IJANS International Journal of Agricultural and Natural Sciences
Uluslararası Tarım ve Doğa Bilimleri Dergisi
E-ISSN:2651-3617 1(3): 238-241, 2018

The Effects of Irrigation on Leaf Nutrient Content of Pomegranate

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Abstract

Pomegranate (*Punica granatum* L.) is a characteristic species of the Mediterranean area whose use and culture are of longstanding tradition. It is an important horticultural crop for both domestic and export markets in Turkey. It adapts to all kinds of climate and soil and it can tolerate long periods of drought once the plant is established but regular irrigation is mandatory in commercial production. We investigated the effect of different irrigation water amounts on nutrient uptake of 10-year old pomegranate trees two consecutive years. Three different irrigation water quantities were applied by drip irrigation system. First leaf samples were taken a week before starting the irrigation treatments and continued until the end of the harvest season with four weeks interval. Results showed that leaf contents of nitrogen, phosphorus, calcium, magnesium, and manganese were affected with quantity of irrigation water in the first year. In the second year, contents of phosphorus, copper, iron, manganese and zinc changed by the irrigation levels.

Key words: *Punica granatum* L, Pomegranate, Izmir 2, deficit irrigation, Plant nutrient

INTRODUCTION

The pomegranate belongs to the *Punicaceae* family. It is one of the oldest known edible fruits. Commercial pomegranate orchards are grown in many regions of the world, including the Mediterranean Basin countries. It adapts to all kinds of climate and soil. It is well adapted to the growth conditions in Turkey and Mediterranean countries are frequently found growing in wild or semi wild conditions. Favorable growth takes place where winters are cool and summers are hot. It is tolerant to drought, salinity, iron chlorosis and active limestone [3]. Pomegranate trees are considered as a crop tolerant to soil water deficit [5]. Regular irrigation is required for obtaining high-quality and bountiful yield. Deficit or excessive irrigation results in a decrease of both quality and the quantity of marketable fruits [12]. The pomegranate fruit reaches ripeness within 4.5 to 6 months after bloom, depending on cultivar and climatic conditions. The fruits should be harvested before they become overripe and crack. Fruit cracking generally happens during maturation period, and the number of cracked fruits rises with ripening. For controlling fruit cracking, it is of great significance to use resistant cultivars, avoid excessive nitrogenous fertilization, protect fruits from sunburn, irrigate regularly and adequately, not delay harvest, and harvest at multiple times [9]. Fruit culture in arid and semiarid areas must be directed towards the use of less water-demanding and more stress-resistant plant materials which, together with deficit irrigation, will allow significant water savings and the profitable production of high quality fruits [11]. Water scarcity in arid and semi-arid areas has led to development of new water saving techniques, such as sustained deficit irrigation [10]. Trees absorb water and nutrients mainly through their root system. Irrigation amount and frequency are very important because of relationship with water content of soil and nutrient uptake of plants.

This study was conducted to determine the effects of different irrigation amounts on leaf plant nutrients of pomegranate trees.

MATERIALS AND METHODS

This study was conducted with ‘Izmir 2’ pomegranate cultivar in the research orchard at Department of Horticulture, Faculty of Agriculture, Ege University of Izmir, Turkey during two consecutive years. The orchard is located in Bornova county of Izmir province of Turkey. The dominant climate condition is a mild Mediterranean climate type in Izmir. The orchard soil has clayey loam texture and weak alkaline reaction. Some physical and chemical properties of the soil were determined at the beginning of this study and given in Table 1. The experiment was designed in a randomized complete block design with three replications. In each replication one tree was used for sampling. Fertilizers were not applied during the experiment.

Three different irrigation water quantities (S_0 = no irrigation, S_1 = 50% and S_2 = 100% of the water quantity evaporating from class A pan) were applied by drip irrigation system. Emitters of system have taken place in the crown of the tree, and whole area per tree was not wetted. Irrigations were applied with 7-day interval. The quantity of irrigation water to be applied was calculated as given below formula.

Table 1. Soil physical and chemical properties of the pomegranate orchard.

