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Relationship of Leaf and Fruit Transpiration Rates to the Incidence of Softening of Tissue in Mango (*Mangifera indica* L.) Cultivars

V.K. Singh, D.K. Singh and S.M. Pathak
Fruit Physiology Laboratory,
Division of Crop Improvement and Production,
Central Institute for Subtropical Horticulture,
Rehmankhera, Lucknow 227 107, India

Abstract: Softening of tissue is a serious problem of mango. It is thought that it may be due to deficiency of minerals specially calcium. Low uptake, movement and distribution of calcium which is controlled by the movement of water through transpiration stream could be one of the main reasons for the incidence of softening in mango. Therefore, the relationship of leaf and fruit transpiration rates with the incidence of softening of tissue in mango cultivars. Dashehari (susceptible) and Chausa and Langra (free from softening tissue) were investigated. Leaf transpiration rates were similar in both the cultivars, however the fruit transpiration rates were significantly higher in cultivar Chausa followed by Langra. Artificially induced variations in fruit transpiration rates using perforated polythene covers, paper bags and vaseline coating of fruits also resulted in significant changes in the occurrence of softening tissue in cv. Dashehari along with alternation in chlorophyll, TSS (°Brix) and carotenoid content in different treatments. The significant and negative relationship ($r = -0.436$ and -0.521) observed between the fruit transpiration rates and softening tissue suggests that the lower fruit transpiration rates in cultivar Dashehari are a varietal specific trait, which results in slower movement of water and mineral to the fruits from the soil/leaf leading to the development of softening of tissue in mango.

Key words: Softening of tissue, transpiration, mineral nutrition, mango

Introduction

Mango is the largest subtropical fruit in India with a total production of approximately 10.99 million metric tonnes but contributes almost nonsignificant towards export. The choice of a commercial grower in northern India particularly in UP, is most confined to Dashehari, Chausa and Langra cultivars. Dashehari is a most delicious and leading commercial variety, however, this cultivar is cursed with several physiological disorders among them, softening of tissue is one of the main burning problem, which brought down the export of this variety. This is characterised by loosening of pulp tissue, jelly formation with browning of tissue around the stone by disintegration of pulp during the advance stage of maturity of fruit. The shelf life and firmness of fruit declined due to this problem and rendered poor marketability of produce. Causative factors for the onset of this disorder are not known. It was thought that it may be due to deficiency of minerals, especially calcium as it has been known to play a role in physiological disorder in temperate and tropical fruits (Martin *et al*., 1975; Joyce *et al*., 2001). A number of workers have reported that pre-or postharvest application of Ca^{++}

Corresponding Author: V.K. Singh, Fruit Physiology Laboratory, Division of Crop Improvement and Production, Central Institute for Subtropical Horticulture, Rehmankhera, Lucknow 227 107, India

extended the shelf life of climacteric fruits including mangoes by maintaining firmness, reducing respiration and ethylene production, to delay the onset of ripening and increasing marketability (Cheour *et al*., 1990; Mootoo, 1991; Van Eeden, 1992). It was also reported that fruits treated with 0.6% Ca^{++} as $CaCl_2$ was free from softening of tissue and the treated fruits could be stored for longer period (Singh *et al*., 1993). The fruits with higher calcium content soften more slowly have led to investigation of the mechanism of calcium action in delaying cell wall breakdown. It is known that the enzyme polygalactouranose (PG) is important in softening as its activity increase immediately after the onset of ripening. The inhibition of PG was reported by $CaCl_2$ (Poovaiah and Nukaya, 1979). In most fruits studied the dissolution of the middle lamella followed by cell separation occurs largely as a result of PG-catalysed degradation of pectic rhamno galactouronase (Hobson, 1981). This dissolution of pectic polymers appears to be the primary cause of tissue softening (Dey and Brinson, 1984).

Contrary to these report deficiencies of mineral specially calcium was not recorded recently in the soil and leaves of mango located at different orchards where the incidence of internal breakdown was prevalent and results with pre harvest sprays of calcium were also inconsistent (Singh, 2004). Similar findings were also reported by other workers for somewhat similar physiological disorder i.e., spongy tissue in Alphonso mango (Gunjate *et al*., 1979, Katrodia and Sheth, 1988). Contradictory results with respect to the above findings may be due to the immobility of calcium through the phloem and also to the effect of environmental factors on the disorder. Environmental factors like relative humidity and light were not given due importance by the earlier workers. These factors were found to have greater influence on the growth and development of tomato and strawberry fruits (Choi *et al*., 1997). An increase in the incidence of internal breakdown was noticed when the fruits were either harvested late or after a spell of heavy rains (Pers. observation). High atmospheric humidity levels have been reported to be related to many fruit disorders in other crops (Bangerth, 1979; Holder and Cockshull, 1990). This may be mainly due to the lower transpiration from the leaves and fruits leading to the lower transportation of mineral nutrients to the fruits (Menzel and Kirkby, 1987). However, no work has been done in this line to know the exact cause of this disorder. Therefore, in this present study an attempt was made to understand the relationship between the softening of tissue around the stone and the transpiration rates of leaves and fruits in susceptible and resistant mango cultivars during the later stage of fruit development.

