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Interactive effects of bud loading, training system and rootstock on growth, crop yield and quality of 'Kalecik Karasi' (*Vitis vinifera* L.) Red wine variety[1]

This experiment was carried out between 2007 and 2010 to determine the effects of four pruning levels (3, 4, 5, 6 buds per 150 g pruning wood) on head training with 3-4 fruiting canes and bilateral cordon, formed on 90 cm-high trunk on growth, crop yield and quality, and vine balance (RI) of Kalecik Karası which is low yielded, but popular Turkish red wine grape cultivar, grown onto three rootstocks (41B, 5BB, 1103P) in Kalecik/Ankara, located at the central north of Anatolia. Statistical evaluation of experimental data showed that interactive effects between bud loading and training system on three rootstocks in both years were significant. Experimental data were summarized as follows:
1. The effects of the treatments widely varied with the years, caused by the climatic differences particularly at flowering periods.
2. Considering their whole performances, rootstocks can be ordered as in 5BB > 41B > 1103P.
3. Bilateral cordon can be preferred to head training mainly due to its higher bud-burst and yield performances.
4. Among bud loading levels, 6-bud loading can be considered as by far the highest performance, combined with " 1103P x BC" for growth and vine balance parameters; with "5BB or 41B x BC or HT" for yield and crop quality; with "41B or 1103P x BC or HT" for berry composition; followed by 3, 5 and 4-bud loading, respectively.
5. Practically, 20-25 buds/vine (5-6 buds per 150 g pruning weight) for bilateral cordon, and 15-20 buds/vine (4-5 buds per 150 g pruning weight) for head training onto 5BB and 41B for limited irrigated grapevines planted with 1.5x3.0 m distances can be recommended for Kalecik Karası in Kalecik/Ankara location.

Key words: 'Kalecik Karası'; Ankara; rootstock; training; bud loading

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Влияние нагрузки глазками, системы формирования куста и подвоя на рост, урожай и качество красного технического сорта винограда 'Kalecik Karasi' (*Vitis vinifera* L.)

Исследования по определению влияния четырех схем обрезки (3, 4, 5, 6 глазков на побег) на формирование кроны двусторонний кордон с высотой штамба 90 см с 3-4 плодоносящими побегами, урожайность и качество, а также виноградный баланс (RI) сорта 'Kalecik Karası', который является низкоурожайным, но популярным турецким красным техническим сортом винограда, выращиваемым на трех подвоях (41B, 5BB, 1103P) в районе Каледжик / Анкара, расположенном в северной части Центральный Анатолии Турции, проводились в период с 2007 по 2010 гг. Статистическая оценка экспериментальных данных показала, что эффекты взаимодействия между нагрузкой глазками и системой формирования на трех подвоях во все года были значительными. Экспериментальные данные обобщены следующим образом:
1. Влияние обработки широко варьировало по годам, вызванное климатическими различиями, в частности, в период цветения.
2. Учитывая все характеристики, перспективность подвоев представляется в следующей последовательности: 5BB> 41B> 1103P.
3. Двусторонний кордон более предпочтительный, чем головчатая форма куста, в основном из-за лучшего развития почек и урожайности.
4. Анализируя уровни нагрузки глазками, можно сделать заключение, что нагрузка в 6 глазков может считаться как наиболее перспективная в сочетании с подвоем 1103PxBC для параметров роста и развития побегов; с 5BB или 41BxBC или HT для урожайности и качества урожая; с 41B или 1103PxBC или HT для строения ягоды; с последующей нагрузкой 3, 5 и 4 глазков соответственно.
5. Для перспективного выращивания сорта 'Kalecik Karası' в районе Каледжик /Анкара практически можно рекомендовать: 20-25 глазков на куст (5-6 глазков на побег) для двустороннего кордона и 15-20 глазков на куст (4-5 глазков на побег) для формирования головчатой формы куста на 5BB и 41B при ограниченном орошении виноградных растений, посаженных по схеме 3x1,5 м.

Ключевые слова: 'Kalecik Karası'; Анкара; подвой; формировка куста; нагрузка глазками.

