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The Effects of Different Irrigation Levels and Mulching on the Yield and Quality Components of Young Grafted Vine of Tekirdag Seedless Variety

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Abstract The objective of this research, carried out in Tekirdağ Viticulture Research Institute, was to investigate the effect of different irrigation levels and mulching on the yield and quality of young grafted vine of Tekirdag Seedless variety. Cuttings of Tekirdag Seedless gape variety grafted on Kober (5BB) rootstock was used. Drip irrigation method was applied to the mulched (M) and non mulched (NM) pilots when 30% (I30), 50% (I50) and 70% I70) of the plant available water was consumed in a Randomized Complete Block Design in split plots with 3 replications. Seedling efficiency, main shoot length, main shoot thickness, main root number, shoot and root growth levels were evaluated. Total irrigation water amount in MI30 treatment was 279.0 mm and 13.3%, 17.2%, 23.7%, 27.6% and 32.6% less than that of the MI50, MI70, NMI30, NMII50 and NMI70 treatments, respectively. As for the seedling quality, considering main shoot length, main shoot thickness, main root number, the level of shoot growth and root growth level, MI30 treatment gave the best results, which was followed by MI50. As a conclusion, frequent irrigation in small amounts is suggested to meet water demand.

Keywords Irrigation Program, Mulch, Vine, Seedling Quality and Yield, Tekirdag

1. Introduction

Turkey is situated on the most favourable climate belt of alluvial regions for vine production. For this reason, it has a very old and rooted viniculture culture and a rich gene potential. Currently, Turkey is one of the top producers of grape with about 4 million tons on 468.80 ha of vineyards. Over 77 million tons of grapes are grown worldwide on more than 7.1 million ha. Turkey ranks fifth in terms of growing area, after Spain, France, China, and Italy, and ranks sixth in production after China, Italy, USA, Spain and France [1].

Total standard vine seedling production of Turkey ranges between 5.0 and 7.5 millions per year (almost 75% is grafted vines)[2,3]. Current number of nurseries having license to produce grapevine planting materials are 31 in different regions [2]. Seedling production by public institutions is less than by the private sector. The produced amount does not meet the country's needs and the unmet part is exported [4].

Given the fact that the vineyards need to be renewed every 40 years for economic production, an area of 14 400 ha should be renewed every year, and about 24 000 000 seedlings are needed at 3 x 2 m planting intervals. This calculation is based on the assumption that all grapevine areas are productive and economical. However, while a significant part of vineyards are not established according to modern production techniques; part of it is out of production due to age, disease and similar reasons. The same is also true for traditional viticulture maintained in the South-eastern Anatolia and the Eastern Mediterranean region [5]. All these reveal the inadequacy of seedling production in our country clearly. If these problems are not solved, the decline in grapevine areas seems to continue in the future [6].

Increasing the healthy vineyards area in Turkey will be possible by increasing the production of quality and productive varieties and rootstocks. Healthy grafted vine seedlings development depends on careful handling of maintenance activities such as irrigation, fertilization, weed control, disease control and pest control during summer growing period after planting in nursery parcels. The young seedlings with limited roots and shoot capacities are very sensitive to soil moisture and require that soil moisture be kept between the desired limits by correct irrigation scheduling. Precisely scheduled irrigation helps root formation, shoot development and seedling growth. Recently, plastic mulch application with drip irrigation has been widely used for water saving and environmental protection in nursery parcels.

There are numerous studies on irrigation scheduling of various plants including grape vine and effectiveness of mulching on water saving however limited research is available on the combined effects of different irrigations levels and mulch treatments on yield and quality of young grafted vine.

The objective of this research was to investigate the effect of different irrigation levels and mulch treatments on the yield and quality of young grafted vine of Tekirdag Seedless variety under Tekirdag condition. This study will help to develop an appropriate irrigation program in the young grafted vine production and to reduce the negative effect of the excess water on the environment.

2. Materials and Methods

2.1. Materials

Experimental Site: This study was carried out in the nursery parcels of Tekirdağ Viticulture Research Institute in the 2007 vegetation period. The study area is located between 40°59′ N Latitude and 27°29′ E Longitudes and at 4.0 m Altitudes.

Soil: The nursery plot is located in a low-lying area in the north-northwest direction. The soil texture was clay-loam, pH was between 7.5-7.6, bulk density in 0-90 cm soil profile ranged between1.55 and 1.61 gr/cm^3, The field capacity was between 24.97% and 25.43% and the wilting point was between 12.74% and 13.80%.

