# THE EFFECTS OF DIFFERENT IRRIGATION PROGRAMS ON THE YIELD AND FRUIT QUALITY OF SANTA ROSA PLUM TREE*

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**Abstract**

Four different irrigation programs using the drip irrigation system were applied to the Plum Tree, Santa Rosa ( *Prunus salicina* Lindl.). Irrigations for trees, generally, commence as 30 or 40% of available water from the field capacity are depleted. Therefore, in this study, Irrigations were initialized as 20% ($I_{0.20}$), 30%($I_{0.30}$), 40%($I_{0.40}$), and 50%($I_{0.50}$) of the available soil moisture through the effective root depth depleted in order to evaluate how 20% and 50% depletion affect the growth, yield and fruit quality rather than other treatments. Recorded amounts of irrigation water were 569 mm for $I_{0.20}$ ,616 mm for $I_{0.30}$, 537 mm for $I_{0.40}$ and 560 mm for $I_{0.50}$ treatment, the subscript referring to the depletion of soil moisture throughout the effective root depth.

Results of this study summarily demonstrate that there is no adverse effect on tree performance by the application of four different irrigation programs. However, within all treatments the lowest water amount was in $I_{0.40}$ treatment, 537 mm. It indicates that more than this amount will be excess water application because higher than this amount has no valuable effect on the yield and quality parameters of Santa Rosa plum trees. That the gap between the Irrigation intervals in $I_{0.40}$ treatment are high caused the evaporation to be less than the others. Consequently, as a strategy for water management in Santa Rosa plum orchards grown in clay soil irrigation should be initiated as 40% of available moisture is depleted through the effective root depth for saving irrigation water in semi-arid regions.

**Key words:** Plum, Santa Rosa (*Prunus salicina* L.), Drip irrigation, Irrigation programs, Fruit quality

### Farklı Sulama Programlarının Santa Rosa Erik Ağaçlarında Verim ve Kalite Üzerine Etkileri

**Özet**

Bu çalışmada, Santa Rosa (*Prunus salicina* Lindl.) çeşidi erik ağaçlarına, damla sulama yöntemi ile dört farklı sulama programı uygulanmıştır. Sulamalara genellikle topraktaki mevcut nemin %30-40'ı tüketildiğinde sulamaya başlanmaktadır. Damla yöntemiyle sulanan ve Japon grubu içerisine giren Santa Rosa çeşidi erik ağaçlarında, 120 cm toprak derinliğindeki kullanılabilir su tutma kapasitesinin %20($I_{0.20}$), %30($I_{0.30}$), %40($I_{0.40}$), %50($I_{0.50}$)'si tüketildiğinde sulamaya başlanmış ve bu sulama programlarının ağaç gelişmesi, meyve verimi, meyve kalitesi üzerine etkileri araştırılmaya çalışılmıştır. $I_{0.20}$ sulama konusunda ortalama 569 mm, $I_{0.30}$ konusun'da 616 mm, $I_{0.40}$ konusun'da 537 mm, $I_{0.50}$ konusun'da 560 mm sulama suyu uygulanmıştır.

Bu çalışmanın sonucunda, dört faklı sulama uygulamasının ağaç verimi ve meyve kalite parametreleri üzerine istatistiki olarak önemli bir fark yaratmadığı tespit edilmiştir. Ancak, bu sulama uygulamalarında en düşük sulama suyu miktarı $I_{0.40}$ konusunda 537 mm olarak bulunmuştur. Bu sonuç, Santa Rosa erik ağaçlarında bu miktarın üzerinde uygulanacak sulama suyunun, aşırı miktarda uygulanacak sulama suyu miktarını ifade etmektedir, çünkü bu miktarın üzerinde uygulanan sulama suyu konusunda elde edilen verim ve kalite parametreleri arasında önemli bir fark görülmemiştir. Ayrıca, kısa aralıklarla yapılan sulamalarda buharlaşmayla oluşacak kayıplar da artış gösterecektir. Sonuç olarak, en az sulama suyu $I_{0.40}$ sulama konusunda elde edildiğinden su tutma kapasitesinin % 40'ı tüketildiğinde sulamaya başlanması daha uygun olacaktır.