Introduction

Kalecik Karası is one of the most popular Turkish red wine grape cultivar, called by the name of Kalecik county of Ankara province, that has been successfully grown along the valley and steeping slopes of the Kızılırmak river near Kalecik, exhibits a specific microclimate, throughout many centuries and gives its best quality wines with carmine color, rich, well-balanced structure. Wines of Kalecik Karası has red fruit, vanilla and cocoa aromas, and a light, fresh and soft/elegant finish, an alcohol ratio between 12-14% v/v and acidity range of 4-7 g/l, also known its similarity with Pinot Noir. Although known as a low yielded variety, with the increasing its popularity, it has been recently grown in other regions of the country e.g. Güney/Denizli and central-south of Anatolia. As the result of a long-term clone selection project conducted by Ankara University with the collaboration of partner institutions between 1972-2010, and four superior clones (numbered as 21, 9, 19, 8) were selected [1].

Although a well-accepted argument, grape fruit and wine quality is substantially determined by the seasonal growth and yield of the grapevines; growth, crop yield and quality parameters are highly influenced by multiple factors including vine age, planting density, rootstock, training system, and location and site characteristics e.g. climate, soil, nutrients, irrigation, and canopy management

[1] This article was prepared from MSc Thesis of Tuğba ÜLGENER titled "Effects of Training and Pruning Severity on Growth, Yield and Quality of Kalecik Karası Wine Grape Cultivar Grown on Three Different Rootstocks in Kalecik" supervised by Prof. Dr. Hasan ÇELİK on 26.10.2010.

practices such as dormant pruning methods, bud loading, canopy design and size, summer pruning and cluster thinning operations [2-8].

This experiment was carried out to reveal the impact of two training systems, four levels of bud loading during dormant pruning onto three rootstocks on seasonal growth, yield, vine balance and crop quality of Kalecik Karası grapevines grown in its original location, Kalecik/ Ankara.

Objects and Methods of Research

Main characteristics of Kalecik Karası [9] and the site of experiment are as follows;

Berries

Color: Blue-black
Shape: Round
Size: 1.5-2.0 g
Seed: 1-2
Flavor: Specific to variety

Clusters

Shape: Winged conical
Size: Small-medium (≈150 g)
Compactness: Medium

Cultural Aptitudes

Yield: Low
Pruning: Semi long cane with maximum 6 buds
Tolerance to frost: Medium to high
Ripening: Mid-September

Experimental vineyard was established on south facing land (slope 7%) with clay loam textured soil onto three rootstocks (41B, 1103P and 5BB) with 2222 vines/ha planting density (1.5x3.0 m) in 1997 at the Viticulture Research and Training Station (Altitude: 750 m; Coordinates: 40°06'44.5" NL, 33°25'43.3" EL; Annual mean temperature: 13.2°C; Rainfall: 379 mm/year).

Grapevines were trained on 90 cm-high trunk as bilateral cordon (BC) and head training (HT) with 3-4 fruiting canes on double T (Ŧ) trellising / supporting system, and limited drip irrigated.

This experiment was aimed to determine the effects of four bud loading levels as 3, 4, 5, 6 buds per 150 g pruning wood on growth, yield, vine balance (RI) as yield/ pruning weight, and crop quality parameters, considering the suggestions of Mancillia and Godoy Avilia (1990) [10]. Experiment was designed randomized blocks as three replications with five grapevines in each replicate. Number of retaining buds on the experimental vines in accordance with bud loading levels are presented in Table 1. Data was evaluated according to the ANOVA Test in SPSS Duncan's Multiple Range Test.

Table 1. Number of Retaining Buds on the Vines in Accordance with Bud Loading Levels per 150 g Pruning Wood

Rootstock	Training	Bud Loading Levels				Mean
		3	4	5	6	
41B	Head	12	16	20	24	18.0
	Cordon	16	21	26	32	23.8
5BB	Head	12	16	20	24	18.0
	Cordon	16	21	26	32	23.8
1103P	Head	12	16	20	24	18.0
	Cordon	15	20	25	30	22.5
Mean		13.8	18.3	22.8	27.7	

Table 2. Phenological Growth Stages

Year	Bud Swelling	Bud-Burst	50% of Bud-Burst	Anthesis	Fruit-Set	Veráison	Harvest
2008	2/4	10-13/4	20-23/4	21-22/5	10-12/6	18-21/7	9/9
2009	3-5/4	13-16/4	25-28/4	23-26/5	14-18/6	19-22/7	18/9

Discussion of the Results

Phenological Growth Stages

Phenological growth stages recorded in the experimental vineyard during the period of the trial were given in Table 2.

