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Effect of different moisture regimes on physico-chemical characters of Red Delicious/M_9 apple

Fayaz Ahmad Misger and Amit Kumar
Krishi Vigyan Kendra/Extension Training Centre
Sher-e-Kashmir University of Agricultural Sciences and Technology-Kashmir
Malangpora-192 308, Pulwama (Jammu and Kashmir), India.

Abstract

Status of water is arguably the single most important factor for any plant that must be controlled through irrigation to obtain higher yields of good quality produce. To achieve the good quality fruits from efficient moisture levels an attempt was conducted in the Division of Pomology, SKUAST-K, Shalimar, Srinagar with the Red Delicious apple trees grafted on M_9 rootstock. Six moisture regimes based on IW: CPE ratio were standardized and the observations were taken on the physio-chemical characters of eighteen year old apple trees. The findings of the present studies conclude that the fruit length (6.48 cm), fruit diameter (6.81 cm), fruit weight (153.62 g), fruit volume (163.35 cm^3) and juice content (53.86 %) increases with the increase of moisture, however, on contrast the firmness (14.71 $lbs/inch^2$), total sugars (6.31 %), reducing sugars (5.25 %), non-reducing sugars (1.06 %), TSS (12.61 %) and acidity (0.21 %) of the fruit decreases.

Keywords: Moisture regimes, apple, physico-chemical characters.

Introduction

Success in commercial fruit culture largely depends upon availability of sufficient moisture, particularly during the critical periods of tree growth and fruit development. A lack of water at a particular stage of the growing cycle may adversely reduce the quality of the fruits. As such, the scientific management of water using techniques such as proper irrigation can maximize production, improve fruit quality and increase water use efficiency of the orchards. As far as apple cultivation in Kashmir, very little scientific information is available on the water requirement as most of the apple orchards are situated in rather cool, rainy areas where irrigation is generally not practiced. To know the effect of different moisture regimes on the physio-chemical characters of Red Delicious apple, an experiment was conducted which ultimately gave an idea about an efficient irrigation regime for consistently maximum production of high quality fruits.

Material and Methods

The present studies were conducted at the research farm of Division of Pomology, SKUAST-K, Shalimar, Srinagar for two consecutive years. The research farm is situated at 34' 01°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 ranged 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 apple plant of Red Delicious cultivar grafted on M_9 rootstock were selected, labelled and grouped into four replications and six treatments (moisture regime) with five plants per treatment. Cultural practices were done regularly during the course of studies.

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.

Treatments	Irrigations applied at IW: CPE	CPE (mm)
T_1	Control	00
T_2	0.25	300
T_3	0.50	150
T_4	0.75	100
T_5	1.00	75
T_6	1.25	60

In all treatments, the irrigation was applied when the cumulative pan evaporation

after deducting rainfall reached the values as in above table. The observations were recorded on the physico-chemical characters like fruit length (cm), fruit diameter (cm). Fruit shape was determined by working out L/D ratio of the fruits and interpreted as (L/D ratio > 1= Oblong, L/D ratio = 1= Round, L/D ratio < 1= Flat), while fruit weight (g), fruit volume (cm^3), firmness ($lbs/inch^2$), juice content (%), acidity (%), TSS (%), reducing sugars (%), non-reducing sugars (%), total sugars (%), sugar/acid ratio were determined as per standard methods (AOAC, 1984). To judge the effect of different treatments, the data were analyzed by the procedures adopted by Cochran and Cox (1963).

Results and Discussion

All the studied characters recorded significant variation in response to different moisture regimes except juice content in the first year of study. Maximum fruit length (6.23 and 6.73 cm) and fruit diameter (6.79 and 6.84 cm) during both the years was recorded under T_6 treatment whereas minimum fruit length (5.58 and 6.38 cm) and fruit diameter (6.10 and 6.39 cm) was observed under T_1 treatment i.e. control. All the treatments were statistically at par with each other for both the characters and in both the years (Table 1). With increase in moisture regimes fruit weight of Red Delicious apple increased significantly during the period of studies. In the first year, maximum fruit weight (152.38 g) was recorded in T_6 treatment and minimum (141.03 g) in T_2 treatment. The treatments T_1, T_2, T_3, T_4 and T_5 were statistically at par with each other, however, in the second year maximum (156.72 g) fruit weight was recorded for T_4 treatment and minimum (144.33 g) for T_1 (control). The treatments T_1, T_2, T_3 and T_4, T_5, T_6 were at par with each other (Table 1). Moisture regimes also influenced fruit volume. T_6 treatment showed maximum (159.25 cm^3) and T_2 minimum (145.78 cm^3) fruit volume in the first year. Treatments T_1, T_2, T_3 and T_4, T_5, T_6 did not show any significant variation with each other. However, in the second year, the maximum (167.75 cm^3) and minimum (152.93 cm^3) fruit volume was recorded in T_6 and T_1 treatments. The treatments T_1, T_2, T_3 and T_4, T_5 were at par with each other (Table 1).

