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Original Article

The Effects of Different Irrigation Intervals and Mulch Applications on Irrigation Water Use in Grafted Vines

Cenk KÜÇÜKYUMUK[1]*, Mustafa KELEN[2]

Eğirdir Horticultural Research Institute, 32500 Isparta, Turkey

[2] Süleyman Demirel University Agriculture Faculty, Horticulture Department, Isparta, Turkey

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Abstract

This study was conducted to determine effects of different irrigation intervals (4, 7, 10 days) and mulch applications (black plastic, rose oil processing wastes, grass clippings, control) on irrigation water using in grafted vines in 2007 and 2008. Alphonse Lavallée variety grafted onto 5 BB, 140 Ru and 41 B rootstocks were used in this study. While nurseries of grafted onto 5BB had the highest amount of irrigation water using, nurseries of grafted onto 140 Ru and 41 B rootstocks had the similar amount of irrigation water using. In the end of this study, it was found that the amounts of irrigation water using varied with rootstocks. At the same time, it was determined that mulch applications decreased evaporation from the soil and irrigation water requirement of nurseries.

Key words: *IWUE, irrigation water, mulches, rootstock, shoot weight.*

Corresponding Author: Cenk Kucukyumuk, cenkkucukyumuk@hotmail.com, phone: +902463132420, fax: +902463132425,

INTRODUCTION

Irrigation is a very important factor which has a direct effect on growth, development, yield and quality in plant production. But, we should be more carefull about using water because of limited water resources and increasing irrigated agriculture areas. Furthermore, increasing amounts of drinking and utilization water at settlement and industry day by day, cause decreasing amounts of irrigation water in using agriculture or decreasing quality of water (Beyazgül et al. 2002). It is predicted that the rate of using water in agriculture will change sides from agriculture to industry and housing in the future. That's why, the water resources which are ours should be used more effective.

The suitable irrigation programmes which are prepared for different district, soil and climate conditions should be determined to use more effective available water resources for growing plants. It should be determined the most suitable irrigation intervals and amount of irrigation water applied at each irrigation for suitable irrigation programme (Barragon and Wu 2001). The root forms and water requirements of rootstocks whih are used in nursery grafted vine production are very different. Because of this different, the rootstocks need different amount of irrigation water.

It is very important that the nurseries have strong growth. If nurseries have strong growth, they can grow better and they have more yields in following years. Therefore, also in nursery production progress, the whole growing technics include determining irrigation programme should apply to obtain the highest succes rate and quality. There are very less studies on production of different nursery species about determining irrigation requirements and irrigation programmes in Turkey. Çelik (1996) and Yükçeken (1998) had studies for increasing succes rate and determining irrigation programmes of peach and pistachio nurseries, respectively.

In this study, it was aimed to determined the effects of different irrigation intervals (4, 7, 10 days) and mulch applications (black plastic, rose oil processing waste, grass clippings) on irrigation water using in nursery production of

Alphonse Lavallée variety grafted onto three different rootstocks.

MATERIALS AND METHODS

This study was carried out at Eğirdir Horticultural Research Institute and it was a part of the doctorate research project "effects of different irrigation intervals and mulch applications on nursery quality and success rate in grafted vines" in 2007 and 2008.

The research area has a transition climate between Mediterranean and Central Anatolia (Çepel 1988). The soil samples for chemical and physical analyses were taken from 30 and 60 centimeters soil depths. Chemical and physical analyses were done at Eğirdir Horticultural Research Institute Agricultural Analysis Laboratory and Süleyman Demirel University Agriculture Faculty Soil Department Laboratory, respectively. The results of soil analysis were presented in Table 1.

