Asian Journal of Plant Sciences

ISSN 1682-3974

science alert

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Asian Journal of Plant Sciences 6 (4): 643-647, 2007
ISSN 1682-3974

The Effects of Different Irrigation Levels on Yield and Quality of Some Early Grape Cultivars Grown in Greenhouse

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Abstract: Five years old grapevines of Early Cardinal, Trakya ilkeren, Ergin cekirdeksizi and Yalova Incisi grown in greenhouse were used. During three years, the effects of three different evaporation coefficient factors (kp1 = 1.0, kp2 = 1.3, kp3 = 1.6) on vines were investigated. Irrigation amounts calculated with respect to each evaporation factor were applied in 4-6 days intervals. In general, cluster weight and berry size were slightly increased with kp2 application while different irrigation levels had no significant effect on bud-break and berry ripening date both in cultivars and years. Considering earliness, grape yield, cluster and berry size, cultivars Early Cardinal and Yalova Incisi with irrigation level kp2 could be recommended for early grape production under greenhouse conditions.

Key words: Grapevine, greenhouse, irrigation, earliness

INTRODUCTION

Mediterranean Region is the second biggest grape producing zone among agricultural regions of Turkey with the values of 103172 ha and 706105 ton, area and production, respectively (Celik *et al*., 2005). For open area grape production, harvesting begins in the middle of June in Cukurova Province (Ergenoglu, 1988; Tangolar *et al*., 1996). In the region, early ripening grape cultivars have always higher income and they have been therefore taking up the growers' attention.

In viticulture researches, in order to obtain earlier crops, many applications have being carried out one of which is to grow vines under greenhouse conditions (Manzo, 1977; Lavee, 1988; Avenant and Loubser, 1994; Li and Zhang, 1994).

In Turkey, use of polyethylene (PE) cover in viticulture studies has been increasing and many researches have focused on the improvement of earliness. In some researches carried out by Uzun (1993), Uzun and Ozbas (1995) and Ergenoglu *et al*. (1998 and 1999), it was shown that ripening was earlier for 14-29 days than open field grown vines. These studies indicate that favorable conditions of Mediterranean Region induce growers to produce grape under PE coverage.

Grapes require certain amount of water in the soil for normal vegetative growth and maturity. In greenhouse production technique, which collects increasing interest of Cukurova grape growers, irrigation is required apart from open field grape growing. Under greenhouse condition, as the vines get limited rainfall water, additional irrigation after covering is necessary to obtain high quality of grapes. Furthermore in many researches, it was implied that additional water must be supplied in vineyards when the rainfall is not enough (Winkler *et al*., 1974; Weaver, 1976; Wildman *et al*., 1976; Cifre *et al*., 2005; Rana *et al*., 2004). For this reason, it is essential to highlight accurate applications and calculations such as irrigation procedures (Van Zyl and Van Hyssteen, 1988; Ergenoglu *et al*., 1992 and 1997), water consumption of vine (Bastug *et al*., 1998), irrigation times and water requirement (Grimes and Williams, 1990; Naor *et al*., 1993; Nadal and Arola, 1995; Rana *et al*., 2004; Zabihi, 2004; Keller *et al*., 2005; Reynolds *et al*., 2005).

In this study, the determination of the irrigation water requirement for vines grown under greenhouse conditions was aimed under Mediterranean type climate.

MATERIALS AND METHODS

This research was carried out in Research and Application Vineyard of Cukurova University, Agriculture Faculty, Horticulture Department during 2000-2002. In the study, guyot system trained Yalova incisi, Trakya ilkeren,

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Table 1: Irrigation requirements calculated with respect to total evaporation in different years (L vine^{-1})

Years	Irrigation numbers (n)	Total irrigation time (day)	Total evaporation (mm)*	Total irrigation requirements (L vine^{-1})		
				kp1	kp2	kp3
2000	6	26	111	83.3	108.2	133.2
2001	7	30	104	78.0	101.4	124.8
2002	9	46	245	183.8	238.9	294.0

* Total evaporation was measured between 18 May -12 June in 2000; 3 May-1 June in 2001; 16 March -31 May in 2002