Materials and Methods

The study was conducted using 20 years old Dashehari (susceptible), Chausa and Langra (free from this disorder) trees at Rehmankhera Farm of the Central Institute for Subtropical Horticulture, Lucknow located at latitude 26.55°N and longitude 85.59°E and at an altitude of 128 m MSL, during the year 2003-2004, 2004-2005. Fifty fruits were randomly labelled on five trees (10 fruits on each tree). Leaf as well as fruit gas exchange parameters were recorded from the second week of May and to second week of June using portable photosynthesis system (Model Licor-6200, closed system). Leaf and fruit gas exchange parameters were recorded using 0.25 and 4.0 l chambers and expressed per unit area and per unit weight respectively. All the parameters were recorded during bright sunny days between 10.30 to 11.30 h as was standardised earlier (Yadava and Singh, 1995). Fruits were 70-90 days old at the time of first observation in both the cultivars.

Five more Dashehari trees were selected for altering the fruit transpiration rates. Fruits were selected for vaseline smearing, polythene and paper bag covering treatments as explained above. Vaseline was smeared during the first week of May to reduce the transpiration of fruits. In other

Table 1: Leaf photosynthesis and transpiration rate in mango cultivars

	Photosynthesis rate (μ mol CO_2 m^{-2} s^{-1})		Transpiration (m mol H_2O m^{-2} s^{-1})	
Cultivars	IInd week of May	Ist week of June	IInd week of May	Ist week of June
Dashehari	6.21	6.9	3.5	3.9
Chausa	7.61	8.2	3.6	4.1
Langra	4.69	5.1	3.4	3.8
CD ($p = 0.05$)	0.65	0.71	NS	NS

Table 2: Gas exchange parameters of fruits recorded in the IInd week of May (I) and Ist week of June (II) of mango in the field

	Transpiration (m mol H_2O m^{-2} s^{-1})		Respiration (μ mol CO_2 m^{-2} s^{-1})	
Cultivars	I	II	I	II
Dashehari	3.7	4.6	7.21	10.63
Chausa	6.6	9.3	9.53	8.75
Langra	5.5	7.8	8.05	9.15
CD ($p = 0.05$)	0.62	0.73	0.85	0.78

Table 3: Fruit gas exchange parameters in fruit during IInd week of May (I) and 2nd week of June (II) in mango cv. Dashehari

	Transpiration (m mol H_2O m^{-2} s^{-1})		Respiration (μ mol CO_2 m^{-2} s^{-1})		
Cultivars	I	II	I	II	Internal breakdown (%)
Control	3.4	3.7	7.21	8.24	40.2 (127.57)
Vaseline	1.2	1.3	4.47	6.51	51.4 (163.12)
Polythene	8.9	7.1	6.35	9.26	10.28 (32.62)
Paper bag	8.0	7.5	6.50	9.01	11.56 (36.69)
CD ($p = 0.05$)	0.62	0.25	0.85	0.52	-

Data in parentheses are the angular transformed values of percent affected fruits

treatments, perforated polythene cover and paper bag were used to cover the fruit to increase transpiration. Perforation made in the cover avoided the build up of humidity; however, the temperature rose inside the cover (data not reported) due to radiation trapping and increased the transpiration rates of fruits.

Fruits were harvested during second week of June and allowed to ripen under normal conditions in storage boxes. Incidence of softening of tissue was recorded after slicing the fruit and expressed as percent affected fruit within a treatment. Photosynthesis, transpiration rate, rate of respiration and quality parameters viz., chlorophyll content, TSS, acidity and carotenoids was estimated over varieties using completely randomised design.

Results

It is clear from the data presented in Table 1 that there were significant differences between the cultivars in photosynthetic rate however; the differences in leaf transpiration rates were non-significant. Data on fruit gas exchange parameters (Table 2) clearly showed significant differences between the cultivars in both transpiration as well as respiration rates as indicated by higher transpiration rate in Chausa and Langra as compared to Dashehari. However, transpiration was nearly double in cv. Chausa, hence fruit transpiration rather than the respiration rate was probably more closely associated with development of softening of tissue in fruits.