Soil properties	Soil depth (cm)	
	0 – 30	30 – 60
Field capacity (% Pw)	26.95	25.67
Wilting point (% Pw)	16.94	16.55
Bulk density (g cm^{-3})	1.27	1.35
pH	7.42	7.47
Total salt content (%)	0.155	0.13
Lime (%)	13.22	14.46
Texture	Clayey loam	Clayey loam
Organic matter (%)	2.84	1.75
Total N (%)	0.098	0.1652
Uptakeable P (ppm)	2.60	0.99
Uptakeable K (ppm)	439	430
Uptakeable Na (ppm)	25	25
Uptakeable Ca (ppm)	5954	5954
Uptakeable Mg (ppm)	284	267
Uptakeable Fe (ppm)	2.95	2.51
Uptakeable Zn (ppm)	1.43	1.06
Uptakeable Mn (ppm)	2.34	1.63
Uptakeable Cu (ppm)	7.35	2.05

I = Epan ×Kcp × A × P
I: The quantity of irrigation water (liters)
Epan: The quantity of evaporation in class A pan (mm)
Kcp: Crop pan coefficient (0.50 for S_1 and 1.00 for S_2)
A: Tree area (18 m^2 per tree)
P: Wetted area percentage (%30)

Evaporation was measured in class A-pan placed near the research area. The crop pan coefficients (Kcp) for I_1 and I_2 irrigation treatment was taken 0.50 and 1.00, respectively. The soil moisture to the field capacity within 60 cm soil depth at each treatment was provided a week before starting the irrigation treatments. Irrigation was started 16th June and 6th July; finished 8th and 14th September in first and second years, respectively.

First leaf samples were taken a week before starting the irrigation treatments and continued until the end of the harvest season with four weeks interval. In the first year, leaf samples were taken June 5, July 3, July 31, August 28 and October. In the second year of experiment, they were taken June 25, July 23, August 20, September 17 and October 25. The leaf samples were taken totally five times in both years.

Nutrients content, except nitrogen, was measured with ICP OES emission spectroscopy (SpectroGenesis EOP II, Spectro Analytical Instruments GmbH, Kleve, Germany). Nitrogen analysis was made by the Kjehdahl method [7].

Statistical analyses of all data were performed with SPSS Version 16.0 (SPSS Inc., Chicago, IL, USA). Differences between the means were compared by Duncan test at a significance level of $P<0.05$.

RESULTS AND DISCUSSION

Depending on irrigation water quantity, leaf average nitrogen content varied between 1.406% – 1.666%, phosphorus between 0.162% – 0.188%, potassium between 0.973% – 1.059%, calcium between 2.488% – 2.875%, magnesium between 0.213% – 0.242%, copper between 28.272 – 39.918 ppm, iron between 76.417 – 90.438 ppm, manganese between 31.917 – 41.200 ppm and zinc between 22.103 – 27.864 ppm in the first year (Table 2). In the second year, those values were 1.381% – 1.586% for N, 0.314% – 0.272% for phosphorus, 1.378% – 1.794% for potassium, 2.719% – 3.139% for calcium, 0.218% – 0.236% for magnesium, 9.649 – 13.376 ppm for copper, 100.884 – 148.584 ppm for iron, 29.827 – 38.385 ppm for manganese and 29.500 – 48.326 ppm (Table 3).

Table 2. Nutrient contents of leaves (1st year)

Irrig. Treat.	Sample	N	P	K	Ca	Mg	Cu	Fe	Mn	Zn
	No	(%)	(%)	(%)	(%)	(%)	(ppm)	(ppm)	(ppm)	(ppm)
0% (S_0)	June, 05	1,443	0,239	1,147	1,440	0,158	47,360	98,034	24,846	36,622
	July, 03	1,345	0,236	0,995	1,638	0,196	38,048	92,802	33,420	32,839
	July, 31	1,316	0,185	1,076	2,222	0,242	53,477	107,968	34,924	32,780
	August, 28	1,483	0,120	0,878	2,340	0,235	15,938	62,633	31,974	16,891
	October, 5	1,443	0,161	0,770	2,875	0,236	26,673	90,752	34,423	20,186
	Average	1,406c	0,188a	0,973	2,103b	0,213b	36,299	90,438	31,917b	27,864
50% (S_1)	June, 05	1,597	0,206	1,190	1,734	0,171	48,952	73,548	25,425	26,422
	July, 03	1,528	0,183	1,085	1,882	0,215	32,989	80,436	31,458	23,750
	July, 31	1,568	0,173	1,299	2,558	0,272	70,505	120,740	36,767	39,738
	August, 28	1,598	0,114	0,854	2,777	0,248	32,320	66,002	35,717	19,878
	October, 5	1,551	0,147	0,870	3,489	0,243	14,822	71,273	33,225	19,561
	Average	1,568b	0,165ab	1,059	2,488a	0,230ab	39,918	82,400	32,518ab	25,870
100% (S_2)	June, 05	1,582	0,200	1,091	1,695	0,168	22,334	68,507	26,432	26,478
	July, 03	1,764	0,188	1,034	2,063	0,221	23,419	90,721	36,972	22,863
	July, 31	1,806	0,157	1,162	2,837	0,291	41,959	79,840	37,968	21,259
	August, 28	1,485	0,104	0,815	3,317	0,278	30,476	73,886	44,657	21,938
	October, 5	1,695	0,160	0,794	3,667	0,253	23,174	69,129	39,519	17,975
	Average	1,666a	0,162b	0,979	2,716a	0,242a	28,272	76,417	41,200a	22,103