Growth Parameters

Bud-Burst (%)

As the independent (non-interactive) evaluation, while effects of rootstocks and years were negligible; bud loading and training systems influenced the bud-burst ratio, markedly. Highest rates were observed in 5-bud loading (91.7%), and bilateral cordon training (92.3%) (Table 3). The top-five combinations were listed in order on Table 4. Data showed that grapevines trained with cordon on 1103P, and 41B had higher bud-burst performances. General mean was 86.4%.

Pruning Wood Weight / Vine (g)

Pruning weight values of training systems and years were exactly the same (472 g), but 6-bud loading (541 g) showed markedly higher growth performance than all other bud loading levels, and 1103P (491 g) than 5BB (452 g) (Table 3). Data of highest valued combinations is quite similar to bud-burst performances, with the exception of the highest performance of head-training with 6-bud loading in 2009 (816.6 g) (Table 4). General mean was 472 g/vine.

Yield Parameters

Number of Clusters / Vine

According to the non-interactive means, while 1103P had significantly lower number of cluster (23.7); 6-bud loading (34.2), cordon training (29.3), and the year 2009 (29.9) presented markedly higher values than their partners. General mean was 27.4 (Table 3). Concerning the triple interactive effects of the factors, 5BB x BC x 4 buds in 2009 had the highest value (53.3), combinations of 6-bud loading showed the highest fruitfulness as expected, especially in 2009 (Table 5).

Yield/m^2 (kg)

While the differences between rootstocks and years were negligible, cordon had markedly higher yield than head training, and the performance of 3-bud loading were found to be significantly lower than other loading levels. General mean was 0.939 kg (Table 3). Among the interactive combinations, bilateral cordon training system combined with 5BB and 41B rootstocks and 6, 5, 4-bud loading respectively in 2009 exhibit the highest yields per square meter (Table 5).

Yield/Vine (kg)

Differences in the performances of rootstocks, bud loads, training systems and years were significant, in favor of 5BB (4.7 kg), 6-bud loading (5.3 kg), bilateral cordon (4.7 kg), and the year 2009 (4.5 kg). General mean was 4.3 kg (Table 3). Highest values were recorded in 5BB x BC x 6 buds (6.7 kg), followed by 5BB x BC x 5 buds (6.6 kg) and 41B x BC x 6 buds (6.6 kg) all in 2009 (Table 5).

Crop Quality

Cluster Weight (g)

Concerning the independent effects of four factors, only 6-bud loading had the significantly heavier clusters

Table 3. Effects of Rootstock, Bud Loading, Training, and Year[1]

	Bud-Burst (%)	Pruning Wt. (g)	Number of Clusters/ Vine	Yield/m² (kg)	Yield/Vine (kg)	Ravaz Index (RI)	Cluster Wt. (g)	Number of Berries / Cluster	Berry Wt. (g)	TSS (°B)	Total Acid (g/l)	pH
Rootstocks												
41B	89.4a	470ab	29.2a	0.895a	4.1b	8.8b	135.7a	78.9a	1.77a	23.8a	8.4a	3.30a
5BB	83.4a	452b	29.0a	1.045a	4.7a	11.6a	136.2a	75.0a	1.87a	23.9a	7.8a	3.29a
1103P	88.0a	491a	23.7b	0.850a	4.0b	9.2b	133.8a	75.1a	1.84a	23.4a	7.8a	3.32a
Mean	84.9	471	27.3	0.930	4.3	9.9	135.2	76.3	1.83	23.7	8.0	3.30
Bud Loading per 150 g Pruning Wt.												
3 Buds	82.3b	446b	20.5c	0.768b	3.5c	9.3ab	130.4b	76.1b	1.77a	23.8a	8.0a	3.23a
4 Buds	88.3ab	441b	27.7b	0.965a	4.1bc	8.1b	126.4b	74.3b	1.78a	24.0a	8.0a	3.26a
5 Buds	91.7a	458b	27.1b	0.981a	4.4ab	10.2a	121.5b	66.8c	1.87a	23.2a	7.8a	3.29a
6 Buds	85.3ab	541a	34.2a	1.073a	5.3a	10.4a	162.5a	87.9a	1.89a	23.8a	8.1a	3.31a
Mean	86.9	472	27.4	0.947	4.3	9.5	135.2	76.3	1.82	23.7	8.0	3.27
Training Systems												
Head	81.3b	471a	25.4b	0.841b	3.9b	8.3b	134.1a	75.2a	1.84a	24.1a	8.0a	3.27a
Cordon	92.3a	472a	29.3a	1.053a	4.7a	10.6a	136.3a	77.4a	1.82a	23.3a	7.9a	3.28a
Mean	86.8	472	27.4	0.947	4.3	9.5	135.2	76.3	1.83	23.7	7.95	3.28
Years												
2008	86.9a	471a	24.6b	0.887a	4.0b	9.1b	135.2a	85.9a	1.59b	23.5a	8.0a	3.29a
2009	86.8a	472a	29.9a	0.973a	4.5a	10.6a	135.3a	66.7b	2.06a	23.9a	7.9a	3.26a
Mean	86.9	472	27.3	0.930	4.3	9.9	135.3	76.3	1.83	23.7	7.95	3.28
Gen. Mean	86.4	472	27.4	0.939	4.3	9.5	135.2	76.3	1.83	23.7	8.0	3.28