**Anahtar Kelimeler:** Erik, Santa Rosa(*Prunus salicina* L.), Damla sulama, Sulama programlaması, Meyve kalitesi

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## 1. Introduction

Modern irrigation systems have been widespread in all around the world in two decades. Drip irrigation system is one of them as well, since it has two main distinct features; high frequency for allowing daily replacement of nondeficit or deficit of the water and localized water application (Burt and Styles, 1994 and Yildirim, 1996). This opportunity of the drip irrigation system enables water to be kept at the desired level throughout the root depth. The most suitable moisture level throughout the effective root depth, having any negative effect on phenological and pomological characteristics of plants, has to be determined to predict suitable irrigation time for all kinds of plant.

The better way for irrigation scheduling in fruit trees is to monitor the soil moisture by using some sensors instead of using some models using different climatologic data. It, however, needs long time to obtain accurate field measurements. Eventhough, there exist quite a lot of research works using some models predicting vegetable and field crops' water requirement, there is no enough research study for predicting water requirement, especially for plum, cherry, sour cherry, quince, apricot and also other fruits. Therefore, in practice there is not enough research work for fruit trees. For this reason, the depth of water needed by crops has to be determined by using some soil sensors to meet the water loss through evapotranspiration (Fereres and Puench 1981, Renguist, 1987, Smith and Fereres 1988, Goldhamer and Syneder 1989).

According to some researchers, fruit size growing under moisture deficit is smaller (Ryall and Aldrich. 1937, Lord and et.al.1963, Landsberg and Jones, 1981,), and fruits have lower water content, higher soluble solids as compared with fruits taking full irrigation water (Drake et.al. 1981, Morris et.al, 1962). Fruits on trees taking deficit moisture are reported to have higher quality and taste (Guelfat et.al. 1974). Moisture deficit causes fruit size, fruit juice and soluble solids concentration (SSC) to be less (Uriu et.al. 1967, Proebsting et.al. 1984)

Maturing of plum fruits starts in May and June, their maturing process is slow, at the beginning stage, and then ripens quickly. The most effective factor affecting fruit size and weight is the fruit load in tree (Miller, 1981). Westwood(1978) reported the best sign in maturing of plum fruits is the soluble solid, which should be in the range between 14 and 16%. However, fruit color and taste are the best signs for harvesting time of plum fruits says Miller (1981).

This study was carried out to determine the most suitable moisture level for irrigation timing of the Santa Rosa (*Prunus salicina* Lindl.) plum tree is. Irrigation was started to refill water by reaching to the field capacity throughout the effective root depth as 20% ($I_{0.20}$), 30% ($I_{0.30}$), 40% ($I_{0.40}$) and 50% ($I_{0.50}$) drop of the available soil moisture. These treatments have been continued from May to the October through the experiment years.

## 2. Materials and Methods

***Experimental site and design.*** This study was conducted in 2001, 2002, and 2003 using "Santa Rosa" plum trees on grafted rootstock grown at Ankara University, Agriculture Research Center. The experimental site is located at a latitude of $36^0$ 36' N and longtitude of $32^0$40' E. Altitude is 1050m. The trees were planted in 1994 at a spacing of 6x4 m in the clay soil. Orchards have been planted in a shape that each 3 lines are the same species. The irrigation treatments were replicated by randomizing blocks (Fig.1). The central trees were used as the harvesting plot, and vegetative and generative parameters were measured at the fruits from these trees. The outside trees in each plot were guard row received the same irrigation treatment. In all three years, the water application rates were applied by double-lateral lines per tree row. The soils have not salinity and drainage problems such as water table, some properties of soil are presented in table 1.