Table 1. Soil characteristics of trial plots

	Depth (cm)	
	0-30	30-60
γ (g/cm^3)	1.48	1.39
FC (%)	27.0	29.0
WP (%)	13.0	15.0
EC (ECx10^6)	150	147
pH	8.1	8.2
Lime (%)	2.2	8.6
Saturation (%)	48	45
Organic matter (%)	1.61	2.44
P (ppm)	13.2	6.3
K (ppm)	214	127.2
Texture	Clay loam	Clay loam

γ: unit weight of soil; FC: field capacity; WP: wilting point

Treatments were arranged according to a randomized block design. 5 BB, 140 Ru, 41 B as rootsocks and Alphonse Lavallée as variety were used in the study. 5 BB rootstock has middle deep or shallow root system and it is sensitive to drought. 140 Ru rootstock has deeper root system than 5 BB and 41 B rootstocks and it is resistant to drought. 41 B rootstock has a middle deep root system. It is also medium resistant to drought. Three different irrigation intervals (4, 7, 10 days) and four mulch applications (control, C; black plastic, Bp; rose oil processing wastes, Rw; grass clippings, Gc) were used for each rootstocks. Grafted scions were planted at 0.90m x 0.10 m spacing on May both 2007 and 2008. This research was planned three replication and each replications had twenty five grafted vine. Distance between plots was two meters and each plot area was 6.75 m^2. Grafted vines were removed on November in both 2007 and 2008 after the whole leaves of nurseries were shredded.

Mulch materials (Bp, Rw, Gc) laid out each side for grafted vines and they have 80 cm width and each side has 40 cm. Drip irrigation system was used in this study and single line lateral was used for each nursery rows. Irrigation water was supplied by a pump from an irrigation canal. Irrigation water was transferred by a pipe (63 mm in diameter). Fertilizers were applied in the irrigation water through a drip system. The water was in C_2S_1 class (EC is low; sodium risk is low) and it can be used for irrigation. A counter was used to measure amounts of irrigation water. Precipitation and evaporation values were taken from a nearby weather station.

Irrigation water was applied up to field capacity at 0-60 soil depth for each irrigation intervals. Soil water profile, up to the 60 cm depth in 30 cm increments, was measured gravimetrically (oven dry basis) before each irrigation.

Equality 2 was used in calculation of applied water amount (Kanber 2002).

$$Ir = \frac{(Pw_{TK} - Pw)}{100} \times D \times \gamma \times P \qquad (2)$$

Where Ir is the amount of applied irrigation water (mm), Pw_{TK} is field capacity (%), Pw is water level in soil before irrigation (%), D is wetting depth or root depth (cm), γ is unit weight of soil (g/cm^3) and P is wetting percentage (%). P was determined as 33 % end of the calculating.

Irrigation water use efficiency (IWUE) was calculated using Equality 3.

$$IWUE = \frac{\text{Shoot weights (kg ha}^{-1})}{I} \qquad (3)$$

Where IWUE is the irrigation water use efficiency (kg ha^{-1} mm) and I the yield.

The shoots in a squaremeter per plots were weighed as cutting and average shoot weights were calculated each treatment when nurseries were removed on. There were eleven nurseries in a square meter in this study. And then, IWUE values were calculated taking account nurseries in one hectare and amounts of irrigation water.

Grafted vines were planted on 15 May in 2007. From planting to 29 May, a total of 56 mm water was applied to all treatments. All plots were irrigated until they reached field capacity at 0-60 cm depth on 29 May and then scheduled irrigations were initiated. Grafted vines were planted on 17 May in 2008. From planting to 2 June, a total of 35 mm water was applied to all treatments. All plots were irrigated until they reached field capacity at 0-60 cm depth on 2 June and then scheduled irrigations were initiated.

RESULTS AND DISCUSSION

Table 2 presents the informative data about irrigation treatments in 2007 and 2008. During the growing seasons, treatments were irrigated at 4, 7 and 10 days intervals for 24, 15 and 11 times, respectively in 2007. There were 884.4 mm of evaporation and 40.1 mm of precipitation. During the growing seasons in 2008, treatments were irrigated at 4, 7 and 10 days intervals for 23, 14 and 10 times respectively. There were 866.4 mm of evaporation and 26.3 mm of precipitation.