Values followed by different letters in the column denote significant differences among irrigation levels at $P<0.05$.

Table 3. Nutrient contents of leaves (2nd year)

Irrig. Treat.	Sampling Date	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Cu (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)
0% (S_0)	June, 25	1,372	0,193	1,185	2,197	0,206	16,926	86,182	36,055	40,925
	July, 23	2,800	0,137	1,200	3,266	0,265	14,755	93,595	43,385	29,172
	August, 20	1,400	0,143	0,932	3,701	0,261	22,838	142,121	45,676	31,642
	September, 17	1,148	0,120	5,009	2,867	0,231	7,143	82,764	39,562	25,460
	October, 25	1,120	0,123	0,506	1,564	0,170	2,243	103,953	27,245	20,303
	Average	1,568	0,143a	1,767	2,719	0,227	12,781a	101,723b	38,385a	29,500a
50% (S_1)	June, 25	1,484	0,166	1,086	1,946	0,178	5,598	57,839	29,423	27,280
	July, 23	1,638	0,112	1,152	2,908	0,238	15,450	109,265	37,511	34,624
	August, 20	1,400	0,106	1,544	3,855	0,253	19,701	124,780	41,302	48,854
	September, 17	1,260	0,080	0,914	3,993	0,233	3,460	91,931	41,745	19,833
	October, 25	1,122	0,104	2,195	2,994	0,188	4,035	120,605	33,226	22,745
	Average	1,381	0,114b	1,378	3,139	0,218	9,649b	100,884b	36,641a	30,667ab
100% (S_2)	June, 25	1,526	0,166	1,160	2,311	0,209	4,243	237,049	27,841	125,098
	July, 23	1,848	0,124	1,339	2,790	0,256	24,154	164,400	32,188	43,977
	August, 20	1,610	0,106	1,376	3,501	0,288	21,815	142,935	34,406	23,453
	September, 17	1,456	0,085	3,439	3,658	0,222	12,087	87,818	28,981	27,047
	October, 25	1,291	0,113	1,655	3,030	0,206	4,683	110,719	25,721	22,057
	Average	1,546	0,119ab	1,794	3,058	0,236	13,396a	148,584a	29,827b	48,326b

Values followed by different letters in the column denote significant differences among irrigation levels at $P<0.05$.

Nitrogen (N) content was significantly influenced by irrigation treatments only in the first year. It increased by the irrigation amount. In the second year it was higher at the non-irrigation and full irrigation treatments than mid-irrigation treatment while there was no difference among irrigation treatments. In both years N content increased until July then started to decrease and reached the lowest level after the harvest time. Low leaf nitrogen concentration in spring was associated with a period of intense vegetative growth and this situation is caused by the transport to the fruits and other organs [1], and related to elevated accumulation of carbohydrates comparing to proteins in the plant during maturity period. Reductions in leaf N concentrations during season have also been observed by Hepaksoy et al. [3, 4].

Phosphorus content (P) was significantly influenced by irrigation treatments in both years. Also it was changed significantly throughout development periods. Leaf P level was highest in the first year and lowest in the second year at non-irrigated treatment. Average P contents were found to be 0,188%, 0,165% and 0,162% in the first year; 0,143%, 0,114% and 0,119% in the second year at the non-irrigated, deficit irrigation and full irrigation treatments, respectively. Leaf phosphorus (P) content decreased in all irrigation treatments starting from beginning of the vegetation period until towards ripening. The following harvest, it increased a little again. This changing was statistically significant in the both years (Table 2 and 3). Leaf phosphorus content is expected to decrease with vegetation because plants uptake a large portion of phosphorus and potassium they need during the first periods of development [6].