Table 2: Physical and chemical properties of the experimental area soil

Properties	0-30 cm	30-60 cm	Average	Evaluation*
P (mg kg^{-1})	3.9	8.1	6.0	Low
K (mg kg^{-1})	225	128	177	Sufficient
Ca (mg kg^{-1})	5773	5633	5703	High
Mg (mg kg^{-1})	610	513	562	High
Fe (mg kg^{-1})	2.75	2.63	2.69	Medium
Zn (mg kg^{-1})	0.39	0.27	0.33	Low
Cu (mg kg^{-1})	0.43	0.36	0.39	Sufficient
Mn (mg kg^{-1})	2.76	1.64	2.20	Very low
Lime (%)	51	56	54	Very high

*According to the Gunes *et al.* (2004)

Ergin cekirdeksizi and Early Cardinal cultivars with the density of 1.0×1.5 m were used. Vines were grown in three equal sized PE greenhouse, 2.0 m in height, 30 m in length and 3.0 m in width, the PE containing UV+IR was 300 μm in thickness. In the middle of February, PE was covered on the greenhouses in which no additional heating system was installed. In the investigation the effects of three irrigation levels on grape yield and quality were compared under greenhouse. For irrigation, following equation suggested by Goldberg *et al.* (1976) was utilized: IR = kp. Epan.A.R where IR is the irrigation requirement (L. vine^{-1}), kp evaporation coefficient [in the study kp1, kp 2 and kp 3 were used as 1.0 (whole amount of water equal to evaporation), 1.3 (whole amount with additional 30%) and 1.6 (whole amount with additional 60%), respectively)], Epan the amount of cumulative evaporation from class A-Pan during an irrigation interval (mm or L), A each plant area (1.5 m^2) and R Percentage of wetted area (taken as 0.5). Irrigations were applied in 4-6 days intervals depending on evaporation amounts by drip irrigation system. Class A Pan was located at the experiment area.

Irrigation numbers, evaporation values and irrigation requirements with respect to irrigation applications were given in Table 1.

In drip irrigation system, laterals were laid on each plant row and droppers of 4 L h^{-1} capacity were arranged in 75 cm intervals on lateral lines.

The soil properties, based on 0-30 and 30-60 cm depths were Shown in Table 2. Only in 2002 year 50 kg N ha^{-1} as urea and 15 kg P_2O_5 ha^{-1} as phosphoric acid were applied to the experiment area as fertilizer.

The following parameters were examined to compare applications: Bud-break and ripening dates, yield (g vine^{-1}), cluster weight (g), berry weight (g), berry volume (mL), total soluble solids (TSS, %), acidity (g 100 mL juice^{-1}) (Anonymous, 1997). Fifteen vines were examined for each application in five replications. Variance analyses were done according to the ANOVA Randomized Complete Blocks for evaluation of data and the differences between average values were determined with LSD test.

RESULTS AND DISCUSSION

As can be seen in Table 3, bud-break dates varied from season to season due to alteration in responses of cultivars to climatic conditions. Different irrigation levels applied in greenhouse both in cultivars and years had no significant effect on bud-break and ripening date. Trakya Ilkeren and Early Cardinal were earlier than the others in both ripening and bud break dates (Table 3).

On the other hand, cluster and berry weights with yield were affected from applications (Table 4 and 5). In general kp2 level were slightly increased these characteristics. Differences were evident between cultivars. The biggest and the smallest clusters were obtained with Ergin cekirdeksizi and Trakya ilkeren, respectively. By the determination of grape yields, kp1 and kp2 gave higher results with all cultivars. Differences among the different cultivars affected the general mean value. Early Cardinal surpassed the others significantly about the yield. With the evaluation of about 6000 vines per hectare with density of 1.5×1.0 m, grape yields were 10470 kg ha^{-1} with Trakya ilkeren; 17904 kg ha^{-1} with Ergin cekirdeksizi and 22398 kg ha^{-1} with Yalova Incisi, while Early C ardinal had the yield as high as 24918 kg ha^{-1}. Considering the mean grape production value of Turkiye (6792 kg ha^{-1}) (Celik *et al.*, 2005) with its important regions Aegean (8924 kg ha^{-1}) and

Table 3: Effects of different applications on bud break and ripening dates (day month)