Irrigation water requirements of rootstocks which had different root systems were determined very different. The highest irrigation water using was found in nurseries grafted onto 5 BB rootstocks in both years. While irrigation water using of nurseries grafted onto 5 BB rootstock ranged from 344.9 mm to 963.9 mm, irrigation water using of nurseries grafted onto 140 Ru and 41 B rootstocks ranged from 316.9 mm to 787.7 mm and from 286.9 to 821.2 mm, respectively in 2007. Irrigation water using of nurseries grafted onto 5 BB, 140 Ru and 41 B rootstocks were determined between 391.8-996.1 mm, 365.6-844.4 mm, and 334.2-831.3 mm, respectively in 2008.

As seen on Table 2, amounts of irrigation water increased in frequently irrigated treatments. As irrigation intervals were increasing, amounts of irrigation water decreased. While the highest amounts of irrigation water using were found in 4 days irrigation intervals, the lowest amounts of irrigation water using were found in 10 days irrigation intervals. Amounts of irrigation water using of 4 days treatments were between 418.6 and 963.9 mm in 2007. The values of 7 and 10 days treatments ranged from 318.2 to 726.4 mm and from 286.9 to 642.7 mm, respectively. While irrigation water using of nurseries in 4 days treatments ranged from 482.6 to 996.1 mm, the values in 7 and 10 days treatments ranged from 334.2 to 801.7 mm and from 365.6 to 605.6 mm, respectively in 2008.

When the effects of mulch applications on amounts of irrigation water using were obtained, it was determined that the highest and lowest irrigation water applied to C and Bp treatments, respectively in both 2007 and 2008. Amounts of irrigation water using in C treatments were between 514.8 and 963.9 mm in 2007. While amounts of irrigation water using in Rw treatments were between 397.7 and 712.9 m, the values of Gc and Bp treatments ranged 380.9 from 677.9 mm and from 286.9 to 468.4 mm, respectively. Amounts of irrigation water using of C, Rw, Gc and Bp treatments were ranged from 545.3 to 996.1 mm, from 392.7 to 647.3 mm, from 424.9 to 714.8 mm and from 334.2 to 515.0 mm, respectively in 2008.

If the amounts of irrigation water using were obtained, generally, the highest irrigation water using was determined in C treatments in 4 days irrigation intervals of nurseries grafted onto 5 BB, 41 B and 140 Ru rootstocks in 2007 and 2008. The Bp treatments in 10 days irrigation intervals of nurseries grafted onto 5 BB, 41 B and 140 Ru rootstocks had the lowest irrigation water using in 2007. While Bp treatments in 10 days irrigation intervals of nurseries grafted onto 5 BB and 140 Ru rootstocks had lowest irrigation water using, 7 days irrigation intervals of nurseries grafted onto 41 B rootstock had the lowest irrigation water using in 2008.

The values of total amounts of irrigation water, total shoot weights of nurseries in per hectare and Irrigation Water Use Efficiency (IWUE) were seen on Table 3.

While the highest values of IWUE were obtained from Bp treatments, the lowest IWUE were determined in C treatments in three different rootstocks in both years. The highest IWUE (14.50 kg ha^{-1} mm) in nurseries grafted onto 5 BB rootstock were obtained from 4 days irrigation intervals in Bp treatments in 2007. The lowest value (0.99 kg ha^{-1} mm) was obtained from 4 days irrigation intervals in C treatments. While Bp treatments in 4 days irrigation interval of nurseries grafted onto 140 Ru rootstock had the highest IWUE (4.69 kg ha^{-1} mm), the lowest IWUE (0.39 kg ha^{-1} mm) was determined in C treatments of 10 days irrigation interval. Bp treatments in 7 days irrigation interval of nurseries grafted onto 41 B rootstock had the highest IWUE (5.30 kg ha^{-1} mm). The lowest IWUE (0.13 kg ha^{-1} mm) was obtained from C treatments in 10 days irrigation interval.