Both the years showed similar trend for fruit firmness, with T_1 (16.27 $lbs/inch^2$) as maximum and T_6 (14.71 $lbs/inch^2$) minimum. All the treatments were at par with each other in the first year, however, only treatment T_2 and T_3 did not show any significant variation in the second year for fruit firmness. The apples from trees with increased soil moisture yielded maximum juice content.

Fruit juice content was significantly influenced by various moisture regimes during second year of study, however, in the first year no significant effect was observed. During second year maximum (55.53 %) and minimum (50.94 %) fruit juice was obtained from T_6 and T_1 treatments, respectively. Acidity and total soluble solids (TSS) content were recorded minimum in the fruits receiving maximum moisture. No significant variation was recorded for acidity during the study, however, maximum (13.31 % and 14.12 %) TSS was recorded in T_2 and minimum (12.48 % and 12.74 %) was observed in T_6 treatment in the both years (Table 2).

Maximum total sugar (7.33 %) and reducing sugar (5.83 %) during the first year was recorded under the treatment T_2 whereas minimum (6.36 % and 5.33 %) was observed in T_6 treatment. However, in the second year maximum total sugar (7.70 %) and reducing sugar (6.04 %) was noted in T_3 treatment and minimum (6.26 % and 5.17 %) in T_6 treatment. Non-reducing sugar was observed to be maximum under T_5 (1.43 %) in the first year and in T_1 (1.86 %) in the second year, whereas minimum was recorded in T_6 treatment as 1.03 and 1.09 in the first and second year, respectively. All the treatments were statistically at par with each other in both the years for the total sugars, reducing sugar and non-reducing sugar. During both the years, maximum sugar/acid ratio was observed in the T_3 treatment which was significantly higher,

Table 1. Effect of moisture regimes on physical characters of Red Delicious/M_9 apple fruits

Moisture regimes (IW/CPE)	Fruit length (cm)			Fruit diameter (cm)			L/D ratio			Fruit weight (g)			Fruit volume (cm^3)		
	1st year	2nd year	Average	1st year	2nd year	Average	1st year	2nd year	Average	1st year	2nd year	Average	1st year	2nd year	Average
T_1	5.58	6.38	5.98	6.10	6.39	6.25	0.914	0.998	0.956	142.80	144.33	143.56	149.12	152.93	151.02
T_2	5.62	6.49	6.05	6.33	6.50	6.42	0.887	0.998	0.942	141.03	147.66	144.34	145.78	156.13	150.95
T_3	5.77	6.58	6.17	6.38	6.59	6.48	0.904	0.998	0.951	142.40	148.72	145.56	150.43	154.24	152.33
T_4	5.81	6.62	6.21	6.72	6.61	6.66	0.865	1.001	0.933	144.63	156.72	148.44	153.60	161.27	157.43
T_5	6.14	6.68	6.41	6.78	6.70	6.74	0.906	0.997	0.951	146.24	152.26	151.48	153.78	164.51	159.14
T_6	6.23	6.73	6.48	6.79	6.84	6.81	0.918	0.984	0.951	152.38	154.87	153.62	159.25	167.75	163.35
CD (P=0.05)	0.60	0.89		0.53	0.40		NS	0.014		6.78	4.57		7.01	5.17	

in the second year it was statistically at par with treatment T_1. Minimum sugar/acid ratio in the first and second year was recorded in the T_6 treatment which was statistically at par with the T_1 treatment in the first year and T_5 in the second year (Table 3).