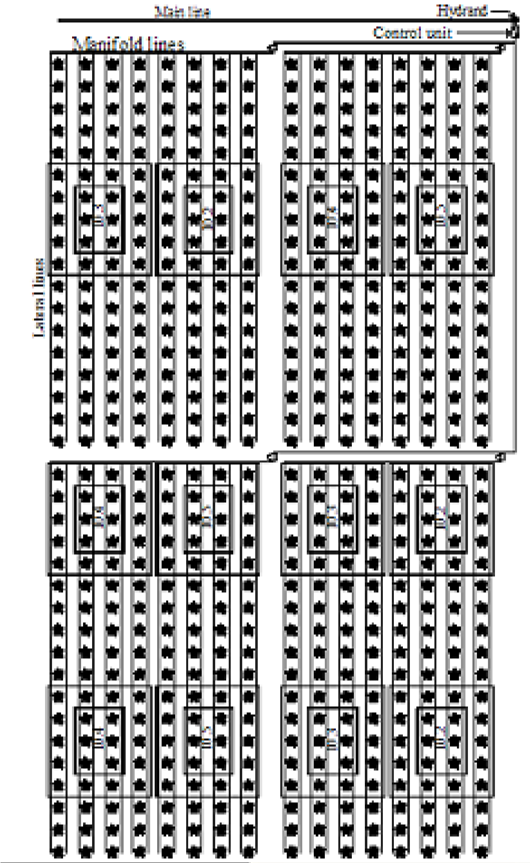


Figure 1 Experimental layout

Monthly averages of climatological data taken during the experimental years are given in table 2.

***Irrigation.*** The trees were trickle irrigated through drippers, spacing 0.75m and having 5 L $h^{-1}$ at 1.5 atmosphere(atm). Each tree row had double-drip lines, spacing 1 m. Irrigation was applied according to the electronic digital tensiometers. A set of them was installed in each treatment for observation of soil matric potential (SMP). Sensor placement for all four treatments was the same. (Fig.2). To its specification, 5 tensiometers were placed in each cluster to measure the SMP from soil surface to the effective root depth (150cm) at each 30 cm level. In order to draw a soil water retention curve, the gravimetric soil water content of different soil layers was measured frequently during the periods when the soil matric potential declined from the highest to the lowest at a time interval of once everyday. The values converted to dry weight basis in percent. The soil water retention curve is given in fig. 3

Table 1 Some properties of soils of the experimental site

| Depth (cm) | Texture | Bulk density ($g/cm^3$) | Field capacity (%) | Wilting point (%) |
|---|---|---|---|---|
| 0-30 | C | 1.09 | 33.22 | 17.14 |
| 30-60 | C | 1.10 | 34.52 | 19.11 |
| 60-90 | C | 1.16 | 35.84 | 20.95 |
| 90-120 | C | 1.06 | 36.52 | 19.86 |
| 120-150 | C | 1.05 | 35.86 | 18.92 |

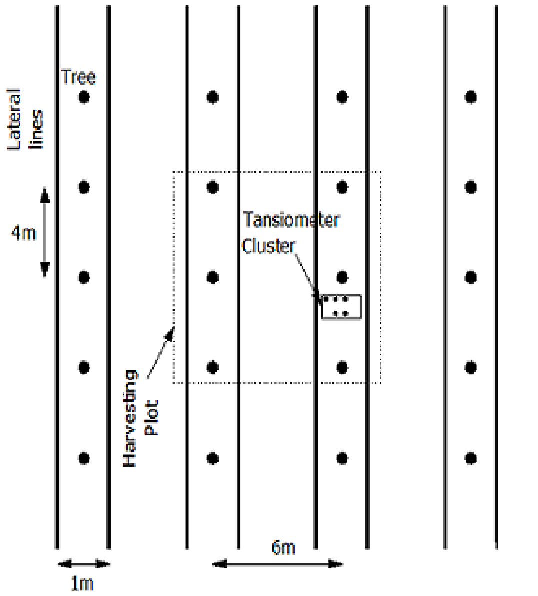


Figure 2 Harvesting plot

Crop evapotranspiration (ET) was estimated using the water balance equation given below(Doorenbos and Kassam, 1979),

