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Effect of ammonium nitrate fertilizer and calcium chloride foliar spray on fruit cracking and sunburn of Manfalouty pomegranate trees

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ABSTRACT

A field experiment was carried out during 2013 and 2014 seasons on 13 years old Manfalouty pomegranate trees grown in sandy soil under drip irrigation system from well at El-Maghara Experimental Station, Desert Research Center, North Sinai Governorate, Egypt. The main objective of this work is to study the effect of four rates of ammonium nitrate fertilizer (600, 900, 1200 and 1500 g/tree) and three concentrations of calcium chloride spray at (0, 1 and 2%) on vegetative growth parameters, yield and fruit quality (especially fruit cracking and sunburn damage) of Manfalouty pomegranate trees. Obtained results showed that ammonium nitrate fertilizer and/or calcium chloride alone or in combination enhanced vegetative growth parameters, yield, fruit quality traits and reducing fruit cracking and sunburn damage through increasing vegetative development and thereby improve protection of the fruits from direct sunlight and the role of Ca in controlling physiological disorders of fruit.

1. Introduction

In Middle Sinai, Egypt, late cultivars such as 'Manfalouty' is considered one of the most important pomegranate cultivars grown successfully in Egypt that ripen in autumn and is exposed throughout the summer to strong solar radiation and hot temperatures where summer temperatures normally rise above 40 °C are much more vulnerable to fruits cracking and sunburn damage.

Pomegranate (*Punica granatum* L.) belonging to the family *Punicaceae* is one of the most favorable fruits of tropical and subtropical regions. The fruit is a native of Iran and is extensively cultivated in Mediterranean regions since ages, especially in Spain, Morocco, Egypt and Afghanistan (Sheikh and Manjula, 2012). Pomegranate arils, the edible portion of the fruit, are rich in sugars, vitamins, polysaccharides, polyphenols, and minerals (Melgarejo and Artíes, 2000; Ferrara et al., 2014). The fruit skins and membranes are rich in ellagitannins, which have a wide array of health-promoting bioactivities (Seeram et al., 2006) and the seeds have a good content of oil and are rich in CLA (Ferrara et al., 2011, 2014).

Fruit disorders such as cracking and sunburn damage are considered the most important factors believed to be responsible for the reduction of pomegranate production. Cracking of the fruits of pomegranate is one of the serious problems in the orchard of pomegranate because it causes loss of about 50% of the fruit market value. Sunburn damage can be led to losses 30% of the harvested fruit (Melgarejo et al., 2004). Fruit that has been sunburned are more susceptible to cracking than non sunburned fruit (Racskoí and Schrader, 2012). Furthermore, cracking is the last and most serious stage of skin sunburn (Visai et al.,1989). The main cause for cracking and sunburn is the combined action of high solar radiation, low humidity, high temperatures and low calcium concentrations (Sheikh and Manjula, 2012; Yazici and Kaymak, 2006; Torres-Olivar et al., 2014).

Pomegranates are especially sensitive to sun because they are terminal-bearing plants, with skinny branches bend with an increase in weight of fruit as the season proceedes. Some varieties that can take several ways to reduce the incidence of sunburn. Some fruits that are more resistant to sunburn or have more leaf surface area, thereby providing better shading over the fruits. Enhanced fertilization programs, especially nitrogen fertilization can improve the development of vegetative growth and thus provides shade fruits and protection from clear sunlight. Alternatively, shades or screens could be created to cover trees and fruits from direct exposure to sunlight (Melgarejo et al., 2004). In spite of artificial shading efficacy for sunburn control, screen nets are not likely to be economical in tree fruit production in many countries. Moreover, fruit that is naturally shaded within the interior canopy did not need coverage (Racskoí and Schrader, 2012).

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Mitra (1997) found that fertilization with nitrogen and calcium play an important role in reducing fruit cracking phenomenon, improved fruit growth and create a state of water balance between epicarp and inside fruit tissues, as well as maintain fruit cell walls elasticity and firmness. Al-Hmadawi et al. (2011) reported that fig tree fertilization with nitrogen alone and/or in combination with calcium and GA_3 produced a significant increase in leaf area, total chlorophyll and a decrease of fruit cracking percentage as compared with control treatment.

Meanwhile, it was also recorded fertilization of mineral nutrients to control weakness sunburn vulnerability of apples. Racsko et al. (2006) applied different rates of nitrogen and found a negative relationship between nitrogen applied and sunburn susceptibility of apples. They pointed to a direct effect (i.e., modification of fruit peel formation) and an indirect effect of N (i.e., development of a denser canopy) on sunburn structure.