		Bud break			Ripening		
Cultivars	Treatments[1]	2000	2001	2002	2000	2001	2002
	kp1	31.3	11.3	28.2	25.6	19.6	13.6
Yalova	kp2	29.3	9.3	1.3	23.6	19.6	13.6
Incisi	kp3	30.3	8.3	28.2	24.6	19.6	13.6
	Mean	30.3	9.3	28.2	24.6	19.6	13.6
	kp1	28.3	6.3	23.2	16.6	7.6	6.6
Trakya	kp2	28.3	4.3	22.2	16.6	7.6	5.6
Ilkeren	kp3	26.3	5.3	21.2	16.6	7.6	7.6
	Mean	27.3	5.3	22.2	16.6	7.6	6.6
	kp1	26.3	7.3	22.2	24.6	27.6	25.6
Ergin	kp2	26.3	6.3	22.2	23.6	27.6	25.6
Cekirdeksizi	kp3	24.3	6.3	21.2	23.6	27.6	25.6
	Mean	25.6	6.3	22.2	23.6	27.6	25.6
	kp1	30.3	6.3	23.2	19.6	12.6	12.6
Early	kp2	30.3	4.3	23.2	20.6	12.6	9.6
Cardinal	kp3	30.3	4.3	23.2	19.6	12.6	10.6
	Mean	30.3	5.3	23.2	19.6	12.6	10.6
	kp1	29.3	8.3	24.2	21.6	16.6	14.6
General	kp2	28.3	6.3	24.2	21.6	16.6	13.6
Mean	kp3	28.3	6.3	23.2	21.6	16.6	14.6

[1]kp1 = 1.0; kp2 = 1.3; kp3 = 1.6

Table 4: Effects of different applications on cluster weight and grape yield of cultivars

		Cluster weight (g)[2]			Yield (g vine^{-1}) [2]		
Cultivars	Treatments[1]	2000	2001	2002	2000	2001	2002
	kp1	246.5	247.5	244.1	3970	4751	5693
Early	kp2	237.8	235.6	365.6	3394	3365	4750
Cardinal	kp3	242.7	264.0	297.3	3578	3735	4142
	Mean	242.3c	249.0c	302.3c	3648a	3950a	4862a
	kp1	307.2	311.6	352.5	3299	3563	4616
Yalova	kp2	285.2	343.3	360.2	3695	3586	4354
Incisi	kp3	291.8	282.3	291.2	3531	3217	3737
	Mean	294.7b	312.4b	334.6b	3508a	3455b	4236b
	kp1	184.0	196.2	222.7	1381	1496	1946
Trakya	kp2	175.4	203.3	220.7	1903	1924	1999
Ilkeren	kp3	166.3	166.5	231.4	1542	1694	1815
	Mean	175.2d	188.7d	224.9d	1609c	1705d	1920d
	kp1	445.5	543.4	578.7	2669	2872	3838
Ergin	kp2	572.4	579.5	604.5	2698	3416	3423
Cekirdeksizi	kp3	405.0	509.0	530.6	2192	2509	3236
	Mean	475.3a	544.0a	571.3a	2520b	2932c	3499c
	kp1	295.8ab	325.0ab	349.5b	2830	3171a	4023a
General	kp2	317.7a	340.4a	387.8a	2923	3073a	3632b
Mean	kp3	276.5b	305.5b	337.6b	2710	2789b	3233c
Treatment LSD 5%	26.1	24.0	21.1	NS	280	332	
Cultivar LSD 5%	30.2	27.4	24.3	211	323	384	
Interaction	**	NS	**	**	**	NS	

[1]kp1=1.0; kp2=1.3; kp3=1.6; [2]NS, Not Significant; **p<0.01; *p<0.05; differences between means in the same column indicated by the same letter (s) are not statistically significant

Mediterranean (6844 kg ha^{-1}) (Celik *et al*., 2005) and some leading cities (Izmir, 8260 kg ha^{-1}) (Nevsehir, 8130 kg ha^{-1}), these yield values of the study were fairly high.

As the irrigation applications commenced in 2002 was earlier (16th March, twenty days after bud break) than the other experimental years, increases in yield, cluster weight and berry size were recorded (Table 4 and 5). These increases possible were due to much more water applications per vines during 2002 period (Table 1).

Evaluation results of application on 100 berry weight (g) and volume (mL) were presented in Table 5. The biggest berries (5.47 g and 5.18 mL) were obtained with Early cardinal with respect to mean value of 3 year study. Significant differences in TSS and acidity grades were found between Irrigation treatments and cultivars (Table 6). Irrigation applications had slight influence on TSS and acid content of berry must. By the investigation of general mean values regarding to effect of irrigation applications, it could be shown that kp2 level provided better results than kp1 and kp3 level.

