Changes in Photosynthetic Rate, Specific Leaf Weight and Sugar Contents in Mango (*Mangifera indica* L.)

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Abstract: To evaluate the cultivar variation in photosynthetic rate (Pn) of mango, observations were taken in 25 cultivars representing different agro-climatic region of the country at two stages i.e. full bloom (March) and developed fruit stage (May). Seven cultivars, Papatio, Lucknow Safeda, Neelam, Mulgoa, Khas-ul-khas, Himsagar and Nisar Pasand showed the higher Pn rate at both the stages, while nine genotypes, Kishan Bhog, Langra, Chausa, Kesar, Fazri, Vanraj, Fernandin, Dashehari and Mallika showed medium Pn rate at both the stages. Specific leaf weight (SLW), total sugar and reducing sugar contents in leaves were also estimated in five commercially grown mango varieties, viz., Dashehari, Langra, Chausa, Amrapali and Mallika during the day at three times, 7:30 a.m., 12:30 p.m. and 5:30 p.m. at flower bud differentiation (November) and full bloom (March) stage to evaluate the cultivar variation in photosynthate production and their translocation efficiency. Total sugar and reducing sugar contents were generally low during November, while SLW was observed at lower level in March in all the cultivars, indicated better photosynthate movement from leaves in March and SLW level increased likewise sugar content from morning to noon and decreased gradually till evening. Higher photosynthates production and greater translocation was observed in Chausa and Langra and its maximum level was recorded during full bloom stage (March). The study brings out the importance of SLW for screening the genetic stocks of mango cultivars with regard to photosynthetic rate and translocation of photosynthates from leaves to other plant parts.

INTRODUCTION

Photosynthesis process seems to be quite important as it contributes a lot to growth, development and fruit yield in plants but perennial trees like mango have very low orchard efficiency [1] in terms of commercial fruit production and many commercial cultivars have a tendency for biennial or alternate bearing although it bears luxuriant growth. The exhaustion of the carbohydrate supply by fruiting has been implicated as one of the factors responsible for biennial bearing in mango [1]. Vigorously growing mango cultivars have low starch contents [2, 3] and diversion of assimilates from shoot apices to floral primordia results floral inhibition. Low rate of photosynthate production and lower partitioning may be one of the reasons for its low productivity. Plant growth and yield is the product of photosynthesis and accumulated photosynthates which regulate critical growth events under stress situations but at flowering and fruiting, the increased demand is to be met by current photosynthesis from the existing source, the leaves. Photosynthates produced by leaves are either used immediately by the nearest sink, the flowers and fruits [4], or in other situations stored throughout the tree, if the sink is limited. Hence, photosynthates production plays an important role in the plant productivity however, it varies from location to location and genotype to genotype. Chacko *et al.* [5] also reported significant differences in photosynthesis rate in mango cultivars. Keeping this in view, mango cultivars were evaluated for leaf photosynthesis at two developmental stages, full flowering and fully developed fruit stage. Photosynthates translocation also plays an important role in meeting the urgent requirement of sink, fruit and leaves. Therefore, changes in SLW, total and reducing sugar contents were worked out to know the behavior of photosynthate movement / translocation from the leaves.

The photosynthetic potential of leaves is reported to be quantitatively inherited [6] may be more useful if it is coupled with faster translocation efficiency which results in higher yield. However, the information on the variability in leaf photosynthates translocation efficiency in mango is very meager. Screening large number mango genotypes for photosynthates translocation efficiency is very difficult, as it is time consuming hence, the development of selection criterion would be desirable. Specific leaf weight (SLW), defined as the leaf dry weight per unit area, has been reported to have a strong association with total sugar and photosynthates production [7, 8]. Therefore, the present study was undertaken with the view to assess the variability in the photosynthetic rate and their translocation efficiency in terms of leaf total and reducing sugar contents and their impact on SLW.

MATERIALS AND METHODS

Twenty five cultivars of 25 years of age representing different agro-climatic regions at the Central Institute for Subtropical Horticulture, Lucknow, located at latitude 26.55°N and longitude 85.59°E in the subtropical zone of India, were evaluated for leaf photosynthetic rate at two stages, i.e. full bloom (March) and full grown stage of fruit (May). The photosynthetic rate (Pn) was measured in the previously tagged leaves by portable photosynthesis system

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(LI - 6200) at 11:00 a.m. at both the stages. The fully matured middle leaves as were standardized for mango [9] facing towards east-south direction was used for measuring photosynthetic rate. Ten leaves per tree were selected for its measurement and average data were presented.

In an another experiment five commercially grown mango varieties, Dashehari, Langra, Chausa, Amrapali and Mallika of the same age were selected for the purpose of determination of leaf area, leaf fresh weight, total sugar and reducing sugar contents thrice a day i.e. 7:30 a.m. morning, 12:30 p.m. noon and 5:30 p.m. evening at flower bud differentiation and full bloom stages.