$$ET=I+P\pm\Delta S-R-D$$

Where; I is the irrigation amount, P the precipitation, ΔS the change in soil water content that occurred between May and September(growing period). R the surface runoff, and D is the downward flux below the crop root zone.

To estimate ΔS, soil water content in the soil profile(down to 150 cm) just before each irrigation and harvesting were determined by gravimetric measurements. Surface runoff was ignored because precipitation during the growing season was very small. Deep percolation was zero since irrigation was continued until soil moisture reached to the field capacity through the effective root depth. Irrigation was started

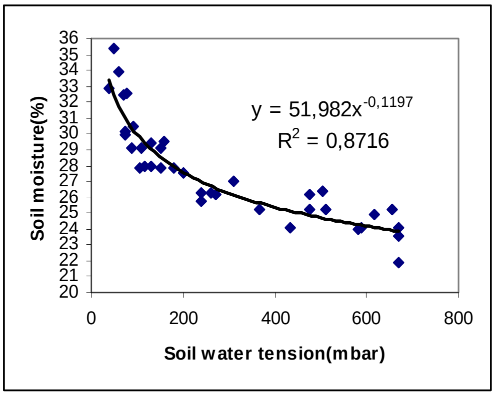


Figure 3 Soil water retention curve

to the readings of the tensiometers in the depth of 30-60 cm, and 60-90 cm. The four irrigation treatments were started based on two tensiometers readings, given in Table 3. Water, however, was refilled to the field capacity according to the readings of 5 tensiometers. They were read once daily. Four irrigation programs applied were as follows; $I_{0.20}$ (20%) treatment was started as 20% of the available soil moisture throughout the effective root depth of Santa Rosa plum trees were depleted, and other treatments were $I_{0.30}$ (30%), $I_{0.40}$ (40%), $I_{0.50}$ (50%). Soil moisture was measured at each harvesting plot. Irrigation-starting dates were on 22 May in 2001, 14 May 2002, and 2003, and continued to 1 September for all years.

***Measurements.*** Trunk cross-sectional area (TCA) was estimated from the measurements of trunk diameter on March, and canopy volume was estimated from that of canopy diameter and canopy height,as well. Fruits were harvested from each plots to evaluate the influence of maturity on fruit quality. Skin color, firmness, moisture, soluble solids, titratable acidity were measured after each harvest. The skin color and flesh color of 5 plums was measured using a Minolta Chronemeter (Mc Guire, 1992). Penetrometer was used to measure the firmness of fruits. Soluble solids were determined on a blended composite using a Carl-Zeis Abbe hand refrectometer. Titratable acidity was determined for the composite consisting of 10 ml fruit juice and 20 ml distilled water by titrating to an