The highest (3.53 kg ha^{-1} mm) and lowest IWUE (0.10 kg ha^{-1} mm) in nurseries grafted onto 5 BB rootstock were obtained from 4 days irrigation intervals-Bp and 7 days irrigation intervals-C treatments in 2008. While Bp treatments in 7 days irrigation interval of nurseries grafted onto 140 Ru rootstock had the highest IWUE (2.94 kg ha^{-1} mm), the lowest IWUE (0.29 kg ha^{-1} mm) was determined in C treatments of 10 days irrigation intervals. C treatments in 4 days irrigation interval of nurseries grafted onto 41 B rootstock had the lowest IWUE (0.09 kg ha^{-1} mm). The highest IWUE was obtained from Bp treatments in 7 days irrigation intervals (2.26 kg ha^{-1} mm).

The effects of different rootstocks, mulches and irrigation intervals on irrigation water using of nurseries were significantly in this study. According to results of study, it was determined that nurseries grafted onto 5 BB rootstocks which was known sensitive to drought used more irrigation water than nurseries grafted onto 41 B and 140 Ru rootstocks which was known resistant to drought. This state was corresponded with root systems and general properties of rootstocks. Grants and Matthews (1996) ve Paranychianakis et al. (2004) stated that rootstocks affected shoot growing. Because shoots growing were very different, nurseries growing were different too. So, amount of irrigation water using of different rootstocks were very different.

Table 2 Monthly and total irrigation water amount (mm) in 2007 and 2008.

Treatments			Monthly and total irrigation water amounts (mm)									
			2007					2008				
Rootstocks	Irrigation intervals	Mulches	May	June	July	Augusr	Total	May	June	July	Augusr	Total
5 BB	4 days	C*	70.4	189.1	330.5	373.9	963.9	35.0	218.0	348.6	394.5	996.1
		Rw	66.2	144.2	250.1	252.4	712.9	35.0	157.1	194.6	240.0	626.7
		Gc	67.8	145.2	220.6	244.3	677.9	35.0	183.1	223.2	273.5	714.8
		Bp	64.2	103.2	154.1	146.9	468.4	35.0	135.5	168.4	176.1	515.0
	7 days	C	72.5	115.7	293.6	244.6	726.4	35.0	223.3	288.5	254.9	801.7
		Rw	67.2	89.4	214.3	167.4	538.3	35.0	147.1	181.4	186.2	549.7
		Gc	69.4	92.2	185.2	142.3	489.1	35.0	141.6	190.1	195.5	562.2
		Bp	66.1	66.6	143.5	112.2	388.4	35.0	100.8	130.5	140.2	406.5
	10 days	C	78.4	127.3	213.8	223.2	642.7	35.0	145.5	231.5	193.6	605.6
		Rw	73.2	90.0	138.6	141.0	442.8	35.0	88.5	164.3	166.8	454.6
		Gc	74.5	77.1	158.7	156.3	466.6	35.0	106.3	170.3	177.7	489.3
		Bp	70.2	59.5	111.3	103.9	344.9	35.0	80.1	135.3	141.4	391.8
140 Ru	4 days	C	71.2	196.5	255.3	259.7	782.7	35.0	188.6	266.5	354.3	844.4
		Rw	66.5	139.6	155.3	139.0	500.4	35.0	156.3	189.0	208.9	589.2
		Gc	68.2	147.0	163.9	176.4	555.5	35.0	156.1	191.5	225.6	608.2
		Bp	66.1	114.0	129.7	108.8	418.6	35.0	121.7	163.9	178.6	499.2
	7 days	C	75.4	114.0	225.2	171.6	586.2	35.0	147.4	180.4	214.3	577.1
		Rw	71.2	92.8	150.5	118.8	433.3	35.0	111.7	120.7	125.3	392.7
		Gc	73.4	96.7	155.2	114.9	440.2	35.0	107.2	145.4	147.3	434.9
		Bp	66.1	54.7	134.1	103.6	358.5	35.0	92.1	117.8	124.6	369.5
	10 days	C	75.9	96.4	168.8	173.7	514.8	35.0	137.3	215.0	185.0	572.3
		Rw	72.8	86.1	128.7	126.7	414.3	35.0	92.2	132.7	149.6	409.5
		Gc	73.8	75.1	124.5	130.0	403.4	35.0	95.9	160.2	169.9	461.0
		Bp	68.8	61.2	94.4	92.5	316.9	35.0	75.5	126.3	128.8	365.6
41 B	4 days	C	72.2	207.6	281.8	259.6	821.2	35.0	189.4	267.6	339.3	831.3
		Rw	67.1	153.9	178.5	180.7	580.2	35.0	152.2	208.7	251.4	647.3
		Gc	68.0	143.8	168.9	158.5	539.2	35.0	161.3	188.9	217.0	602.2
		Bp	66.1	102.1	138.7	117.5	424.4	35.0	120.6	156.5	170.5	482.6
	7 days	C	74.1	112.1	205.2	154.5	545.9	35.0	156.9	187.9	194.7	574.5
		Rw	70.2	87.3	159.8	123.7	441.0	35.0	75.8	144.3	150.9	451.0
		Gc	71.0	81.1	133.1	95.7	380.9	35.0	104.0	140.1	145.8	424.9
		Bp	66.1	57.5	111.7	82.9	318.2	35.0	94.1	95.5	109.6	334.2
	10 days	C	76.5	105.3	171.4	172.4	525.6	35.0	121.9	209.8	178.6	545.3
		Rw	72.4	82.3	124.1	118.9	397.7	35.0	92.6	138.9	138.5	405.0
		Gc	74.7	79.2	117.6	139.9	411.4	35.0	95.7	164.6	172.3	467.6
		Bp	66.5	50.1	83.5	86.8	286.9	35.0	81.6	127.7	133.5	377.8