Table 5: Effects of different applications levels on berry weight and volume of cultivars

		100 berries' weight (g)[2]			100 berries' volume (mL)[2]		
Cultivars	Treatments[1]	2000	2001	2002	2000	2001	2002
	kp1	526	547	526	443	492	498
Early	kp2	538	565	571	545	520	548
Cardinal	kp3	497	584	578	526	536	560
	Mean	520a	565a	558a	505a	516a	535a
	kp1	324	369	373	302	328	356
Yalova	kp2	334	377	383	241	343	366
Incisi	kp3	302	339	362	276	338	345
	Mean	320b	362b	373b	273b	336b	356b
	kp1	215	209	230	207	190	225
Trakya	kp2	189	217	268	178	214	254
Ilkeren	kp3	191	206	250	167	163	248
	Mean	198d	211d	249d	184c	189c	242c
	kp1	297	324	349	315	342	350
Ergin	kp2	256	336	372	266	329	358
Cekirdeksizi	kp3	241	291	323	280	306	343
	Mean	265c	317c	348c	287b	326b	350b
	kp1	341a	362	370b	317	338	357b
General	kp2	329ab	374	399a	308	352	382a
Mean	kp3	308b	355	378b	312	336	374ab
Treatment LSD 5%		22	NS	18	NS	NS	19
Cultivar LSD 5%		25	22	21	27	22	22
Interaction		NS	NS	NS	**	*	NS

[1]kp1=1.0; kp2=1.3; kp3=1.6; [2] NS, Not Significant; **p<0.01; *p<0.05; differences between means in the same column indicated by the same letter (s) are not statistically significant

Table 6: Effects of different applications on TSS and acidity characteristics of cultivars

		TSS (%)[2]			Acidity (%)[2]		
Cultivars	Treatments[1]	2000	2001	2002	2000	2001	2002
	kp1	11.4	12.4	13.6	0.390	0.645	0.609
Early	kp2	11.7	13.6	13.7	0.437	0.576	0.547
Cardinal	kp3	11.5	13.4	14.1	0.381	0.550	0.581
	Mean	11.5b	13.1c	13.8bc	0.403b	0.590b	0.579c
	kp1	12.3	13.6	13.6	0.583	0.418	0.369
Yalova	kp2	11.6	14.7	13.4	0.518	0.360	0.384
Incisi	kp3	12.0	14.1	13.5	0.581	0.344	0.394
	Mean	12.0ab	14.1b	13.5c	0.561a	0.374c	0.382d
	kp1	12.1	16.3	17.1	0.612	0.552	0.680
Trakya	kp2	12.3	15.2	18.0	0.546	0.529	0.619
Ilkeren	kp3	12.3	15.3	15.7	0.583	0.638	0.711
	Mean	12.2a	15.6a	16.9a	0.580a	0.573b	0.670a
	kp1	12.8	11.3	14.1	0.554	0.851	0.631
Ergin	kp2	13.0	12.4	14.4	0.599	0.792	0.657
Cekirdeksizi	kp3	12.0	11.1	13.4	0.578	0.791	0.628
	Mean	12.6a	11.6d	14.0b	0.577a	0.811a	0.639b
	kp1	12.2	13.4	14.6a	0.535	0.616a	0.572
General	kp2	12.1	14.0	14.9a	0.525	0.564b	0.552
Mean	kp3	12.0	13.5	14.2b	0.531	0.581b	0.579
Treatment LSD 5%	NS	NS	0.3	NS	0.026	NS	
Cultivar LSD 5%	0.5	0.5	0.3	0.021	0.030	0.027	
Interaction	NS	**	**	**	**	**	

1kp1=1.0; kp2=1.3; kp3=1.6; [2]NS, Not Significant; **p<0.01; *p<0.05; differences between means in the same column indicated by the same letters are not statistically significant

CONCLUSIONS

At the end of the study, by going through the observed ripening dates of especially Trakya ilkeren and Early Cardinal grown under the greenhouse conditions, these cultivars could be recommended for early table grape production.

Upon the results of this study, it can be concluded that it is useful to maintain viticulture researches about this subject by using different cultivars and conditions and to disclose the best applications with other researches comparatively. It is considered that there is an existence of linear relationship between vine age and effectiveness of irrigation. It is also suggested that the

lower coefficient factor than kp = 1.6 in irrigation levels and the irrigation must start prior or at the bud break with the consideration of early covering. Different irrigation times and intervals also must be examined in greenhouse viticulture.

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