Grapevine variety and rootstock: Cuttings of Tekirdag Seedless gape variety grafted on Kober (5BB) rootstock was used. Tekirdag Seedless, breaded by Tekirdağ Viticulture Research Institute, is coloured, middle season grape varietywith large berries. It is a highly preferred variety both at home and abroad in recent years due to these properties. 5BB rootstock does not like very dry soils, is resistant to nematodes and suitable for damp and clayey soils. Its vegetation period is shorter than that of the most of the other rootstocks and can easily grow in northern climatic regions [7].

Irrigation water: Electrical conductivity of irrigation water ranged from 0.25 to 0.75dS/m. It has no salinity and alkalinity problem.

Climate: The study area is located in the semi-arid climatic zone with an average annual temperature of 13.8 °C. Considering the average monthly temperature, January is the coldest month with 4.9 °C and the hottest month is July with 23.6 °C. The average annual precipitation is 571.9 mm and the peak season coincides between October and March. The average annual relative humidity is 77%, which falls to 71% in July and rises to 82% in December-January. The annual mean wind speed is 2.7 m/s at a height of 2.0 m. The average temperature, precipitation and relative humidity during the experiment were recorded (Table 1).

Table 1. The average temperature, precipitation and relative humidity of the research year and average of last ten years [8]

Months	Average of last ten years			Research year (2007)		
	Aver. Rel. Hum. %	**Aver. Temp. (°C)**	**Aver. Prec. (mm)**	**Aver. Rel. Hum. %**	**Aver. Temp(°C)**	**Aver. Prec. (mm)**
January	82.6	5.0	53	8.0	18.8	90.7
February	80.3	5.3	68.2	6.9	33.2	92.8
March	79.6	7.7	55.5	8.6	42.8	92.5
April	78.1	11.9	41.2	10.3	17.4	85.8
May	75.6	17	36.8	18.4	45.9	88.3

June	73.7	21.7	29.5	24.2	9.1	78.4
July	71.4	24.7	22.8	26.0	-	68.1
August	73.8	24.4	17.2	25.5	3.1	76.3
September	76.8	20.1	49.0	19.1	33.1	84.5
October	80.5	15.7	75.5	17.0	41.3	90.5
November	83.1	10.9	60.6	10.2	242.0	84.4
December	83.3	6.6	87.8	5.8	60.2	77.9
Total precipitation						**597.1**

2.2. Methodology

Scion and cutting preparation and planting: Scions of Tekirdag grapevine variety in the same length (35-40 cm) and diameter (8-12 mm) and Kober 5BB rootstock cuttings were collected in Febrary 2007.

The rootstocks and scions were bundled into a mixture of 0.5% chinosol for 15 hours in order to prevent the growth of fungi and bacterial diseases during storage before and after grafting time. The grafting materials treated with chinosol were first placed in 90x60cm white plastic bags and then put into 95x65 cm tied black plastic bags to stored at 1-4 °C in and 85-90% relative humidity. The grafted scions were paraffinized by immersing them in paraffin to prevent loss of moisture from the grafting point until full coalescence was achieved. Then grafted scions were taken into folding container whose bottom were filled with active coal and water up to 10 cm. The germination water was changed every 2-3 days by overflowing through holes at 10 cm height of the container. .

The folding containers, each of which had 850-900 grafted scions, were kept in germination room for 21 days at 26-28 °C and 85-90 % relative humidity in order to accelerate callus formation. At the end of this period, they were subjected to 18-20 °C temperature and 65-70% relative humidity for 6-7 days to adapt to field conditions.

The roots emerging from the bottom parts are shortened to 2.0 cm and the shoots extending from the top are shortened to 1.5-2.0 cm. The grafted cuttings are then re-paraffinized.

In grapevine nursery, soil cupolas were established with an interval of 80.0 cm, height of 20.0 cm and a width of 60.0 cm and covered by black cover to form mulched plots. Holes with intervals of 20.0 cm between and 8 cm in rows were opened on the mulching plastic.

The sapling was done inserting 2/3 of grafted cuttings into the soil through the holes (Figure 1). A similar procedure was followed for NM plots. Considering the nutritional status of the nursery soil, sufficient amount of fertilizers were applied before planting.

Figure 1: The grapevine nursery and mulched plots.