Leaf potassium (K) content did not change by the irrigation in both years, but the changes that took place with the progress of fruit development. In the first season, towards fruit ripening and after harvest time K content was obtained at the lowest level whereas to be found the highest level in the second season (Tables 2 and 3). Potassium plays a central role in maintenance of photosynthesis and related processes.

Calcium (Ca) contents were statistically affected by irrigation water quantities, between the sampling dates in the first year while the statistically significant differences were observed only between the sampling dates in the second year. In the first year Ca content increased by irrigation water quantities. In the first year calcium concentration of leaf were increased continuously throughout the vegetation season and reached the highest level after harvest time in all irrigation treatments (Table 2). It content was lower at the beginning of vegetation and after harvest, whereas higher content was observed in the middle of vegetation in all irrigation treatments in the second year (Table 3). Old leaves generally contain a higher level of calcium compared to young leaves. For this reason, as leaves got older with vegetation, the level of Ca was found to be higher [6].

Concentration (%) of magnesium (Mg) in the leaves was affected significantly by irrigation quantities in the first year whereas was not affected in the second year. In the first year, average Mg contents increased by the irrigation and it was found to be 0,213%, 0,230% and 0,242 % at the non-irrigated, deficit irrigation and full irrigation treatments, respectively. But they changed significantly during the season in both years. In general, Mg content was found to be higher in the middle of the development season compared to the beginning. The lowest values were found at the beginning of season in all treatments at the both years. Magnesium plays a key role in photosynthesis. The rate of bonding of total magnesium in plant leaves to chlorophyll molecule is closely associated with magnesium [8].

Copper, iron, manganese and zinc were analyzed as micro elements. The leaf copper (Cu) content was not affected significantly by irrigation treatments in the first season whereas was affected in the second season. They were higher at the non and full irrigation treatments than deficit irrigation treatment. Leaf copper contents differed during vegetation period in both years and the highest and lowest values were obtained at the middle of season and after fruit harvested, respectively.

In the first season of the experiment leaf iron content was not changed by the irrigation treatments while changed during the development season. In the second year it was contrary. Iron content of the leaf was decreased by the irrigation level in the first year but this changing was not significant as a statistical. In the second year contents were higher at the full irrigation treatment than other treatments and these differences were significant. Leaf iron was increased until mid- season and started to decrease towards ripening and after harvest it increased again in both years.

Manganese contents were statistically affected by irrigation water quantities and the sampling dates in the both seasons. In the first year it was increased, in the second year it was decreased by the irrigation water amounts. First year, average Mn contents were found to be 31,917 ppm, 32,518 ppm and 41,200 ppm at the non-irrigated, deficit irrigation and full irrigation treatments, respectively. Average contents were found to be 38,385 ppm, 36,641 ppm and 29,827 ppm at the non-irrigated, deficit irrigation and full irrigation treatments, respectively. In general Mn contents were higher in the mid season than beginning of vegetation period and after harvest time.

The contents of zinc (Zn) in leaves were not significantly affected in the first year, whereas they were affected in the second year by irrigation quantities. The highest average leaf zinc was obtained in the full irrigated in the second year contrary in the non-irrigated treatment in the first year. Generally, it decreased during vegetation periods and reached the lowest level after the harvest time in both years. Zinc is an essential trace element for plants, being involved in many enzymatic reactions and regulating the protein and carbohydrate metabolism [13]. For this reason it is necessary for their good growth and development. So it is expected that reducing throughout the vegetation season.

CONCLUSION

Experiment results showed that contents of nitrogen, phosphorus, calcium, magnesium and manganese in leaves were affected with quantity of irrigation water in the first year while phosphorus, cupper, iron, manganese and zinc were affected in the second year. In general higher concentrations were obtained from full irrigated trees. Leaf nutrient elements changed during the vegetation periods. Data showed differences between years. Irrigation frequency and amount is very effective on the uptake of water and nutrients by the plant [2]. Different results were obtained during the experiments seasons. For this reason irrigation experiments should be done for a long term.

ACKNOWLEDGEMENTS

The research was supported by the Ege University, Scientific Research Foundation.

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