L6	0.17 b	0.09 b	0.130	0.07 ns
S1= Right P3=Apical				
L1	0.14 c	0.08 a	0.110	0.06 ns
L2	0.37 a	0.18 a	0.275	0.19 **
L3	0.34 a	0.16 a	0.250	0.18 **
L4	0.35 a	0.19 a	0.270	0.16 *
L5	0.32 a	0.17 a	0.245	0.15 **
L6	0.27 b	0.08 a	0.175	0.19 **
S2=Right P1=Lower				
L1	0.12 b	0.01 b	0.065	0.11 ns
L2	0.23 a	0.16 a	0.195	0.07 ns
L3	0.27 a	0.16 a	0.215	0.11 ns
L4	0.20 a	0.20 a	0.190	0.02 ns
L5	0.17 ab	0.21 a	0.190	-0.04 ns
L6	0.13 b	0.07 b	0.100	0.06 ns
S2=Right P2=Middle				
L1	0.13 b	0.02 c	0.075	0.11 ns
L2	0.28 a	0.26 a	0.270	0.02 ns
L3	0.26 a	0.27 a	0.265	0.02 ns
L4	0.27 a	0.25 a	0.260	-0.01 ns
L5	0.27 a	0.22 a	0.245	0.02 ns
L6	0.14 b	0.09 b	0.125	0.05 ns
S2= Right P3=Apical				
L1	0.12 b	0.04 c	0.080	0.08 ns
L2	0.21 a	0.13 b	0.170	0.08 ns
L3	0.24 a	0.27 a	0.255	-0.03 ns
L4	0.24 a	0.26 a	0.250	-0.02 ns
L5	0.28 a	0.29 a	0.285	0.01 ns
L6	0.14 b	0.12 b	0.130	0.02 ns
V-Mean	0.221	0.145	0.183	0.076

** = significant at 1% level, * = significant at 5% level ns = not significant

In a column under each P x S, means followed by a common letter are not significantly different at the 5% level by DMRT.

Comparison	S.E.D.	LSD (5%)	LSD (1%)
N x P x S x V	0.07	0.13	0.18

Table 4. Transpiration (mmol m^{-2} s^{-1}) in different leaves of diploid and triploid banana varieties in different portion of left and right side of mid rib at 120 days after planting (DAP)

Leaf Number (N)	Variety (V)			
	Ney poovan (AB)	Karpuravalli (ABB)	N-Mean	Diff
S=Left P= Lower				
L1	3.07 c	1.45 c	2.260	1.62 *
L2	5.47 b	3.68 b	4.570	1.79 *
L3	7.30 a	4.59 a	5.940	2.71 **
L4	6.88 a	4.08 a	5.480	2.88 **
L5	6.51 a	4.81 a	5.660	1.70 *
L6	6.07 ab	2.41 bc	4.240	3.66 **
S-Left P-Middle				
L1	4.22 c	2.55 c	3.385	1.67 *
L2	6.60 a	4.62 a	5.610	1.98 **
L3	6.68 a	5.01 a	5.845	1.67 **
L4	6.28 a	4.95 a	5.615	1.33 *
L5	6.23 a	4.57 a	5.400	1.66 **
L6	5.76 b	3.51 b	4.635	2.24 **
S=Left P=Apical				
L1	4.32 b	3.71 b	4.015	0.61 ns
L2	6.33 a	3.88 b	5.105	2.45 *
L3	6.17 a	4.91 a	5.540	1.26 **
L4	6.50 a	5.76 a	6.130	0.74 ns
L5	7.57 a	5.02 a	6.295	2.55 **
L6	6.93 a	4.00 b	5.466	2.93 **
S=Right P=Lower				
L1	4.36 b	0.80 c	2.580	3.56 **
L2	4.84 b	4.60 b	4.720	0.24 ns
L3	5.88 a	5.81 a	5.845	0.07 ns
L4	5.77 a	5.94 a	5.855	-0.17ns
L5	5.59 a	5.49 a	5.540	0.10 ns
L6	4.87 b	3.57 b	4.220	1.30 ns
S=Right P=Middle				
L1	4.62 b	1.13 d	2.875	3.49 **
L2	5.30 b	4.28 bc	4.290	1.02 *
L3	6.97 a	5.34 a	6.155	1.63*
L4	7.17 a	6.43 a	6.800	0.74 ns
L5	6.94 a	6.57 a	6.755	0.37 ns
L6	5.92 ab	3.76 c	4.840	2.16 **
S=Right P=Apical				
L1	3.38 b	1.93 d	2.655	1.45*
L2	4.25 b	4.45 bc	4.350	-0.20 ns
L3	5.90 a	6.36 a	6.130	-0.46 ns
L4	5.62 a	6.91 a	5.365	-1.29 *
L5	5.32 a	6.23 a	5.725	-0.91 ns
6	5.49 a	5.11 b	5.300	0.38 ns
V-Mean	5.752	4.395	5.074	1.357

** = significant at 1% level, * = significant at 5% level ns = not significant

In a column under each P x S, means followed by a common letter are not significantly different at the 5% level by DMRT.

Comparison	S.E.D.	LSD (5%)	LSD (1%)
N x P x S x V	0.70	1.28	1.62

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