Experimental Design: The study was set up in a Randomized Complete Block Design in split plots with 3 replications. Mulched (M) and non-mulched (NM) treatments took place in the main plots whereas irrigation treatments took place in the sub-plots. There were 3 irrigation treatments: starting irrigation when 30% of plant-available water in 30.0 cm soil profile was consumed (I30); starting irrigation when 50% of plant-available water in 30.0 cm soil profile was consumed (I50); starting irrigation when 70% of plant-available water in 30.0

cm soil profile was consumed (I70). Therefore there were 18 parcels in total (2 main treatments x 3 sub treatments and 3 replications), and 100 scions grafted on 5BB rootstock in each parcel. Water deficit in the soil profile was completed to field capacity by drip irrigation system. Irrigation scheduling was based on the gravimetric water content monitoring following the procedure given by [9]. To monitor gravimetric water content, soil samples were collected daily from 0-10, 10-20 and 20-30 cm soil profile and 15.0 cm off the plant row using auger hole method and oven dried at 105.0 °C for 24 hours.

Measurements of efficiency and quality parameters of grafted and rooted saplings: To investigate the impact of three irrigation levels under M and NM conditions, seedling efficiency, main shoot length, main shoot thickness, main root number, shoot and root growth level were evaluated after harvesting grafted and rooted scions.

Seedling efficiency (%): The ratio of obtained the 1st and the 2nd quality seedling number to the total sapling number is defined as sapling efficiency. 1st and 2nd quality saplings are decided according to TS 3981 codex for grafted grapevine seedling. Well-develop grafted seedlings with 35.0 cm and above stem length, 8.0 mm and above stem diameter, 3 and above root and healthy callus formation are classified as the 1st quality seedling. Similarly, seedlings with 35.0 cm and above stem length, 6.0 mm and above stem diameter, 2 and above root and healthy callus formation (but not as good as in the 1st quality) are classified as the 2nd quality seedling.

Main shoot length, thickness and development level: The main shoot lengths of the grafted scions and the main shoot thickness between the second and third knots of the grafted scions were measured. The shoot development level was qualified as "1 = weak", "2 = medium", "3 = strong" and "4 = very strong" following the procedure described in [10].

Main root number and development level: The roots from the bottom of the grafted scions and thicker than 3 mm were defined as main root. The root development level was qualified as "1 = weak", "2 = medium", "3 = strong" and "4 = very strong" following the procedure described in [10].

Statistical (ANOVA) analyses were conducted to investigate the differences between the treatments.

3. Results and Discussion

3.1. Number of irrigation and amount of irrigation water

The number of irrigation and amount of irrigation water for different irrigation treatments under M and NM conditions are presented in Table 2. Table 2 shows that mulching significantly decreased the number of irrigation and amount of irrigation water because of preventing evaporation from the soil surface. The largest irrigation water and the least number of irrigation was applied to I70 irrigation treatments and this was followed by I50 and I30, respectively, for both mulched and NM plots. Total irrigation water amount was 13.3%, 17.2%, 23.7%, 27.6% and 32.6% less than that of the MI50, MI70, NMI30, NMII50 and NMI70 treatments, respectively. Effectiveness of mulch application to reduce evapotranspiration and amount of irrigation water was also reported by many authors under different experimental conditions for different plants [11, 12, 13, 14, 15, 16]. On the other hand, [17] found that the application of black mulch had a negative effect on the quality and yield of the seedlings because of excessive heat generation of black mulch. The less the plant available water was allowed to consume to start irrigation the more frequent irrigation was obtained. Similar results were also abstained by [18] for sugar beet, sunflower, wheat and maize under Tekirdag conditions.

Table 2: The number of irrigation and amount of irrigation water for different irrigation treatments under M and NM conditions (I30, I50 and I70 represent when 30, 50 and 70% of the plant available water in 30 cm soil profile is consumed, respectively).

	Mulched treatments			**Non-mulched treatment**		
	I30	**I50**	**I70**	**I30**	**I50**	**I70**
Number of irrigation	16	11	8	20	12	9
Total irrigation (mm)	279.0	316.0	327.0	345.0	356.0	370.0

3.2. Main shoot length, thickness and development level

Main shoot length (mm), main shoot thickness and main shoot development levels for different irrigation treatments under M and NM conditions are presented in Table 3, Table 4 and Table 5, respectively.

Table 3: Main shoot length (mm) for different irrigation treatments under M and NM conditions (I30, I50 and I70 represent when 30, 50 and 70% of the plant available water in 30 cm soil profile is consumed, respectively).