The leaf samples were collected in the morning, noon and evening brought in polythene bags to the laboratory with minimum loss of time. Leaf area was measured by leaf area meter (LI - 3000) and fresh weight was recorded for each sample each time. The samples were then kept in preheated oven at 100°C and temperature maintained at 80°C till the constant weight of the dry leaves was recorded. SLW was calculated using dry weight of leaves and leaf area. Total and reducing sugar contents were analysed in the leaf samples following the method of Morris [10] using Spectrophotometer - Chemito 2010. All measurements were performed in triplicate and repeated thrice. The critical difference of the data were calculated at 5% (p = 0.05) as described by Panse and Sukhatme [11].

RESULTS AND DISCUSSION

The results presented in Table **1** revealed that the value of photosynthetic rate (Pn) was in general, comparatively low at full bloom stage (March) as compared to fully devel-

Table 1. Leaf Photosynthetic Rate (μ mol m^{-2} s^{-1}) in Different Mango Cultivars at Full Bloom and Fully Developed Fruit Stage

S. No.	Genotypes	Photosynthetic Rate	
		Full Bloom Stage	Fully Developed Fruit Stage
1	Papatio	7.518	8.900
2	Lucknow Safeda	7.479	8.610
3	Neelam	7.384	8.134
4	Mulgoa	7.194	7.547
5	Khas-ul-Khas	7.156	7.468
6	Himsagar	7.155	7.144
7	Nisar Pasand	7.144	7.140
8	Kishan Bhog	6.040	6.080
9	Langra	6.006	6.061
10	Chausa	6.004	6.060
11	Kesar	5.896	6.047
12	Fazari	5.808	6.020
13	Vanraj	5.588	6.012
14	Fernandin	5.562	5.990
15	Dashehari	5.469	5.965
16	Mallika	5.300	5.593
17	Amrapali	4.660	4.724
18	Rataul	4.090	4.106
19	Alphonso	4.000	4.091
20	Banglora	3.195	3.902
21	Swernerkha	3.100	3.190
22	Benganpalli	2.993	3.100
23	Bombay green	2.990	3.092
24	Zardalu	2.982	2.990
25	Mankurad	1.998	2.580
CD at 5% (p = 0.05)		**0.412**	**0.802**

oped fruit stage (May) in all the genotypes but the trend of genotypic Pn was almost similar at both the stages. Seven genotypes Papatio, Lucknow Safeda, Neelam, Mulgoa, Khas ul Khas, Himsagar and Nisar Pasand showed the higher photosynthetic rate at both the stages while nine genotypes, Kishan Bhog, Langra, Chausa, Kesar, Fazri, Vanraj, Fernandin, Dashehari and Mallika showed medium Pn in the same environmental conditions. Rest of the genotypes was poor in Pn rate at both the stages. Significant variation in the Pn in mango cultivars suggested that there is a possibility of improvement in their photosynthetic efficiency through breeding manipulations.

Results presented in Table **2** suggest that specific leaf weight (SLW) differed significantly and was comparatively low during full bloom stage (March) in all the mango cultivars. The increase in SLW was maximum from morning to noon as was recorded in Langra (36.0 and 31.2%) and Chausa (33.8 and 28.5%) during flower bud differentiation (November) and full bloom stage (March), respectively. This indicated the higher photosynthate production and accumulation in leaves due to higher photosynthetic rate from morning to noon. The SLW decreased at evening and the maximum reduction was recorded in Langra (15.3 and 14.6%) and in Chausa (15.5 and 15.8%) in both the stage of observation i.e. flower bud and full bloom stages, respectively which indicates the higher rate of photosynthate translocation from source (leaves) to sink (other plant parts). Saini and Joshi [7] also observed similar trend while working on ragi leaves.

Total sugar contents was also varied significantly in different mango cultivars during both the stages of flowering (Table **2**) and total sugar markedly increased in leaves up to noon and maximum increase was recorded in Chausa (303.0 and 304.1%) and in Langra (249.0 and 298.0%) during flowering bud differentiation stage (November) and full bloom stage (March), respectively. However its level was decreased from noon to evening and greater reduction was observed in Langra (47.9 and 57.5%) and in Chausa (41.4 and 51.6%) in the corresponding stages of flowering, which suggests the superiority of these cultivars in Pn and photosynthate translocation efficiency. Similar informations are available showing marked variation in total sugar content during day time in other crops [7].

Reducing sugar contents has also showed significant variation among the cultivars (Table **2**). In general reducing sugar was higher at full bloom stage in all the cultivars. Increase in reducing sugar content from morning to noon was noticed in both the stages but was more marked at full bloom stage in both Chausa (94.2 and 105.2%) and Langra (119.1 and 137.1%) cultivars. The reducing sugar contents decreased at evening and decline was observed maximum in Chausa (72.5 to 73.5%) and Langra (70.0 to 74.4%) in corresponding stage of flowering as compared to rest of the cultivars. However, the rate of reduction of reducing sugar was comparatively more than total sugar content.