It is evident from the results that the increase in moisture levels has direct effect on the physical and chemical characters of fruits of Red Delicious apple. Increase in fruit length and diameter as a result of increased soil moisture has also been reported by Blasse *et al.* (1988) and Hugget *et al.* (1992). This increase in fruit length and diameter could possibly be attributed to the increase in isodiametrical cell size under increased moisture levels due to pronounced cell hydration which results in cell extensibility. With the increase in soil moisture Mills *et al.* (1996) and Atkinson *et al.* (1993) also found increase in fruit weight. Ebel *et al.* (1995) reported suppression in fruit volume as a result of deficit irrigation compared to control (irrigated) which recorded increase in fruit volume. The rapid growth of fruit in terms of weight and volume of fruits corresponds to the phase of cell division followed by a transitory period of cell expansion or enlargement. The reduction in fruit firmness in the present study is attributed to the substantial increase in fruit size resulting from added irrigation (Unrath, 1972) because the smaller fruits tend to be firmer in view of high cellular density under un-irrigated conditions (Ebel *et al.*, 1993). The overall appraisal of the sugars, TSS and acidity indicated a decreasing trend with increase in soil moisture levels. Similar decrease in sugars with increase in soil moisture under irrigated conditions has been reported by Mills *et al.* (1994). This observed accumulation or high content of sugars under deficit irrigation has been reported to be a concentration effect due to reduced cell water content in the fruits (Mills *et al.*, 1996). The increase in TSS content under reduced moisture can possibly be attributed to the increased concentration of sugars as a result of conversion of starch to sugars and the high acid content under reduced moisture conditions can possibly be due to its high concentration under water stress conditions. The increase in juice content under high moisture levels in the present study could be due to sufficient available soil moisture resulting in bigger sized fruits which corresponds with the softening of the fruit flesh and as such maximum juice extraction. Similar observations were recorded by Mills *et al.* (1994). Fruits under high moisture levels are significantly less sweet as compared to fruits which received either no or moisture of medium rates as is clear from the present study. This may be attributed to the variation in sugar and acid contents of irrigated and un-irrigated fruits.

Table 2. Effect of moisture regimes on physico-chemical characters of Red Delicious/M_9 apple fruits

Moisture regimes (IW/CPE)	Firmness (lbs/inch^2)			Juice content (%)			Total soluble solids (%)			Acidity (%)		
	1st year	2nd year	Aver age	1st year	2nd year	Aver age	1st year	2nd year	Aver age	1st year	2nd year	Aver age
T_1	16.56	15.98	16.27	50.25	50.94	50.59	13.12	13.98	13.55	0.21	0.22	0.22
T_2	16.29	15.80	16.05	49.94	51.51	50.72	13.31	14.12	13.72	0.21	0.22	0.22
T_3	15.98	15.66	15.82	50.12	52.80	51.46	13.04	13.91	13.48	0.21	0.22	0.22
T_4	15.90	15.31	15.60	43.73	52.95	48.34	13.08	13.19	13.13	0.20	0.21	0.21
T_5	15.55	14.97	15.26	50.91	53.31	52.11	12.69	12.98	12.83	0.21	0.21	0.21
T_6	14.99	14.44	14.71	52.16	55.53	53.86	12.48	12.74	12.61	0.20	0.21	0.21
CD (P=0.05)	0.60	0.16		NS	0.99		0.40	0.28		0.03	0.01	

Table 3. Effect of moisture regimes on chemical characters of Red Delicious/M, apple fruits

Moisture regimes (IW/CPE)	Total sugars (%)			Reducing sugars (%)			Non-reducing sugars (%)			Sugar-acid ratio		
	1st year	2nd year	Average	1st year	2nd year	Average	1st year	2nd year	Average	1st year	2nd year	Average
T_1	6.97	7.56	7.26	5.59	5.69	5.64	1.38	1.86	1.62	31.05	35.90	33.47
T_2	7.33	7.26	7.30	5.83	5.56	5.69	1.26	1.70	1.48	33.11	34.35	33.73
T_3	6.98	7.70	7.34	5.70	6.04	5.87	1.29	1.67	1.48	35.92	36.79	36.35
T_4	7.04	6.88	6.96	5.70	5.68	5.69	1.34	1.20	1.27	33.92	33.16	33.54
T_5	7.08	6.40	6.74	5.64	4.87	5.26	1.43	1.53	1.48	33.91	31.05	32.48
T_6	6.36	6.26	6.31	5.33	5.17	5.25	1.03	1.09	1.06	30.35	30.68	30.51
CD (P=0.05)	0.71	0.84		0.43	0.91		0.27	0.39		1.09	1.78	

Conclusion

Present study clearly indicates that under high moisture regimes IW : CPE @ 1.25 (T_6) the quality of the fruit with respect to its length, diameter, weight, volume and juice content increased, however, the fruit firmness, sugars, total soluble solids and acidity was decreased.

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