Table 2 Monthly average climatologically data

| Years | Climatological data | Months | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 2001 | Precipitation(mm) | 31.8 | 28.8 | 78.3 | - | 34.6 | 21.8 | 12.6 |
| | Temperature($^o$C) | 10 | 10.7 | 12.9 | 19.5 | 23.8 | 21.9 | 18.3 |
| | R.humidity(%) | 75.3 | 75.4 | 75.4 | 66.3 | 63.9 | 71.9 | 68.9 |
| | Wind Speed(m/s) | 2.9 | 3 | 2.9 | 2.9 | 2.6 | 2.6 | 2.7 |
| 2002 | Precipitation(mm) | 37.1 | 83.7 | 19.4 | 11 | 47.7 | 3.6 | 69.4 |
| | Temperature($^o$C) | 6.5 | 8.3 | 13.8 | 18.3 | 22.6 | 20.6 | 16.8 |
| | R.humidity(%) | 77.8 | 81.9 | 70.6 | 67.8 | 64.4 | 63.6 | 69.1 |
| | Wind Speed(m/s) | 3 | 2.6 | 2.6 | 2.9 | 2.7 | 2.7 | 2.7 |
| 2003 | Precipitation(mm) | 20.4 | 62.1 | 45.7 | 7 | 3.5 | 0.3 | 17.2 |
| | Temperature($^o$C) | 0.9 | 8.2 | 16.4 | 19.9 | 21.3 | 21.6 | 16.1 |
| | R.humidity(%) | 77.8 | 76.8 | 68.5 | 63.8 | 60.8 | 62.7 | 69.7 |
| | Wind Speed(m/s) | 2.9 | 2.9 | 2.4 | 2.6 | 2.9 | 2.8 | 2.8 |

Table 3 Tensiometer readings in two depths for Irrigation timing

| Depths (cm) | Irrigation treatments | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | $I_{0.20}$ | | $I_{0.30}$ | | $I_{0.40}$ | | $I_{0.50}$ | |
| | % | mbar | % | mbar | % | mbar | % | mbar |
| 30-60 | 31.44 | 75 | 29.90 | 95 | 28.36 | 130 | 26.82 | 200 |
| 60-90 | 32.86 | 60 | 31.37 | 80 | 29.88 | 95 | 28.40 | 180 |
| Readings to start the treatments | 32.15 | 70-80 | 30.64 | 90-100 | 29.12 | 120-130 | 27.61 | 190-200 |

end point of pH 8.1 with 0.1N NaOH and expressed as malic acid. All yield and quality parameters were examined by analysis of variance in the Minitab statistical packages. Any differences with $P<0.05$ were referred to as significant by using Duncan's multiple range test.

## 3. Results and Discussion

According to the result of the 3 years of this experiment, all irrigation treatments have statistically no significant effect on the yield. and fruit quality parameters. In these programs, the lowest seasonal irrigation water was obtained from the treatment of $I_{0.40}$ (537.6 mm), followed by 560.1 mm for $I_{0.50}$, 569.2 for $I_{0.20}$, and 616.0 mm for $I_{0.30}$ treatments (Table 4). In the first year of the experiment, there was almost no difference in the applied water except for $I_{0.20}$ treatment, in which the lowest amount of water was applied. However, in the subsequent years, the applied irrigation water gradually increased in the treatment of $I_{0.20}$ and $I_{0.30}$ rather than those of $I_{0.40}$, $I_{0.50}$. The increment was very clear in the third year of the experiment. The reason of the increment in both applied water and evapotranspiration may cause evaporation to be very high because of the short irrigation intervals (ave. 3 days) in the $I_{0.20}$ and $I_{0.30}$ treatments. On the other hand, decreasing in evaporation in the treatments, $I_{0.40}$ and $I_{0.50}$, made the irrigation intervals longer (ave. 5 days).

Table 4 The amount of applied water, evapotranspiration, canopy volume, trunk cross sectional area, yield

