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Short communication

Stomatal behaviour of Red Delicious apple leaves as influenced by different moisture levels

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Water in plants and animals contributes as much to the essential properties of life as do fats, proteins, carbohydrates and minerals. It is the principal medium in which all metabolic processes occur in plants. It not only serves as a carrier of ions to and from cells, but also participates in all the processes of plant growth and development (Westwood, 4). The process of transpiration in plants and the opening and closing of stomata in the leaves is controlled by soil moisture. Success in commercial fruit culture largely depends upon availability of sufficient moisture, particularly during critical periods of tree growth and fruit development. However, because of the positive influence of irrigation on tree growth, fruit yield and quality of apple fruit, the development and adoption of an efficient irrigation regime is of prime importance which is still lacking in Kashmir region.

The present studies were conducted at the research farm of Division of Pomology, SKUAST, Shalimar, Srinagar for two consecutive years. The research farm is situated at 34' 1°N latitude and 74'89°E longitude at an elevation of 1685 m amsl. The annual rainfall during the study was 1052.5 and 706.2 mm, respectively with annual evaporation of 796.5 and 925.5 mm during respective years. The maximum and minimum temperature ranges between 5.6 to 29.3°C and - 2.5 to 16.5°C during 1st year and 2.7 to 31.2°C and - 0.18 to 18.6°C during 2nd year of study. Eighteen-year old Red Delicious apple trees grafted on M9 rootstock were selected, labelled and grouped into four replications and six treatments (moisture regimes) with five trees per treatment. Recommended cultural practices were performed regularly. Six moisture regimes were given on the basis IW:CPE ratios with irrigation depth (IW) of 7.5 cm in the tree basins having radius of 101.0 cm and the cumulative pan evaporation (CPE) was determined by adding daily evaporation rates as obtained from US Weather Bearuae Pan evaporimeter.

There were six different treatments, *i.e.* T_1 = IW:CPE (Control) – CPE (00 mm), T_2 = IW:CPE (0.25) – CPE (300 mm), T_3 = IW:CPE (0.50) – CPE (150 mm), T_4 = IW:CPE (0.75) – CPE (100 mm), T_5 = IW:CPE (1.00) – CPE (75 mm), T_6 = IW:CPE (1.25) – CPE (60 mm), respectively. In all treatments, the irrigation was applied when the cumulative pan evaporation after deducting rainfall received during the period. Stomatal studies were carried out by replica method using adhesive quick fix as described by Beakbane and Majumder (1). Immediately after collection of leaf sample from each treatment, a thin film of adhesive was applied on the dorsal surface of the leaf, midway between the third and fourth vein counting from promixal end of the leaf blade on one side only. After sometime the dried film tighter with the leaf hair on the lower surface of leaf were removed and discarded. A very thin film of quick fix was immediately applied on the same area and the dried film bearing impression of the cuticle was stripped off with the help of colourless adhesive tape. These prints along with adhesive tape were fixed on dry glass slides and studied under microscope (10 × and 40 ×). The observations were taken in June in both the years. For statistical analysis factorial randomized block design was followed and the critical differences were calculated to find out the significance among treatments. The data were analyzed by the procedures adopted by Cochran and Cox (3).

The data in Table 1 revealed that there was a gradual increase in all the characters and were significantly influenced by moisture regimes. In both the years, maximum leaf area (45.13 cm^2) and (48.84 cm^2) was recorded under the treatment T_6 whereas minimum (36.31 and 38.22 cm^2) in treatment T_1, *i.e.* control. Leaf area was significantly higher than other treatments under T_6 treatment. However, treatment T_1 was at par with T_2, T_3 and T_4 in the first year and with only T_2 in the second year. The average of two years indicated a similar trend with respect to maximum and minimum leaf area of 46.98 and 37.26 cm^2 in treatments T_6 and T_1, respectively.