**control, C; rose oil processing wastes, Rw; grass clippings, Gc; black plastic, Bp*

Table 3 Total irrigation water amount (mm), shoot weight (kg ha^{-1}), IWUE(kg ha^{-1} mm) in 2007 and 2008

Treatments			2007			2008		
Rootstocks	Irrigation intervals	Mulches	Irrigation water (mm)	Shoot weight (kg ha^{-1})	IWUE (kg ha^{-1} mm)	Irrigation water (mm)	Shoot weight (kg ha^{-1})	IWUE (kg ha^{-1} mm)
5 BB	4 days	C*	963.9	955	0.99	996.1	333	0.33
		Rw	712.9	3386	4.75	626.7	1143	1.82
		Gc	677.9	3275	4.83	714.8	755	1.06
		Bp	468.4	6793	14.50	515.0	1820	3.53
	7 days	C	726.4	877	1.21	801.7	78	0.10
		Rw	538.3	1776	3.30	549.7	821	1.49
		Gc	489.1	2042	4.18	562.2	300	0.53
		Bp	388.4	4973	12.80	406.5	1343	3.30
	10 days	C	642.7	666	1.04	605.6	67	0.11
		Rw	442.8	1210	2.73	454.6	200	0.44
		Gc	466.6	1665	3.57	489.3	233	0.48
		Bp	344.9	4706	13.64	391.8	1310	3.34
140 Ru	4 days	C	782.7	566	0.72	844.4	355	0.42
		Rw	500.4	1055	2.11	589.2	777	1.32
		Gc	555.5	1099	1.98	608.2	500	0.82
		Bp	418.6	1965	4.69	499.2	766	1.53
	7 days	C	586.2	322	0.55	577.1	200	0.35
		Rw	433.3	755	1.74	392.7	511	1.30
		Gc	440.2	666	1.51	434.9	477	1.10
		Bp	358.5	1166	3.25	369.5	1088	2.94
	10 days	C	514.8	200	0.39	572.3	167	0.29
		Rw	414.3	533	1.29	409.5	400	0.98
		Gc	403.4	488	1.21	461.0	233	0.51
		Bp	316.9	1043	3.29	365.6	833	2.28
41 B	4 days	C	821.2	322	0.39	831.3	78	0.09
		Rw	580.2	1099	1.89	647.3	488	0.75
		Gc	539.2	788	1.46	602.2	244	0.41
		Bp	424.4	1665	3.92	482.6	744	1.54
	7 days	C	545.9	189	0.35	574.5	100	0.17
		Rw	441.0	666	1.51	451.0	266	0.59
		Gc	380.9	344	0.90	424.9	555	1.31
		Bp	318.2	1687	5.30	334.2	755	2.26
	10 days	C	525.6	67	0.13	545.3	111	0.20
		Rw	397.7	300	0.75	405.0	133	0.33
		Gc	411.4	167	0.41	467.6	189	0.40
		Bp	286.9	1021	3.56	377.8	755	2.00

**control, C; rose oil processing wastes, Rw; grass clippings, Gc; black plastic, Bp.*

The effetcs of irrigation intervals on amount of irrigation water using were different. While irrigation intervals increased, amount of irrigation water using decreased.