| Parameters | Years | $I_{0.20}$ | $I_{0.30}$ | $I_{0.40}$ | $I_{0.50}$ |
|---|---|---|---|---|---|
| Irrigation numbers (times) | 2001 | 23 | 23 | 18 | 16 |
| | 2002 | 15 | 15 | 16 | 15 |
| | 2003 | 23 | 23 | 15 | 13 |
| | Averages | 20 | 20 | 16 | 15 |
| Irrigation intervals (day) | 2001 | 3 | 3 | 5 | 6 |
| | 2002 | 4 | 4 | 5 | 5 |
| | 2003 | 3 | 4 | 5 | 6 |
| | Averages | 3 | 4 | 5 | 6 |
| Applied water (mm) | 2001 | 453.6 | 532.7 | 575.6 | 586.3 |
| | 2002 | 552.9 | 528.3 | 508.4 | 542.9 |
| | 2003 | 700.9 | 787.1 | 528.9 | 551.1 |
| | Averages | 569.2 | 616.0 | 537.6 | 560.1 |
| Evapotranspiration (mm) | 2001 | 495.3 | 570.6 | 576.2 | 596.4 |
| | 2002 | 657.9 | 642.5 | 616.6 | 616.9 |
| | 2003 | 794.7 | 828.1 | 632.0 | 608.3 |
| | Averages | 649.3 | 680.4 | 608.1 | 607.2 |
| Canopy volume ($m^3$) | 2001 | 18.8 | 20.2 | 18.5 | 20.0 |
| | 2002 | 28.1 | 26.7 | 24.0 | 29.8 |
| | 2003 | 39.7 | 38.4 | 37.2 | 37.9 |
| | Averages | 28.8 | 28.4 | 26.6 | 29.2 |
| Trunk area ($cm^2$) | 2001 | 132.3 | 130.6 | 125.2 | 129.5 |
| | 2002 | 167.5 | 170.4 | 151.4 | 164.8 |
| | 2003 | 215.8 | 218.9 | 195.8 | 212.5 |
| | Averages | 171.9 | 173.3 | 157.4 | 168.9 |
| Yield (kg $tree^{-1}$) | 2001 | 9.6 | 10.3 | 11.0 | 9.8 |
| | 2002 | 1.15 | 0.91 | 0.60 | 0.88 |
| | 2003 | 78.3 | 84.9 | 89.7 | 72.0 |
| | Averages | 29.7 | 32.0 | 33.8 | 27.6 |

Yields ranged from 27.6 kg tree$^{-1}$ to 33.8 kg tree$^{-1}$ (Table 4). The average yield in 2001 was 10.2 kg tree$^{-1}$ , 0.86 kg tree$^{-1}$ in 2002, and 81.2 kg tree$^{-1}$ in 2003. The lowest yield obtained in 2002 was due to the climate, in this year temperature in February was high. That's why, flowering period started in Feb. 2002, then because of the sudden change in the weather almost all flowers were frosted in March. The yield in 2003 was almost eight times higher than the yield of 2001. It may be explained that the trees were 7 years old in 2001, as they reached to 9 years old it may force the trees to produce more fruits and also regular irrigation water applications by drip irrigation system may cause the trees to produce more fruits also. On the contrary to that, fruit size got smaller and fruit moisture became lower, which were because of the heavy fruit load in 2003.

The moisture content of the fruit was accomplished with the fruit size because the higher the fruit size is, the more fruit moisture content is obtained. Therefore, it was higher in 2001 and 2002 as compared with 2003. the low fruit moisture content in 2003 was because of both heavy fruit load and small fruit size. Acidity ranged from 1.67 in 2001, 1.69 in 2002 to 2.30 in 2003.

The increment in acidity was very high in 2003, the reason of which was owing to heavy fruit load, but opposite to the acidity, soluble solid decreased from the year of 2001 through 2003. Skin color was getting lighter through the years, changing from reddish to yellow. Unlike skin color, flesh color was turning from yellow to yellow-reddish tone. The differences in soluble solids and colors were due to heavy fruit load (Table 5). Variance analysis tables of the fruit quality parameters are given from table 6 to table 9.

