Agricultural Water Management 187 (2017) 11–23

Contents lists available at ScienceDirect

Agricultural Water Management

journal homepage: www.elsevier.com/locate/agwat

Determining pomegranate water and nitrogen requirements with drip irrigation

James E. Ayars[a,*], Claude J. Phene[b], Rebecca C. Phene[c], Suduan Gao[a], Dong Wang[a], Kevin R. Day[d], Donald J. Makus[e,1]

[a] USDA, Agricultural Research Service, San Joaquin Valley Agricultural Sciences Center, 9611 South Riverbend Ave., Parlier, CA 93648-9757, USA
[b] SDI+, PO Box 314, Clovis, CA 93613, USA
[c] University of California, Kearney Agricultural Research and Extension Center, 9240 S. Riverbend Ave., Parlier, CA 93648, USA
[d] County Director, Kings and Tulare Counties, University of California, Cooperative Extension, 4437 B S. Laspina, St., Tulare, CA 93274-9537, USA
[e] USDA, Agricultural Research Service, San Joaquin Valley Agricultural Sciences Center, 9611 South Riverbend Ave., Parlier, CA 93619, USA

ARTICLE INFO

Article history:
Received 2 September 2016
Received in revised form 2 March 2017
Accepted 5 March 2017

Keywords:
Subsurface drip irrigation
High frequency drip irrigation
Soil matric potential
Deep percolation

ABSTRACT

Despite being an ancient crop there is limited knowledge on the water and nitrogen (N) requirements of pomegranate. We conducted research at the University of California, Kearney Agricultural Research and Extension Center (KARE) to determine the water and N requirements of a developing pomegranate orchard. Pomegranate trees (*Punica granatum* L. var. Wonderful) were planted in 2010. The irrigation treatments were surface drip irrigation (DI) and subsurface drip irrigation (SDI) with three N subtreatments (N application rates of 50, 100, and 150% of current practice) and 5 replications in split-plot design. A weighing lysimeter located in the experimental field was used to automatically irrigate the orchard after 1.0 mm of measured crop water use. The trees received uniform application of fertilizers and water during the first two years of growth to insure uniform stand establishment prior to beginning the experiment. The pH of the irrigation water was maintained at 6.5 ± 0.5 by injection of N as urea sulfuric acid (US-10; 10% N). Differential N treatments were started in 2012 and continued through the end of the project. Phosphorus (PO_4–P) was continuously injected during irrigation and potassium (K_2T) was injected weekly. We report the results of the study from 2013 to 2015. From 2013 to 2015 the applied N ranged from 62 to 332 kg/ha and the total yields ranged from 33,144 to 57,769 kg/ha. There were no statistical differences in yield within any year related to total applied N. The yearly applied irrigation water increased as the plant size increased. The total water requirement is approximately 952 mm and the maximum daily water use was 10.5 mm. The DI irrigation application went from 645 mm to 932 mm and the SDI application increased from 584 mm to 843 mm from 2013 to 2015. A fifth order polynomial was fitted to the crop coefficient using the 2015 data. The use of SDI resulted in lower weed pressure in the SDI plots than in the DI irrigated plots in all three years. High frequency irrigation resulted in nitrate being managed within the soil profile to a depth of 1.5 m by minimizing deep percolation losses to the groundwater. While the yields were higher in the SDI than the DI system they were not statistically different. Although there were some differences in N content in tree leaves and fruit peels, there were no differences in fruit arils among N rates. The N requirement is in the range of 62–112 kg/ha (109–198 g/tree) for a mature pomegranate orchard and will ultimately depend on the planting density.

Published by Elsevier B.V.