Moisture regimes have direct effect on the density, pore length and pore width of the stomata. During the first year of study, maximum number of stomata (22.75) was counted in the treatment T_6, which was at par with the treatment T_5. The minimum number of stomata (20.50) was observed in T_3. Similar trend was recorded

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in the second year. The stomatal pore length recorded a significant increase with increase in soil moisture under different moisture regimes. The maximum stomatal pore length (21.55 and 22.40 µm) in both the years was recorded under T_6 moisture regimes, whereas, the minimum (17.92 and 19.55 µm) in both the years was observed in plants under T_3 and T_1 treatments, respectively. However, the treatment T_6 was statistically at par with treatments T_5 and T_4 during both the two years. In both the years, *i.e.* in first (8.72 µm) and second (10.37 µm), maximum stomatal pore width was recorded in T_6 and minimum i.e. 7.55 µm in first year and 8.32 µm in second year was observed in T_1 (control). The treatments T_1, T_2, T_3, and T_4 did not show any significant variation for pore width of stomata size in the first year and T_2, T_3, T_4, T_5 in the second year of study. Averages of two years indicated the maximum (9.54 µm) and the minimum (7.93 µm) pore width under T_6 and T_1 moisture regimes, respectively.

The leaf area of Red Delicious apple, *i.e.* its stomatal density (number of stomata), stomatal pore length and width were significantly influenced by various moisture regimes. This increase in length and width of stomata can be attributed to the increased turgor pressure in guard cells with increased leaf relative water content. Earlier Chandel *et al*. (2) also noted gradual increase in the leaf area, stomatal pore length and width with the increase in moisture levels whereas in case of number of stomata they did not record any significant difference. However, Xyloyannis *et al*. (2) observed a significant reduction in length and width of stomata under water deficit conditions.

Perusal of the data in Table 2 shows that moisture regimes had positive and highly significant correlation with leaf area (0.955) and stomatal size (0.937) suggesting that with the increase in water content under different moisture regimes, the leaf area and stomatal size (pore length and pore width) increased significantly. Leaf area (0.961) was also positively and significantly correlated with stomatal size. However, stomatal density was negatively correlated with stomatal size which is clear from the work of Yoon (6).

Present studies revealed that with the increase in moisture levels, the leaf area, stomata number, stomatal pore length and pore width also increased suggesting that moisture had direct effect on the leaves and its stomatal behavior on Red Delicious apples.

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Table 1. Effect of moisture regimes on leaf area, stomatal density, pore length and pore width.

Moisture regime (IW/CPE)	Leaf area (cm^2)			Stomatal density			Stomatal pore length (µm)			Stomatal pore width (µm)		
	1st year	2nd year	Average	1st year	2nd year	Average	1st year	2nd year	Average	1st year	2nd year	Average
T_1	36.31	38.22	37.26	21.50	22.75	22.12	18.17	19.55	18.86	7.55	8.32	7.93
T_2	38.64	39.05	38.84	22.00	23.50	22.75	18.05	20.37	19.21	7.87	8.90	8.38
T_3	39.13	42.36	40.74	20.50	22.50	21.50	17.92	19.92	18.92	7.95	8.67	8.31
T_4	39.40	44.29	41.84	21.00	23.75	22.37	20.15	20.87	20.51	8.07	8.92	8.49
T_5	40.74	43.73	42.23	22.25	24.00	23.12	20.45	21.40	20.92	7.97	9.47	8.72
T_6	45.13	48.84	46.98	22.75	24.75	23.75	21.55	22.40	21.97	8.72	10.37	9.54
$CD_{(0.05)}$	3.87	3.79		0.67	0.94		1.61	1.55		0.81	1.04	

Table 2. Correlation between moisture regimes and leaf area, stomatal density and stomatal size.

Character	Moisture regime	Leaf area	Stomatal density
Leaf area	0.955**		
Stomatal density	0.687	0.687	
Stomatal size	0.937**	0.961**	- 0.857*

Significant at **0.01 and *0.05.

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