Table 5 The effects of the irrigation treatments on fruit quality of Santa Rosa plum trees

| Parameters | Years | $I_{0.20}$ | $I_{0.30}$ | $I_{0.40}$ | $I_{0.50}$ |
|---|---|---|---|---|---|
| Fruit moisture content(%) | 2001 | 56.0 | 55.7 | 56.7 | 53.0 |
| | 2002 | 58.7 | 60.3 | 56.3 | 56.3 |
| | 2003 | 44.7 | 44.7 | 44.7 | 42.3 |
| | Averages | 53.1 | 53.6 | 52.6 | 50.5 |
| Soluble Solid(%) | 2001 | 14.4 | 14.4 | 14.6 | 14.9 |
| | 2002 | 13.9 | 13.6 | 14.2 | 13.7 |
| | 2003 | 11.0 | 12.5 | 12.0 | 11.4 |
| | Averages | 13.1 | 13.5 | 13.6 | 13.3 |
| Titratable acidity (% malic acid) | 2001 | 1.71 | 1.61 | 1.64 | 1.70 |
| | 2002 | 1.68 | 1.62 | 1.66 | 1.80 |
| | 2003 | 2.33 | 2.22 | 2.35 | 2.28 |
| | Averages | 1.91 | 1.82 | 1.88 | 1.93 |
| Skin color ($h^0$) | 2001 | 6.90 | 5.60 | 3.30 | 3.80 |
| | 2002 | 9.90 | 11.6 | 10.5 | 9.90 |
| | 2003 | 10.8 | 9.30 | 10.0 | 8.00 |
| | Averages | 9.2 | 8.8 | 7.90 | 7.23 |
| Flesh color ($h^0$) | 2001 | 71.5 | 70.9 | 68.6 | 71.3 |
| | 2002 | 51.4 | 57.0 | 50.6 | 57.3 |
| | 2003 | 48.4 | 50.6 | 53.4 | 38.3 |
| | Averages | 57.1 | 59.5 | 57.5 | 55.6 |
| Firmness (N) | 2001 | 6.5 | 6.5 | 6.4 | 6.4 |
| | 2002 | 6.0 | 6.0 | 6.1 | 6.5 |
| | 2003 | 6.5 | 6.7 | 6.8 | 6.5 |
| | Averages | 6.3 | 6.4 | 6.4 | 6.5 |

Table 6. Variance analysis for Fruit moisture content

| Years | A.V | S.D | S.S | M.S | F | P |
|---|---|---|---|---|---|---|
| 2001 | Treatments | 3 | 23.3 | 7.8 | 0.57 | 0.656 |
| | Blocks | 2 | 1.2 | 0.6 | 0.04 | 0.959 |
| | Error | 6 | 82.2 | 13.7 | | |
| | Total | 11 | 106.7 | | | |
| 2002 | Treatments | 3 | 34.2 | 11.4 | 1.00 | 0.455 |
| | Blocks | 2 | 26.2 | 13.1 | 1.15 | 0.379 |
| | Error | 6 | 68.5 | 11.4 | | |
| | Total | 11 | 128.9 | | | |
| 2003 | Treatments | 3 | 12.3 | 4.1 | 0.27 | 0.844 |
| | Blocks | 2 | 12.7 | 6.3 | 0.42 | 0.674 |
| | Error | 6 | 90.0 | 15.0 | | |
| | Total | 11 | 114.9 | | | |

## 4. Conclusions

According to the results in this experiment, the lowest seasonal irrigation water was obtained from the treatment of $I_{0.40}$(536.7 mm), followed by those of $I_{0.50}$, $I_{0.20}$, $I_{0.30}$ in which they used extra additional water 4.2%, 5.9%, and 14.6% respectively. Treatments did not create any significant differences in the yield, however, even though having the lowest trunk sectional area and canopy volume, the irrigation treatment of $I_{0.40}$ produced the highest yield, used the lowest amount of irrigation water, also having longer irrigation interval resulted less evapotranspiration.