[1]Different words in the table indicate statistically significant differences between the treatments of each factor at 5% level

Table 4. Highest Valued Combinations for Growth Parameters

Bud-Burst (%)	
1. 1103P x BC x 4 buds (2008)	96.6
2. 1103P x BC x 4 buds (2009)	96.1
3. 1103P x BC x 3 buds (2009)	96.0
4. 41B x BC x 5 buds (2009)	95.4
5. 41B x BC x 4 buds (2009)	95.3
Pruning Wood Wt/Vine (g)	
1. 1103P x HT x 6 buds (2009)	816.6
2. 1103P x BC x 3 buds (2009)	800.0
3. 1103P x BC x 5 buds (2009)	750.0
4. 41B x BC x 6 buds (2008)	666.6
5. 5BB x HT x 3 buds (2008)	663.3

Table 5. Highest Valued Combinations for Yield Parameters

Number of Clusters / Vine	
1. 5BB x BC x 4 buds (2009)	53.3
2. 41B x BC x 6 buds (2009)	50.4
3. 5BB x HT x 6 buds (2009)	44.5
4. 41B x HT x 6 buds (2009)	43.7
5. 5BB x BC x 6 buds (2009)	41.9
Yield/m² (kg)	
1. 5BB x BC x 6 buds (2009)	1.66
2. 5BB x BC x 5 buds (2009)	1.48
3. 41B x BC x 5 buds (2009)	1.31
4. 41B x BC x 6 buds (2009)	1.29
5. 5BB x BC x 4 buds (2009)	1.21
Yield/Vine (kg)	
1. 5BB x BC x 6 buds (2009)	6.7
2. 5BB x BC x 5 buds (2009)	6.6
3. 41B x BC x 6 buds (2009)	6.3
4. 5BB x HT x 6 buds (2009)	5.8
5. 41B x BC x 5 buds (2009)	5.4

(162.5 g) than the other loading levels, unexpectedly. General mean was 135.2 g (Table 3). Among interactive combinations, highest weight of cluster was recorded 5BB and 41B rootstocks combined with BC and HT systems, all with 6-bud loading with the values between 169.2 g – 168.3 g (Table 6).

Berry Number / Cluster (Fruit-Set)

Berry number / cluster as an indicator of fruit-set, was influenced by bud loading levels and years. Berry number in 6-bud loading (87.9) was markedly higher than lower loading levels as unexpected. Values in 2008 (85.9) is also significantly higher than 2009 (66.7) possibly due to weather conditions. General mean was 76.3 (Table 3). The 5 highest valued combinations were all loaded with 6 buds (highest loading) that is another unexpected performance, all in 2008.

Berry Weight (g)

Only the substantial difference were recorded between the years (2.06 g in 2009, 1.59 g in 2008), possibly because of the markedly lower fruit-set ratios in 2009. General mean was 1.83 g (Table 3). Highest valued combinations were recorded in 2009 mostly on 5BB as seen in Table 6.

Berry Composition

Non-interactive effects of rootstocks, bud loading levels, training systems and years were found to be negligible. General means were 23.7 °B as TSS, 8.0 g/l for titratable acidity, and 3.28 as pH of the juice (Table 3). Concerning the interactive effects of factors, the five highest valued combinations for each parameter were presented in Table 7. Highest values were obtained from combinations grafted onto 41B (Table 7).