The present study clearly showed the similar pattern of diurnal changes in SLW, total and reducing sugar in fully

Table 2. Changes in SLW, Total Sugar and Reducing Contents at Two Stages in Five Mango Cultivars

Genotypes	Flower Bud Differentiation Stage														
	SLW (mg / cm^2)					Total Sugar (mg / g fw)					Reducing Sugar (mg / g fw)				
	Morning (1)	Noon (2)	% Increase (1 to 2)	Evening (3)	% Decrease (2 to 3)	Morning (1)	Noon (2)	% Increase (1 to 2)	Evening (3)	% Decrease (2 to 3)	Morning (1)	Noon (2)	% Increase (1 to 2)	Evening (3)	% Decrease (2 to 3)
Dashehari	15.8	18.5	17.1	16.9	-8.7	0.182	0.444	144.0	0.323	-27.3	0.071	0.118	66.2	0.044	-62.7
Langra	12.5	17.0	36.0	14.4	-15.3	0.172	0.601	249.4	0.313	-47.9	0.069	0.134	94.2	0.039	-70.0
Chausa	14.5	19.4	33.8	16.5	-15.5	0.199	0.802	303.0	0.470	-41.4	0.066	0.138	119.1	0.038	-72.5
Amrapali	16.0	19.0	18.8	17.8	-6.3	0.282	0.613	117.4	0.401	-34.6	0.079	0.129	63.3	0.058	-55.0
Mallika	15.3	17.8	16.3	16.2	-9.0	0.193	0.424	119.7	0.282	-13.5	0.070	0.109	55.7	0.050	-54.1
CD at 5%	1.64	1.22		1.06		0.0073	0.081		0.019		0.0034	0.009		0.0033	
Full Bloom Stage															
Dashehari	15.0	17.0	13.3	15.8	-7.1	0.243	0.684	181.5	0.423	-38.2	0.083	0.148	78.3	0.054	-63.5
Langra	12.5	16.4	31.2	14.0	-14.6	0.202	0.804	298.0	0.342	-57.5	0.076	0.156	105.3	0.040	-74.4
Chausa	12.3	15.8	28.5	13.3	-15.8	0.196	0.792	304.1	0.383	-51.6	0.070	0.166	137.1	0.044	-73.5
Amrapali	13.7	16.3	19.0	15.0	-8.0	0.232	0.603	159.9	0.413	-31.5	0.088	0.153	73.9	0.073	-52.2
Mallika	14.4	16.8	16.7	15.4	-8.3	0.257	0.700	172.4	0.444	-36.6	0.080	0.133	66.2	0.059	-55.6
CD at 5%	1.20	1.22		0.96		0.0067	0.053		0.025		0.0068	0.071		0.0032	

expanded leaves of mango, therefore, SLW may be used as one of the selection criterion for screening the photosynthate translocation efficient mango genotypes under north Indian condition. Strong association of SLW with leaf sugar contents have also been reported in other crops [7].

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REFERENCES

[1] Chacko EK, Randhawa GS. Towards an understanding of the factors affecting flowering in mango (*Mangifera indica* L.). Andhra Agri J 1971; 18: 226-36.

[2] Whiley AW, Saranah JB, Wolstenholme BN. Effect of temperature on growth, dry matter production and starch accumulation in 10 mango (*Mangifera indica* L.) cultivars. J Hortic Sci 1989; 64: 753-65.

[3] Whiley AW, Saranah JB, Rasmuseen TS, Winston EC, Wolstenholme BN. Effect of temperature on 10 mango cultivars with relevance to introduction in Australia. Proc. 4th conf. on Tree and Nut. ACOTANC, Lismore 1988; pp. 176-85.

[4] Finazzo SK, Davenport TL, Sckffen B. Partitioning of photosynthates in avocado (*Persea americana* Mill) during flowering and fruit set. Tree Physiol 1994; 14: 153-64.

[5] Chacko EK, La P, Kohli RR. Photoassimilation production and distribution in relation to productivity in mango (*Mangifera indica* L.), Mango – 2000. Marketing Seminar and Production Workshop Proceedings 1995; Distribution of Primary Industries, Brishbane.

[6] Ojima M, Kawashima R, Mikoshiba K. Studies on the seed production of soybean. VII. The ability of photosynthesis in F_1 and F_2 generation. Crop Sci Soc Japan Proc1969; 38: 693-9.

[7] Saini JP, Joshi HC. Diurnal variation in SLW and total sugar in the leaves of ragi. Himalayan Res Develop 1989; 6: 23-4.

[8] Guru SK, Jain V, Pal M, Abrol YP. Relationship between specific leaf weight and photosynthetic rate in two wheat genotypes. Indian J Plant Physiol 1999; 4: 117-20.

[9] Yadava RBR, Singh VK. Selection of leaf and time for photosynthesis in mango (*Mangifera indica* L.) trees. Indian J Plant Physiol 1995; 38: 186-7.

[10] Morris L. Quantative determination of carbohydrates with Drey Wood's Anthrone reagent. Science 1948; 107: 254-5.

[11] Panse VG, Sukhatme P. Statistical Methods for Agricultural Workers, 4th ed. ICAR: New Delhi 1985.

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