Because evaporation from soil surface and weed density were more than mulched treatments, control treatments were applied more irrigation water. Mulched treatments were applied less irrigation water than control treatments in order that mulches covered to soil surface and reduced evaporation from soil surface. Ramakrishna et al. (2006) and Mahajan et al. (2007) reported that mulches inhibited evaporation and

conserved water in soil. Because Bp, Rw and Gc mulches covered the whole soil surface, evaporation from soil surface decreased significantly. Bp mulch treatments were applied less irrigation water than other treatments. Beyazgül et al. (2002) and Phadung et al. (2005) found that Bp mulch conserved soil water longer and decreased irrigation water requirement. Rw and Gc mulches treatments were applied similar amounts of irrigation water. These treatments applied to these treatments less amount of irrigation water than C teratments. Researchers determined that organic mulches like Rw and Gc conserved soil water more than C treatments (Cui et al. 2002; Kar and Kumar 2007; Sekhon et al. 2008). At the same time, mulch applications inhibited weed growth. So they prevented that weeds used water in soil.

According to IWUE values, there were very differences between rootstocks in both years. While the highest values were obtained from nurseries grafted onto 5 BB rootstocks, nurseries grafted onto 140 Ru and 41 B rootstocks had similar values each other. The reason for this, nurseries grafted onto 5 BB rootstocks used more irrigation water and developed longer and thicker shoots. IWUE values were also very different in irrigation intervals. While irrigation intervals increased, amount of irrigation water applied to treatments decreased. At the same time less shoot weights were obtained. There were big differences in mulch applications. Generally, while the highest IWUE values were obtained from Bp treatments, the lowest values were obtained from C treatmens. The closer values were determined in Rw and Gc treatments. Bp treatments had the highest IWUE values, because applied of irrigation water amounts were less than another treatments and shoot weights which was obtained from Bp treatments were higher than other treatments. C treatments had the lowest IWUE values, because applied of irrigation water amounts were more than another treatments and shoot weights which was obtained from C treatments were less than other treatments. As evaluated IWUE results in both years, it was determined that results of IWUE in 2007 were higher than results in 2008. The reason for this, shoot weights in 2008 were less than shoot weights in 2007 in contrast with applied irrigation water amount were close each other in both years.

CONCLUSION

The results of this study showed that irrigation programmes were very important in grafted vines. It was determined that irrigation programmes and applied irrigation water amounts should be different in grafted vines production on different rootstocks. While nurseries grafted onto 5 BB rootstock had the highest amount of irrigation water using, nurseries grafted onto 140 Ru and 41 B rootstocks had amount of irrigation water using less than 5 BB. It was determined that mulch applications saved more irrigation water than control treatments. So that, more agricultural land could be irrigated with saving irrigation water. According to IWUE values, while 5 BB rootstock had the highest IWUE values, 41 B rootstocks had the lowest values. In irrigation intervals, the highest IWUE values were obtained from 4 days irrigation intervals. The lowest values obtained from 10 days irrigation intervals. While the highest results among mulch applications were obtained from Bp treatments, the lowest results were determined in control treatments.

As a result, it is reccommended that mulch materials (black plastic, rose oil processing wastes, grass clippings and etc.) should be used for saving irrigation water in soil. On account of increasing demands for water resource, restriscting agricultural land and decreasing available irrigation water, irrigation scheduling studies have been getting more important day by day. Global climate changes have negative effects of on water resources. Water resources should be used optimum to reduce negative effects. So, it will be good that irrigation programmes for growing different plants should be prepared, applied and transferred to farmers.

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