Table 7. Variance analysis for soluble solid

| Years | A.V | S.D | S.S | M.S | F | P |
|---|---|---|---|---|---|---|
| 2001 | Treatments | 3 | 0.470 | 0.157 | 0.44 | 0.731 |
| | Blocks | 2 | 0.922 | 0.461 | 1.30 | 0.339 |
| | Error | 6 | 2.125 | 0.354 | | |
| | Total | 11 | 3.517 | | | |
| 2002 | Treatments | 3 | 0.677 | 0.226 | 2.28 | 0.179 |
| | Blocks | 2 | 0.060 | 0.030 | 0.30 | 0.749 |
| | Error | 6 | 0.593 | 0.099 | | |
| | Total | 11 | 1.330 | | | |
| 2003 | Treatments | 3 | 4.016 | 1.339 | 5.46* | 0.038 |
| | Blocks | 2 | 4.002 | 2.001 | 8.16* | 0.019 |
| | Error | 6 | 1.472 | 0.245 | | |
| | Total | 11 | 9.489 | | | |

Table 8. Variance analysis for Titratable acidity

| Years | A.V | S.D | S.S | M.S | F | P |
|---|---|---|---|---|---|---|
| 2001 | Treatments | 3 | 0.0240 | 0.0080 | 0.41 | 0.751 |
| | Blocks | 2 | 0.1176 | 0.0588 | 3.01 | 0.124 |
| | Error | 6 | 0.1171 | 0.0195 | | |
| | Total | 11 | 0.2587 | | | |
| 2002 | Treatments | 3 | 0.0509 | 0.0170 | 0.29 | 0.834 |
| | Blocks | 2 | 0.2551 | 0.1276 | 2.15 | 0.197 |
| | Error | 6 | 0.3556 | 0.0593 | | |
| | Total | 11 | 0.6617 | | | |
| 2003 | Treatments | 3 | 0.0314 | 0.0105 | 1.26 | 0.369 |
| | Blocks | 2 | 0.1338 | 0.0669 | 8.05* | 0.020 |
| | Error | 6 | 0.0499 | 0.0083 | | |
| | Total | 11 | 0.2151 | | | |

Table 9. Variance analysis for Firmness

| Years | A.V | S.D | S.S | M.S | F | P |
|---|---|---|---|---|---|---|
| 2001 | Treatments | 3 | 0.0004 | 0.0001 | 0.54 | 0.675 |
| | Blocks | 2 | 0.0013 | 0.0006 | 2.32 | 0.179 |
| | Error | 6 | 0.0016 | 0.0003 | | |
| | Total | 11 | 0.0033 | | | |
| 2002 | Treatments | 3 | 0.0060 | 0.0020 | 0.93 | 0.48 |
| | Blocks | 2 | 0.0040 | 0.0020 | 0.92 | 0.45 |
| | Error | 6 | 0.0129 | 0.0022 | | |
| | Total | 11 | 0.0229 | | | |
| 2003 | Treatments | 3 | 0.0020 | 0.0007 | 0.65 | 0.614 |
| | Blocks | 2 | 0.0003 | 0.0001 | 0.13 | 0.879 |
| | Error | 6 | 0.0061 | 0.0010 | | |
| | Total | 11 | 0.0083 | | | |

In this research, overall average yield of Santa Rosa plum were 29.7, 32.0, 33.8, and 27.6 kg tree$^{-1}$ for $I_{0.20}$, $I_{0.30}$, $I_{0.40}$, $I_{0.50}$ respectively. The yield was twice as compared with a research conducted out on the Santa Rosa plum trees by Kuden et.al.(1994) in the South Anatolia region in Turkey. The increasing yield may due to regular irrigation water applications.

Our data clearly show that regular irrigation water applications increases the yield as almost twice. Irrigation programs, not create severe stress on the trees, gave almost similar quality parameters. Some quality differences between the years may be explained by the heavy fruit load. Another important point in this research was that the applying 537 mm water throughout the growing season explaines that much of this quantity does not increase the yield and also quality. Therefore, since the lowest irrigation water amount was achieved in the treatment of $I_{0.40}$ , Santa Rosa plum trees should be irrigated as 40% of the available soil moisture is depleted through the effective root depth. Hence, this result can be considered as a strategy for water management in Santa Rosa plum orchards.

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