Ravaz Index (RI)

Non-interactive effects of rootstocks, bud loading, training systems and years were found to be significant. Means of each factor were very close to 10 that means

Table 6. High Valued Combinations for Crop Quality

Cluster Wt. (g)	
1. 5BB x BC x 6 buds (2008)	169.2
2. 5BB x BC x 6 buds (2009)	169.0
3. 5BB x HT x 6 buds (2009)	168.4
4. 41B x HT x 6 buds (2008)	168.3
5. 41B x HT x 6 buds (2009)	168.3
Number of Berries / Cluster	
1. 5BB x HT x 6 buds (2008)	101.8
2. 41B x HT x 6 buds (2008)	100.8
3. 5BB x BC x 6 buds (2008)	100.6
4. 41B x BC x 6 buds (2008)	99.9
5. 1103P x BC x 6 buds (2008)	93.9
Berry Wt. (g)	
1. 5BB x BC x 6 buds (2009)	2,28
2. 5BB x BC x 3 buds (2009)	2,24
3. 5BB x HT x 4 buds (2009)	2.21
4. 5BB x HT x 5 buds (2009)	2.20
5. 1103P x HT x 6 buds (2009)	2.18

Table 7. Highest Valued Combinations for Berry Composition

TSS (°B)	
1. 41B x HT x 3 buds (2009)	26.0
2. 41B x BC x 6 buds (2008)	25.9
3. 5BB x BC x 4 buds (2009)	25.5
4. 41B x HT x 6 buds (2009)	25.4
5. 1103P x HT x 3 buds (2008)	25.4
Acidity (g/l)	
1. 41B x BC x 3 buds (2008)	10.13
2. 41B x HT x 3 buds (2008)	9.30
3. 41B x BC x 6 buds (2008)	9.23
4. 1103P x HT x 4 buds (2009)	9.23
5. 41B x HT x 6 buds (2008)	8.53
pH	
1. 41B x BC x 5 buds (2008)	3.80
2. 1103P x BC x 6 buds (2009)	3.80
3. 41B x HT x 6 buds (2008)	3.68
4. 41B x HT x 4 buds (2009)	3.43
5. 1103P x HT x 4 buds (2008)	3.43

Table 8. Highest and Lowest Valued "Ravaz Index" Combinations

	Highest Valued Combinations	RI	Lowest Valued Combinations	RI
1	5BB x BC x 3 buds (2009)	23.0	1103P x BC x 5 buds (2009)	5.1
2	5BB x BC x 6 buds (2009)	21.4	1103P x HT x 4 buds (2009)	5.2
3	5BB x BC x 5 buds (2009)	18.9	1103P x BC x 3 buds (2009)	5.8
4	1103P x BC x 3 buds (2008)	16.5	1103P x HT x 3 buds (2009)	5.8
5	1103P x HT x 6 buds (2008)	15.7	41B x BC x 3 buds (2008)	6.0

the grapevines were slightly over cropped. General mean was 9.5 (Table 3).

Considering the significance of interactive effects between bud loading and training system. "Ravaz Index" values as the indicator of vine balance, ranged in 5.1 (1103P x BC x 5 buds loading) in 2009 and 23.0 (5BB x BC x 3 buds loading) in 2009. Combinations having the highest and lowest values were represented in Table 8. Data in Table 8 indicate growth promotion effect of 1103P, and adversely growth retardation effect of 5BB, on scion variety.

Conclusions

Interactive effects between bud loading and training system in almost all parameters were found to be significant for three rootstocks and both years. Regarding the bud-burst and pruning weight performances; rootstocks ranged in 1103P > 41B > 5BB, 5-bud loading for bud-burst and 6-bud loading for pruning weight had highest values, bilateral cordon dominated head training for bud-burst ratio. In yield parameters including number of clusters and crop yield, performances of 5BB and 41B, 6-bud loading and bilateral cordon were relatively higher. Unexpected higher berry number / cluster and cluster weight in 6-bud loading may be attributed to high water uptake of heavy loaded grapevines. Vine balance performances defined as RI mostly ranged between 5 and 10 that is considered the appropriate vine balance range. Rootstocks, bud loading levels, and training systems had no marked effect on berry composition. These findings were highly coincided with the results and recommendations of related studies [2-8,10], with a few explicable exceptions.

As a final conclusion of whole data, 5BB, 41B and 1103P respectively combined with 4-5 buds for head training, 5-6 buds for bilateral cordon, retained per 150 g pruning weight on bilateral cordon can be recommended for limited irrigated Kalecik Karası grapevines planted with 1.5 m x 3.0 m distances in Kalecik/Ankara location.

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