1. Introduction

Pomegranate has been cultivated throughout the Mediterranean region continuously from 3000 BCE (Stover and Mercure, 2007). It is widely considered that pomegranate was native to northern India and areas of Iran and from those origins spread throughout the world reaching China by 100 BCE. In the 1500s and 1600s it was introduced in Central and South America and in the early 1700s in Florida and Georgia in the United States. By 1770 it

* Corresponding author.
E-mail addresses: james.ayars@ars.usda.gov (J.E. Ayars), claudejphene@gmail.com (C.J. Phene), rcphene@ucanr.edu (R.C. Phene), suduan.gao@ars.usda.gov (S. Gao), dong.wang@ars.usda.gov (D. Wang), krday@ucdavis.edu (K.R. Day).

[1] Deceased.

http://dx.doi.org/10.1016/j.agwat.2017.03.007
0378-3774/Published by Elsevier B.V.

had made its way to the west coast of the United States and was being grown in the Franciscan missions in California. Pomegranate is ideally suited to a Mediterranean climate with a warm summer and a mild winter which describes the climatic conditions found in the San Joaquin Valley of California, the principal production area in the United States. There are approximately 12,145 ha under production in California compared to 108,000 ha in India, 71,000 ha in China, 65,000 ha in Iran, 27,000 ha in Turkey, and 6000 ha in Spain (Stover and Mercure, 2007).

One of the drivers of the interest in pomegranate in the United States was the recent demand for juices with healthy bioactive compounds, mineral nutrients, and high antioxidant content (Basu and Penugonda, 2008). The medicinal qualities of pomegranate were recognized 1000s of years ago, with extracts of the tannin rich roots being used to rid people of tapeworms. Pomegranate extractions were also used as plasters to reduce eye and skin inflammation and to aid in digestion. There is an extensive literature on uses of pomegranate in medicine that include: treating diabetes, leprosy, to halting diarrhea, and hemorrhage. Various parts of the tree (leaves, bark, and roots) as well as the fruit are used for medicinal purposes. Some of the medicinal uses have been supported by recent studies (Mertens-Talcott et al., 2006; Al-Muammar and Khan, 2012; Galindo et al., 2014; Li et al., 2015).

Despite this long history of use throughout the world there is limited literature that has quantified the basic agronomic requirements (fertilizer, water) for production of pomegranate. Research has evaluated the effect of N on the juice quality and the effect on the antioxidant properties but very little on the N requirement for crop production and the effect of N levels on yield. Dhillon et al. (2011) evaluated the N requirement of developing pomegranate and found that increasing the level of N from 0 to 60 g/tree/year resulted in larger trees and yield for the highest N levels with the number of fruit and fruit size increasing as well. This was characterized as being a result of the increase in tree size. The maximum N rate was equivalent to 36 kg/ha of N. Other studies on mature trees estimated the N requirement as 500–625 g N/tree (Prabhakar et al., 2006). Current N usage in California is approximately 60–112 kg/ha where N is commonly applied as a split application in the winter and then in the spring. Initial studies didn't show any benefit to yield, size and fruit quality from the application of P and K (La Rue, 1977)

Pomegranate is characterized as being drought tolerant but few studies have quantified the actual water requirement. Kattah et al. (2011) found that the yield increased as the applied water increased from 280 to 600 mm of applied water in a 20-year-old pomegranate orchard. Most studies determined the water requirement for surface (furrow, sprinkler) irrigated crops using a variety of water balance methods to determine evapotranspiration and to develop crop coefficients for irrigation scheduling. Meshram et al. (2011) estimated the water requirement for a pomegranate orchard up to five years of age using surface drip irrigation. They found the maximum crop coefficient (k_c) to be 1.18 and daily water use of 5.3 mm/day for a 5-year-old tree.

High level of nitrate (NO_3^-) in the groundwater is a significant problem in California aquifers (Harter et al., 2002; Harter et al., 2012) and irrigated agriculture has been identified as a significant source of nitrate pollution. Nightingale (1972) sampled groundwater aquifers under areas in grape, orchard, row crop production, and fallow and found a significant correlation between the crop N management and the levels of nitrate in the soil profile and in the groundwater. This was at a time when furrow irrigation was the principal irrigation method and deep percolation losses were significant and would be the transport mechanism for nitrate. Since that time drip irrigation has been widely adopted on many perennial crops and the potential for nitrate transport has been significantly reduced with the implementation of improved irrigation scheduling and irrigation system management. Research has shown that well- managed surface drip irrigation (DI) and subsurface drip irrigation (SDI) systems can eliminate runoff, deep drainage, minimize surface soil and plant evaporation, reduce transpiration of drought tolerant crops, and significantly reduce fertilizer losses, thus protecting groundwater quality (Ayars et al., 1999).