To substantiate this hypothesis, the fruit transpiration was artificially manipulated in the field in cv. Dashehari. Vaseline coating was used to decrease the transpiration. Covering fruits by perforated polythene covers and paper bag were used to increase the transpiration. Paper bag covering was used

Table 4: Chlorophyll content of peel in mango cv. Dashehari after six day of storage

Treatment	Chl. a (mg g^{-1} FW)	Chl. b (mg g^{-1} FW)	Total chl. (mg g^{-1} FW)
Control	0.018	0.014	0.032
Poly bag	0.017	0.015	0.031
Paper bag	0.020	0.020	0.041
Vaseline	0.040	0.034	0.075
CD (p = 0.05)	0.005	0.004	0.002.

Table 5: Biochemical changes in different treatments of mango cv. Dashehari after six day of storage

Treatment	TSS (°Brix)	Acidity (%)	Carotenoid (mg/100 g)
Control	18.50	0.97	5.62
Poly bag	20.00	0.90	5.42
Paper bag	19.63	0.57	4.97
Vaseline	17.50	0.84	4.51
CD (p = 0.005)	1.24	0.15	0.93

in this experiment based on the previous finding (Pandey and Tandon, 2004) in which it was reported that paper bag covering induces the uniform ripening along with minimum incidence of softening of tissue in Dashehari mango.

Polythene and paper bag covering treatment significantly increase the transpiration rate of fruit as compared to the control (Table 3). On the other hand vaseline coating significantly reduced the fruit transpiration. The respiration rate of fruits also showed differences between the treatments with lowest rate in the vaseline coated fruits. The transpiration rate was more than doubled in polythene and paper bag covered fruits as compared to the control. These fruits also showed a significant reduction in the incidence of softening of tissue. Reduction in transpiration rate by vaseline coating on the other hand marginally increased the incidence of the disorder. Correlation co-efficient between transpiration and the incidence of internal breakdown also indicated a significant negative relationship (r = -0.436 and -0.521). Uniform ripening with good colour was also obtained in the covered fruits. The colour breakdown in terms of chlorophyll content in the fruits of all the treatment was analysed. The minimum total chlorophyll (0.031 mg g^{-1} f.w.) content was found in poly bag's cover fruits followed by control fruits whereas the maximum total chlorophyll content (0.075 mg g^{-1} f.w.) was recorded in vaseline coated fruits (Table 4).

The carotenoids, TSS and acidity were also determined in the treated fruits and compared with the control after 7 days of the storage. The TSS level was low in vaseline coated fruit, however, there was significant increase in its level in poly and paper bags treatments as compared to control (Table 5). Variation in acidity was recorded in different fruits harvested from different treatment being minimum acidity (0.57%) in paper bag covered fruit as compared to highest in control (0.97%). On the other hand significant decrease in carotenoid (4.51 mg 100 g) was obtained in vaseline treated fruit when compared to control, the other treatments did not show significant difference in carotenoid level.

Discussion

The incidence of softening of tissue in mango even in the calcium and other nutrient rich soil orchard's and inconsistent results obtained by calcium spray may be mainly due to the immobility of the minerals specially calcium through the phloem. Calcium is known to delay softening in apples by virtue of its ability to delay degradation of the cell wall polymers (Sams and Conway, 1984). Thus, lack of uptake, movement and distribution of calcium which is controlled by the movement of water through the transpiration stream (Choi *et al*., 1997) could be one of the main reasons for the incidence of softening in a susceptible cultivar Dashehari.

The present results show that the leaf transpiration rates did not differ significantly between the cultivars even though there was a difference in photosynthetic rates during the later stages of fruit development. This shows that the movement of calcium to the leaf may not be a problem in the susceptible cultivar Dashehari. However, the movement of calcium from root or leaf to the fruit can also be controlled by the fruit transpiration. Data on fruit transpiration clearly show a difference between the cultivars. In other crops transpiration is reported as one of the important reasons for high fruit disorders when grown under high humidity (Bangerth, 1979; Holder and Cockshull, 1990). This was further evident by the higher incidence of softening of tissue observed in late harvested fruit after a spell of rains. In this case high humidity (>85.0%) associated with the rains would have reduced the transpiration rate of fruit; thereby increasing the incidence of softening of tissue in Dashehari. A significant reduction in this disorder along with improvement in fruit quality in the fruits when the fruit transpiration was elevated by using perforated polythene and paper covers as well as marginal increase in the incidence when fruit transpiration was minimised through vaseline, substantiates the fact that fruit transpiration is involved in the development of internal breakdown in mango. Similar results were also reported in other crops when grown under different humidities (Clarkson and Hanson, 1980; Menzel and Kirkby, 1987). Therefore, in mango suitable technologies should be developed to enhance the fruit transpiration in the field to reduce the incidence of softening in mango.

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