	Main shoot length (mm)			Mulching main effect
	I30	**I50**	**I70**	
M	92.8a	72.7b	51.5d	72.4a
NM	55.9c	54.9cd	52.4cd	54.4b
Irrigation treatments main effect	74.4a	63.8b	52.0c	

LSD % 5: 1.6618; LSD % 5: 2.4911; LSD % 5: 3.5229

Table 4: Main shoot thickness (mm) for different irrigation treatments under M and NM conditions (I30, I50 and I70 represent when 30, 50 and 70% of the plant available water in 30 cm soil profile is consumed, respectively)

	Main shoot thickness (mm)			Mulching main effect
	I30	**I50**	**I70**	
M	8.78a	7.02b	4.61e	6.80a
NM	6.11c	5.53d	4.26f	5.30b
Irrigation main effect	7.45a	6.27b	4.43c	

LSD % 5: 1.4741; LSD % 5: 0.0595; LSD % 5: 0.1031

Table 3 and 4 reveal that mulching and irrigation levels have statistically significant effects on main shoot lengths and thickness. The main shoot lengths and thickness of M treatments were found to be higher than that of the NM treatments. The highest main shoot length and thickness were recorded for I30 irrigation level, which were followed by I50 and I70 under M and NM conditions.

Table 5: Shoot development level for different irrigation treatments under M and NM conditions (I30, I50 and I70 represent when 30, 50 and 70% of the plant available water in 30 cm soil profile is consumed, respectively).

	Shoot development level (mm)			Mulching main effect
	I30	**I50**	**I70**	
M	4.0a	3.0b	2.0c	3.0a
NM	2.0c	2.0c	2.0c	2.0b
Irrigation treatments main effect	3.0a	2.5b	2.0c	

The shoot development levels in M treatments were better that in NM treatment. The best results was obtained for I30 treatment, which was followed by I50 and I70 for M condition while the same shoot development level of “2 = medium” was obtained under NM conditions.

Although the amount of irrigation was less, the shoot development was better in more frequent irrigation treatment, i.e. in I30, both in M and NM conditions. Balint and Reynolds [19] also obtained a better shoot development of vine in Niagara-on-the-Lake, Ontario, Canada in full irrigation treatment when compared with the deficit irrigation. Similar results was also found by [20] in Italia, [21] in South Africa, [22] in Spain and [23] in Germany.

3.3. Main root number and development level

Themain root number and their development levels for different irrigation treatments under M and NM conditions are presented in Table 6, and Table 7, respectively.

Table 6: Main root number for different irrigation treatments under M and NM conditions (I30, I50 and I70 represent when 30, 50 and 70% of the plant available water in 30 cm soil profile is consumed, respectively).

	Main root number (mm)			Mulching main effect
	I30	**I50**	**I70**	
M	9.23a	7.10b	5.68d	7.33a
NM	6.10c	4.48f	5.00e	5.19b
Irrigation treatments main effect	7.67a	5.78b	5.33c	

LSD % 5: 0.2560; LSD % 5: 0.3621; LSD % 5: 0.4945

Table 6 shows that mulching and irrigation levels have statistically significant impact on the main root number. The main root number of M treatments were found to be higher than that of the NM treatments. The highest main shoot length was recorded for I30 irrigation level, which was followed by I50 and I70 under M and NM conditions. Similar results were obtained for the root development level (Table 7).[20] observed a significant negative effects of deficit irrigation on root development. [24] stated that, for field grown grafted Monastrell grapevines rootstock-scion combination, high irrigation volumes applied to the wet part of the root were critical for increasing root growth and improving performance under semiarid condition. [25] found the same root development results in the experiment to investigate and compare the first year of growth of grapevines planted on raised beds with vines established under conventional soil management.

Table 7: Root development level for different irrigation treatments under M and NM conditions (I30, I50 and I70 represent when 30, 50 and 70% of the plant available water in 30 cm soil profile is consumed, respectively).

	Root development level			Mulching
	I30	**I50**	**I70**	**main effect**
M	4.0a	3.0b	2.0c	3.0a
NM	2.6b	2.0c	2.0c	2.2b
Irrigation treatments main effect	3.3a	2.5b	2.0c	

LSD %5: 0.1793; LSD %5: 0.3150; LSD %5: 0.4455

3.4. Seedling efficiency (%)

The 1st, the 2nd and total quality seedling efficiencies for different irrigation treatments under M and NM conditions are presented in Figure 2.