This project was initiated to determine the water and N requirements of a 6-year-old fully irrigated pomegranate orchard using high frequency surface and subsurface drip irrigation.

2. Materials and methods

This project was located on the University of California Kearney Agricultural Research and Extension Center (KARE) on a 1.4 ha field that included a large weighing lysimeter (Phene et al., 1991; Ayars et al., 2003). Pomegranate trees (*Punica granatum* L. var. Wonderful) were planted in 2010 with 4.9 m between row spacing and a within row spacing of 3.6 m (567 trees/ha). The orchard was laid out in a split-plot design with 2 irrigation methods as the main treatments and 3 N levels as the sub-treatments with 5 replicates (Fig. 1). Each plot contained 3 tree rows and a minimum of 7 trees per row. The center row was used as the experimental row with the center 5 trees being sampled for yield and fruit quality data. The trees were allowed to grow free form with multiple trunks (Day and Wilkins, 2011) with little pruning and the height maintained at approximately 3 m.

The main treatments were surface drip irrigation (DI) and subsurface drip irrigation (SDI) with the drip laterals installed at a depth of 50–55 cm. There were 2 drip laterals per tree row with a lateral located on each side of the tree row at a distance of 1.1 m from the row. The emitter discharge rate was 2 L/h spaced at 1 m apart along the lateral. The trees were irrigated after 1 mm of crop water use had been measured in the lysimeter. During peak crop water use this could result in up to 8–12 irrigations per day.

The 3 N fertility sub treatments were designed to be 50% (N1), 100% (N2), and 150% (N3) of current California practice (60–112 kg/ha) (La Rue, 1977). The N was applied by continuous injection of urea sulfuric acid (US 10;10% N as urea, 18% S) to maintain the pH of the irrigation water at 6.5 ± 0.5 to avoid precipitation of phosphates that typically starts occurring with pH greater than 7.2. Ammonium nitrate (AN-20; 10% NH_4–N and 10% NO_3–N) was injected as needed to provide the additional N required for treatments N2 and N3.

Previous research (Bauer et al., 2002; Liu et al., 2011; Buckman and Brady, 1966) has shown that phosphorus (P) can become deficient for a variety of crops at soil depths greater than 20 cm. To prevent P deficiency in this study phosphoric acid (H_3PO_4, PO_4–P) was continuously injected at a concentration of P = 15–20 mg/L to maintain adequate P level in both the DI and SDI treatments.

Previous research has shown that potassium may become extremely deficient in sandy loam soil (Bauer et al., 2002; Phene et al., 1989), especially as soil depth increases. In this study potassium (K_2T) was injected once weekly at a concentration of K = 50 mg/L to maintain adequate K level in both SDI and DI treatments. The total application of K was increased as the plants grew.

The soil profile was sampled in the spring and fall to a depth of 1.2 m in 15 cm increments in each replication of each treatment and analyzed for nitrate using a 1:1 soil water extract and filtered prior to analysis. The filtrate was analyzed using a colorimetric method (Mulvaney, 1996) with an Astoria 2 Analyzer (Astoria-Pacific Inc., Clackamas, OR, USA). Tree leaf samples were collected biweekly from each treatment, dried at 42 °C, ground and analyzed for total N. After harvest fruits were separated into arils and peels and were processed similar to the leaf samples and analyzed for total N. The

Download English Version:

https://daneshyari.com/en/article/5758488

Download Persian Version:

https://daneshyari.com/article/5758488

Daneshyari.com