Calcium is a cell-binding material, and spraying of calcium chloride at the concentration of 1% or calcium ammonium nitrate at the concentration of 2% reduces pomegranate fruit cracking (Sheikh and Manjula, 2012). Moreover, calcium is applied before harvest to improve quality of various fruit crops (Pooviah, 1979; Cheour et al., 1990). Calcium is regulating the activity of enzymes and photosynthesis (Mignani et al., 1995; Jackman and Stanley, 1995).

This investigation aimed to study the effect of four rates of ammonium nitrate fertilizer and three concentrations of calcium chloride spray as well as their combinations on vegetative growth parameters, yield, fruit quality, fruit cracking and fruits sunburn damage of Manfalouty pomegranate.

2. Materials and methods

This study was conducted during two successive seasons of 2013 and 2014 at El−Maghara Experimental Station, Desert Research Center, North Sinai Governorate, Egypt, 30° 43" N latitude, 33° 19" E longitude, at an elevation of 200 m above sea level. Thirteen years old Manfalouty pomegranate trees *(Punica granatum* L.) grown in sandy soil and spaced 3.6 × 3.6 m apart subjected to drip irrigation system from well. Physical and chemical analyses of the experimental soil are shown in Table 1. Meanwhile, the chemical analysis of the used water for irrigation is recorded in Table 2. Seventy two trees healthy, nearly uniform in shape and size and productivity and received the same horticultural practices were selected as test plants. The present study was a factorial experiment with two factors i.e. the first factor consisted of 4 rates of ammonium nitrate fertilizer (600, 900, 1200, and 1500 g/tree) and the second one involved 3 concentrations of calcium chloride spray (0, 1 and 2%). The experiment was designed as randomized complete block design with three replicates for each treatment and each replicate was represented by two trees. However, ammonium nitrate fertilizer was added as soil application in 10 cm depth and 1 m from the trunk at three times, first (50% of ammonium nitrate fertilizer was added at the end of December), second (25% ammonium nitrate fertilizer was added at the first week of March) and third (25% ammonium nitrate fertilizer was added at the first week of July). Moreover, Calcium chloride treatments were sprayed four times in the first week of March, May, 1st, July, 1st and September, 1st. Meanwhile, the control trees were sprayed with tap water. Tween-20 was added at 0.1% as a surfactant to spray solution including the control "tap water". Spraying was carried out using compression sprayers (5 L solution/tree) at the previously mentioned times.

Response of Manfalouty pomegranate trees to the tested treatments was evaluated through the following determinations

2.1. Vegetative growth

At the end of October plant height (m) of each tree was measured from the soil surface to the main branch apex and plant canopy volume (m^3) was calculated using the formula for the volume of a cylinder:

$$\text{Plant canopy volume} = (\pi)\,(\text{tree height})\,(\text{radius}^2)$$

Each tree was measured for crown radius (m) in eight directions (every 45°) beginning with magnetic north, around the entire tree circumference. Radiuses were measured from the center of the trunk with a compass and a plummet placed in the most external point of the profile for each considered direction (Smith et al., 1997). The resulting measurements were summed and plant canopy volume was determined. The area of leaves was determined by using portable area planimeter Mod Li3100 Ali (Li-Cor) while leaf total chlorophyll content was determined by Minolta chlorophyll meter SPAD-502.

Table 1
Analysis of the tested soil of El-Maghara region, North Sinai Governorate in 2013 and 2014 seasons.

Physical analysis of El-Maghara soil					
Soil depth (cm)	Particle size distribution		Texture class	Moisture content (%)	
	Total sand	Silt + clay		Field capacity	Wilting point
0–30	96.5	3.5	Sand	11.3	4.2
30–60	98	2	Sand	11.1	4.1

Chemical analysis of El-Maghara soil											
Soil depth (cm)	$CaCO_3$	pH soil past	E Ce (dS m^{-1})	Soluble cations (mequiv./l)				Soluble anions (mequiv./l)			
				Na^+	K^+	Ca^{2+}	Mg^{2+}	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}
0–30	5.89	7.7	0.6	1.26	0.5	2.5	1.5	–	1.8	1.4	2.11
30–60	3.8	7.7	0.7	1.57	0.08	3	2.0	–	1.8	2	2.85

Table 2
Chemical analysis of water used for irrigation at El-Maghara region, North Sinai Governorate in 2013 and 2014 seasons.

pH	E.C. (dS m^{-1})	O.M (%)	Soluble cations (mequiv./l)				Soluble anions (mequiv./l)			
			Ca^{2+}	Mg^{2+}	Na^+	K^+	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}
8.36	4.06	1.40	11.40	3.48	24.60	0.69	–	4.40	32.20	3.57