No statistically significant difference was observed among the treatments in terms of 1st quality seedling efficiency. I30 treatments gave the best results whereas the lowest efficiencies were observed in I70 treatments under M and NM conditions. There was no statistically significant difference among the treatments in terms of 2nd quality seedling efficiency.

As for the total seedling efficiency, there were not any differences statistically among the treatments. However, the total seedling efficiency of treatments NMI30 and NMI50 were slightly higher than that of the other treatments. The reason why the yield of M treatments was slightly lower than that of the NM treatments was because of the contamination of the soil-borne root disease later on in the seedlings due to aeration problems in M treatments.

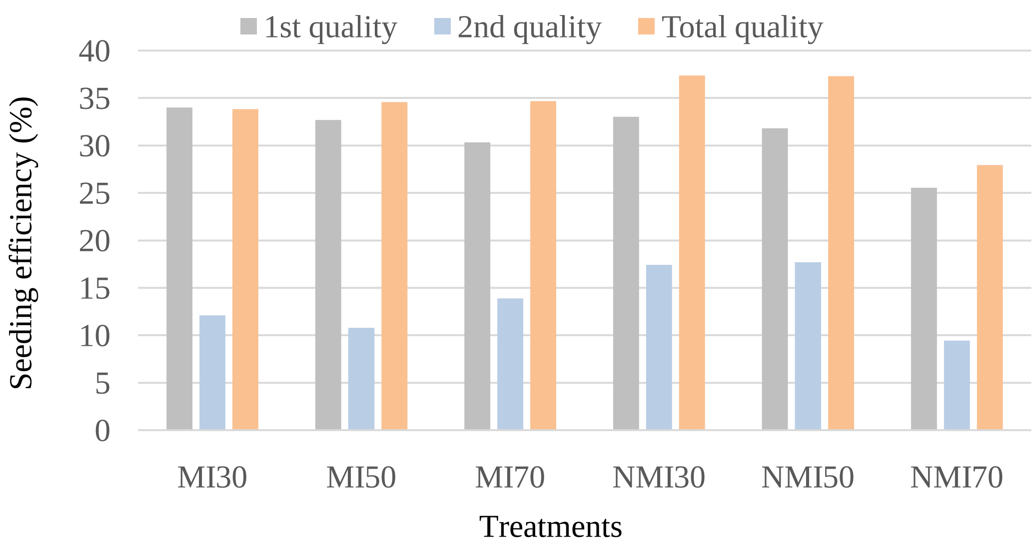

Figure 2: The 1st, the 2nd and total quality seedling efficiencies for different irrigation treatments under M and NM conditions (I30, I50 and I70 represent when 30, 50 and 70% of the plant available water in 30 cm soil profile is consumed, respectively).

4. Conclusions and recommendation

In terms of total irrigation water amount, MI30 gave the best results, i.e. the least irrigation water was applied. When this treatment was compared with the MI50, MI70, NMI30, NMI50 and NMI70 treatments, it is possible to save 13.3%, 17.2%, 23.7%, 27.6% and 32.6% of irrigation water, respectively.

The main shoot lengths and thickness of M treatments were found to higher than that of the NM treatments. The highest main shoot length and thickness were recorded for I30 irrigation level, which were followed by I50 and I70 under M and NM conditions.

The shoot development levels in M treatments were better than that in NM treatment. The best results was obtained for I30 treatment, which was followed by I50 and I70 for M condition while the same shoot development level of “2 = medium” was obtained under NM conditions. Although the amount of irrigation was less, the shoot development was better in more frequent irrigation treatment, i.e. in I30, both in M and NM conditions.

The main root number of M treatments were found to higher than that of the NM treatments. The highest main shoot length was recorded for I30 irrigation level, which was followed by I50 and I70 under M and NM conditions. Similar results were obtained for the root development level.

As for the 1st quality seedling efficiency, I30 treatments gave the best results whereas the lowest efficiencies were observed in I70 treatments under M and NM conditions. There was no statistically significant difference among the treatments in terms of 2ndquality seedling efficiency.

In terms of total seedling efficiency, treatments NMI30 and NMI50 were slightly higher than that of the other treatments.

Under Tekirdağ and similar conditions, the more frequent irrigation application under M condition (MI30) is recommended. However, soil-borne root diseases in the seedlings due to aeration problems in M and more frequent irrigation treatments should be carefully considered.

Research studies on fertigation under M and NM conditions should also be studied in seedling production.

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